Lake Elsinore Fisheries Management Report
Final

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GEI 50 YEARS

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EXECUTIVE SUMMARY

Background and Purpose

Lake Elsinore is a natural, large inland lake that lies at the base of the 780 square mile (mi^2) San Jacinto River watershed. It is located approximately five miles downstream of Canyon Lake, a reservoir constructed in 1928. Over 90 percent (%) of the San Jacinto River watershed drains into Canyon Lake. Below Canyon Lake, the drainage area to Lake Elsinore is only 47 mi^2. Additional sources of water to Lake Elsinore include overflows from Canyon Lake, which only occur in wet years, production from non-potable wells on islands in the lake, and the discharge of reclaimed water from the Elsinore Valley Municipal Water District.

Lake Elsinore Watershed in Southern California

Historically, Lake Elsinore has fluctuated dramatically in expanse and depth through long-term wet and dry climatic periods, from completely dried up to overflowing into Temescal Creek. Given the variability in lake elevation and resultant water quality (especially salinity), the resident biological community (fish, zooplankton, and phytoplankton) has also varied significantly. Water quality assessments in the 1990s showed that Lake Elsinore was not attaining water quality standards due to excessive nitrogen and phosphorus. As a consequence, the lake was listed as impaired on the state's 303(d) List for several nutrient-related constituents, and a Total Maximum Daily Load (TMDL) for these constituents was adopted in 2004. Later, Lake Elsinore was also found to be impaired for PCBs and DDT due to elevated levels of these pollutants in fish tissue.

After the TMDL became effective in 2005, area stakeholders formally organized as the Lake Elsinore/Canyon Lake TMDL Task Force (LECL Task Force) to work collaboratively on the implementation of the TMDL. The LECL Task Force, administered by the Lake Elsinore and San Jacinto Watersheds Authority (LESJWA), has worked collectively to improve water quality in Lake Elsinore through fishery management, habitat improvements and water quality monitoring. These efforts included development of a fisheries management plan (EIP Associates 2005), implementation of a carp control program, sport fish stocking program, and periodic aquatic biological community surveys. Additional efforts to improve water quality and habitat in Lake Elsinore include implementation of Lake Elsinore Management Program in the 1990s, construction and operation of the Lake Elsinore Aeration and Mixing System (LEAMS) beginning in 2007, and addition of reclaimed water from the Elsinore Valley Municipal Water District to help maintain lake levels.

The LECL Task Force in collaboration with LESJWA and the Santa Ana Water Board completed draft revisions to the existing TMDL in 2018. The revised TMDL includes fishery management as a potentially important component of a long-term TMDL implementation program. To further evaluate how fishery management could be used as a tool to improve water quality, LESJWA commissioned a study on behalf of the LECL Task Force to assess the current status of the Lake Elsinore fishery and identify potential management measures to further improve the fishery and supporting aquatic habitat. The study objectives included:

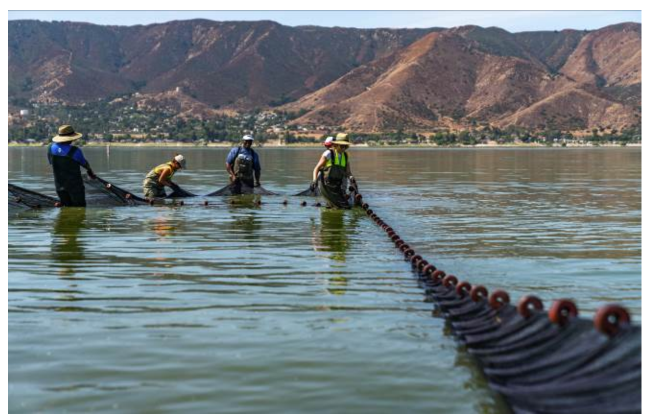
- Develop recommendations to improve the Lake Elsinore fishery and habitat to support efforts to implement the revised nutrient TMDL;
- Determine appropriate fish species for future fish stockings in the lake; and
- Determine the need for additional removal of fish nuisance species impacting water quality.

In addition to these objectives, the study also included an assessment of current PCBs and DDT levels in fish tissue and determine the potential to remove the lake from the state's 303(d) List for these constituents.

Study Design

The study design focused on the three key components of the aquatic community of Lake Elsinore: fish, zooplankton, and phytoplankton. Specifically,

- Fish Survey – Conduct fish sampling during late summer/early fall seasons so that young-of-the-year fish from spring spawning would be large enough to capture during survey events and also make it possible to evaluate species recruitment. Three different survey methods were employed: (a) beach seining to assess shallow, nearshore areas; (b) benthic otter trawls to assess deep bottom dwelling fish communities; and (c) purse seining to assess pelagic fish communities in the deeper areas of the lake.
- Plankton Survey - Three plankton surveys were conducted: once each during summer, fall and winter seasons at three different locations in the lake to assess phytoplankton and zooplankton community structure and variability, both spatially and temporally.


Beach Seining in Lake Elsinore, Fall 2019

Results

Fish Community

Ten species of fish were collected through the various survey methods. The three most common fish species observed during all surveys combined were silverside minnows (*Menidia* *spp*.), Mosquitofish (*Gambusia affinis*) and Common Carp (*Cyprinus carpio*), respectively in order of abundance. Of the remaining seven species the majority were Bluegill (*Lepomis macrochirus*), followed by in order of descending abundance: Channel Catfish (*Ictalurus punctatus*), Largemouth Bass (*Micropterus salmoides*), Black Crappie (*Pomoxis nigromaculatus*), Threadfin Shad (*Dorosoma petenense*), Redear Sunfish (*Lepomis microlophus*), and Green Sunfish (*Lepomis cyanellus*).

Because Common Carp is one of the largest fish in Lake Elsinore and the third most abundant fish observed, this species had the highest estimated whole lake biomass, percent biomass, and biomass density of all fish species. Biomass and biomass density of this species were greatest in shallow water (≤8 feet). Despite its small size, the silverside minnows had the second largest biomass, percent biomass, and biomass density of fish species in Lake Elsinore. The highest biomass and biomass density for this species were observed in moderate depths (8-16 feet). All other species collected were estimated to have very low biomass and biomass densities.

Zooplankton

A total of fourteen zooplankton taxa, categorized into three major groups (Cladocera, Copepoda and Rotifera), were observed across the three survey periods. The October 2019 survey results showed much higher zooplankton density and biomass than was observed during other survey events. Copepods and rotifers equally dominated the zooplankton community in July 2019. Rotifera dominated the community in October 2019. In contrast, copepods strongly dominated the community in February 2020. Cladocera represented a very small portion of the zooplankton community during all survey events.


Daphnia spp., Lake Elsinore, July 2019

Phytoplankton Community

A total of 76 phytoplankton taxa were observed, categorized into eight major algal groups. The Blue-green algae (Cyanobacteria) were by far the most dominant group during all sample events. Diatoms (Bacillariophyta) were the second most common group, with the most diatoms observed during the February 2020 survey event. Green algae (Chlorophyta, Chrysophyta, and Cryptophyta) were the third most common algae, but at a very low density compared to Blue-green algae.

Fish Tissue Collections

Four primary species were targeted for collection of fish tissue to be analyzed for PCBs, DDTs, and nutrients: Common Carp, Largemouth Bass, Crappie, and Channel Catfish. Common Carp was the only primary target species for which the goal of 15 individual fish were collected. The remaining primary species did not reach the 15 fish goal: Largemouth Bass (n=3), Crappie (n=2), and Channel Catfish (n=3). Additional secondary target species were also collected and archived for potential tissue analysis: Bluegill (n=11) and Redear Sunfish (n=1).

The Common Carp were batched into three replicates of 5 fish each and delivered to the laboratory for tissue analysis on January 17, 2020. Upon further discussions with LECL Task Force, it was decided that while not meeting the goal of 15 individuals, the Largemouth Bass, Channel Catfish, and Bluegill would also be analyzed. These fish were delivered to the laboratory on July 16, 2020. The Largemouth Bass were batched into two replicates: 1) one large fish, and 2) two smaller fish. The Channel Catfish were also batched into two replicates: 1) one large fish, and 2) two smaller fish. The Bluegill were batched into three replicates of 5, 4, and 2 based on the location in which they were collected. Bluegill in all replicates were approximately the same size. The results of the fish tissue analysis will be reported under a separate cover in Fall 2020.

Key Findings and Observations

<u>Fish Community</u>

The Lake Elsinore fish community is made up solely of non-native fish species. The report provides a brief summary of what is known of the native fishery and the history of activities that have occurred over many years to establish a recreational sport fishery in the lake. Fish stocking to support this sport fishery first began in the late 1800s, became common during the 1900s, and continues today.

The 2019 fish survey is the most comprehensive survey to date given that it included data collection from multiple habitats and depth layers. The 2019 survey analysis does not assume an even distribution of fish and survey results were weighted according to depth strata area. This approach is very different from previous surveys, but provides a more accurate representation of the fish community in Lake Elsinore. Results from the 2019 survey were compared with findings from surveys dating back to 2002. Overall, there has been a significant shift in the most abundant fish species (%) observed, e.g.:

Largemouth Bass, Lake Elsinore, Fall 2019

- *2002* – Four fish species dominated the fish community with Common Carp (34%), Threadfin Shad (23%), Channel Catfish (22%) and Largemouth Bass (10%) comprising almost 90% of the observed abundance of fish during the survey.
- *2003* – Common Carp dominated with this species representing approximately 88% of the fish observed during that year's survey. Channel Catfish represented the second most common fish comprising 8.7% of observed abundance.

- *2008-2009* – Comprising ~80% of fish, Common Carp and Bluegill dominated. Threadfin Shad were common in 2008, but were not observed in the 2009 survey.
- *2015* – Threadfin Shad dominated the fish community comprising about 96% of the fish observed during that survey (results were from a hydroacoustic survey and based on previous history it was assumed that the small fish were Threadfin Shad rather than silverside minnows or mosquitofish).
- *2019* – Community has shifted significantly with silverside minnows and Mosquitofish comprising more than 90% of fish abundance. Neither species was collected in previous surveys. Carp represented only about 7% of the abundance of fish in this latest survey.

Zooplankton Community

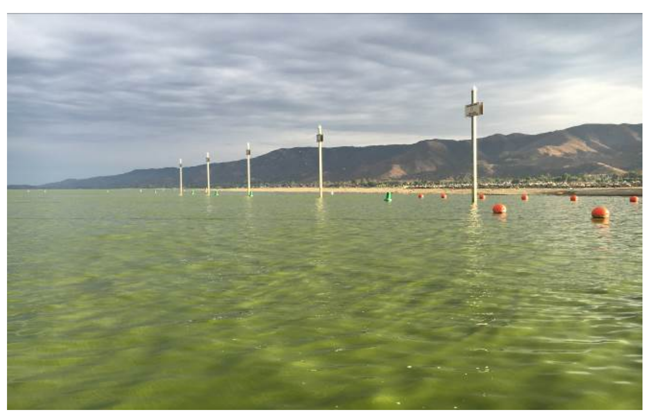
The 2019-2020 zooplankton density and biomass varied by season with the highest observed in October. A review of previous zooplankton surveys dating back to 2003 shows similar variability. In general, the lowest densities are observed in the winter and the highest densities are observed in late summer or fall. Total zooplankton density as well as the densities of major zooplankton groups were generally lower in 2009 and 2010 (as much as an order of magnitude in some seasons), than zooplankton densities observed in 2003, 2004, and 2019 (however, some of these differences among surveys may be the result of differences in the mesh size of the collection net).

Taxa richness has ranged from about 3 to 10 per survey date over the period of record; the 2019-2020 observations tended toward the higher richness values observed over time (7 to 9 taxa). Species diversity (Simpson's Diversity Index) has ranged from approximately 0.13 to 0.78 over the period of record with the highest diversity being recorded in the most recently completed surveys.

Phytoplankton Community

Key findings from the 2019-2020 phytoplankton surveys include:

- Highest algal densities were observed in July and October, during the period of warmer water temperatures.
- Blue-green algae were dominant during all sample events in 2019-2020, consistent with previous surveys.
- Several of the blue-green algae taxa observed in the current survey have the potential to produce harmful cyanotoxins; however, many other blue-green algae that were relatively abundant during various seasons in



Algal Bloom, Lake Elsinore, 2016

the 2019-2020 survey are not known to be harmful.

- A pattern of seasonal succession observed in previous long-term surveys (dominance of diatoms in the winter and spring to a community dominated by blue-green algae in the summer and fall), was not observed in the 2019-2020 surveys.

Factors that Affect the Lake Elsinore Aquatic Community

Given the dynamic nature of Lake Elsinore, there are several key factors that have the potential to affect aquatic community conditions of Lake Elsinore including:

Carp Removal

The EIP Associates (2005) report indicated that carp removal should be a high priority given the significant impact carp may have on water quality and habitat. Carp removal efforts from 2003 to 2008 successfully reduced carp biomass density from a range of 503 to 1,100 lbs/acre in 2003 to only 62 lbs/acre in 2008. The 2019 survey provided the first estimate of carp biomass density in more than ten years. Study findings revealed that the 2019-2020 carp biomass density was similar to that observed in 2008, at approximately 55.3 lbs/acre.

Fish Stocking

Black Crappie, Lake Elsinore, 2019

The composition of the Lake Elsinore fishery is greatly influenced through periodic efforts to stock gamefish to support area recreational activities. Recently, Black Crappie, Bluegill, Channel Catfish, and Largemouth Bass have been stocked in Lake Elsinore each year from 2016 to 2019. Redear Sunfish have also been stocked in most years. Of these stocked species, Black Crappie and Bluegill appear to have fared best and reproduction is potentially occurring. In contrast, 2019 survey data suggest survival of Channel Catfish, Largemouth Bass and Redear Sunfish has been poor. However, other factors may account for the infrequent capture of these species, including, e.g., successful capture by fisherman or under representation in the 2019 catch simply because these species can be more common in areas of the lake that are difficult to survey with the gear types utilized in the current study, e.g., around submerged vegetation.

Fish Kills Events

Fish kill events have the potential to alter the fish community composition, especially if the dominant species are significantly impacted by the event. Recent fish kills since 2015 noted the large number of Common Carp and/or Threadfin Shad impacted by the events. The full scope of these periodic events is unknown, but previous surveys suggest that they may have impacted fish community composition. For example, the small fish community is currently dominated by silverside minnows and Mosquitofish rather than Threadfin Shad as noted in previous years. These small fish species occupy a similar niche formerly occupied by Threadfin Shad.

Water Quality

EIP Associates (2005) stated the following regarding establishment of a successful sport fish community in Lake Elsinore:

> *"In order to change the environment of Lake Elsinore in a direct way that will be more favorable to a sport fish community, these factors must be addressed: Lake level fluctuations; poor water quality; Carp predation and competition; poor food supply; poor feeding conditions; poor habitat; and poor reproduction. In terms of managing Lake Elsinore to support a viable sport fish community, control of the first two factors is imperative. The [Fishery Management Plan] acknowledges that without control of these factors, management to improve other conditions will not be successful."*

Based on the outcome of the 2019-2020 survey activities, these findings remain true. The first two factors listed above, lake level and water quality, are closely linked – especially for constituents such as salinity, dissolved oxygen (DO) and chlorophyll-*a*. LESJWA (2018) provides a synopsis of the known potential impacts of each of these constituents on the aquatic communities of Lake Elsinore. Current lake management activities are focused on addressing these important factors impacting water quality. For example, as noted above, the TMDL for nutrient related constituents, including DO and chlorophyll-*a*, is currently under revision for Lake Elsinore. This TMDL focuses on a wet lake management strategy that seeks to maximize lake levels which will have water quality benefits.

