Walker Lake Ecological Monitoring of the Status and Trends of the Benthic Ecosystem: Invertebrate Populations, Algae, Lake Level, Salinity and Waterbird Surveys

David B. Herbst, R. Bruce Medhurst, and Ian D.Bell
Sierra Nevada Aquatic Research Laboratory
University of California

June 30, 2013

Introduction

Drought conditions in 2012 in the Sierra Nevada restricted stream flows to less than 50% of the historic normal runoff (Figure 1). With upstream agricultural irrigation diversions, even less than this reached saline Walker Lake. After a respite in 2011, lake levels again dropped and salinity increased into ranges that are limiting to the physiological capacity and habitat requirements of benthic invertebrates in the lake. More of the same is on the way in 2013, with snowpack lagging behind even the drought of the previous year. Tracking ecological changes during this impending critical period is essential to understanding how aquatic life responds and documenting the needs for recovery of a sustainable ecosystem. This report updates trends and incorporates new information on the dynamics of the algae food resources, and of waterbirds that feed at the lake.

Over a period of time since 2010, these data show differences between near-average, high runoff, and drought conditions as sublethal and lethal salinity limits are approached. Salinity is at about 20 g/L and temperatures over the past low flow drought year been significantly warmer than in higher flow years (Figures 2 and 3). How have populations of benthic invertebrates changed? For the birds that feed at the lake, what is the species composition and seasonality and abundance of waterbirds over a year? The productivity of the lake is at least partly temperature-driven so how much do temperatures differ with time between wet and dry years? What is the seasonality of benthic standing crop of algae, the base of the food chain? These and other questions are answered by the studies presented here. In addition, recognizing the importance of public outreach in presenting this information, we have developed a graphic data-cartoon that shows how the benthic portion of the food web of the lake is controlled by salinity and has changed with time as salinity limits are exceeded. Expressing the impacts of lost inflows to the lake to the public might best be accomplished with visual imagery, so this graphic is also easy to explain in community forums. These kinds of meetings could be organized for bringing attention to the imperiled state of the lake while still emphasizing that this ecosystem can easily be recovered by returning water. To promote the importance of salinity limits in awareness in the academic community, and provide validation of these effects, the results of our salinity bioassay are in publication press at the Journal of insect Conservation (in press: Herbst, D.B., S.W. Roberts, and R.B. Medhurst. 2013. Defining salinity limits on the survival and growth of benthic insects for the conservation management of saline Walker Lake, Nevada, USA). This could also provide technical support for natural resources damages assessment.

Findings:

Benthic Invertebrate Population Changes

The algae-feeding midge *Cricotopus ornatus*, abundant in the shallow littoral of the lake, showed some salt stress in low population numbers in 2010 and recovering in wet 2011 into 2012 but late in 2012 into 2013 have again fallen to low levels as the lake also declines. Spring and fall biannual adult emergence generations are evident as are growth through size classes each generation. The population abundance of the damselfly *Enallagma clausum* appears to increase from wet 2011 to 2012, suggesting that strong recruitment (development and emergence success) into the single-generation population during the high lake stages (2011) produced an enhanced reproductive output in the next generation (2012). The upcoming year of low lake levels and rising salinity will be telling in the responses of these species to the changing environment.

Deeper littoral and profundal benthic sampling in Walker Lake using the Ekman dredge continues to reveal an abundant population of the deeper water midge *Tanypus grodhausi*, a detritus feeder and facultative predator (Figure 6). Higher densities were found in deep water in 2009, but all other years including this last year show more or less equivalent abundance across the depth range of 2 to 15 meters, consistent with published results showing densities around 10,000 /m^2 over this range but only about 1 percent of this abundance in shallow water.

Other benthic invertebrates present include the segmented worm *Monopylephorus*, and the alkali fly *Ephydra hians* (a brine fly), both becoming more abundant as the salinity of the lake increases (Figure 7). Other invertebrates also persisting are represented in the diving beetle *Hygrotus masculinus*, water boatman *Corisella decolor*, deer fly *Chrysops*, biting midge *Culicoides*, and water beetle *Laccobius*.

Benthic Algae Seasonal Standing Crop and Composition

The chlorophyll biomass of benthic algae was measured on rocks in the shallow eulittoral region by random selection of 5 cobble-size rocks at each of the 8 monitoring stations on the west shore. The rocks within each station were scrubbed clean in a bucket of water with a nylon brush and the dimensions of all rocks measured as length, width, height and maximum circumference to estimate total surface area sampled. All filamentous algae was strained out in a net and the fibers cut into snips of several mm with scissors and returned to the bucket so only very short strands were suspended in the water. The contents of the scrub bucket brought up to a constant volume (15.25 Liters) were stirred thoroughly and subsampled so that 600 mL of homogenized mixed sample was returned to the lab. This was subsampled in the lab by drawing into a syringe and filtering volumes of 5-50 mL (depending on algae density) through a A/E glass fiber filter, 1 µm pore size. These filters were stored frozen, then extracted with 10 mL cold 95% ethanol, and read in a fluorometer relative to a calibration curve. The relative composition of algae types, placed in categories of filamentous green, diatoms, or blue-green (cyanobacteria) types, or absent, were scored as the dominant visual form(s) present on any given rock during the invertebrate sampling protocol of 8 cobble-size rocks at each station.

The density of chlorophyll increased from spring through summer and greatly into fall, from less than 1 to 5 µg/cm2 in April to September (Figure 8). Within the shallow depths of the eulittoral, algae were slightly less frequent at 84-88% cover in depths less than 30 cm deep compared to 93-100% at 30 to 60 cm depth (Figure 9). Filamentous greens and diatoms were most common overall, and tended to be dominated in deeper water by green filamentous and cyanobacteria, and diatoms in shallower water. The relative abundance of algae types by date showed that diatoms abundance was inverse to that over filamentous algae and cyanobacteria, the strands of which may shade out diatoms and make them capable of growth on rock surfaces (Figure 10). The fall peak in chlorophyll coincides with peaks in the cover of filamentous green algae and cyanobacteria.

