NICHES: Nearshore Indicators for Clarity, Habitat and Ecological Sustainability
Development of nearshore fish indicators for Lake Tahoe

Executive Summary

Christine Ka Lai Ngai, Dr. Sudeep Chandra

Department of Natural Resources and Environmental Science
University of Nevada-Reno
1000 Valley Road/ MS 186, Reno NV

Andrew Tucker, Dr. Craig Willamson, Dr. Jim Oris, Amanda Gevertz

Department of Zoology
Miami University
212 Pearson Hall, Oxford OH

Lake Tahoe's fishery is among one of the least studied of all the large lakes in the world. Over time there have been a variety of stressors (e.g. introduction of species, eutrophication, nearshore habitat modification), which has altered the fishery. However, only a limited number of studies have been conducted to investigate these impacts or determine the status of a particular species. With little to no information on the status of fishery, in particular the nearshore components where most of the native, littoral fish reside, scientists from the University of Nevada at Reno, Miami University in Ohio, and University of California at Davis TERC have compiled information to determine 1) the status of the nearshore fish community, 2) if there are quantifiable indicators and methodologies that can be created to determine the condition of the nearshore fishery, and 3) if ultraviolet radiation (UV) can be used to link nearshore and non-native fish ecology to the physical environment.

Similar to the early 1990s, the scientists found that the predominant fish species caught in the nearshore remains to be Lake Tahoe's native minnows, Lahontan reside shiners (*Richardsonius egregious*) and speckled dace (*Rhinichthys osculus robustus*). However, current catch of these and other species have declined. Overall, nearshore fish densities have undergone general decrease (58% of historically sampled sites) between 1988-89 and 2009. In particular, Lahontan redside shiner densities have declined (25-100%) at 42% of the historically sampled sites. These fishes were also found to be consuming a wider range of food types and relying more on surface food sources than before. These changes may be attributed to recent nearshore

habitat modifications, altering food availability or nearshore clarity. Alternatively, predation from game fish (e.g. lake trout) may also contribute to the decline when native fishes move offshore in the winter. Changes in spawning activities (spawning behavior and egg presence) and condition of spawning habitats (substrate types) were observed in 30% of the sites when compared to historical data collected by Allen and Reuter (1996). The observed changes are thought to be due to alteration in substrate types at various spawning sites as a result of decrease in lake water levels.

Researchers have also suggested the use of novel indicators (such as, trophic niche and UV radiation) to examine short- and long-term changes in nearshore fishery. Trophic niche, a tool used to look at how energy (food) is utilized among species in a community for growth and reproduction, can be used to determine changes in food web dynamics across different systems and timescales. Changes in the trophic niche of certain species were found in Lake Tahoe. All fish species examined, except Tahoe sucker (*Catostomus tahoensis*) have demonstrated change in reliance of food source from benthic (lake bottom) to pelagic (open water) food source. In addition, all fish species have shown reduced trophic position.

The research team also discovered that there is a strong linkage between clarity through UV light penetration and biodiversity in Lake Tahoe, and suggest that water transparency to ultraviolet radiation may be an additional factor that regulates the current and future distribution of non-native fishes. In Lake Tahoe, a variety of disturbances have been associated with a decrease in the average annual Secchi transparency from 31 m in 1968 to 21 m by 1998 (Jassby et al, 1999). During this same time a number of non-native warmwater fish species became established in portions of the lake (Reuter and Miller 2000), suggesting that decreasing water transparency may create a refuge for non-native species that are more sensitive to the optical properties of water such as ultraviolet radiation. High UV transparency can reduce the reproductive success of warmwater fish in shallow waters (Williamson et al, 1997; Huff et al, 2004; Olson et al, 2006). Data from nearhore-to-offshore UV profiling transects in Lake Tahoe demonstrate that shallow environments nearshore to some of the major inflows are far less UV transparent than offshore (Rose et al, 2009) and that patterns of UV transparency change from month to month. This is important because nearshore habitats that are suitable for spawning must be present during summer months that provide both the warm temperatures and low UV conditions that favor spawning by exotic species such as largemouth bass (Carlander, 1977). In

Lake Tahoe, native minnow species and introduced warmwater fish both inhabit the nearshore environment. Currently, the only well established non-native fish populations are limited to sites in the southern end of the lake characterized by extensive development and in close proximity to some of the lake's largest tributaries (Kamerath et al, 2008). Water transparency at these sites tends to be lower than elsewhere in the lake and may explain the suitability of such sites for the non-native fish. Native minnows occur widely and in habitats with high levels of UV.

