COW HEAD TUI CHUB
***Siphateles thalassinus vaccaceps* (Bills and Bond)**

Status: High Concern. Because of its extremely small range and level of human alteration to habitats within that range, the Cow Head tui chub is vulnerable to both human-induced and natural perturbation, especially during periods of severe drought.

Description: The Cow Head tui chub (CHTC) is similar to the Klamath tui chub, *Siphateles bicolor bicolor*, but is differentiated primarily on the basis of more gill rakers (Bills and Bond 1980). The CHTC has 19-25 (mean = 22.5) short, "bluntly rounded" gill rakers, compared with 10-15 gill rakers in *S. b. bicolor*. Other morphological features that characterize this subspecies are: the head is not as deep as in other chubs, is relatively longer, and is convex in profile with a rounded interorbital; a nuchal hump is present, but low; the lower jaw is not overhung by the upper jaw; and the caudal peduncle is relatively deep. Predorsal scales number from 26-35 (mean = 31) and there are approximately 57 lateral line scales. The pectoral fin has 15-17 rays and the pelvic fin has 8-9 rays. Pharyngeal tooth counts are 0,5-4,0; 0,4-4,0; 0,5-5,0. Coloration is similar to other subspecies, except there is a dark lateral stripe with speckles on the head region, especially the cheek and operculum, and on the lower body. Reproductive males and females develop breeding tubercles, especially on the anterior rays of the pectoral fins. Smaller tubercles develop in rows on the edges of the breast scales. In males, tubercles also develop on the scales above the pectorals and across the nape. The largest CHTC on record is 235 mm (Scoppettone and Rissler 2003).

Taxonomic Relationships: The CHTC was first recognized as a distinct form by Hubbs and Miller (1948) and was formally described by Bills and Bond (1980). A genetic study using mitochondrial DNA found that tui chub populations in the Cow Head, Warner and Goose lake basins were closely related and were genetically distinct from other tui chubs, meriting recognition as a single species under the name *Siphateles thalassinus* (Harris 2000). Harris recognized two lineages within *S. thalassinus*, one in Goose Lake and the other in Pluvial Lake Warner, which includes both the Cow Head and Warner basins. Harris's findings supported Hubbs and Miller's (1948) postulation of a possible relationship between CHTC and chubs from the lakes in Warner Valley, Oregon, because of the connection that exists between the Cow Head Basin and the Warner Valley drainage (see Distribution section below). Bills and Bond (1980) had disputed this hypothesis on the basis of differences in gill-raker length and fin and head shapes between the two populations. In 2007, a study using microsatellite DNA allowed greater resolution of the taxonomy of the tui chub of the northwestern Great Basin (Chen et al. 2009). Chen's results supported Harris' systematics regarding *S. thalassinus* and also found that the CHTC was sufficiently distinct to warrant subspecies status as *S. t. vaccaceps.* For a more detailed discussion of tui chub taxonomy, see the Lahontan Lake tui chub, *S. b. pectinifer,* account in this report.

Moyle et al. (1995) and Moyle (2002) list the common name of the chub as "Cowhead Lake tui chub" but Reid (2007) indicated that Cow Head tui chub is more accurate (the chub mostly does not live in the lake) and more consistent with the geographic name.

Life History: Cow Head tui chubs grow to 40-50 mm SL during their first year and 60-80 mm SL during their second year (Moyle unpublished data). By five years of age they reach an average of 100 mm SL, with larger individuals uncommon. The largest individual captured was 235 mm SL and over ten years old (Scoppettone and Rissler 2003). Most tui chubs spawn from late April to early July, beginning in their second to fourth year (Moyle 2002). Although there is little specific information on the reproductive behavior of CHTC, it is believed that they first spawn at two or three years of age (Reid 2006). Fecundity is relatively high, and a female of 100 mm produces approximately 4,000 eggs, which she lays over a series of spawning events. Like other tui chubs, CHTC presumably spawn in groups over aquatic vegetation, algae covered rocks, or gravel with several males attending to each female. Eggs adhere to plants or to substrates. Embryos hatch in 3-6 days and larvae begin feeding soon after hatching (Moyle 2002).

Tui chubs are generally opportunistic omnivores and feed on invertebrates (i.e. snails, clams, insects, and crustaceans), algae and other plant material, and small fish associated with the benthos or aquatic plants (Moyle 2002). Scoppettone and Rissler (2003) examined the stomach contents of 64 CHTC from various sites. Aquatic insects accounted for 28% of the total food by volume, while terrestrial insects accounted for 20%, and algae formed 31%. A single stomach contained an unidentified fish. Unidentifiable animal remains (presumably invertebrates) formed the remaining 19 % of total volume.