Waterbirds of Walker Lake

Shoreline surveys of waterbirds were conducted at each monitoring station on each sample date in 2012. This will be an important source of trend information on location-controlled abundance by bird species over the years that can be linked directly to littoral invertebrate sampling data on abundance, life stage, and seasonality. The surveys were performed using a spotting scope and binoculars among three observers prior to any of our benthic sampling. We counted from shore in a radius onto the lake only as far as we could reliably see. Conditions were always calm to winds less than 10 mph (we cannot do benthic littoral sampling otherwise) and clear. Showing only the most abundant birds, but including common loon numbers because this is of special interest, there are distinctive groups found by season, as expected (Figure 11). There were 27 other species of water-associated birds we observed over the year (Table 1). Some birds were seen predominantly at one site (the southern-most rocky lagoon station where cormorants and pelicans were most common), but most were spread across the sites. Among abundant birds where some date-counts exceeded 1,000 (Figure 11), American coots were most abundant in fall and winter, gulls and grebes peaked in summer, and ruddy ducks in the fall. Among common birds, but whose counts did not exceed 1,000 but were in the hundreds (Figure 12), northern shovelers were winter birds, redhead ducks in spring through summer and declining in fall and winter, phalaropes were summer birds (mixed redneck and Wilson) and pelicans and cormorants were year-around except migrating away in the winter.

Dynamics of a Salinity-Dependent Food Web

Communication of the plight of Walker Lake to the public and to elected officials is an important outreach need for the research being conducted at the lake. In order to combine information about the salinity tolerance limits of the invertebrates and fish of the lake, with the food web linking them, a graphic illustration was developed to show how salinity drives the interconnections (Figure 13). This "science-cartoon" shows that as lake levels and salinity varies, different food sources to fish and birds appear or disappear or are under stress. Past and future scenarios may also be described using this graphic but most essential is that this illustration emphasizes that while the present lake is at the edge of losses of invertebrate prey organisms that could propagate through the food web, it is also a system that can be rejuvenated by adjustment of salinity through restored river inflow. A poster-size version of this could be used in public forums for communicating ecological problems and solutions.

Table 1. List of bird species seen at Walker Lake shore surveys 2012.

American Coot
American White Pelican
American Avocet
Blacknecked Stilt
Bufflehead
California Gull
Canada Goose
Common Goldeneye
Common Loon
Curlew
Double-crested Cormorant
Eared Grebe
Gadwall
Great Blue Heron
Killdeer
Lesser Scaup
Mallard
Northern Shoveler
Phalarope
Redhead
Redwinged Blackbird
Ruddy Duck
Violet Green Swallow
Western Grebe
Western Sandpiper
White Faced Ibis
Yellowheaded Blackbird

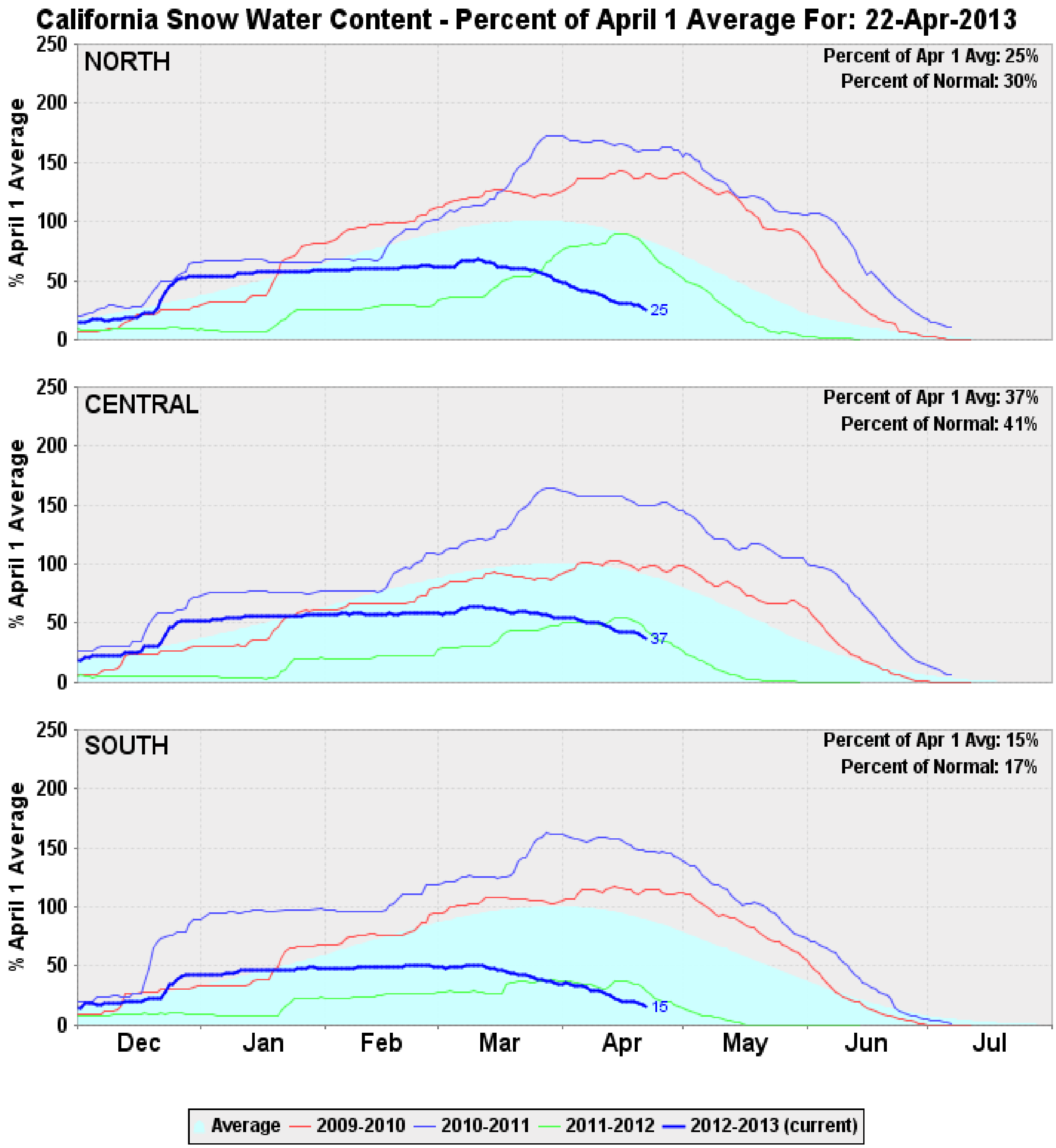

Figure 1. Sierra Nevada regional snowpack as snow-water equivalents contrasting the near-normal water year of 2009-10 with high flow of 2010-11 and droughts of 2011-12, 2012-13 (to current).