UV exposure and in situ incubation experiments show that UV transparency of nearshore sites significantly impacts the survival of warmwater fish larvae and influences whether these potentially invasive fish species are able to establish in nearshore Lake Tahoe. Native fish larvae (Lahontan redside shiner) were at least six times more tolerant of UV exposure than non-native warmwater fish larvae (bluegill and largemouth bass). The observed difference in UV tolerance in native versus non-native fish was used to develop a UV attainment threshold (UVAT, i.e. a water clarity threshold based on water transparency to UV) that is lethal to non-native fish larvae with no observed effect on native fish larvae. Measurements of UV transparency around the lake showed that more than half of the sites sampled were in non-attainment of the UVAT, suggesting the potential for widespread warmwater fish establishment.

Previous studies conducted by Cordone (unpublished data 1960) and Thiede (1997) have already shown a sharp decline in nearshore native fish density of nearly 10-fold between the 1960s and late 1990s. Our contemporary assessment also suggests that the health of Lake Tahoe's nearshore native fishery is continuing to deteriorate. Given potential expansion of suitable habitat for non-native fishes as a result of increasing spread of invasive plants, elevated lake water temperature, and reduction in UV transparency, as well as other related threats (e.g. nearshore development), the future of Lake Tahoe's nearshore native fishery may be in trouble. Scientists believe that a long-term nearshore monitoring and warmwater fish prevention program utilizing ecologically relevant metrics is necessary to help better understand Lake Tahoe's nearshore native fishery, and assist stakeholders to more effectively manage and restore the lake's precious native biodiversity.

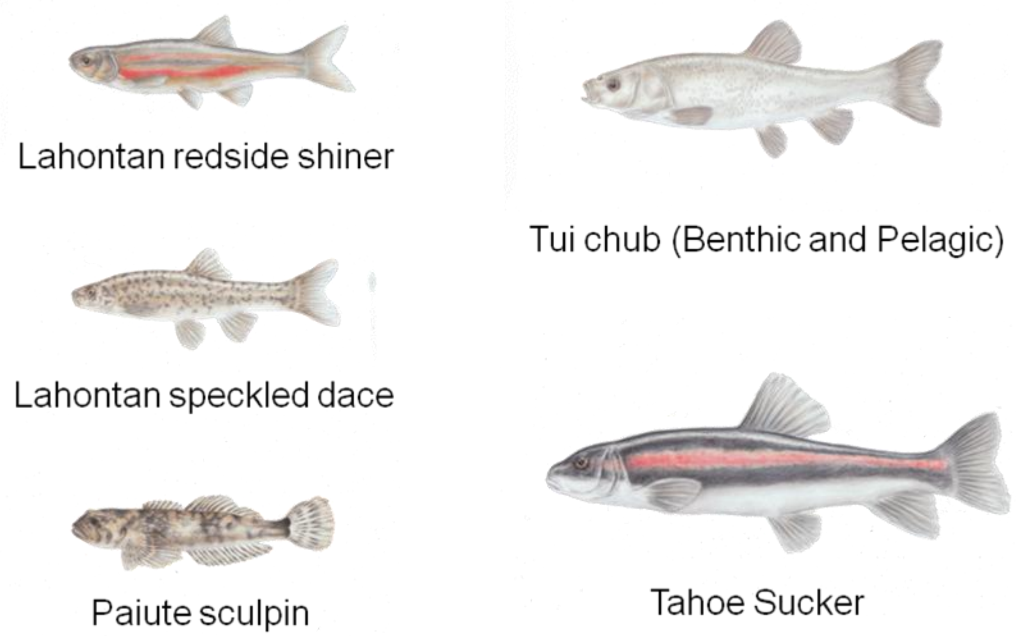

Figure 1. Native fishes commonly found in the nearshore of Lake Tahoe (Illustrated by S. Adler and L. Hennessy, Properties of UC Davis TERC)