Lake Elsinore, Fall 2019

Lake Management Strategies – Key Recommendations

Based on the findings from the 2019-2020 surveys, the following recommendations were developed to support ongoing efforts to manage the Lake Elsinore fishery:

Carp Removal

Recommendation No. 1: A key objective of the 2019 fish survey was to evaluate the Common Carp population to determine the need for additional carp management activities. Based on the survey findings (see above) additional carp removal is not necessary at this time; however, periodic assessment of the carp population should occur to verify that carp biomass density remains low.

Fish Stocking

The following recommendations are provided to support continued development of a sport fishery in Lake Elsinore.

Recommendation No. 1: Stock Striped/White Bass hybrids ("Hybrid Bass"), also known as "Wipers", "Palmetto Bass", or "Sunshine Bass" for the following reasons:

- These species will provide top-down biomanipulation of the Lake Elsinore aquatic community.
- Hybrid Bass life history is suitable for Lake Elsinore. Specifically, they (a) naturally reproduce only to a limited extent; (b) grow quickly during their first two years of life; and (c) survive in water quality unfavorable to many other species, especially with regard to high salinity and low DO.
- Successful stockings of Hybrid Bass have previously occurred in Lake Elsinore in 2004 and 2005.
- Continued stocking could result in this species becoming the dominant sportfish in Lake Elsinore and would be readily fished for by anglers.

Recommendation No. 2: Discontinue stocking of Channel Catfish, Largemouth Bass, and Redear Sunfish; survey data suggest that survival of these species from 2016 to 2019 has been poor.

Recommendation No. 3: Continue stocking Black Crappie and Bluegill; survey data suggest that survival of these species has been good. If implemented, only fish greater than 150 mm in length should be stocked to avoid predation by Hybrid Bass (although, their offspring may be preyed on).

Silverside Minnows, Lake Elsinore, 2019

Recommendation No. 4: Do not stock any baitfish at this time. Silverside minnows and Mosquitofish are already present in Lake Elsinore at high numbers. They appear to be reproducing and maintaining a viable population.

Recommendation No. 5: Continue to conduct periodic fish surveys to evaluate success of ongoing fish stocking activities, assess the potential to modify the species stocked and evaluate populations of other species. Any such surveys should rely on the use of consistent sampling and data analysis methods which will allow for more accurate comparisons of the characteristics of the fish community between years.

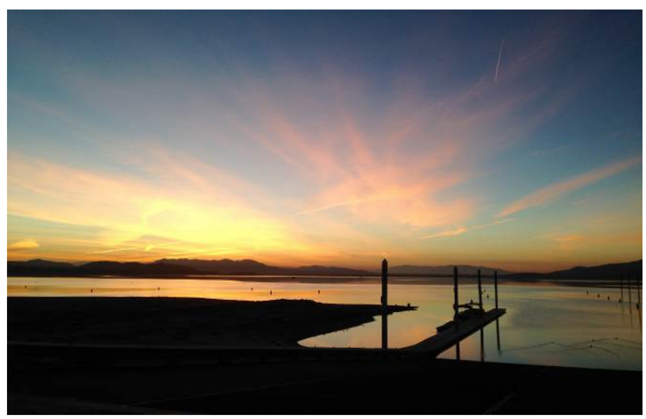
Habitat Improvements

It may be possible to improve fish habitat in Lake Elsinore. Ideally this would occur best through stabilization of lake levels. Alternatively, it might be possible to improve habitat through projects to reconfigure the shoreline in selected areas to create peninsulas or small coves or even create islands. The outcome of any of these types of macro-habitat modifications would be to increase the amount of available shoreline habitat where fish densities tend to be higher. If habitat improvements are implemented, the recommendations are provided:

Recommendation No. 1: Plant rooted aquatic and emergent vegetation, as originally proposed in EIP Associates (2005). Increased vegetation would provide (a) spawning habitat for many fish species; (b) habitat for small fish; (c) ambush habitat for large fish; (d) shelter for zooplankton; and (e) nesting habitat and food for waterfowl. In addition, aquatic plants uptake nutrients otherwise used by algae and reduce resuspension of sediments due to wind and wave action.

Recommendation No. 2: Until appropriate water levels can be maintained, a temporary alternative to planting shoreline vegetation is to consider installation of anchored floating vegetation mats. These mats, which will rise and fall with the water offer many of the same benefits as shoreline and submerged vegetation; however, they are not as aesthetically pleasing.

Recommendation No. 3: Create physical, non-plant structures to serve as fish habitat. Example structures may include addition of gravel patches, rock piles, large woody materials, brush piles, or other fish attractors. These structures, which can be placed in deeper water where plants are not able to grow, can provide habitat for larger fish, such as Hybrid Bass that do not utilize shoreline vegetation. In addition, these structures are not as readily disturbed or subject to damage by Common Carp, birds, wave action, and human activity.



Lake Elsinore Sunrise, 2016

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
#	number
%	percent
±	plus or minus
°C	degrees Celsius
µg/L	micrograms per liter
µm	micrometer(s)
µS/cm	microsiemens per centimeter
AFY	acre feet/year
Avg	average
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CFGMC	California Fish and Game Commission
cm	centimeter
COMM	Commercial and Sportfishing
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
EVMWD	Elsinore Valley Municipal Water District
ft	Feet
g	gram(s)
Indiv/L	individual/liter
K	thousand
kg	kilogram(s)
L	liter(s)
Lat	latitude
lbs	pounds
LC_{50}	lethal concentration in water causing 50% mortality
LD_{50}	lethal dose of a material causing 50% mortality
LEAMS	lake Elsinore Aeration and Mixing System
LECL Task Force	Lake Elsinore/Canyon Lake Task Force
LEMP	Lake Elsinore Management Project
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
Long	longitude
M	million
m	meter(s)
mi^2	square miles
mgd	million gallons per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mL	milliliter(s)

ACRONYMS AND ABBREVIATIONS (Continued)

Acronym	Definition
mm	millimeter(s)
No	number
NWt	non-=weighted
PCBs	polychlorinated biphenyls
pH	potential of hydrogen
ppt	parts per thousand
RARE	Rare, Threatened or Endangered Species
REC1	Water Contact Recreation
REC2	Non-Contact Water Recreation
Santa Ana Water Board	Santa Ana Regional Water Quality Control Board
SDI	Simpson’s Diversity Index
sp	unspecified species
spp	several unspecified species
State Water Board	State Water Resources Control Board
TDS	total dissolved solids
TMDL	Total Maximum Daily Load
TN	total nitrogen
TP	total phosphorus
USEPA	U.S. Environmental Protection Agency
WARM	Warm Freshwater Habitat
WILD	Wildlife Habitat
WQO	Water Quality Objective
Wt	weighted
X	times

ACRONYMS AND ABBREVIATIONS (Continued)

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1.0 INTRODUCTION

1.1 Overview of Lake Elsinore

Lake Elsinore is a natural, large inland lake that lies at the base of the 780 square mile (mi^2) San Jacinto River watershed (Figure 1-1). It is located approximately five miles downstream of Canyon Lake, a reservoir established by the construction of the Railroad Canyon Dam in 1928. The following sections provide a description of key characteristics associated with this inland lake.

1.1.1 Physical Characteristics

Over 90 percent (%) of the San Jacinto River watershed drains into Canyon Lake. Below Canyon Lake, the drainage area to Lake Elsinore is only 47 mi^2. Additional sources of water to Lake Elsinore include overflows from Canyon Lake, which only occur in wet years, production from non-potable wells on islands in the lake, and the discharge of reclaimed water from the Elsinore Valley Municipal Water District (EVMWD).

Lake Elsinore, September 2016

Lake management activities, which include addition of reclaimed water, seek to maintain a lake elevation of at least 1,240 feet (ft). At this elevation, Lake Elsinore is a terminal lake with no outflow. Historically, Lake Elsinore has fluctuated dramatically in expanse and depth through long-term wet and dry climatic periods. During extended periods of drought Lake Elsinore has completely dried up. For example, from 1954 to 1964, the lake was dry for extended periods of time. In contrast, during very wet climatic periods Lake Elsinore can overflow into Temescal Creek if the lake elevation reaches 1,255 ft. No overflows to Temescal Creek have occurred since 1995 and the long-term historical record shows that overflows to Temescal Creek occur in only approximately 10% of hydrologic years (Anderson 2016a).

Given this significant variability in lake conditions, it is not surprising that lake water quality (especially salinity) and the resident biological community (fish, zooplankton, and phytoplankton) can also vary significantly (LESJWA 2018). Efforts to manage water quality and improve lake level management have been ongoing for many years. An important project designed specifically to address these issues was the Lake Elsinore Management Project (LEMP) in the early 1990s. The LEMP resulted in the construction of a levee that separated the main lake from its southeast floodplain (or so-called back basin). The outcome was a lake with a reduced surface area (from about 6,000 to 3,000 acres) and a greater average depth (from a range 0 to 21 ft to a range of 9 to 27 ft). An additional anticipated benefit of LEMP included a significant reduction in evaporative losses, which could improve water quality and recreational opportunities. Monitoring data indicate that with the exception of brief periods of stratification Lake Elsinore is typically well-mixed with a limited thermocline (LESJWA 2018).

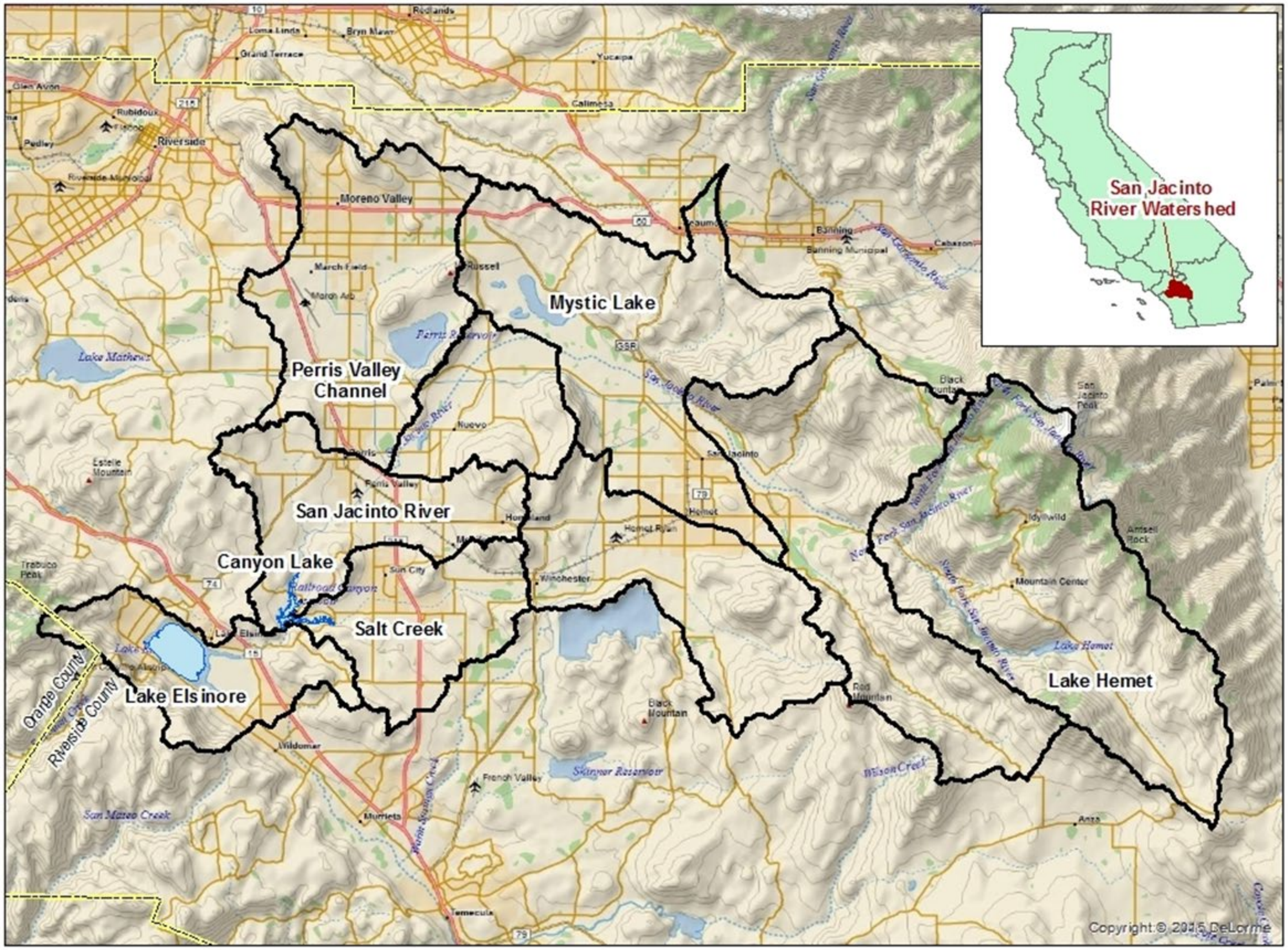


Figure 1.1. Location of Lake Elsinore at the Base of the San Jacinto River Watershed (from LESJWA 2018)

1.1.2 Water Quality

The Water Quality Control Plan for the Santa Ana River Basin designates the following beneficial uses for Lake Elsinore: Warm Freshwater Habitat – (WARM), Water Contact Recreation (REC1), Non-Contact Water Recreation (REC2), Rare, Threatened or Endangered Species (RARE), Commercial and Sportfishing (COMM), and Wildlife Habitat (WILD). Water quality is routinely monitored and assessed throughout the Santa Ana Region to evaluate whether existing water quality is protective of beneficial uses. If an assessment indicates that a beneficial use is not being met in a particular waterbody, then the waterbody is found to be impaired and placed on the state's impaired waters list (or 303(d) list). Waterbodies on the 303(d) list require development of a Total Maximum Daily Load (TMDL). A TMDL establishes the maximum amount of a pollutant that a waterbody can receive (from both point and nonpoint sources) and still meet water quality objectives (WQO).

Water quality assessments from Lake Elsinore and Canyon Lake, in 1994 and 1998 respectively, showed that neither waterbody was attaining its water quality standards due to excessive nitrogen and phosphorus. Subsequently, the Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) placed both waterbodies on the State of California 303(d) list. Subsequently, the Santa Ana Water Board developed nutrient TMDLs for both Lake Elsinore and Canyon Lake. TMDLs were set for total phosphorus (TP), total nitrogen (TN), ammonia nitrogen, chlorophyll-*a*, and dissolved oxygen (DO). Per the TMDLs final compliance targets are to be met no later than the end of 2020. Interim targets, established for chlorophyll-*a* and DO, were to be attained no later than 2015.

The Santa Ana Water Board adopted the nutrient TMDLs on December 20, 2004 (Resolution No. No. R8-2004-0037); the State Water Resources Control Board (State Water Board) approved the TMDLs on May 19, 2005 (Resolution No. 2005-0038). The TMDLs became effective with United States Environmental Protection Agency (USEPA) approval on September 30, 2005.