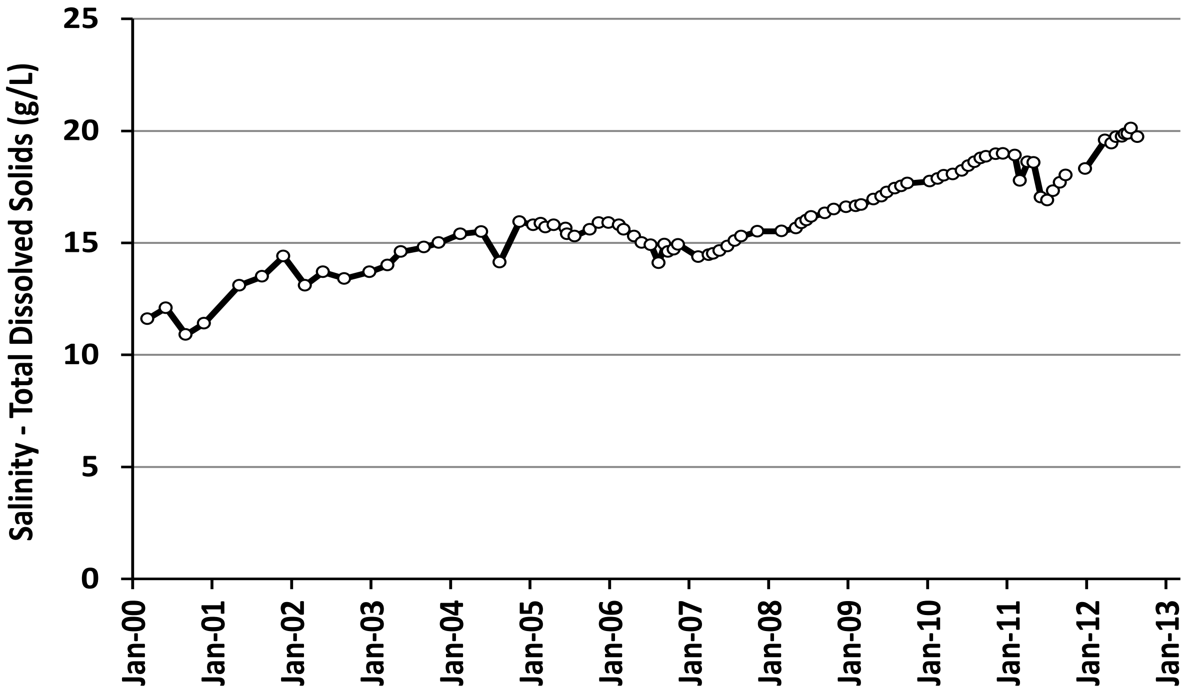

Figure 2. Salinity of Walker Lake from 2000 through 2012.

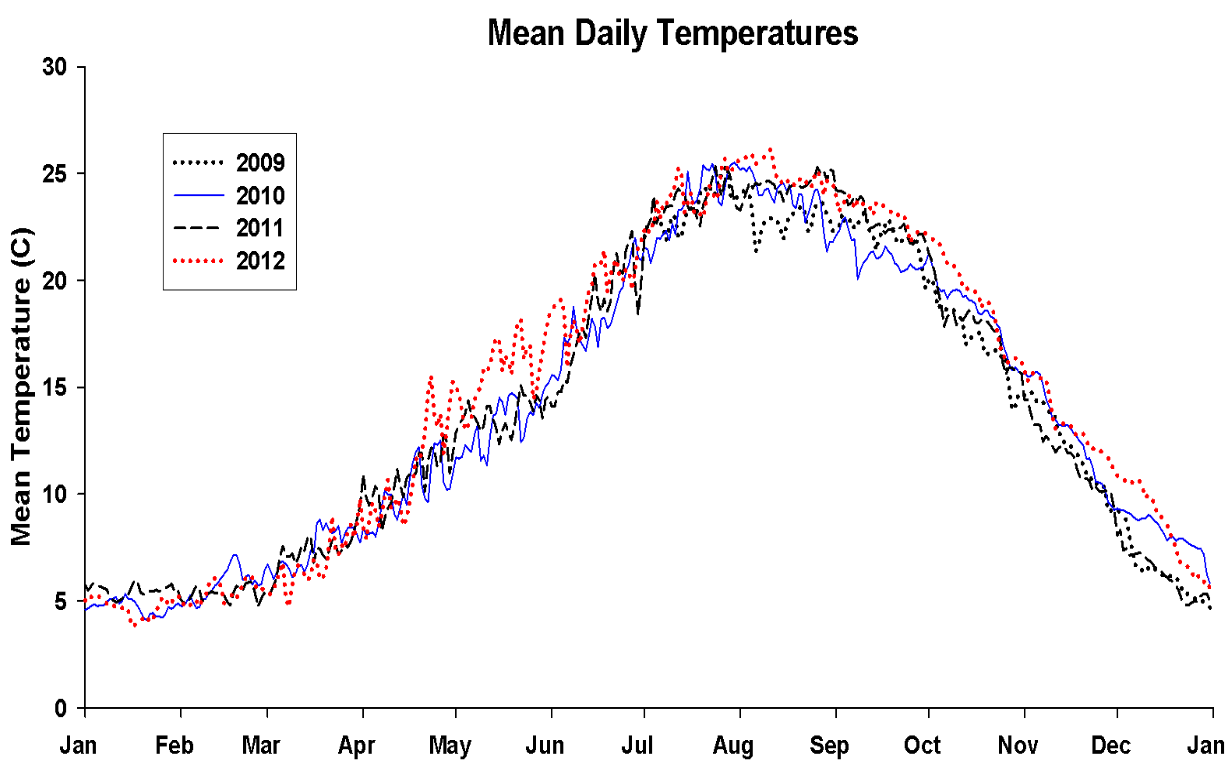

Figure 3. Temperature profiles over years of monitoring 2009 tthrough 2012. Showing differences in spring months between cooler wet years and warm dry 2012.