Habitat Requirements: Having evolved in the arid Great Basin, tui chubs like CHTC are highly tolerant of high alkalinity, turbidity, high temperatures and low levels of dissolved oxygen (Castleberry and Cech 1986, Moyle 2002, Reid 2006). The most generalized characteristics of suitable CHTC habitat are quiet water with abundant aquatic plants and bottom substrates of sand or finer materials. Thus, CHTC typically occupy pool areas in streams and open water channels with dense beds of aquatic vegetation (Sato 1992b, 1993a, Homuth 2000, Scoppettone and Rissler 2003, 2006).

Distribution: The range of CHTC is limited to the Cow Head Basin in extreme northeastern California and northwestern Nevada (Reid 2006). The Cow Head Basin is relatively small (25,700 acres) and drains north into the Warner Basin of Oregon through Cow Head Slough and Twelve Mile Creek. Cow Head Slough is a small, muddy creek. Under summer water conditions, the creek consists of a series of pools (95%) and riffles (5%) and meanders through a lava canyon approximately 50 m wide. The pools are fairly large, approximately 50 m^2, and are interconnected by shallow trickles. Landownership in the Cow Head Basin is both private and Federal (U.S. Bureau of Land Management (BLM)), but most perennial CHTC habitat is on private land (Reid 2006).

Historically, the basin contained a shallow, marshy lake during wet climate periods. However, Cow Head Lake was altered in the 1930s to allow seasonal drainage of the lake to facilitate farming of the lakebed during spring, summer and fall. The lake still fills during winter in high precipitation years but is drained by active pumping in spring. Populations of CHTC occupy all principal low gradient streams in the basin (Cow Head Slough and Barrel, West Barrel and Keno creeks) and a relatively large population still exists in the permanent channels that drain the lake bed (Scoppettone and Rissler 2006).

Recent surveys have identified seven areas of occupied perennial habitat in five sub-drainages within the Cow Head Basin. Each area is seasonally isolated and is maintained by separate springs or creeks and each contains a population of 1,000-10,000 individuals of all age classes (Reid 2006). During wet periods, stream populations of chubs expand throughout most of the low gradient stream habitat in the basin. Connectivity between stream populations of chubs is generally unobstructed during springtime flows but, as summer progresses and streams dry, all populations become restricted to isolated perennial pools (Reid 2006). Recent genetic research indicates that the genetic variability of CHTC is appropriate for a stream resident population (Chen 2006).

Trends in Abundance: In 1998, when CHTC were proposed for listing as a federally threatened species (see Status), they were only known to occur in Cow Head Slough and Pump Canal (Reid 2006). The only population estimates available at the time were qualitative and based on limited sampling with minnow traps and dip nets (Sato 1992b, 1993a-b, Olson 1997). In 1999, a limited sampling program was conducted with minnow traps in the southern BLM portion of Cow Head Slough and estimated 108 CHTC (39-113 mm FL) were present in this reach (Richey 1999). However, this survey was limited to BLM land that composes only a small portion of the habitat available.

Population estimates conducted in August, 2002 found approximately 3 km of occupied habitat in Barrel Creek and 4 km in Cow head Slough, with a combined population of several thousand chubs over 40 mm (Scoppettone and Rissler 2003). The largest single population was found in the Pump Canal. Although no rigorous population analysis was conducted, four small seine hauls spaced at 200 m intervals produced 936 chubs (22-148 mm) in 2001. Even considering the sampling limitations, if these results were expanded out to the full kilometer of available perennial habitat, a very rough Pump Canal population estimate would exceed 20,000 fish (Reid 2006).

Nature and Degree of Threats: Cow Head tui chubs exist in a small, isolated basin where native aquatic habitats and stream and lake hydrology have been highly altered by human activities, especially agriculture and grazing.

Agriculture. The main threat to the continued existence of CHTC is water diversion from Cow Head Slough for pasture, especially during periods of drought. For example, in 1992, the chubs were largely confined to a short section of slough that was entirely on private land with a water supply that depended, in part, on inflow from an irrigation ditch. The Cow Head lakebed has been used for production crop agriculture in the past and may be utilized as such in the future. Such a transition from ranching to tilled agriculture could have direct impact on water allocation in the Cow Head Basin. Pest control programs that introduce pesticides into the drainage (e.g., USDA-APHIS Grasshopper Control Program) are also a potential threat, although this issue has not been studied in the Cow Head Basin.