Stakeholders in the watershed have worked collaboratively on TMDL coordination efforts since August 2000, well before adoption of the 2004 Nutrient TMDLs. These activities were coordinated and administered through the Lake Elsinore and San Jacinto Watersheds Authority (LESJWA). Following TMDL adoption and approval, the existing TMDL stakeholders formally organized into a funded Lake Elsinore/Canyon Lake TMDL Task Force (LECL Task Force) in 2006.

1.2 Lake Management Activities to Support TMDL Implementation

The LECL Task Force, in coordination with LESJWA, continues to work collaboratively to support implementation of the nutrient TMDLs. Key activities directed towards improving water quality in Lake Elsinore have included fishery management, habitat improvements and water quality monitoring as described in the sections below.

1.2.1 Fishery Management

Through the efforts of LESJWA and the LECL Task Force significant efforts have been directed towards improving the Lake Elsinore fishery. For almost two decades, these efforts have included the following studies or activities:

- *Fisheries Management Plan* – In 2005, LESJWA commissioned EIP Associates to develop a “fisheries enhancement and maintenance program that will create a balanced, self-sustaining and valued sport fishery.” The resulting program identified five enhancement objectives (EIP Associates 2005). In order of priority, these objectives included: (1) carp control; (2) zooplankton enhancement; (3) aquatic and emergent vegetation restoration; (4) fish habitat improvement; and (5) fish community structure improvement. It was noted that without carp control, the other objectives would not be attainable.
- *Carp Control Program* – Common Carp (*Cyprinus carpio*), through their foraging behavior which causes resuspension of lake bottom sediments, can impact water quality because resuspended sediments release bioavailable nutrients into the water column. To help address this issue, a carp removal program was implemented from 2002 to 2008. This program resulted in the removal of an estimated 1.3 million pounds (lbs) of carp from the lake, resulting in beneficial reductions of TP in the water column (LECL Task Force 2016).
- *Sport Fish Stocking Program* – Sport fish have been periodically stocked in Lake Elsinore to support efforts to reduce populations of nuisance Common Carp and Threadfin Shad and also improve fishing recreational opportunities. Shad control was identified as an important need in Lake Elsinore because of the impact this species can have on zooplankton populations (EIP Associates 2005). In addition, the LECL Task Force, which developed a long-term strategy to control nutrients released from in-lake sediments, noted that stocking sport fish was significantly reducing the number of both carp and shad, thereby helping to improve water quality in the lake (LECL Task Force 2007).
- *Fish Surveys* – Dr. Michael Anderson (University California Riverside) conducted hydroacoustic fish surveys in Lake Elsinore in Spring 2008 and 2015. The 2015 survey found that the fish community was dominated by small fish (95.6% were less than 3.5 centimeter (cm) in length – consistent with threadfin shad) with an estimated areal density of 54,100 fish/acre (Anderson 2016b). In contrast, the density of large fish (greater than 20 cm in length) was estimated to be only 12.3 fish/acre in 2015.
- *Zooplankton and Phytoplankton Surveys* – Various studies have evaluated the zooplankton and phytoplankton communities of Lake Elsinore – both critical elements to a functioning fish community. Veiga-Nascimento and Anderson (2004) found that copepods and rotifers dominated the zooplankton community during each survey event. In contrast, only low densities of cladocerans were observed; dominant species were often small-bodied cladocerans which are not effective phytoplankton grazers. Anderson et al. (2011) generally found similar zooplankton community characteristics during their

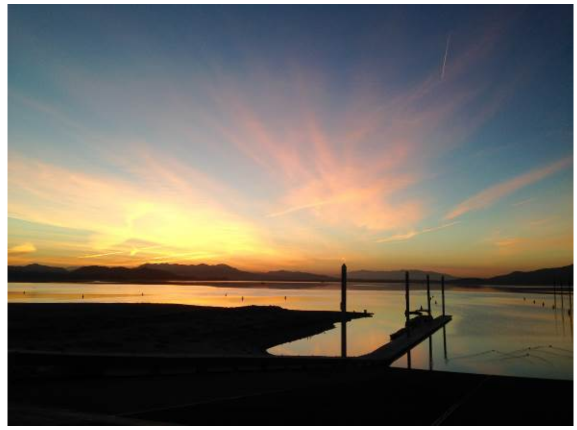
later survey. A comprehensive phytoplankton survey conducted in 2010-2011 observed changes in dominance by phytoplankton algal groups by season. Diatoms dominated during February and April surveys and blue-green algae dominated during other survey months (Anderson et al. 2011). A limited survey in March 2015 found blue-green algae dominant Anderson (2016b). In addition to characterizing these aquatic communities, Veiga-Nascimento and Anderson (2004) and Anderson et al. (2011) noted the impact of increased salinity on the zooplankton and the importance of addressing this water quality issue before considering other strategies to manage the biological community. Anderson (2016b) further observed how increased salinity is influencing zooplankton and phytoplankton community characteristics in Lake Elsinore.

1.2.2 Water Quality and Habitat Improvements

Efforts to improve water quality and habitat in Lake Elsinore have been ongoing since the early 1990s with implementation of the LEMP. As noted above, LEMP greatly modified the physical characteristics of Lake Elsinore. Additional projects that have been implemented to further improve habitat (in particular stabilize lake levels) and water quality include:

- *Lake Elsinore Aeration and Mixing System (LEAMS)* - LEAMS was constructed in 2007 as a joint project developed by LESJWA and co-sponsored by EVMWD, the City of Lake Elsinore and Riverside County. LEAMS is designed to increase the circulation of water in Lake Elsinore to improve DO concentrations. Specifically, LEAMS, through the combination of slow-turning sub-surface propellers in the lake and use of shoreline compressors to disperse air from pipelines anchored to the bottom of the lake, increases water circulation in the water column. Specifically, LEAMS pushes bottom water low in DO toward the surface where it is re-aerated naturally by wind and wave action. Mixing the lake in this manner helps increase DO in the water column and helps prevent chemical reduction of iron that releases bound phosphorus to a soluble form that may be released to the water column by diffusive exchange. LEAMS may also facilitate coupled nitrification-denitrification, a process that converts ammonia to nitrate in oxygenated waters and then converts nitrate to nitrogen gas when anoxic conditions return (LECL Task Force 2016; LESJWA 2018).
- *Supplemental Water Addition* – LESJWA (2018) noted that from 2007 to 2017, EVMWD discharged an average of more than four million gallons per day (mgd) of reclaimed water to Lake Elsinore (> 4,600-acre feet/year [AFY]). The addition of reclaimed water continues today and is a key factor that supports local efforts to stabilize water levels in Lake Elsinore. LECL Task Force (2016) estimated that reclaimed water replaced about 56% of lake volume annually lost to natural evaporation. Moreover, without the addition of recycled water it was estimated that Lake Elsinore would have dried up by mid-2015 (LESJWA 2018). As the watershed continues to develop, it is estimated that EVMWD will continue to increase additions of reclaimed water to the lake, potentially up to approximately nine mgd (approximately 10,000 AFY). If implemented, this additional volume of reclaimed water will greatly support efforts to achieve a stable lake level in the future (LECL Task Force 2016; LESJWA 2018).

1.3 Study Objectives


Lake Elsinore Sunrise, 2016

The LECL Task Force in collaboration with LESJWA and the Santa Ana Water Board completed draft revisions to the 2004 nutrient TMDL applicable to Lake Elsinore in 2018 (LESJWA 2018). The Santa Ana Water Board anticipates the adoption of the revised TMDL in late 2020 or early 2021 with final approval by the USEPA occurring in 2021. The revised TMDL considers the findings from various studies and water quality management actions conducted in Lake Elsinore since adoption of the 2004 TMDL. The TMDL Technical Report that provides the justification for modifications to the existing TMDL includes fishery management as a potentially important component of a long-term TMDL implementation program to meet the revised numeric water quality targets for the lake (LESJWA 2018).

Additionally, Lake Elsinore is listed as impaired for polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT). The impairment listings for these constituents are based on elevated fish tissue concentrations observed during various fish tissue studies, with the most recent data being collected in a State Water Board 2007 study (Davis et al. 2009). DDT was listed as an impairment despite an analysis of available fish tissue data dating back to the early 1980s indicating that the concentration of the banned pesticide had declined markedly from the 1980s to 2007. However, no recent fish tissue data are available for DDT or PCBs for Lake Elsinore to quantify how much fish tissue PCB and DDT concentrations have declined in the 12 years since the previous samples were analysed.

To further evaluate how fishery management could be used as a tool to improve water quality under the revised TMDL and to evaluate trends in PCB and DDT fish tissue concentrations over time, LESJWA commissioned a study on behalf of the LECL Task Force to assess the current status of the Lake Elsinore fishery and identify potential management measures to further improve the fishery and supporting aquatic habitat. The results from the study will be used to address the following objectives:

- Develop recommendations to improve the Lake Elsinore fishery and habitat to support efforts to implement the revised nutrient TMDL;
- Determine appropriate fish species for future fish stockings in the lake; and
- Determine the need for additional removal of fish nuisance species impacting water quality
- Determine the potential for a 303(d) de-listing of Lake Elsinore for PCBs and DDT.

1.4 Study Design

The commissioned study included the implementation of a number of fish, zooplankton, and phytoplankton surveys to update information on the aquatic communities of Lake Elsinore. The findings from these surveys have been evaluated within the context of findings from previous surveys. To capture potential seasonal variation in plankton communities and obtain the best estimate of fish populations, the Study Design included the key components described in the sections below (LESJWA 2019a).

Lake Elsinore Survey Crew, September 4, 2019

1.4.1 Fish Survey

Fish sampling occurred during the late summer/early fall seasons so that young-of-the-year fish from spring spawning would be large enough to capture during survey events and also make it possible to evaluate species recruitment. The design of fish survey events was based on the assumption that fish are not evenly distributed across the lake depth strata. Accordingly, three different survey methods were included in the Study Design to maximize information about the fish communities resident in the lake:

1. Beach Seining – assess the distribution and abundance of fish in shallow nearshore areas.
2. Benthic Otter Trawls - assess demersal (i.e., bottom dwelling) fish communities.
3. Purse Seining - target pelagic fish communities in the deeper areas of the lake.

1.4.2 Plankton Survey

To develop information about the food web available to support the fishery, the Study Design included plankton surveys. Three plankton surveys were conducted during summer, fall and winter seasons at three different locations in the lake to assess phytoplankton and zooplankton community structure and variability, both spatially and temporally.

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2.0 SURVEY METHODS

The Lake Elsinore Fisheries Management Work Plan and Quality Assurance Project Plan provides complete details on the fish and plankton sample collection procedures implemented under this study (LESJWA 2019a). Below is a general summary of the methods employed by the project team.

2.1 Fish Community

Previous fish surveys have used gill netting (CDFW 2002), electrofishing (CDFW 2002, Ewing 2010a, Ewing 2010b, Fish 2014), beach seining (City of Lake Elsinore 2008), hydroacoustics (Anderson 2008, Anderson 2016b), minnow trapping (Fish 2014), and tag-and-recapture methods (City of Lake Elsinore 2008) to assess fish community structure, distribution and abundance in Lake Elsinore. While these methods are scientifically proven and valid, all have their limitations when assessing fish population for a whole lake. For example, sampling performed in only shallow water (i.e., beach seining and electrofishing) produces abundance estimates that may not be applicable to other portions of the lake if the fish are not evenly distributed. For the 2019 Study, Lake Elsinore fish were not assumed to be evenly distributed across depth strata within the lake. Accordingly, three different survey methods were included in this study to maximize information about the fish communities resident in the lake as described above: beach seining, benthic otter trawls, and purse seining

Figure 2-1 illustrates where each of these survey methods occurred relative to the bathymetry of Lake Elsinore. Based on the bathymetry, survey activities targeted three depth strata: 0 – 8 ft; 8.1 – 16 ft; > 16 ft (Figure 2-2). Table 2-1 provides the estimated area of Lake Elsinore that falls within each depth strata. The general methods associated with each fish survey method are described below.

2.1.1 Survey Methods

All captured fish were measured using total length and fork length. The first 50 individuals of any species of a sampling event were measured to the nearest millimeter (mm) and weighed to the nearest gram (g). If more than 50 fish were captured, the next 150 were individually measured but batch weighed. If more than 200 fish were captured, the remainder were only batch-weighed to provide an estimate of total abundance and biomass.

Table 2-1. Estimated Acreage of Depth Strata in Lake Elsinore

Depth Strata (ft)	Area of Lake Elsinore (acres)
Shallow: 0 to 8	679
Moderate: 8.1 to 16	1,480
Deep: > 16	797
Total Acreage	**2,956**

Figure 2-1. Bathymetry of Lake Elsinore and Areas Targeted for Fish Survey Activities

Figure 2-2. Areas and Depth Strata Targeted for Fish Survey Activities

2.1.1.1 Beach Seining

Beach seining was performed at 14 stations within four general areas along the shoreline of Lake Elsinore in the summer and fall of 2019 (Figure 2-2). Beach seine sampling occurred on three separate dates between September 4 and October 15 in water with a depth ranging from 0 to 8 ft. Four seines were conducted at the beach just east of the Launch Point boat ramp, five seines at Elm Grove Beach in the eastern most portion of the lake, one in the channel where water enters Lake Elsinore from Canyon Lake, and four at Small Cove in the southeastern lake (Table 2-2). These stations were selected due to their popularity among fishermen and because they allow for easy access to perform the beach seine surveys with small vessels and trucks on the beach, and limited in-lake hazards which could snag and tear the net. Generalized regions of the lake were selected rather than specific beaches to allow for flexibility in sampling to overcome obstacles such as: (1) poor catch at the primary location; and (2) restricted access for support vessels or trucks.

Beach Seining in Lake Elsinore, September 2019

A seine net measuring 450 ft long by 8 ft tall with ¼ inch mesh was used at each sampling station to collect fish. All Common Carp collected on September 4 and 24, 2019 were tagged using Floy anchor tags and released. Bass, catfish, bluegill, and crappie were tagged using fin clips and released. During the second and third beach seining events occurring on September 24 and October 15, the intent was to record the tag numbers of previously tagged fish when captured. However, no tagged fish were collected during subsequent sample dates.

Tagging Carp at Lake Elsinore, September 4, 2019

2.1.1.2 Otter Trawl

Otter trawling was performed at 13 stations throughout Lake Elsinore on October 10, 2019 (Table 2-3; see Figure 2-2). The sampling effort used an otter trawl (16 ft headrope; 1-inch mesh in the body; ½ inch mesh in the cod-end) towed on the bottom for a total of five minutes at each location. Trawling occurred at a speed-over-ground rate of 1.0 meter (m) per second (1.5 to 2.0 knots). The length of each trawl varied based on site characteristics; however, the overall goal was to target a maximum five-minute trawl to stay within an approximate 500-m radius of each target sampling location. The goal was to sample the near-bottom habitat in deeper portions of the northwest, central, and southeast portions of the lake. The northeast and southwest portions of the lake were not sampled via otter trawl in order to avoid damaging the bottom-mounted LEAMS aeration lines.