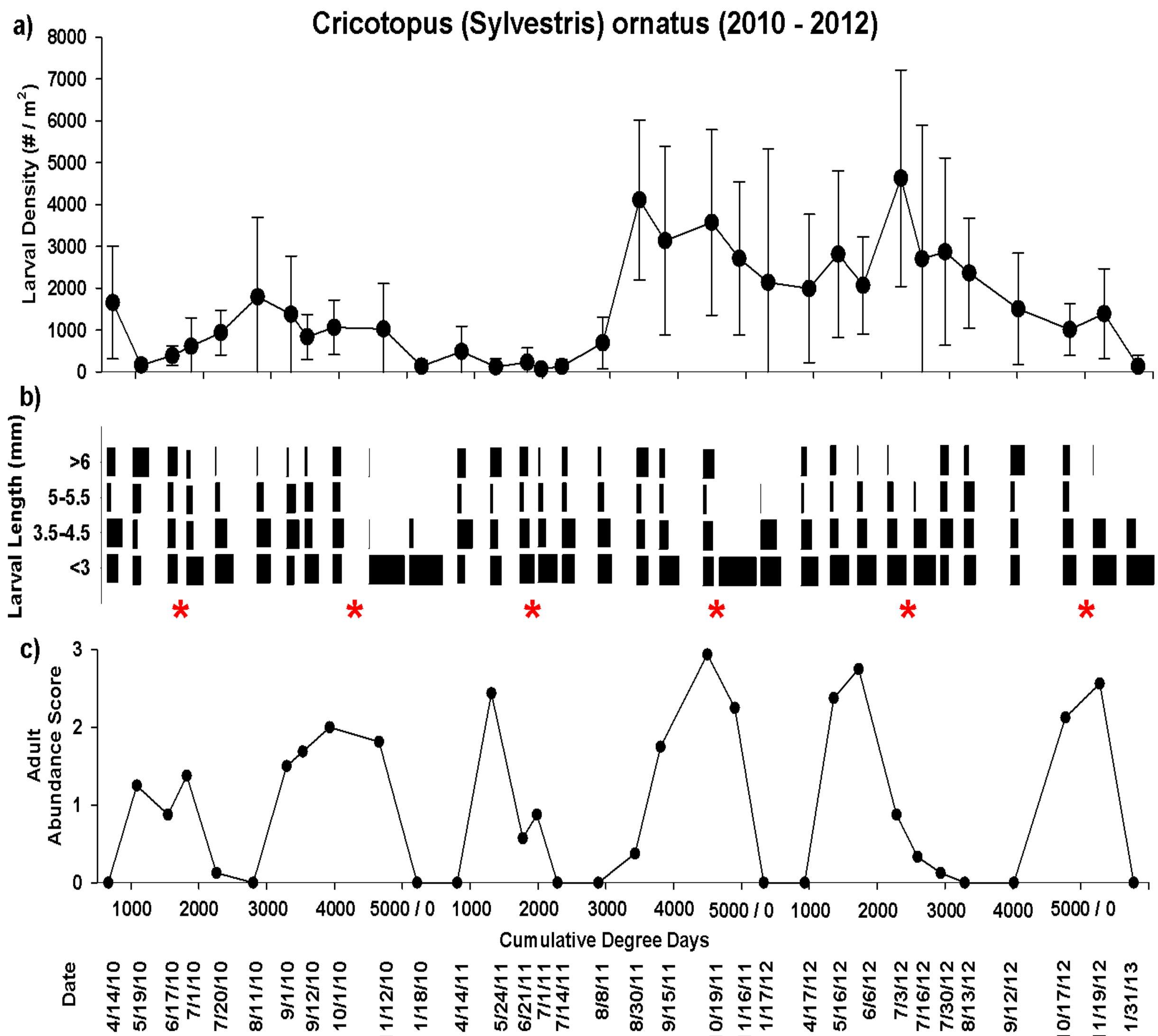

Figure 4. (a) Density of *Cricotopus ornatus* larvae on rock substrates as mean and standard deviations for this abundance at 8 west-shore stations from 2010 through 2012. (b) Percent relative abundance of each larval size class by date. (c) Adult abundance index by degree-day temperature accumulation during each year (cumulative sum °C temperatures by day), and by sample date.

