

## BEFORE SPECIES INVASION: THE ORIGINAL BIOTA OF THE LAKE

Prior to invasive species introductions, Lake Tahoe contained a relatively simple food web for such a large, deep lake ecosystem. It contained

- 2-5 aquatic plants
- 12 benthic invertebrate Orders
- 6 zooplankton species
- and 8 fish types, including the dominant game fish Lahontan cutthroat trout (Fig 1).



Fig 1. A photo of native Lahontan cutthroat trout. Once the largest trout in North America, these trout were extirpated from the lake by the 1930's.

## NONNATIVE SPECIES INTRODUCTIONS

Similar to other lakes in the Western United States, Lake Tahoe has undergone numerous nonnative introductions during the last 140 years (Fig 2).

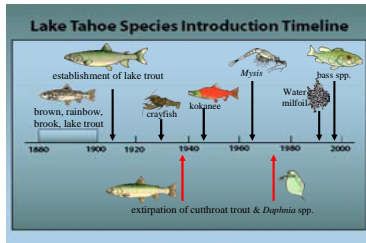


Fig 2. Timeline of invasive species introductions into Lake Tahoe over time. Many of these introductions were intentional and have had lasting consequences to the ecology of the lake.

These introductions have led to a variety of impacts including the decline of native cutthroat trout by predation from lake trout and virtual elimination of cladocerans *Daphnia* & *Bosmina* (Fig 4). Reduction in native zooplankton caused decreases in kokanee size and spawning numbers and shifted the feeding behavior of some native chubs. It is thought that daily migration (>400 m) of Mysids from the lake bottom to lake surface transport particles from the sediment, thereby reducing water clarity.

## THE LATEST INVADERS OF TAHOE: CAN WE CONTROL THEM?

In the last decade four new invasive taxa (water milfoil, curly leaf pondweed, asian clam & warmwater fish) have been found in the lake.

### Water Milfoil and Curly Leaf Pondweed

Water milfoil is spreading along the shoreline (Fig 5). Modifying the nearshore environment, this invasive species is a nuisance to motorcraft, may pump phosphorus into the water column (decreasing water clarity), & creates habitat for invasive fishes.

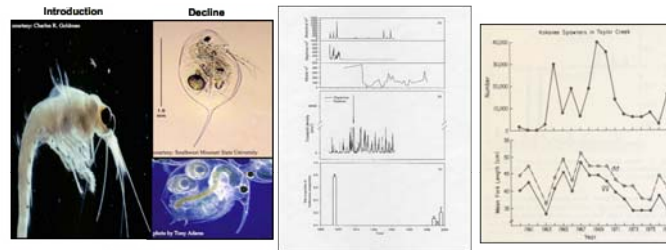


Fig 4. a) photos of the opossum shrimp (*Mysis relicta*) and the native zooplankton (*Daphnia* & *Bosmina*) eliminated from the lake. b) Graph showing the population decline of *Daphnia* & *Bosmina* species but stable, seasonal fluctuations of copepods, another zooplankton. Over time *Mysis* reduce their dependence on zooplankton from 78% to 10%. c) Kokanee salmon, which prefer *Daphnia* as a food source decrease their spawning numbers and size over time. d) Mysids restructure the whole lake food web to depend more on pelagic (open water) energy sources.

### Warmwater Fishes

Largemouth bass & bluegill are spreading around the lake. Once found only in the Tahoe Keys, the slight warming of the lake due to climate change, combined with habitat modification from invasive milfoil & food supplied by invasive crayfish, facilitate their range expansion. We are currently investigating if the Tahoe Keys area is the largest source of invasives to the lake.

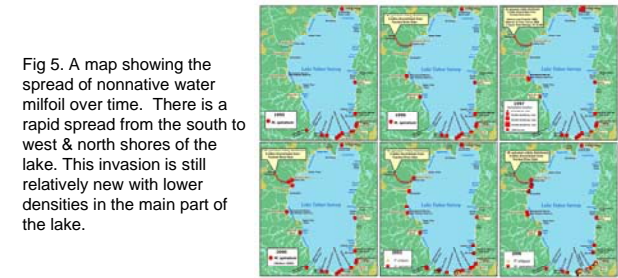


Fig 5. A map showing the spread of nonnative water milfoil over time. There is a rapid spread from the south to west & north shores of the lake. This invasion is still relatively new with lower densities in the main part of the lake.

In May 2008, we started a tagging program to track invasive fish to determine when they leave the Tahoe keys and where they move in the lake (Fig 6).

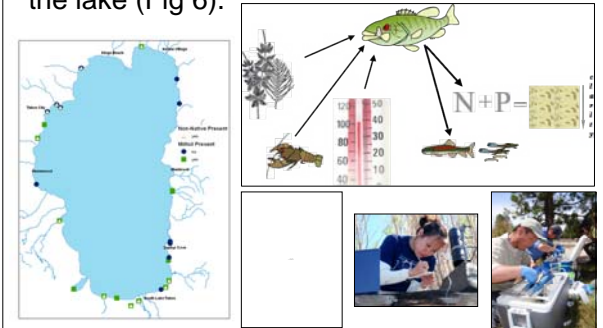


Fig 6. a) map of warmwater fishes & invasive milfoil locations. There is a significant amount of overlap between invasive milfoil, which creates habitat & structure, and the fishes. b) a conceptual diagram depicting the drivers of fish establishment & range expansion within the shoreline. Their spread could result in the excretion of nutrients (resulting in decreased nearshore clarity) and a further decrease in native fish populations. c) photos showing the process of collection using a California Fish and Game electroshocking boat, surgical implantation of tags to track invasive fish, and the receiver used to collect information on their movements.

### Clams and Mussels

There has been concern that quagga and zebra mussel may invade and that Asian clams may expand in the lake. A preliminary risk assessment model suggests select locations (Tahoe keys marina and existing invasive Asian clam beds) may support populations of quagga mussel. Other research suggests that Asian clams beds have expanded since their first sightings in 2001. While research is pending for a complete analysis, we have been working with the invasive species working group to create a plan for control and prevention of introduction of mussels and clams.