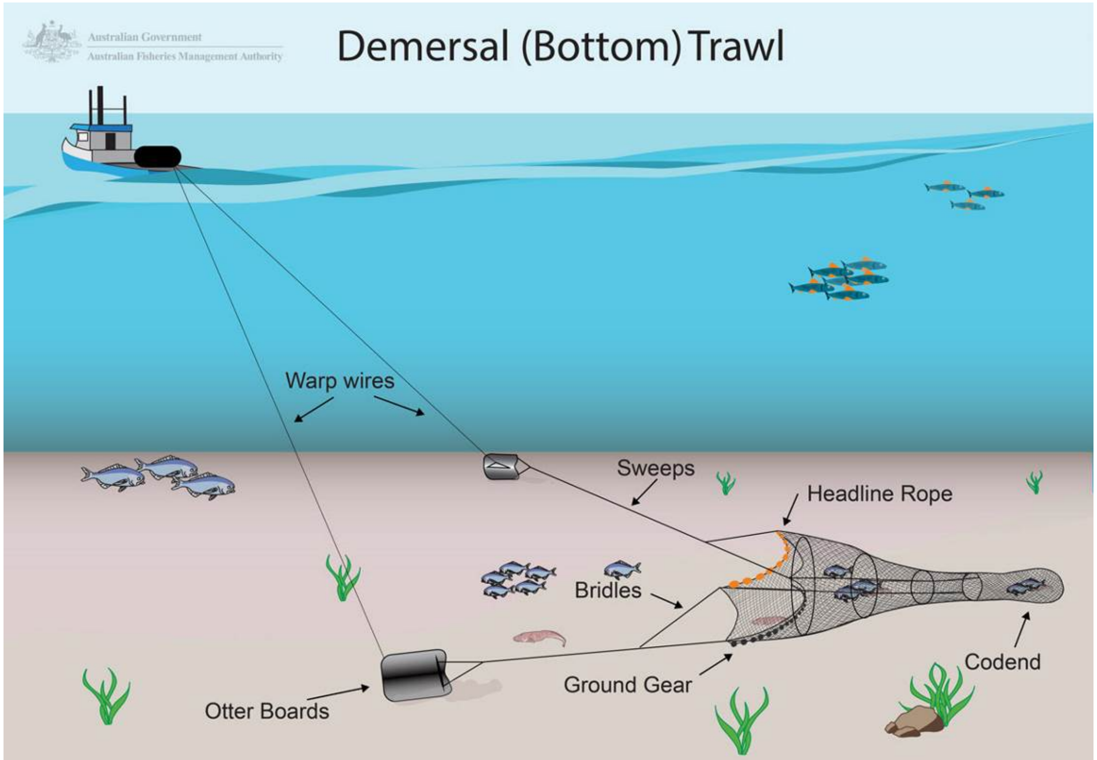


Figure 2-3. Illustration of Otter Trawling Method (Source: Australian Fisheries Management Authority)

Table 2-2. Beach Seine Sampling in Lake Elsinore, Summer and Fall 2019

Survey Date	Sample Station	Latitude	Longitude	Area Sampled (Acres)
September 4	Launch Pointe	33.673908	-117.367996	0.60
	Elm Grove 1	33.664623	-117.334071	0.99
	Elm Grove 2	33.665938	-117.335451	0.83
	Small Cove	33.652159	-117.331086	0.49
September 24	Launch Pointe	33.673846	-117.368083	0.72
	Elm Grove 1	33.66673	-117.336547	0.84
	Elm Grove 2	33.666234	-117.335739	0.62
	Small Cove Mouth	33.655188	-117.331508	0.77
	Small Cove Mouth 2	33.655826	-117.331498	0.55
October 15	Launch Pointe 1	33.673829	-117.36813	0.54
	Launch Pointe 2	33.674001	-117.367874	0.33
	Elm Grove	33.666109	-117.335856	0.81
	Channel	33.658499	-117.324719	0.91
	Small Cove Mouth	33.655188	-117.331508	0.66
Total				**9.66**

Table 2-3. Otter Trawl Sampling in Lake Elsinore, October 10, 2019

Trawl ID	Water Depth Strata (ft)	Start Latitude	Start Longitude	Area Sampled (acres)
LE-T-1_2	8.1 - 16	33.665997	-117.3685	0.59
LE-T-1_3	8.1 - 16	33.669433	-117.36622	0.67
LE-T-2_1	> 16	33.665157	-117.357888	0.74
LE-T-2_2	> 16	33.660755	-117.351231	0.78
LE-T-3_1	8.1 - 16	33.648556	-117.344339	0.73
LE-T-3_2	8.1 - 16	33.653523	-117.338917	0.77
LE-T-4_1	0 - 8	33.660332	-117.332501	0.73
LE-T-5_1	0 - 8	33.655833	-117.334218	0.69
LE-T-6_1	0 - 8	33.648577	-117.339968	0.69
LE-T-7_1	8.1 - 16	33.663643	-117.374532	0.77
LE-T-8_1	0 - 8	33.674708	-117.364816	0.70
LE-T-8_2	8.1 - 16	33.678276	-117.360361	0.71
LE-T-8_3	> 16	33.674185	-117.359798	0.74
Total				**10.03**

2.1.1.3 Purse Seine

Purse seining was performed at six stations in the northwest, central, and southeast portions of Lake Elsinore on October 9, 2019 (see Figure 2-2). Table 2-4 summarizes the information associated with each of the survey stations. This purse seining event occurred within three weeks of a beach seine event to maximize the possibility of recapturing tagged or fin-clipped fish. The ½-in mesh purse seine used to implement this survey measured 230 ft in length and 20 ft in depth.

Purse Seine Deployment, October 9, 2019

Table 2-4. Purse Seine Sampling in Lake Elsinore, October 9, 2019

Survey Station ID	Water Depth Strata (ft)	Latitude	Longitude	Area Sampled (acres)
PS3_1	> 16	33.654999	-117.341299	0.085
PS3_2	> 16	33.65503	-117.342695	0.085
PS2_4	> 16	33.663843	-117.353961	0.085
PS2_3	> 16	33.664874	-117.356235	0.085
PS1_2	8.1 - 16	33.669041	-117.364053	0.085
PS1_3	8.1 - 16	33.66882	-117.365145	0.085
Total				**0.51**

2.1.2 Data Analysis

Recording the Fish Catch for Silversides and Mosquitofish, September 4, 2019

The analysis of fish data included the following elements:

- *Fish Catch* - Summary of fish abundance data by species, sample method (beach seine, purse seine, or otter trawl), and lake depth or stratum collected (0 to 8 ft, 8.1-16 ft, or > 16 ft).
- *Fish Size* – Size characteristics of collected fish summarized by:
  - *Length* - Minimum, maximum, and mean lengths for each species. Findings calculated using length data from up to 200 fish from each site.
  - *Weight* - Minimum and maximum weights for each species using weights from individual fish (up to 50 fish from each site). The average weight of a species was calculated as all individual weights plus total batch weights (when applicable) divided by the total number of fish collected.
- *Fish Community* – The following measures of the characteristics of the fish community were calculated separately for each species by depth strata and survey method:
  - Density was calculated as the number of fish divided by area sampled;
  - Total abundance was calculated as density multiplied by area in the lake;
  - Biomass was calculated as abundance multiplied by species average weight; and
  - Biomass density was calculated as biomass divided by area in lake.

Fish survey data were generally combined by lake depth strata and/or species to provide estimates of fish community characteristics for the entire lake. None of the fish tagged during surveys were recaptured during the study. Therefore, population estimates could not be calculated from the tagged fish data.

2.1.3 Fish Tissue Collections

Fish were opportunistically collected for tissue analysis of PCBs, DDTs, and nutrients during the fish community surveys. Four primary species were targeted for PCB and DDT tissue analysis to represent the primary resident fish sought by fishermen for consumption, including Common Carp, Largemouth Bass, Crappie, and Channel Catfish. Additionally, nutrients (TN and TP) were analyzed in the tissues of these species as well as Threadfin Shad for potential use in quantifying nutrient sources removed from the lake during future carp-removal efforts, or if some species are removed as a result of future fish kill events. Two secondary alternate species were also opportunistically collected for potential analysis, including bluegill and redear sunfish.

Weighing Lake Elsinore Carp, September 4, 2019

The goal was to collect fifteen individuals of each species that could then be combined into three composites, consisting of five individuals each; however, if this goal could not be met, the minimum fish collection requirement for each species was nine individual fish combined into three composites, consisting of three individuals in each. Skin-off filets of muscle tissue were prepared by the analytical laboratory for PCB and DDT analysis to be consistent with analytical methods used for the prior 303(d) listing process (Davis et al. 2009). Tissue analyses for nutrients used whole fish. Analysis included percent lipids, percent solids, nutrients (TN and TP), DDT (and degradants), PCB congeners and PCB Aroclors. A full detailed description of fish tissue sampling and analysis methods are contained in the Lake Elsinore Fisheries Management Work Plan and Quality Assurance Project Plan (LESJWA 2019a). While a brief summary of fish collected as part of the tissue analysis study is presented in the results section to follow, a full report of fish tissue PCB, DDT, and nutrient results will be detailed under a separate cover.

2.2 Planktonic Community

Zooplankton and phytoplankton sample collection occurred on three occasions, during the summer, fall and winter of the 2019-2020 season at three central locations in Lake Elsinore (Table 2-5; Figure 2-4).

Table 2-5. Plankton Sampling Locations in Lake Elsinore

Sample Location ID	Latitude	Longitude
LE-P-1 (LE01)	33.668978	-117.364185
LE-P-2 (LE02)	33.663344	-117.354213
LE-P-3 (LE03)	33.654939	-117.341653

Figure 2-4. Lake Elsinore Plankton Monitoring Locations, 2019-2020

2.2.1 Zooplankton

Three zooplankton sample collection events occurred at each of the three sample locations: July 26 and October 17, 2019 and February 18, 2020. Duplicate, vertical tows were made during each event using a Wisconsin plankton net with a 120-millimeter (mm) opening and 63-micron (µm) mesh. Vertical tow volumes ranged from 52.0 to 78.0 liters (L); the samples collected from the duplicate tows were composited. Zooplankton were preserved with 2%

Lugol's solution and kept cool in the dark. Zooplankton in each composite sample were identified at a certified zooplankton taxonomy laboratory to the lowest practicable taxonomic level.

2.2.2 Phytoplankton

Three phytoplankton sample collection events occurred at each of the three sample locations: August 27 and October 17, 2019 and February 18, 2020 (Figure 2-3). Samples were collected from the top two meters of the water column at each station using a peristaltic pump. The inlet tube was lowered/raised through the water column at a uniform speed to collect a composite from which two 250 milliliter (mL) sub-samples of lake water were taken: soft-bodied algae and diatoms. Soft-bodied algae samples were preserved with 2% Lugol's solution, while diatoms were preserved with a 10% buffered formalin; both sample types were kept cool and in the dark. Phytoplankton were identified by a certified algal taxonomy laboratory to the lowest practicable taxonomic level and enumerated as cells/mL and units/mL[1]

2.2.3 Data Analysis Methods

Phytoplankton density (cells/mL and units/mL) and zooplankton density and biomass were calculated for each sample location for each taxon (at the lowest identified taxonomic level). Sample results are summarized by major taxonomic groups. Characteristics of planktonic communities are presented as follows:

- *Richness* - Represents the number of taxa (i.e. lowest identified taxonomic units) at each site on each sample date; richness values were averaged across sites to provide whole lake values.
- *Diversity* – The Simpson's Diversity Index (SDI), was used to calculate species diversity for each sample date at each site (Simpson 1949):

  $$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right)$$ *where,*

  D = SDI,

  n = total number of organisms of a particular species, and

  N = the total number of organisms of all species. SDI values range from 0 (where one taxon completely dominates the community), to 1 (where all taxa are equally distributed). The SDI was averaged across all sites to provide whole lake values.

[1] An algal unit is a growth form, such as a colony, filament, or unicellular organism. Unit density (expressed as units/mL) is determined by counting the number of algal units in a subsample. Cell density, expressed as cells/mL, is the number of algal cells in a growth form, such as a colony, filament, or unicellular organism, and is determined by counting the number of cells in ten growth forms of a particular alga encountered during the analysis. These ten counts are averaged and multiplied by the total number of units found to estimate algal cell density (NCDEP 2016).

3.0 FISH SURVEY RESULTS

3.1 Fish Catch Summary

Table 3-1 summarizes the total area of each depth strata sampled by each fish survey method in the context of the entire area of Lake Elsinore. The area sampled by the beach seine and otter trawl methods was similar; purse seining covered much less area of the lake. The majority of sampling occurred in the shallowest depth layer (0 - 8 ft), which represents about a quarter of the total lake acreage, as it was anticipated that the majority of the fish live in the shallower areas of the lake due to higher oxygenation.

Table 3-1. Acres of Lake Elsinore Surveyed by Each Survey Method by Lake Depth

Survey Method/Area (acres)		Depth Strata			Total
		0 – 8 ft	8.1 – 16 ft	> 16 ft	
Lake Area Surveyed	Beach Seine	9.7	--	--	9.7
	Purse Seine	--	0.2	0.3	0.5
	Otter Trawl	2.8	4.2	2.3	9.3
	Total Area Surveyed (all methods)	12.5	4.4	2.6	19.5
Total Lake Acreage	Total Area in Lake Elsinore	679	1,480	797	2,956
	Portion of Lake Elsinore within Depth Strata (%)	23%	50%	27%	100%

Table 3-2 provides a list of the common and scientific names of all fish species collected during the study. Figure 3-1 illustrates the relative abundance of all species observed regardless of fish survey method or depth strata.

Table 3-3 summarizes fish catch numbers for each fish species by survey method and depth strata. In general, beach seining collected about nine times as many fish as purse seining and 95 times more fish than otter trawling. Small portions of the lake with aquatic vegetation that some species prefer (i.e., Largemouth Bass, Green or Redear Sunfish, Black Crappie, and Bluegill) were inaccessible by the survey methods and their numbers may be underrepresented. Overall, the three most common fish species observed during all surveys combined were *Menidia spp.* (likely Mississippi Silverside, *Menidia audens; but* possibly Inland Silverside, *Menidia beryllina*), Mosquitofish and Common Carp.

Beach and purse seine catches were both dominated by Mississippi Silverside. Mosquitofish were the second most common fish species collected by each of these survey methods. Otter trawl catch data differed from the other two survey methods, in that while at low numbers, the majority of fish captured were Bluegill and Common Carp collected in shallow and moderate water depths.