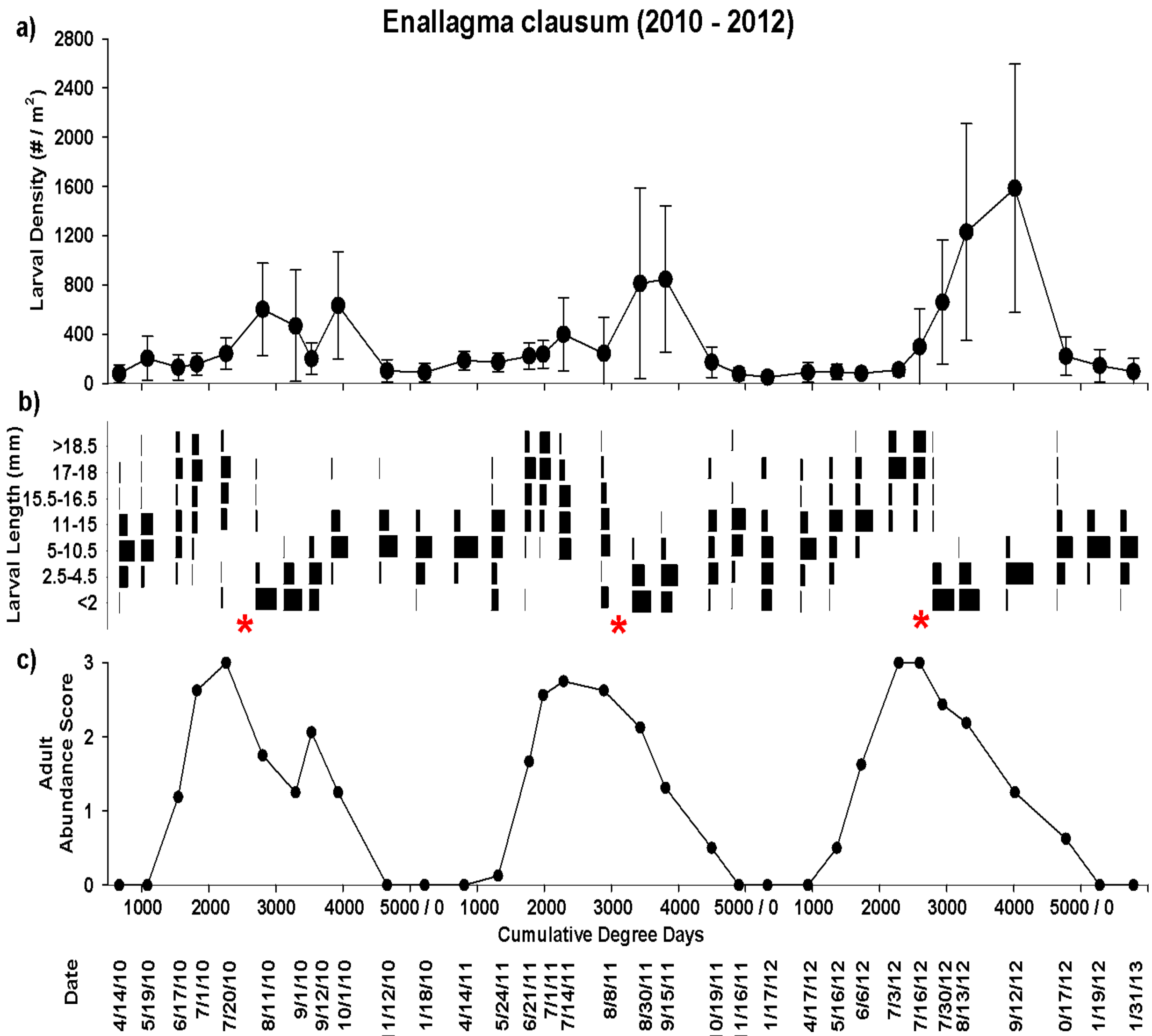

Figure 5. (a) Density of *Enallagma clausum* nymphs on rock substrates as mean and standard deviations for this abundance at 8 west-shore stations from 2010 through 2012. (b) Percent relative abundance of each larval size class by date. (c) Adult abundance index by degree-day temperature accumulation during each year (cumulative sum °C temperatures by day), and by sample date.

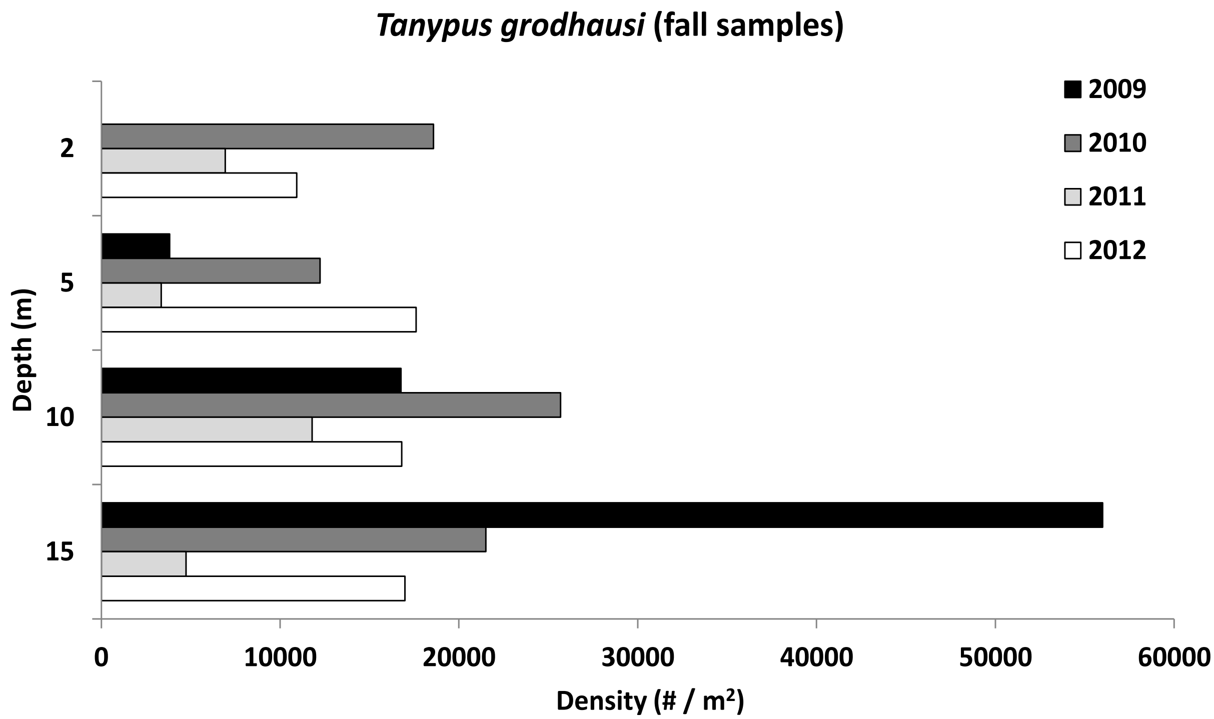

Figure 6. Abundance of the midge *Tanypus grodhausi* by depth and year.