Grazing. Grazing in the area has removed riparian vegetation, reducing cover available to fish, making them more vulnerable to predation. Natural predators include garter snakes and fish-eating birds, both of which prey on juveniles and adults, and aquatic insects which prey on eggs, larvae, and juveniles (Reid 2006).

Alien species. While no alien species apparently exist in the watershed at the present time, an illegal introduction of other fish species could easily happen (as has occurred in many other equally isolated parts of the state) and has the potential to threaten the subspecies with rapid extinction due to its limited range.

	Rating	Explanation
Major dams	n/a	
Agriculture	High	Agriculture has degraded habitats and can divert large amounts of water
Grazing	High	Almost all habitat is impacted by grazing
Rural residential	Low	Low population densities and relatively little residential pressure on water supplies
Urbanization	n/a	
Instream mining	n/a	
Mining	n/a	
Transportation	Low	No known impact, but roads run along or cross much of CHTC habitat
Logging	Low	No known impact but may accelerate sedimentation
Fire	Low	No known impact but fires common in desert regions
Estuary alteration	n/a	
Recreation	n/a	
Harvest	n/a	
Hatcheries	n/a	
Alien species	Medium	Although there are no alien species in the watershed at present, illegally introduced species could rapidly deplete populations

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Cow Head tui chub in California. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction unlikely as a result; and a factor rated "no" has no known negative impact to the taxon under consideration. Certainty of these judgments is high. See methods section for descriptions of the factors and explanation of the rating protocol.

Effects of Climate Change: Snow melt and spring recharge from winter rains, the principle sources of water for all CHTC habitat, are likely to substantially decrease as the climate warms, and standard climate models indicate water temperatures are likely to increase 2-4 degrees C by the end of the century. Increased human demand for water is also likely, given the limited supply in the basin and the increased likelihood of long-term drought. Moyle et al. (2013) rated the CHTC as highly vulnerable to extinction from

climate change because of its limited habitat in an area that is already very dry and hot, conditions likely to exacerbated by climate change.

Status Determination Score = 2.4 - High Concern (see Methods section Table 2). The CHTC was proposed for federal listing as a threatened species in 1998 but the petition was withdrawn after a conservation action plan was established and new sampling revealed a much larger population than previously known. However, because of the extremely small range and level of human alteration within that range, the CHTC is still vulnerable to both human-induced and natural changes to its habitats. Its status should be re-evaluated every five years or annually during periods of severe drought. The CHTC is listed by the American Fisheries Society as "Endangered" (Jelks et al. 2008) and by NatureServe as "Imperiled".

Metric	Score	Justification
Area occupied	1	Limited to a single, small basin
Estimated adult abundance	4	Relatively large, but variable populations in pump canals with five other smaller populations in perennial habitats
Intervention dependence	3	The largest population lives in an artificial ditch, so management of this habitat is crucial for survival
Tolerance	3	Tolerant of wide range of environmental conditions but, during drought, tolerances may be exceeded
Genetic risk	2	Isolated population with little or no gene flow
Climate change	2	Snow melt and spring recharge for all habitats are likely to decrease
Anthropogenic threats	2	See Table 1
Average	2.4	17/7
Certainty (1-4)	4	Good recent data generated from ESA listing studies

Table 2. Metrics for determining the status of Cow Head tui chub in California, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

Management Recommendations: On October 22, 1999, stakeholders in the Cow Head watershed signed a conservation agreement (CA) and conservation strategy (CS), with the stated purpose of ensuring the long-term survival of the CHTC (USFWS 1999). Signatories included the US Fish and Wildlife Service, private landowners of Cow Head Lake, Cow Head Slough and the California reach of Barrel Creek (four owners, all CA signatories), principal permittees on BLM lands within the drainage, California and Modoc County Cattlemen's Associations, the California Farm Bureau Federation, the U.S. Bureau of Land Management (BLM - Surprise Field Office), and California Department of Fish and Wildlife (CDFW). The two owners on West Barrel and the single owner for perennial reaches of Barrel and Keno creeks (Nevada) were not original signatories to the CA, because these populations were not recognized at the time;

however, they have been collaborative in providing access to meet the needs of the Conservation Strategy (Reid 2006).

Management directives laid out under phase 2 of the Conservation Agreement and Strategy, which must be implemented, are as follows:

- Create more stable habitat for populations downstream of the Pump Canal.
- Provide greater stability for the chub population upstream of the pump canal by creating, to the extent feasible, additional habitat in the area of historic Cow Head Lake.
- Monitor, as appropriate, the status of chub populations and effectiveness of conservation actions.
- Establish a monitoring program, whereby chub populations are sampled at least once a year.