Table 3-2. Fish Species Collected from Lake Elsinore during 2019 Surveys

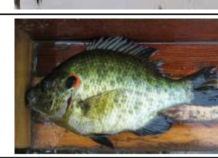
Common Name	Scientific Name	Photograph
Black Crappie	*Pomoxis nigromaculatus*	
Bluegill	*Lepomis macrochirus*	
Channel Catfish	*Ictalurus punctatus*	
Common Carp	*Cyprinus carpio*	
Green Sunfish	*Lepomis cyanellus*	
Silverside Minnows (Mississippi or Inland Silverside)	*Menidia spp. (Menidia audens* or *Menidia beryllina*)	
Largemouth Bass	*Micropterus salmoides*	
Mosquitofish	*Gambusia affinis*	
Redear Sunfish	*Lepomis microlophus*	
Threadfin Shad	*Dorosoma petenense*	

Table 3-3. Fish Catch Summary by Survey Method and Depth Strata in Lake Elsinore (n = number captured)

Fish Species	Beach Seine		Purse Seine				Otter Trawl						All Methods	
	0 – 8 ft		8.1 - 16 ft		> 16 ft		0 - 8 ft		8.1 - 16 ft		> 16 ft		All Depths	
	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%[1]	n	%
Black Crappie	0	0.0	1	0	1	1	0	0.0	0	0	0	0	2	0.0
Bluegill	62	1.4	0	0	0	0	11	55.0	15	65	0	0	88	1.8
Channel Catfish	2	0.0	0	0	0	0	1	5.0	0	0	0	0	3	0.1
Common Carp	289	6.8	2	1	2	2	8	40.0	8	35	2	100	311	6.5
Green Sunfish	1	0.0	0	0	0	0	0	0.0	0	0	0	0	1	0.0
Mississippi Silverside	2,350	54.9	340	90	74	82	0	0.0	0	0	0	0	2,764	57.7
Largemouth Bass	4	0.1	0	0	0	0	0	0.0	0	0	0	0	4	0.1
Mosquitofish	1,567	36.6	36	9	13	14	0	0.0	0	0	0	0	1,616	33.7
Redear Sunfish	1	0.0	0	0	0	0	0	0.0	0	0	0	0	1	0.0
Threadfin Shad	1	0.0	0	0	0	0	0	0.0	0	0	0	0	1	0.0
Grand Total	**4,277**	**--**	**379**	**--**	**90**	**--**	**20**	**--**	**23**	**--**	**2**	**--**	**4,791**	**--**

[1] Value represents percent of total catch of that species within the depth stratum for that survey method

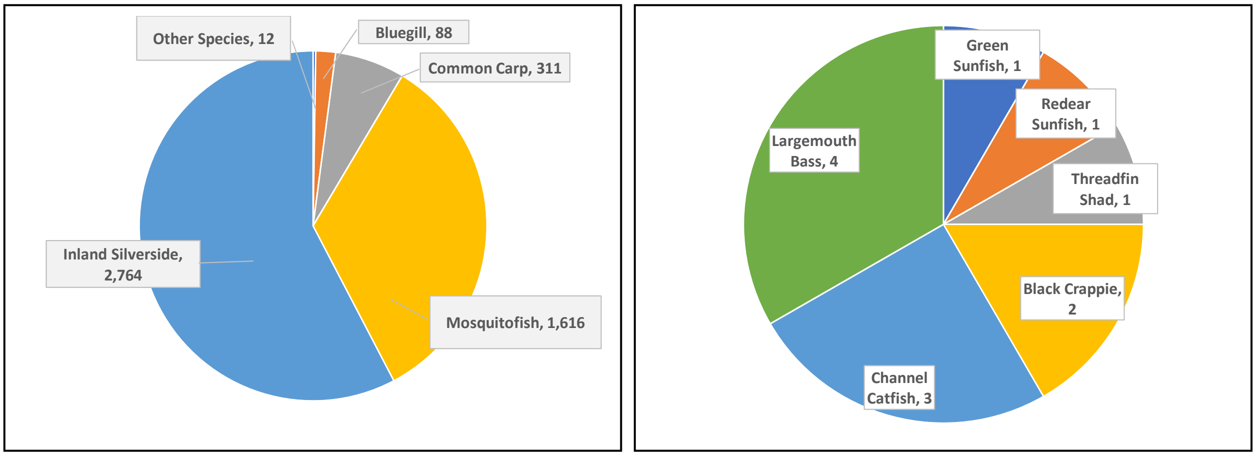


Figure 3-1. Total Fish Catch by Species by All Methods and Depth Strata Combined: (a) Left: Total number of fish captured; (b) Right: Fish species included in the "Other Species" of left figure.

3.2 Fish Community Characteristics

Table 3-4 summarizes the estimated density and abundance of fish for all species observed during the 2019 survey. Total abundance of each species is the sum of the abundances observed across all depths; total density is the average of the densities of each species observed within each depth strata. Table 3-5 provides the estimated biomass and biomass density of these same species. The total biomass of each species is the sum of the biomass observed across all depths; total biomass density is the average of the biomass densities of each species observed at each depth strata. Fish were not assumed to be evenly distributed throughout the lake, as the abundance data appeared to demonstrate. Therefore, before estimating the overall fish community characteristics of Lake Elsinore, survey results were first weighted by the lake area associated with the depth strata in which the fish were captured (see Table 3-1).

3.2.1 Density and Abundance

Mississippi Silverside had the highest whole lake estimated density and abundance with Mosquitofish being the second most abundant. The density and abundance of these two species were greatest in water of moderate depth. Common Carp and Bluegill were also common but were much less prominent with their highest abundance and density observed in the shallow depth strata. All other species collected, including Threadfin Shad which were the third most abundant fish captured in the 2004 EIP study, were estimated at very low densities and abundances.

Table 3-4. Estimated Density and Abundance of Species within Each Depth Strata and the Whole Lake

Fish Species	0 - 8 ft	8.1 - 16 ft	> 16 ft	All Depths
Density (No. of Fish/Acre)				
Black Crappie	0.0	2.9	1.5	1.5
Bluegill	5.2	1.8	0.0	2.3
Channel Catfish	0.3	0.0	0.0	0.1
Common Carp	16.4	6.8	3.4	8.9
Green Sunfish	0.1	0.0	0.0	0.02
Mississippi Silverside	122	997	109	409
Largemouth Bass	0.2	0.0	0.0	0.1
Mosquitofish	81.1	106	19.1	68.6
Redear Sunfish	0.1	0.0	0.0	0.02
Threadfin Shad	0.1	0.0	0.0	0.02
Total	**225**	**1,114**	**133**	**491**
Abundance (No. of Fish)				
Black Crappie	0	8,682	2,338	11,020
Bluegill	7,022	5,244	0	12,266
Channel Catfish	383	0	0	383
Common Carp	22,249	20,161	5,379	47,789
Green Sunfish	70	0	0	70
Mississippi Silverside	165,162	2,951,905	172,990	3,290,057
Largemouth Bass	281	0	0	281
Mosquitofish	110,131	312,555	30,390	453,076
Redear Sunfish	70	0	0	70
Threadfin Shad	70	0	0	70
Total	**305,438**	**3,298,547**	**211,097**	**3,815,082**
Abundance (%)				
Black Crappie	0.0	0.3	1.1	0.3
Bluegill	2.3	0.2	0.0	0.3
Channel Catfish	0.1	0.0	0.0	0.01
Common Carp	7.3	0.6	2.5	1.3
Green Sunfish	0.02	0.0	0.0	0.002
Mississippi Silverside	54.1	89.5	81.9	86.2
Largemouth Bass	0.1	0.0	0.0	0.01
Mosquitofish	36.1	9.5	14.4	11.9
Redear Sunfish	0.02	0.0	0.0	0.002
Threadfin Shad	0.02	0.0	0.0	0.002

Table 3-5. Estimated Biomass and Biomass Density of Species within Each Depth Strata and Whole Lake

Metric/Species	0-8 ft	8.1-16 ft	16.1+ ft	All Depths
Biomass (kilograms [kg] (lbs))				
Black Crappie	0 (0)	4 (10)	1 (3)	6 (12)
Bluegill	200 (441)	305 (672)	0 (0)	505 (1,113)
Channel Catfish	122 (269)	0 (0)	0 (0)	122 (269)
Common Carp	18,257 (40,250)	15,478 (34,124)	4,040 (8,906)	37,775 (83,280)
Green Sunfish	< 0.001 (< 0.001)	0 (0)	0 (0)	< 0.001 (< 0.001)
Mississippi Silverside	478 (1,054)	3,351 (7,388)	230 (508)	4,060 (8,950)
Largemouth Bass	25 (55)	0 (0)	0 (0)	25 (55)
Mosquitofish	98 (216)	87 (191)	15 (33)	200 (441)
Redear Sunfish	1 (2)	0 (0)	0 (0)	1 (2)
Threadfin Shad	2 (5)	0 (0)	0 (0)	2 (5)
Total	**19,183 (42,291)**	**19,226 (42,385)**	**4,287 (9,450)**	**42,695 (94,127)**
Biomass (%)				
Black Crappie	0.0	0.0	0.0	0.0
Bluegill	1.0	1.6	0.0	1.2
Channel Catfish	0.6	0.0	0.0	0.3
Common Carp	95.2	80.5	94.2	88.5
Green Sunfish	< 0.001	0.0	0.0	< 0.001
Mississippi Silverside	2.5	17.4	5.4	9.5
Largemouth Bass	0.1	0.0	0.0	0.1
Mosquitofish	0.5	0.5	0.4	0.5
Redear Sunfish	0.004	0.0	0.0	0.002
Threadfin Shad	0.01	0.0	0.0	0.006
Biomass Density [kg/acre (lbs/acre)]				
Black Crappie	0.00 (0.00)	0.002 (0.0032)	< 0.001 (0.002)	< 0.001 (0.002)
Bluegill	0.15 (0.32)	0.10 (0.23)	0.00 (0.00)	0.08 (0.18)
Channel Catfish	0.09 (0.20)	0.00 (0.00)	0.00 (0.00)	0.03 (0.07)
Common Carp	13.44 (29.64)	5.23 (11.53)	2.53 (5.59)	7.07 (15.58)
Green Sunfish	< 0.001 (< 0.001)	0.00 (0.00)	0.00 (0.00)	< 0.001 (< 0.001)
Mississippi Silverside	0.35 (0.78)	1.13 (2.50)	0.14 (0.32)	0.54 (1.20)
Largemouth Bass	0.02 (0.04)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
Mosquitofish	0.07 (0.16)	0.03 (0.06)	0.01 (0.02)	0.04 (0.08)
Redear Sunfish	0.001 (0.001)	0.00 (0.00)	0.00 (0.00)	< 0.001 (0.001)
Threadfin Shad	0.002 (0.004)	0.00 (0.00)	0.00 (0.00)	0.001 (0.001)
Total	**14.13 (31.14)**	**6.5 (14.32)**	**2.69 (5.93)**	**7.77 (17.13)**

3.2.2 Biomass and Biomass Density

As a result of the Common Carp being one of the largest fish in Lake Elsinore and the third most abundant fish observed, this species had the highest estimated whole lake biomass, percent biomass, and biomass density of all fish species. Biomass and biomass density were greatest in shallow water for Common Carp. Despite its small size, the Mississippi Silversides had the second largest biomass, percent biomass, and biomass density of fish species in Lake Elsinore. The highest biomass and biomass density for this species were observed in moderate depths. All other species collected, including Threadfin Shad, were estimated to have very low biomass and biomass densities.

3.3 Fish Size

The size of fish in Lake Elsinore varied greatly. Small fish, commonly described as less than 200 mm, accounted for 89% of all fish. The vast majority of these fish ranged from 11 to 100 mm in total length (86%). Lake-wide estimates for fish less than 200 mm total length were 435 fish/acre, with a total abundance of 3,387,603.

Table 3-6 summarizes the length and weight characteristics of fish species observed during the Study. Fish species with the highest average weight were Common Carp and Channel Catfish; however, with the exception of Common Carp, large fish represented only a small portion of the total fish community. The observed fish lengths for the four dominant species (see Figure 3-1) can be characterized as follows:

- Bluegill appear to consist of two distinct size classes representing different age groups (Figure 3-2) (Peterson et al. 2010; Tomcko and Pierce 1997):[2] (a) 43% fell within a group that is generally 31 to 70 mm in length (generally less than two years old); (b) 39% are within a group that is 121 to 160 mm in length (approximately 4-5 years old). The most common lengths of Bluegill collected were between 41 to 50 mm (18%) and 141-150 mm (14%).
- Common Carp lengths spanned a wide range (Figure 3-3). While based on the unimodal length distribution it appears that the majority of carp are within one recruitment class, it is difficult to identify specific age classes considering Common Carp spawn multiple times a year and age classes can overlap. Most Common Carp collected (81%) were between 341 and 490 mm in length with 371 to 380 being the most common lengths collected (18%). Based on the range of length measurements the age of most of the carp captured is estimated to be 4 to 6 years old (Vilizzi et al. 2015).
- Lengths of Mosquitofish were relatively consistent (Figure 3-4), with the vast majority of fish (96%) between 21 to 50 mm in length and the largest portion being 31 to 40 mm (42%) in length. Based on these measurements the age of the majority of Mosquitofish captured is likely to be greater than two years old (Erguden 2013; Pyke 2005).

[2] As noted in Section 2.1.1, different net mesh sizes were used for the three fish survey methods. These differences may have influenced the relative proportion of observed smaller fish.

- Mississippi Silverside lengths exhibited a unimodal distribution (Figure 3-5). The majority of fish (88%) were from 51 to 100 mm with the largest portion being 81 to 90 mm (27%) in length. The maximum reported age of silversides is about 2 years old. Based on the measurement data collected during this survey it is likely that the majority of Silversides captured were less than one year old (Laird and Page 1996; USFWS 2017).

Table 3-6. Length and Weight Characteristics of Fish Species Observed in Fish Surveys

Fish Species	Length (mm)[1]				Weight (g)[2]			
	n	Min	Max	Average	n	Min	Max	Average
Black Crappie	2	17	18	18	2	1	1	1
Bluegill	88	20	168	92	88	1	115	28
Channel Catfish	3	195	550	318	3	60	1,450	529
Common Carp	311	32	675	373	311	1	3,700	827
Green Sunfish	1	49	49	49	1	1	1	1
Mississippi Silverside	1,590	16	110	75	2,764	1	8	3
Largemouth Bass	4	138	214	180	4	37	140	89
Mosquitofish	721	5	59	36	1,616	1	3	1
Redear Sunfish	1	90	90	90	1	12	12	12
Threadfin Shad	1	135	135	135	1	34	34	34

[1] The first 200 fish captured at each sampling station were measured. “n” represents the total number of length measurements made for each species captured in the Study

[2] The first 50 fish captured at each sampling station were individually weighed; the remainder of the fish were batch weighed. “n” represents the total number of fish captured for each species during the Study.