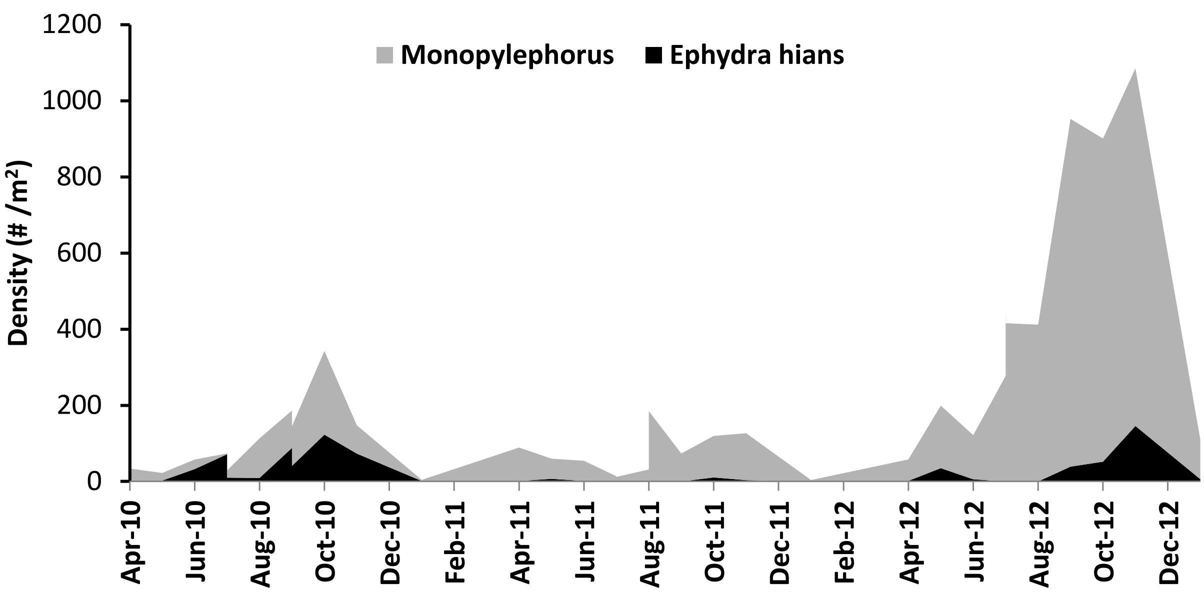

Figure 7. Abundance of oligochaete segmented worms (*Monopylephorus*) and alkali fly larvae and pupae (*Ephydra hians*) over 2010-2012. Note the fall peaks under more saline conditions.

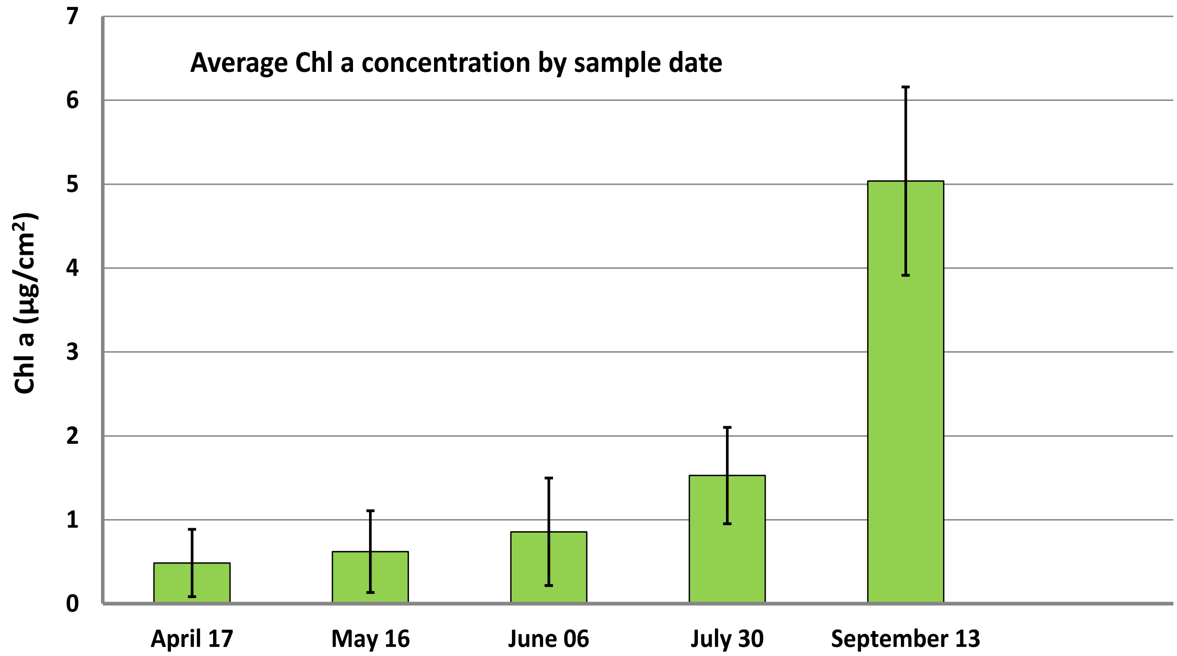

Figure 8. Standing crop of benthic algae in 2012 (chlorophyll a biomass). Mean and standard deviation for all 8 westshore Walker Lake monitoring stations.

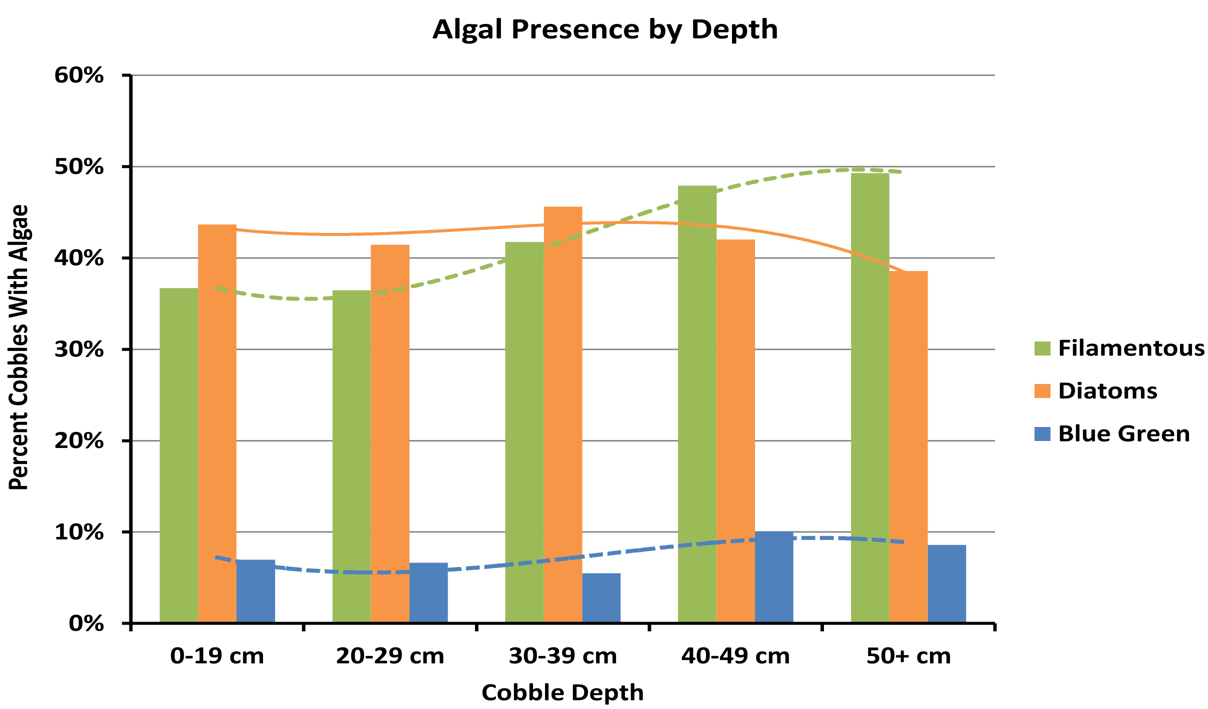

Figure 9. Frequency of cover occurrence of benthic algae by depth summed over the year (2012).