In addition:

- A study of the environmental requirements of CHTC is needed.
- Slough reaches on public lands should be designated as Areas of Critical Environmental Concern and methods and locations to establish a permanent refuge for the CHTC on public land should be identified.
- Cow Head slough should be fenced to reduce or eliminate cattle grazing in riparian areas.

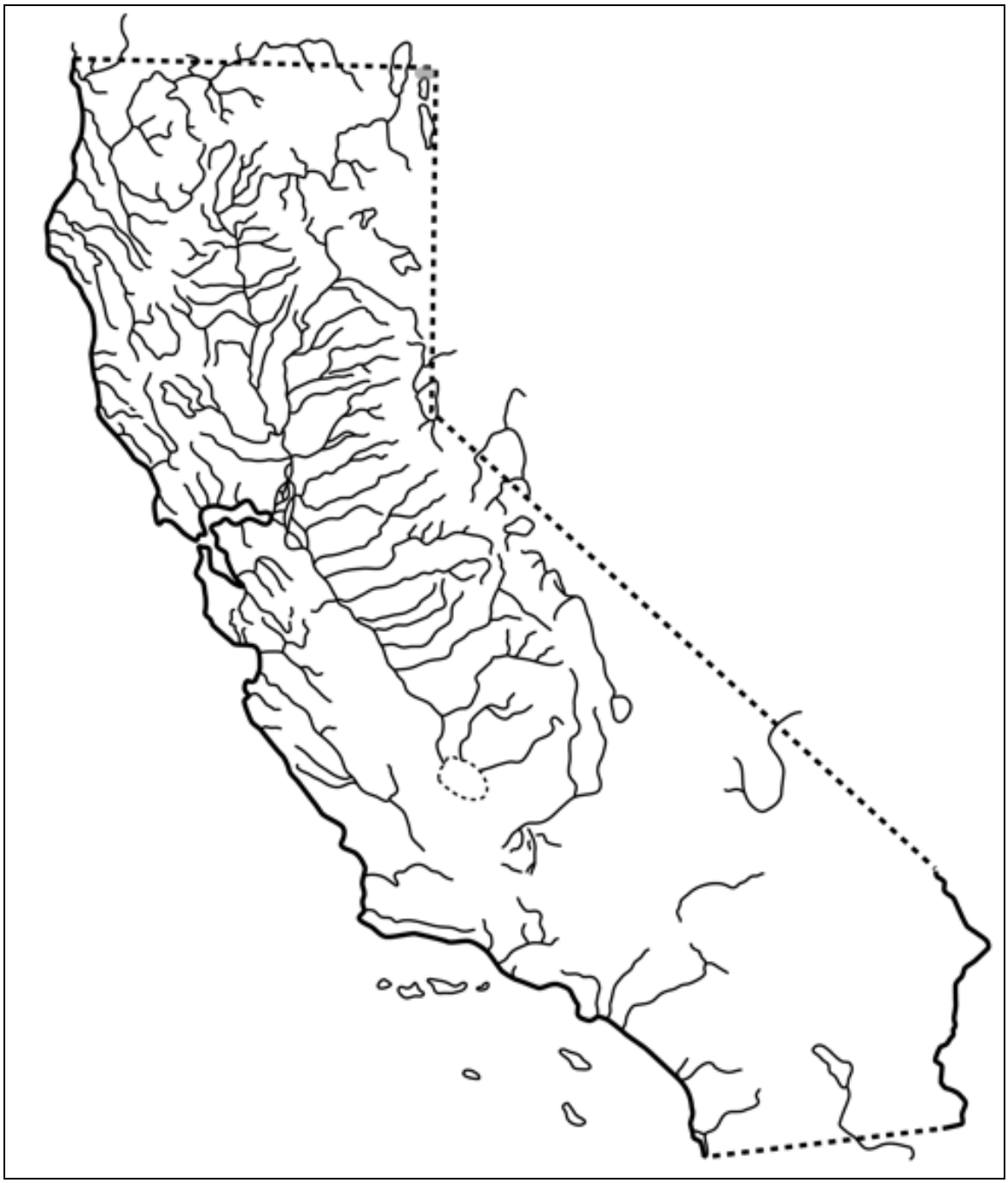

Figure 1. Distribution of Cow Head tui chub, *Siphateles thalassinus vaccaceps*, in California.