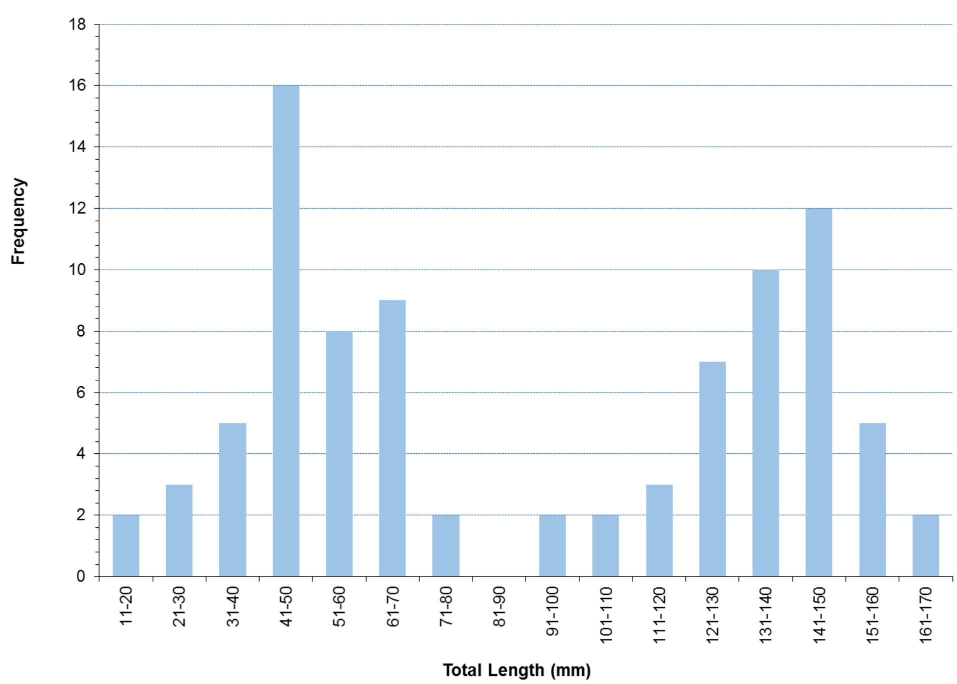


Figure 3-2. Histogram of Fish Length - Bluegill from Lake Elsinore, Fall 2019

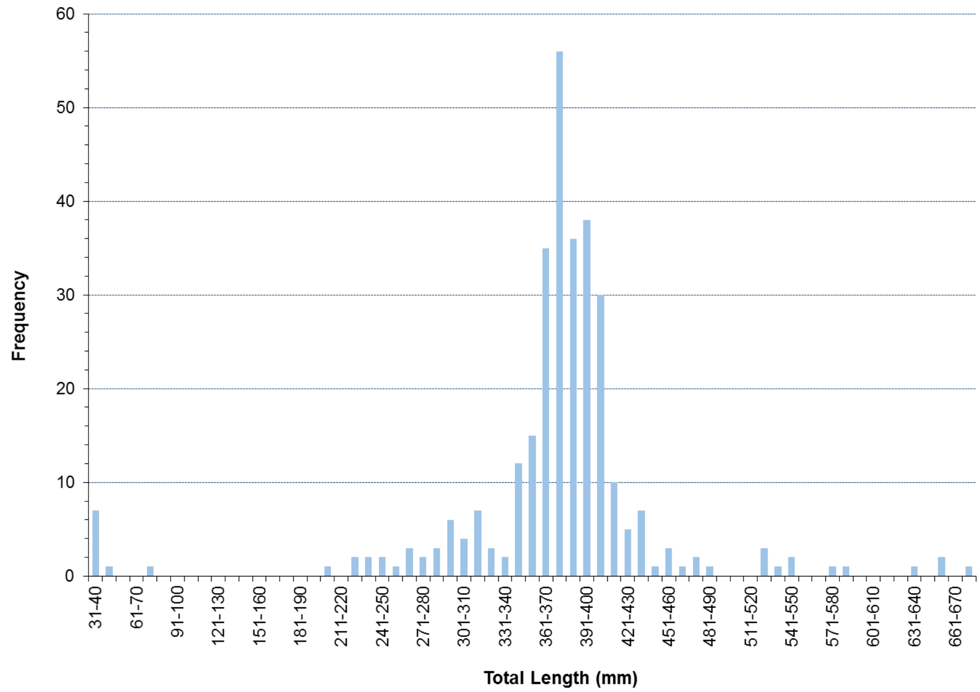


Figure 3-3. Histogram of Fish Length - Common Carp from Lake Elsinore, Fall 2019

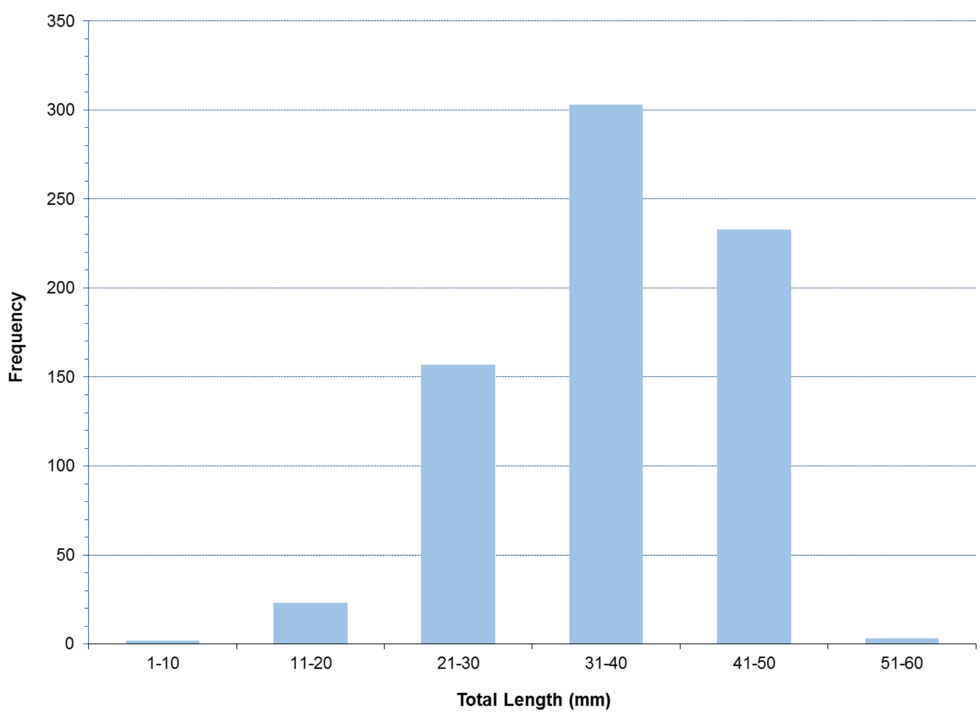


Figure 3-4. Histogram of Fish Length - Mosquitofish from Lake Elsinore, Fall 2019

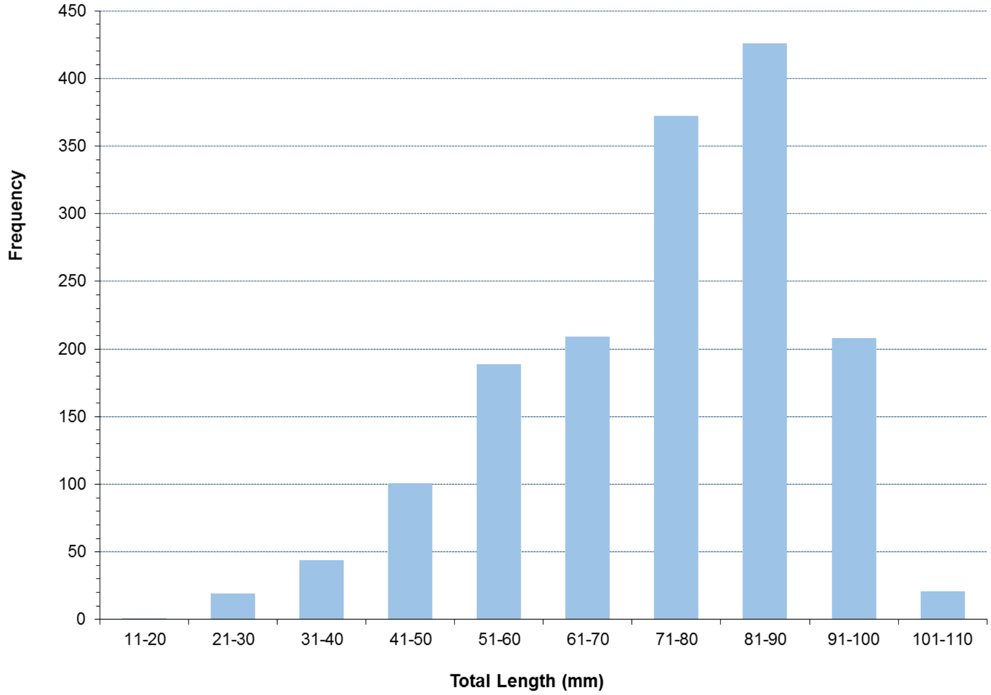


Figure 3-5. Histogram of Fish Length - Mississippi Silverside from Lake Elsinore, Fall 2019

4.0 PLANKTON SURVEY RESULTS

4.1.1 Zooplankton Community

Zooplankton surveys were conducted at three open lake locations on three different sample dates in July and October 2019 and February 2020. A total of fourteen zooplankton taxa, categorized into three major groups, were observed across the three surveys (Table 4-1; see Appendix C for zooplankton photographs).

Table 4-1. Zooplankton Taxa Observed from the 2019-2020 Lake Elsinore Study

Zooplankton Group	Unique Taxon
Cladocera 	*Daphnia rosea*
	Daphnia sp.
	Diaphanosoma sp.
Copepoda 	*Acanthocyclops robustus*
	Calanoida - copepodites
	Cyclopoida - copepodites
	Leptodiaptomus siciloides
	Copepoda - nauplii (juvenile)
Rotifera 	*Brachionus angularis*
	Brachionus caudatus
	Brachionus plicatilis
	Filinia longiseta
	Filinia terminalis
	Keratella valga

For each of the survey dates, the characteristics of the zooplankton community were very similar regardless of the sample location. Therefore, to simplify the characterization of the zooplankton community in the lake, the sample results from each of the three sample locations were averaged together for each survey event. Figures 4-1 and 4-2 illustrate the change in density and biomass among the major zooplankton groups by season. Table 4-2 summarizes the estimated zooplankton density and biomass density observed during the Study. Table 4-3 provides richness and diversity indices. The following sections provide additional information regarding zooplankton community characteristics observed during each survey event.

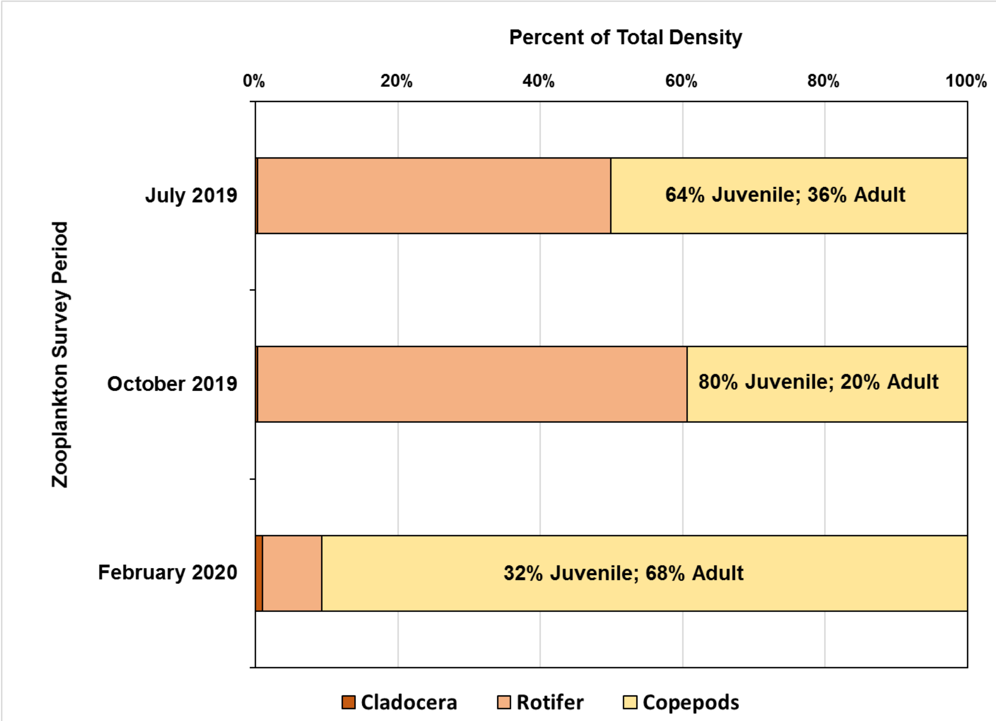


Figure 4-1. Percent Average Total Density of Major Zooplankton Groups during 2019-2020 Lake Elsinore Study

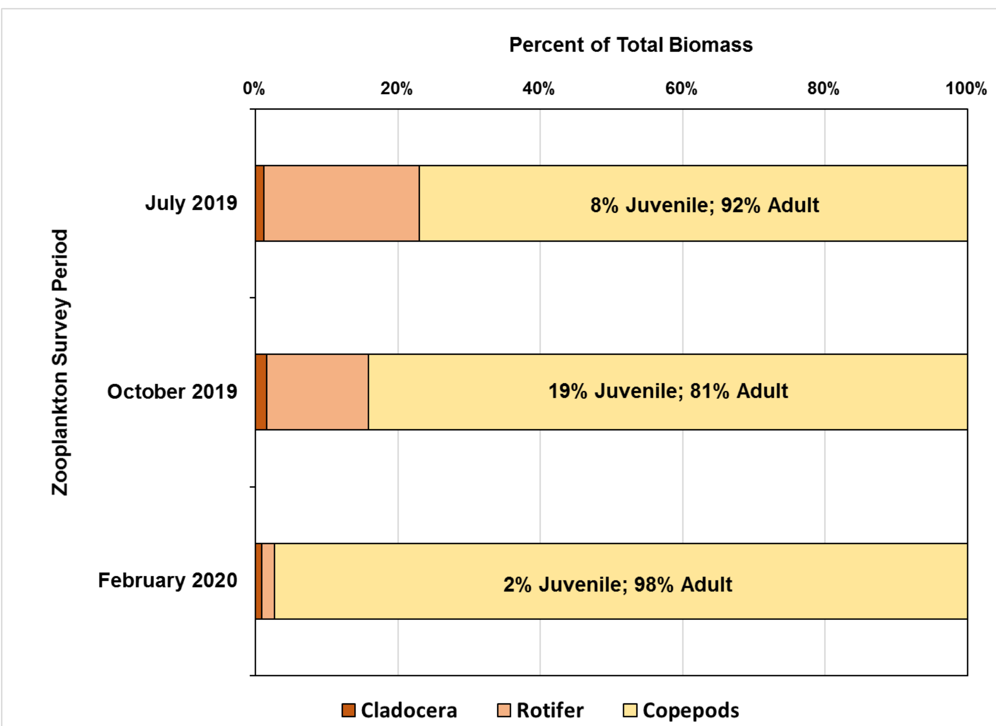


Figure 4-2. Percent Average Total Biomass Density Represented by Major Zooplankton Groups during 2019-2020 Lake Elsinore Study

Table 4-2. Average Zooplankton Density Observed from Lake Elsinore Surveys

Metric/Taxa	July 2019		October 2019		February 2020	
	Average	%	Average	%	Average	%
Density (Individuals/L)						
Cladocera	2.2	0.2	24.1	0.3	2.3	0.51
Rotifer	494	49.7	5,137	60.3	21	48.1
Total Copepod	499	50.1	3,353	39.4	228	51.5
Juvenile Copepod	318	31.9	2,697	31.7	73.5	16.6
Adult Copepod	181	18.2	657	7.7	155	34.9
Total	**996**	**--**	**8,515**	**--**	**44**	**--**
Biomass Density (micrograms/liter [µg/L])						
Cladocera	6.5	1.2	33.7	1.5	4.6	0.90
Rotifer	119	21.8	314	14.3	9.1	1.77
Total Copepod	419	77.0	1,845	84.1	500	97.3
Juvenile Copepod	33.9	6.2	350	16.0	10.8	2.11
Adult Copepod	385	70.8	1,495	68.2	489	95.2
Total	**544**	**--**	**2,192**	**--**	**514**	**--**

Table 4-3. Zooplankton Richness and Diversity in Lake Elsinore

Community Metric	Survey Month		
	July 2019	October 2019	February 2020
Taxa Richness	7	9	9
Simpson's Diversity Index (SDI)	0.68	0.73	0.78

July 2019 Observations

- Rotifer and total Copepod densities each accounted for approximately 50% of the zooplankton community.
- Cladocerans, represented by three taxa, accounted for only a small portion of the community (0.2%).
- Rotifers consisted of two taxa: *Brachionus angularis* and *Brachionus plicatilis*.