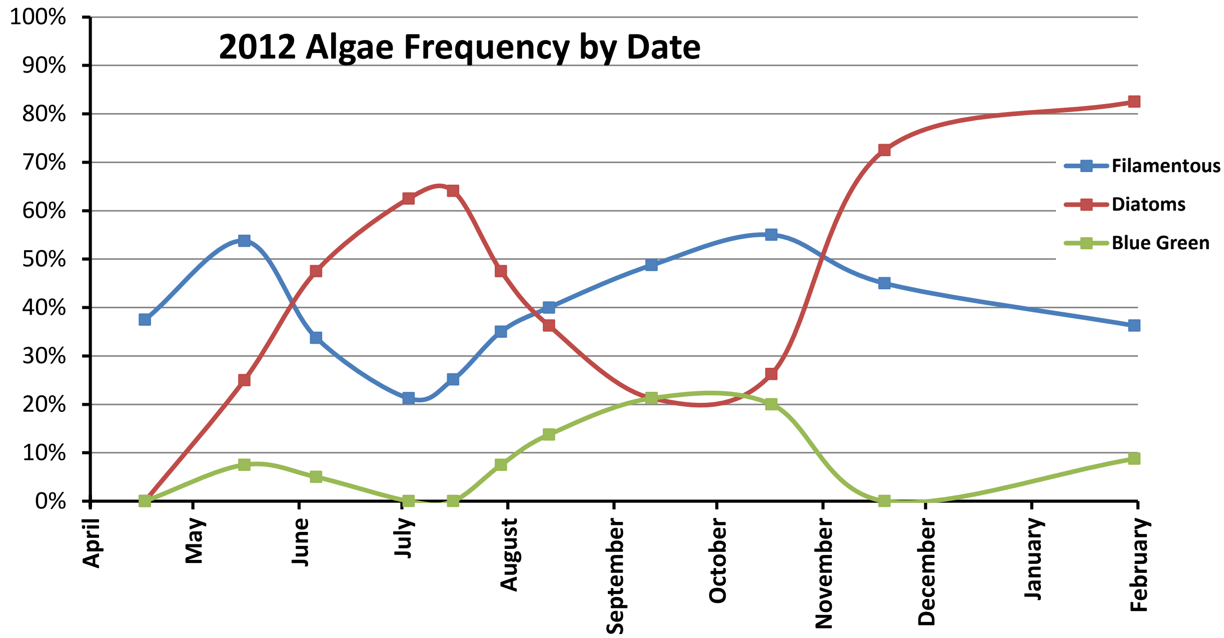

Figure 10. Walker Lake benthic algae types as a proportion of cover for 2012 into 2013.

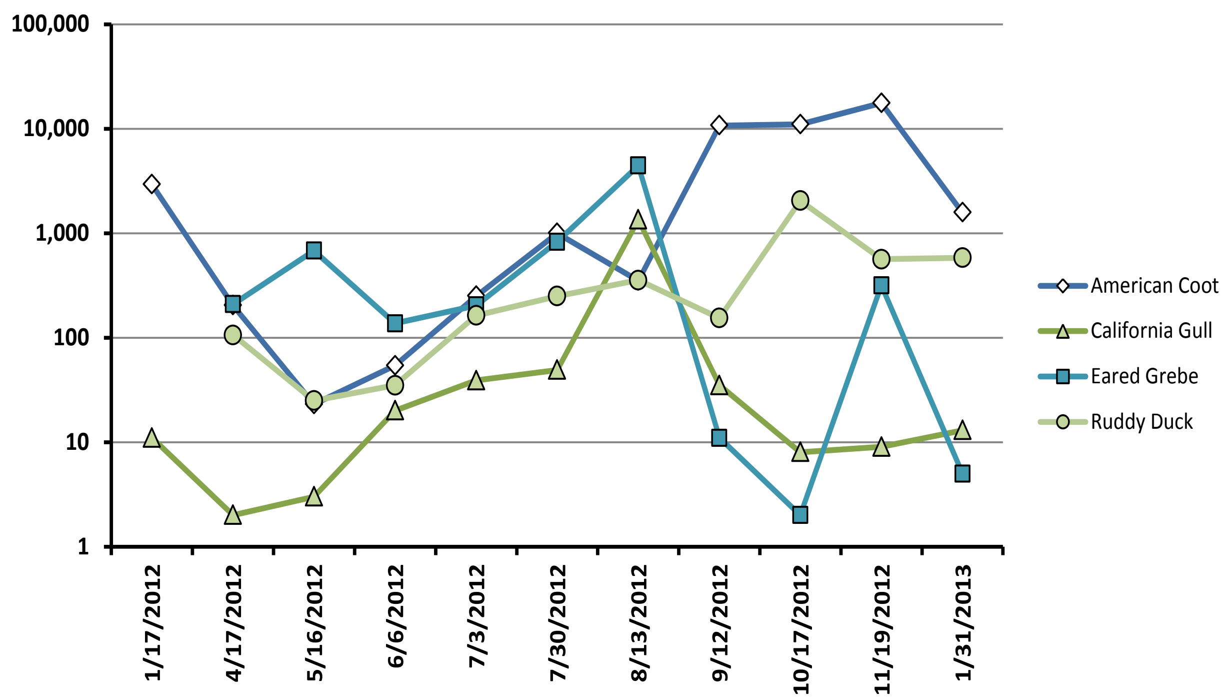

Figure 11. Abundant waterbirds of Walker Lake 2012 (some counts >1,000).