Figure 2. Lahontan redside shiner fish eggs in gravel (Photo by Hollund Rudolph)

Figure 3. UV exposure experiments on the roof top of TCES with fish larvae (Photo by Molly Mehling)

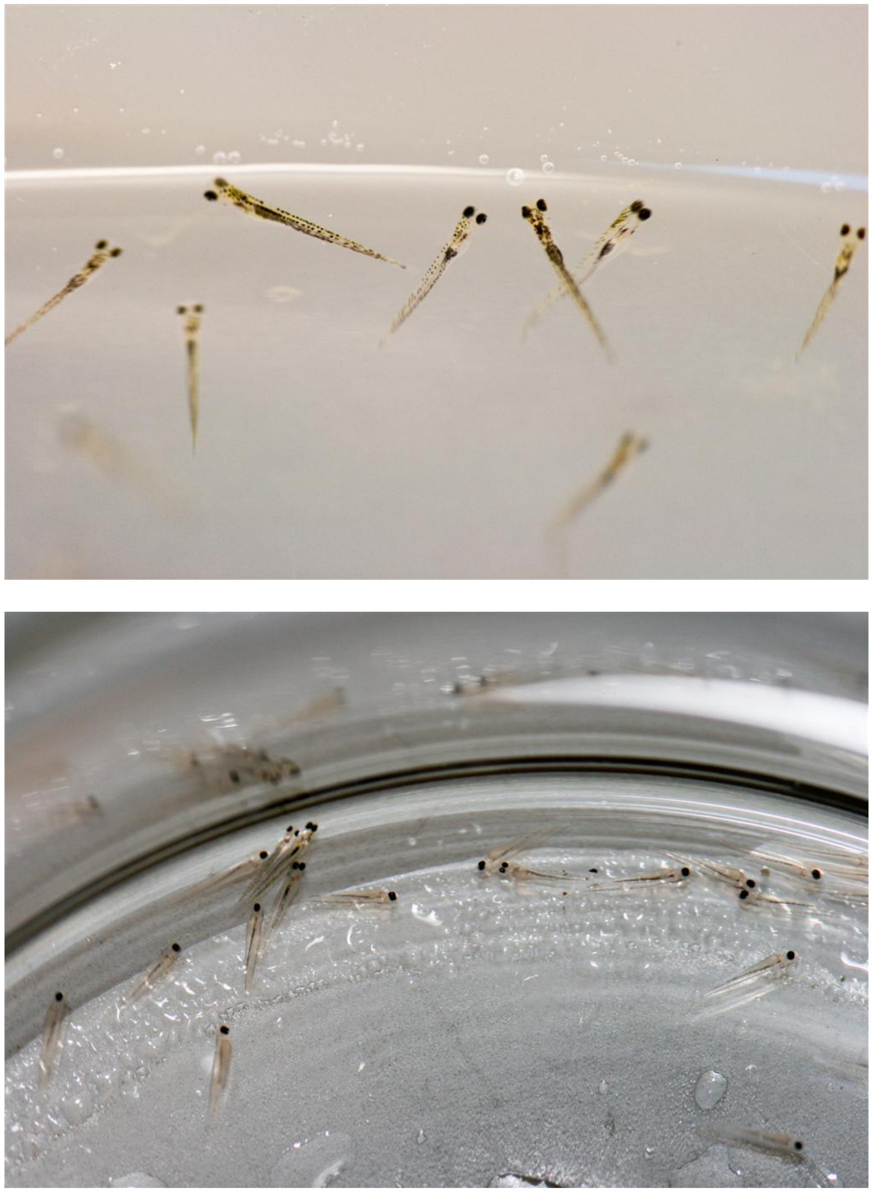

Figure 4. Fish larvae, Lahontan redside shiner-native to Lake Tahoe (top) and largemouth bass-nonnative to Lake Tahoe (Photo by Molly Mehling)