- Copepods were approximately 36% adults and 64% juveniles (nauplii); adult Copepods were 75% *Cyclopoida* (*Copepodites*) and 25% *Acanthocyclops robustus.* Juvenile Copepods were not identified to a lower taxonomic level.
- Total Copepods comprised approximately three quarters of the total zooplankton biomass density with most of that biomass contributed by adult Copepods.
- The SDI value of 0.68 in July is within the upper range of diversity values recorded in Lake Elsinore during two separate studies conducted in 2003-2004 and 2009-2011 by Veiga-Nascimento and Anderson (2004) and Tobin (2011) indicating a moderate to highly diverse zooplankton community for this waterbody.

<u>October 2019 Observations</u>

- Rotifer density accounted for 60% of the zooplankton population (an increase approximately 10% from the July event); dominant taxa included *Keratella valga* (59%) and *Brachionus angularis* (26%).
- Total Copepods comprised 39% of the density with 80% being adults. This density represented an approximate 10%% decrease in copepod abundance as compared to the July event.
- Cladocerans continued to represent only a small portion of zooplankton density (0.3%); only one taxon was observed - *Diaphanosoma sp.*
- The majority of the biomass (84%) was comprised of Copepods.
- The SDI value of 0.73 in October indicates a moderate to highly diverse zooplankton community for Lake Elsinore based on prior studies by Veiga-Nascimento and Anderson (2004) and Tobin (2011).

<u>February 2020 Observations</u>

- Similar to July 2019, Rotifer and Total Copepod densities each accounted for approximately 50% of the zooplankton community; dominant taxa included *Brachionus angularis* (76%) and *Keratella valga* (17%).
- For Copepods, approximately two-thirds were adults. Calanoida Copepods were more common than Cyclopoida Copepods.
- As during other survey events, cladocerans represented only a very small portion of zooplankton density (0.5%); only one taxon was observed - *Diaphanosoma* sp.
- More than 97% of the observed biomass was comprised of Copepods.
- The SDI value of 0.78 in February indicates a moderate to highly diverse zooplankton community for Lake Elsinore based on prior studies by Veiga-Nascimento and Anderson (2004) and Tobin (2011).

4.1.2 Phytoplankton Community

Phytoplankton surveys were conducted at three open lake locations on three different sample dates in August and October 2019, and February 2020. A total of 76 phytoplankton taxa were observed, categorized into eight major algal groups (Table 4-4; see Appendix B for example photographs of phytoplankton species observed during the survey). For each of the survey dates, the characteristics of the phytoplankton community were very similar regardless of the sample location. Therefore, to simplify the characterization of the phytoplankton community in the lake, the sample results from each of the three sample locations were averaged together for each survey event. Table 4-5 summarizes the resulting estimated phytoplankton density and biomass density observed during the study. Table 4-6 provides richness and diversity indices. The following sections describe the phytoplankton community characteristics observed during each survey event:

<u>August 2019 Observations</u> (Figure 4-3)

- Blue-green algae (25 taxa) was the most diverse algal group and displayed by far the greatest density: cells/mL (> 97%); units/mL (84.9%).
- Approximately 60% of the blue-green algae group (units/mL) was comprised of five species *Aphanocapsa delicatissima* (7.4%), *Eucapsis parallelepipedon* (12.0%), *Microcystis cf. aeruginosa* (11%), *Pseudanabaena cf. acicularis* (17.3%), and *Raphidiopsis sp.* (straight) (12.9%).
- Five of the observed blue-green algal species (~5% of total species observed) have the potential to produce cyanotoxins: *Dolichospermum sp 2* (straight, elliptical akinete next to heterocyst); *Microcystis cf. aeruginosa*; *Raphidiopsis sp 1 (spiral)*; *Raphidiopsis sp 2 (straight)*; *Raphidiopsis sp 1 (akinetes)*. These species comprised approximately 27% of the phytoplankton density (units/mL) observed in August with *Microcystis cf. aeruginosa* and *Raphidiopsis sp 2 (straight)* being the most common species within this subgroup.
- The green algae group was the second most diverse with 23 taxa, but with much lower density relative to the blue-green algae.
- All other algal groups noted in Table 4-5 had much fewer taxa. Of these groups, *Charophyta* had the highest richness with four taxa.
- Despite biomass dominance by blue-green algae, the average SDI 0.9 was high indicating a diverse phytoplankton community (Table 4-6).

<u>October 2019 Observations</u> (Figure 4-4)

- Blue-green algae (19 taxa) was again the most diverse algal group, and dominated the density estimates even more than the previous August event (cells/mL - 99.7%; units/mL - 96.3%).
- The majority of blue-green algae present in October was *Raphidiopsis sp.* (straight), increasing from 12.9% units/ml in August to 61.4% units/mL in October; some species which were common in August had lower densities (units/mL) by October (*Aphanocapsa*

delicatissima - 2%; *Pseudanabaena cf. acicularis* - 6.5%) or were absent (*Eucapsis parallelepipedon* and *Microcystis cf. aeruginosa*). Species exhibiting notable increases in abundance in October included: *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya & Subba Raju (6.1% units/ml); *Planktolyngbya minor* (Geitler & Ruttner) Komárek & Cronberg (4.5%); and *Raphidiopsis sp 3* (akinetes) (6.3%).

- Five of the observed blue-green algal species (~25% of total species observed) have the potential to produce cyanotoxins: *Dolichospermum sp 2* (straight, elliptical akinete next to heterocyst); *Planktothrix agardhii*; *Raphidiopsis sp 1 (spiral)*; *Raphidiopsis sp 2 (straight)*; *Raphidiopsis sp 1 (akinetes)*. These species comprised approximately 71% of the phytoplankton density (units/mL) observed in August with *Raphidiopsis sp 2 (straight)* being the most common species in this subgroup.
- Green algae had a much lower taxa richness in October with only four taxa represented compared to 23 in August.
- While all other algal groups noted in Table 4-5 were observed in October (except *Euglenophyta*), all contained fewer taxa. Of these groups, *Bacillariophyta* (Diatoms) had the highest richness with five taxa.
- Taxa richness declined from August by approximately 50%; SDI also exhibited a considerably lower index value from 0.9 in August to 0.6 in October for cells/ml.

<u>February 2020 Observations</u> (Figure 4-5)

- Blue-green algae were again by far had the greatest density of algae present (cells/mL - 98%; units/mL – 70.8%), although the number of taxa (12) was approximately half of what was observed in August 2019 (25 taxa).
- Dominant blue-green algae species changed somewhat from previous survey events; almost 90% of blue-green algae (units/mL) consisted of the following four species: *Aphanocapsa delicatissima* (28.1%), *Chroococcus dispersus* (12.7%), *Planktolyngbya minor* (17.7%), and *Planktothrix agardhii* (30.3%), only one of which had previously been in the top five most abundant.
- Two of the observed blue-green algal species (10% of total species observed) have the potential to produce cyanotoxins: *Planktothrix agardhii* and *Raphidiopsis sp 2 (straight)*; These species comprised approximately 31% of the phytoplankton density (units/mL) observed in August, with *P. agardhii* comprising most of this subgroup.
- Similar to October, green algae continued to exhibit lower taxa richness than that observed in August 2019, with only seven taxa represented.
- *Bacillariophyta* (Diatoms) while having only three taxa represented, had increased in density (units/mL) 9x over the October survey, and 2.4x over the August event.
- Of the remaining algal groups noted in Table 4-5, all had three or fewer taxa with the exception of *Euglenophyta,* which was only observed during the August survey.
- The average SDI in February was moderate indicating modest diversity in the phytoplankton community.

Overall, blue-green algae were dominant in Lake Elsinore throughout the summer, fall, and winter with their density and percent abundance highest in the October sample event. The dominant blue-green algae species varied by season, with *Pseudanabaena cf. acicularis, Raphidiopsis sp*., and *Planktothrix agardhii* being the dominant species for August, October, and February, respectively. Green algae, although low in density, had a relatively high taxonomic richness in the summer.

Table 4-4. Phytoplankton Taxa Observed from the 2019-2020 Lake Elsinore Study

Algal Group Common Name (Scientific Name)	Taxon Name
Diatoms (Bacillariophyta)	*Chaetoceros muelleri Lemmermann*
	Cyclotella cf atomus Hustedt
	Cyclotella cf meneghiniana Kützing
	Cyclotella meneghiniana Kützing
	Cyclotella sp.
	Navicula sp.
	Nitzschia sp.
	Nitzschia sp. 1
Charophyte (Charophyta)	*Closterium acutum Brébisson*
	Cosmarium granatum Bréb. ex Ralfs
	Cosmarium sp. 1
	Cosmarium subtumidum var. minutum (Krieg.) Krieg. et Gerloff
Dinoflagellate (Dinophyta)	*Dinoflagellate cell*
Euglena (Euglenophyta)	*Colacium vesiculosum Ehr.*
	Phacus acuminatus Stokes
Green Algae (Chlorophyta)	*Actinastrum hantzschii Lagerheim*
	Carteria sp 1
	Closteriopsis acicularis (Chodat) J.H.Belcher & Swale
	Coelastrum astroideum De Notaris
	Coelastrum microporum Nägeli
	Coenochloris fottii (Hindák) Tsarenko
	Desmodesmus intermedius (Chodat) E.Hegewald
	Desmodesmus sp. 1
	Desmodesmus communis (E.Hegewald) E.Hegewald
	Dictyosphaerium ehrenbergianum Nägeli
	Green coccoid cell d. 5
	Green coccoid cell d. 7.5
	Monoraphidium arcuatum (Korshikov) Hindák
	Monoraphidium contortum (Thuret) Komárková-Legnerová
	Monoraphidium griffithii (Berk.) Komárková-Legnerová

Table 4-4. Phytoplankton Taxa Observed from the 2019-2020 Lake Elsinore Study (Continued)

Algal Group Common Name (Scientific Name)	Taxon Name
Green Algae (Chlorophyta) (continued)	*Monoraphidium minutum (Nägeli) Komárková-Legnerová*
	Monoraphidium sp. 1
	Oocystis lacustris Chodat
	Oocystis parva West & G.S.West
	Oocystis pusilla Hansg.
	Scenedesmus sp 1
	Tetraedron minimum (A. Braun) Hansg.
	Tetrastrum staurogeniiforme (Schröder) Lemmermann
Green Algae (Chrysophyta)	*Chrysophyceae flagellate cell*
	Chrysophyte flagellate
Green Algae (Cryptophyta)	*Cryptomonas erosa Ehr.*
	Cryptomonas sp. 1
Blue Green Algae (Cyanobacteria or Cyanophyta)	*Anabaenopsis sp.1*
	Anathece sp. 1
	Aphanocapsa delicatissima West & G.S.West
	Aphanocapsa planctonica (G.M.Smith) Komárek & Anagnostidis
	Aphanocapsa sp.1
	Aphanothece floccosa (Zalessky) G.Cronberg & J.Komárek
	Aphanothece minutissima (West) J.Komárková-Legnerová & G.Cronberg
	Aphanothece sp. 1
	Chroococcus dispersus (Keissler) Lemmermann
	Cyanobacterial akinete
	Cylindrospermopsis raciborskii (Woloszynska) Seenayya & Subba Raju
	Dolichospermum sp 2 (straight, elliptical akinete next to heterocyst)
	Eucapsis parallelepipedon (Schmidle) Komárek & Hindák
	Geitlerinema sp.
	Geitlerinema sp. 1
	Glaucospira sp. 1
	Limnothrix planctonica (Woloszynska) Meffert
	Merismopedia tenuissima Lemmermann
	Microcystis cf. aeruginosa (Kützing) Kützing
	Planktolyngbya minor (Geitler & Ruttner) Komárek & Cronberg
	Planktothrix agardhii (Gomont) Anagnostidis & Komárek
	Pseudanabaena cf. acicularis (Nygaard) Anagnostidis & Komárek
	Pseudanabaena cf. limnetica (Lemmermann) Komárek
	Raphidiopsis sp 1 (spiral)

Table 4-4. Phytoplankton Taxa Observed from the 2019-2020 Lake Elsinore Study (Continued)

Algal Group Common Name (Scientific Name)	Taxon Name
Blue Green Algae (Cyanobacteria or Cyanophyta) (continued)	*Raphidiopsis sp 2 (straight)*
	Raphidiopsis sp 3 (akinetes)
	Sphaerospermopsis aphanizomenoides
	Sphaerospermopsis cf aphanizomenoides
	Sphaerospermopsis cf aphanizomenoides (Forti) Zapomelová, Jezberová, Hrouzek, Hisem, Reháková & Komárková
	Synechococcus sp. 1

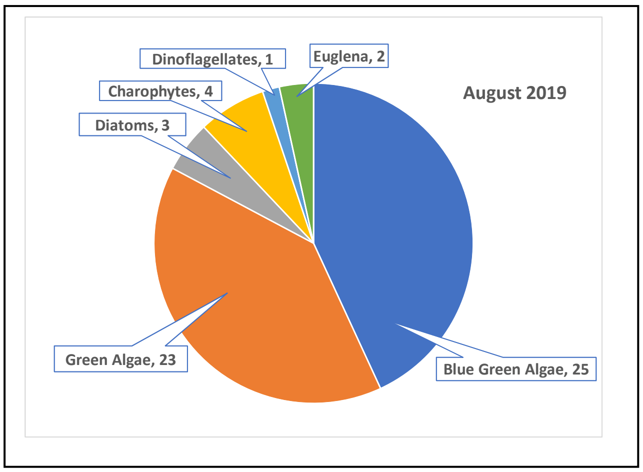
Table 4-5. Average Phytoplankton Density Observed from the 2019-2020 Lake Elsinore Study