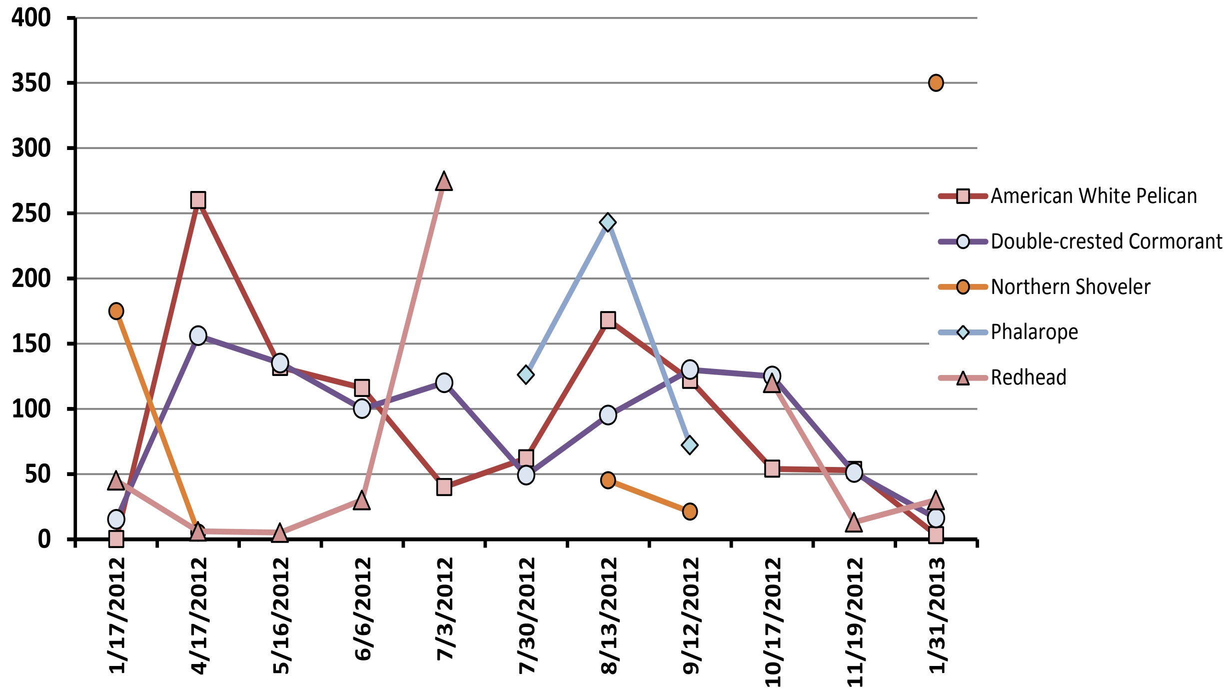

Figure 12. Common waterbirds of Walker Lake (100s but less than 1,000 for any count-date).

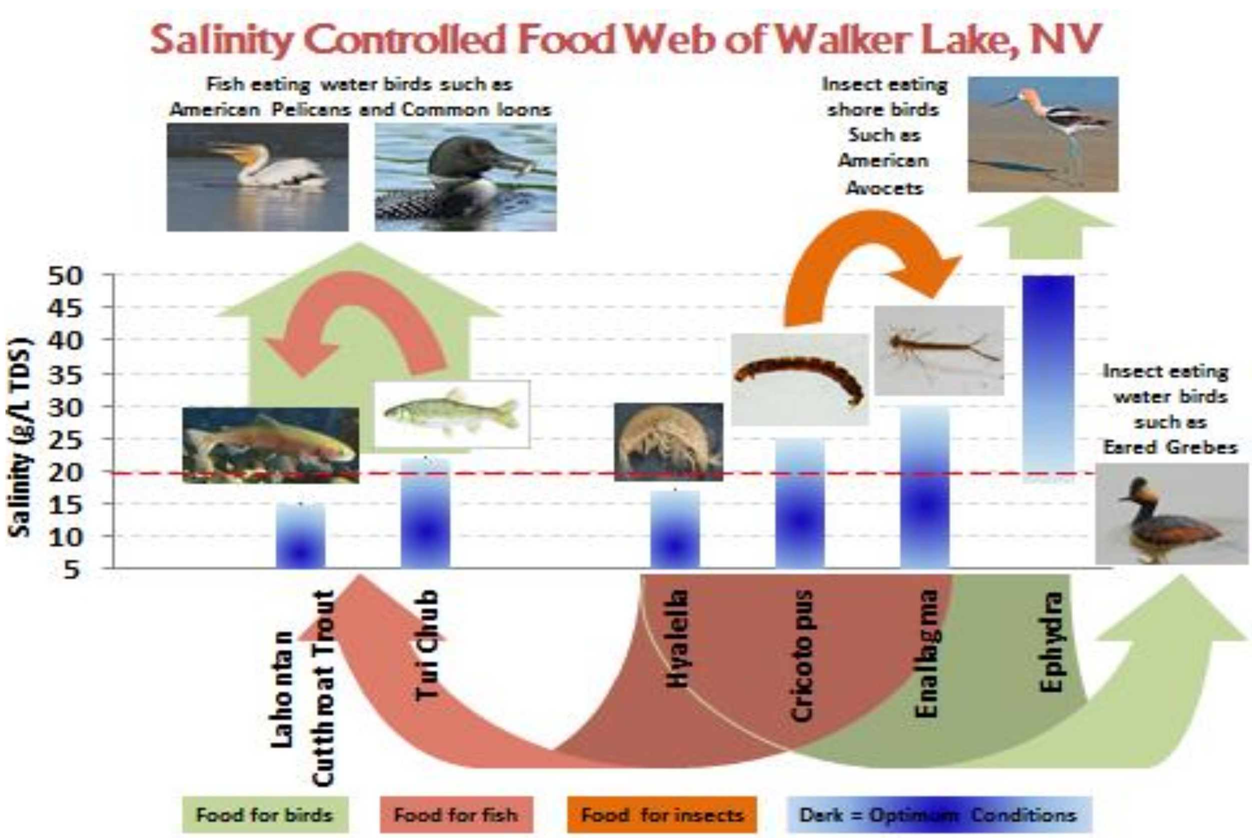

Figure 13. Salinity dependence of the Walker Lake food web; red-line showing present-day salinity limit.