Algal Group	August 2019		October 2019		February 2020	
	Average	%	Average	%	Average	%
Algal Cells/mL						
Diatoms (*Bacillariophyta*)	8,650	0.42	2,275	0.11	20,767	1.27
Charophytes (*Charophyta*)	5,802	0.28	427	0.02	769	0.05
Green Algae (*Chlorophyta*)	29,747	1.43	1,280	0.06	5,714	0.35
Green Algae (*Chrysophyta*)	422	0.02	1,138	0.06	4,121	0.25
Green Algae (*Cryptophyta*)	809	0.04	0	0.00	330	0.02
Blue-green Algae (Cyanobacteria)	2,032,068	97.80	2,045,831	99.72	1,608,753	98.03
Dinoflagellates (*Dinophyta*)	0	0.00	640	0.03	659	0.04
Euglena (*Euglenophyta*)	369	0.02	0	0.00	0	0.00
Total	**2,077,866**	--	**2,051,591**	--	**1,641,113**	--
Algal Units/mL						
Diatoms (*Bacillariophyta*)	8,650	6.15	2,275	1.58	20,767	19.35
Charophytes (*Charophyta*)	2,954	2.10	427	0.30	769	0.72
Green Algae (*Chlorophyta*)	8,017	5.70	853	0.59	4,725	4.40
Green Algae (*Chrysophyta*)	422	0.30	1,138	0.79	4,121	3.84
Green Algae (*Cryptophyta*)	809	0.57	0	0.00	330	0.31
Blue-green Algae (Cyanobacteria)	119,444	84.91	138,503	96.29	75,927	70.76
Dinoflagellates (*Dinophyta*)	0	0.00	640	0.44	659	0.61
Euglena (*Euglenophyta*)	369	0.26	0	0.00	0	0.00
Total	**140,665**	--	**143,835**	--	**107,298**	--

Table 4-6. Phytoplankton Richness and Diversity Observed from the 2019-2020 Lake Elsinore Study

Community Metric	Survey Month		
	August 2019	October 2019	February 2020
Taxa Richness	42.3	21.0	20.0
Simpson's Diversity Index (Cells/mL)	0.9	0.5	0.6
Simpson's Diversity Index (Units/mL)	0.9	0.6	0.8

Figure 4-3. Phytoplankton Community Characteristics, August 2019: Left – Taxa Richness; Right – Density (Units/mL)



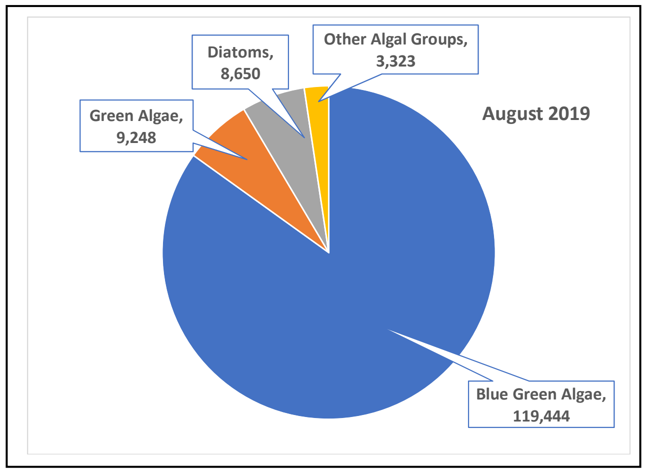
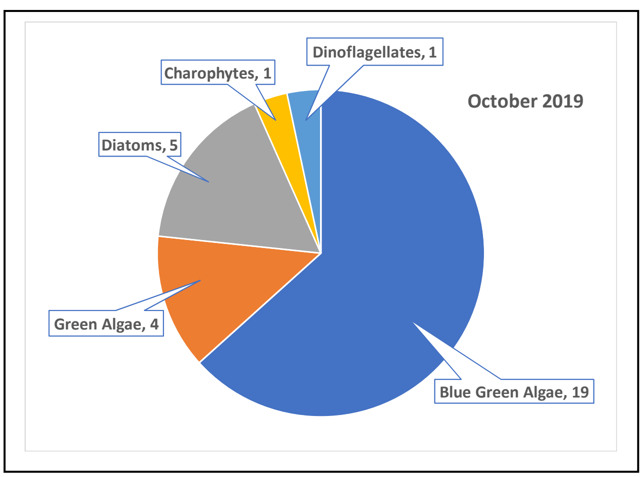


Figure 4-4. Phytoplankton Community Characteristics, October 2019: Left – Taxa Richness; Right – Density (Units/mL)



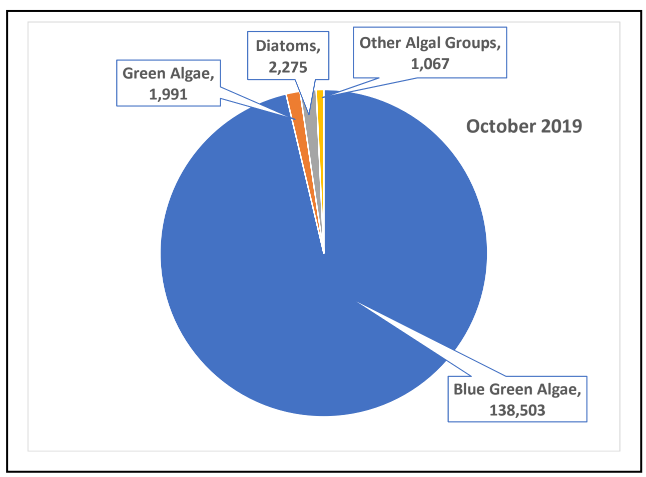
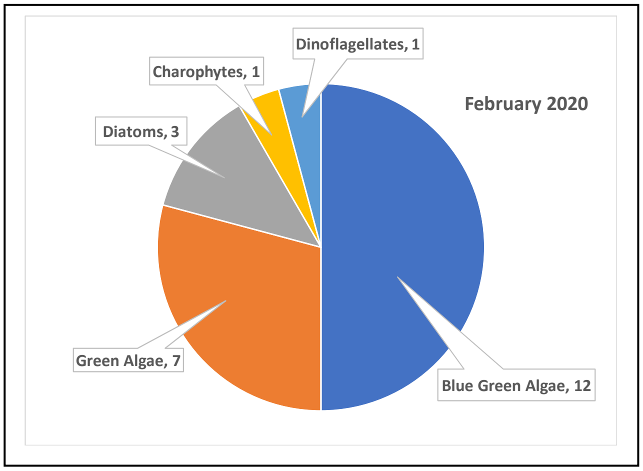
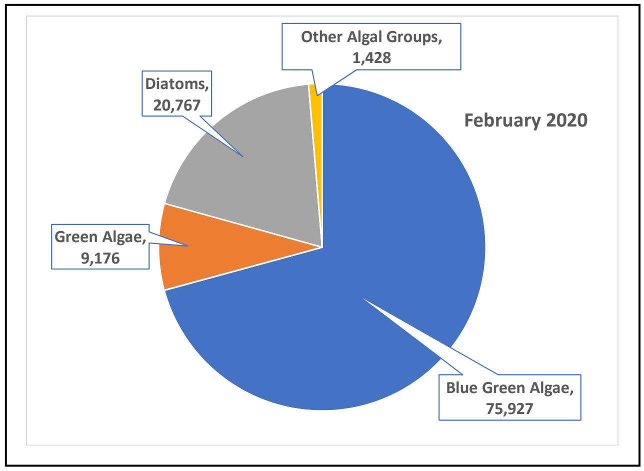


Figure 4-5. Phytoplankton Community Characteristics, February 2020: Left – Taxa Richness; Right – Density (Units/mL





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5.0 FISH TISSUE COLLECTIONS

Four primary species were targeted for collection of fish tissue to be analyzed for PCBs, DDTs, and nutrients: Common Carp, Largemouth Bass, Crappie, and Channel Catfish. Common Carp was the only primary target species for which the goal of 15 individual fish were collected. Table 5.1 provides a complete list of the primary and secondary species that were collected for potential tissue analysis. The 15 carp were divided into three batches (i.e. composites) of 5 fish each and delivered to the analytical laboratory for tissue analysis. The carp were delivered to the analytical laboratory on January 17, 2020. The remaining fish were kept frozen pending further analysis.

An effort was made on December 9, 2019 to collect the remaining balance of Largemouth Bass and Catfish using hook-and-line methods. It was thought that due to the known propensity of Largemouth Bass to congregate in areas of structure (e.g. brush, tree stumps, rock piles), they may have been under-represented in the initial collections, as the sampling gear utilized could not be deployed in these areas. This December 2019 field effort resulted in the collection of no further fish for analysis.

According to the CA EPA Office of Environmental Health Hazard Assessment General Protocol for Sport Fish Sampling and Analysis, a minimum of three fish is required per composite analyzed (OEHHA, 2005). Additionally, the Surface Water Ambient Monitoring Program (SWAMP) Bioaccumulation Oversight Group (BOG) sets a requirement for a minimum number of locations to be sampled in lakes of various sizes (e.g. small, medium, large) (SWAMP, 2008). The 2015 Sampling and Analysis Plan for Long-term Monitoring of Bass Lakes and Reservoirs in California (SWAMP, 2015) considered Lake Elsinore a medium lake, which requires at least two sample locations according to the SWAMP BOG guidelines. Upon further discussions with LECL Task Force, it was decided that while not meeting the Work Plan goal of 15 individuals, or OEHHA's minimum three fish per composite requirement, the Largemouth Bass, Channel Catfish, and Bluegill would also be analyzed. The fish were composited based on location captured (to maintain the minimum two distinct locations) and size. The Largemouth Bass were batched into two replicates: 1) one large fish, and 2) two smaller fish. The Channel Catfish were also batched into two replicates: 1) one large fish, and 2) two smaller fish. The Bluegill were batched into three composites of 5, 4, and 2 fish each. These fish were delivered to the analytical laboratory on July 16, 2020.

All fish within all composite replicates adhered to EPA's 75% rule according to fish size. The results of the fish tissue analysis will be reported under a separate cover in Fall 2020.

Table 5-1. Summary of Fish Collected for PCB, DDT and Nutrient Tissue Analysis during the 2019-2020 Lake Elsinore Study

Species	# Collected	Total Length Range (mm)	Weight Range (g)
Primary Species			
Common Carp	15	375-545	690-2250
Largemouth Bass	3	170-214	62-140
Crappie[1]	0	--	--
Channel Catfish	3	195-550	60-1450
Secondary Alternate Species			
Bluegill	11	113-168	30-115
Redear Sunfish	1	90	12

[1] While two Black Crappie were collected during the survey, they were extremely small (17 and 18mm) and therefore not adequate for tissue analysis

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6.0 DISCUSSION OF KEY FINDINGS AND OBSERVATIONS

This section provides a discussion of the key findings and observations from the 2019-2020 fish and plankton surveys within the context of the historical characteristics of the Lake Elsinore aquatic community and previous survey findings. In addition, this section also provides fishery management recommendations given the findings from the 2019 survey.

6.1 Fish Community

6.1.1 Historical Characteristics

The Lake Elsinore fish community is made up solely of non-native fish species. Following is a brief summary of what is known of the native fishery and history of activities that previously occurred to establish a recreational sport fishery in the lake.

6.1.1.1 Native Fishery

EIP Associates (2005) reviewed the natural fishery in Lake Elsinore and summarized their findings as follows (page 2-65):

> *"The intermittent hydrological characteristics of the San Jacinto River and its tributaries, in conjunction with the periodic desiccation of Lake Elsinore, would have increased the probability of local fish populations becoming extirpated. There is little doubt that fish occupying Lake Elsinore were eliminated numerous times over the millennia when the lake periodically dried out. When the lake refilled sufficiently to provide suitable environmental conditions for fish, it was recolonized by fish from the San Jacinto River and, in times of overflow, by fish from the Santa Ana River."*

> *"Our knowledge of the native fishes of the San Jacinto Basin is extremely limited primarily due to the destruction of habitat and the extirpation of most native fishes prior to scientific study…Native fishes that are known to occur or that probably occurred in the watershed prior to Euro-American settlement include: Pacific lamprey* (*Lampetra tridentata*), *arroyo chu*b (*Gila orcutti*), *Santa Ana speckled dace* (*Rhinichthys osculus* ssp.*), rainbow trout/steelhead* (*Oncorhynchus mykiss), three-spine stickleback* (*Gasterosteus aculeatus*)*, and possibly the Santa Ana sucker* (*Catostomus santaanae*)*."*

EIP Associates (2005) noted that of the above potential fish species, the most probable native fish to occupy Lake Elsinore on a sustained basis was the arroyo chub (page 2-65):

> *"This species of minnow (Family Cyprinidae) is adapted to warm, fluctuating streams. The chub can live in intermittent streams and it is able to survive hypoxic conditions and wide fluctuations in water temperatures (Moyle 2002). The arroyo chub is an omnivore, feeding on algae, insects, and small crustaceans, food items that would have been abundant in Lake Elsinore."*

Records of the collection of arroyo chub from Lake Elsinore (October 28, 1922) and the San Jacinto watershed (1939, 1946) exist. In addition, historical accounts note the presence of arroyo chub in Lake Elsinore until about 1940 (EIP Associates 2005).

6.1.1.2 Modifications to the Fishery

The existing fish community in Lake Elsinore is now comprised of a mix of fish species that are the result of a combination of purposeful fish stocking, passive fish movement in the watershed or illegal dumping of fish (EIP Associates 2005). Active fish stocking began as early as the late 1800s by local residents interested in establishing a sport fishery in the lake. EIP Associates (2005) provides an historical accounting of fish stocking efforts (see Appendix C, Table C-1, for a more detailed summary). In general, EIP Associates (2005) noted the following:

- Earliest clear record of stocking is from 1895 when the following fish from the U.S. Fish Commission's hatchery in Quincy, Illinois were stocked: Northern Largemouth Bass (*Micropterus salmoides salmoides*), Green Sunfish (*Lepomis cyanellus*), and the Common Carp (*Cyprinus carpio*).
- "Bullheads" (most likely Brown Bullheads) and "black bass" (most likely Northern Largemouth Bass) were likely the commonly stocked fish in the early 1900s.
- Relatively early records of Bluegill (1915) and Striped Bass (1916) stocking have also been documented.
- When Lake Elsinore overflowed in 1916, "German carp" (Common Carp), were observed moving up Temescal Wash from the Santa Ana River.

Today fish continue to be regularly stocked on an annual basis to support recreational activities in Lake Elsinore. Section 6.3.2 below provides additional information of current stocking activities.

6.1.2 Fish Survey History

Table 6-1 summarizes fish survey activities that have occurred in Lake Elsinore since 1984 (including the current fish survey) and the fish species observed during each event. Table 6-2 summarizes the methods used during surveys conducted from 2002 through 2015. As can be seen, these surveys were conducted by many different parties using varying methods. In addition, these surveys were often conducted in selected lake habitats or at specific depths. The number of fish collected in these fish surveys were either not scaled up to provide whole lake fish population metrics or, when scaled, were applied to the whole lake, assuming that fish were equally distributed.

Table 6-1. Fish Species Observed in Fish Surveys: 1984-2019 (adapted from Table 2-19, EIP Associates 2005)

Fish Taxa	Year of Record									
	1984[a]	1993[b]	2002[c]	2003[d]	2008[e,f]	2009[f]	2010[f]	2014[g]	2015[h]	2019[i]
Clupeidae										
Threadfin Shad (*Dorosoma petenense*)	X	X	X	X	X	j	j	X	X	X
Cyprinidae										
Golden Shiner (*Notemigonus crysoleucas*)	X									
Goldfish (*Carassius auratus*)				X	X					
Common Carp (*Cyprinus carpio*)	X	X	X	X	X	X	X	X	X	X
Ictaluridae										
Brown bullhead (*Ameiurus nebulosus*)		X								
Yellow bullhead (*Ameiurus natalis*)		X								
Channel catfish (*Ictalurus punctatus*)	X		X	X	X	X	X	X		X
Salmonidae										
Rainbow trout (*Oncorhynchus mykiss*)				X						
Moronidae										
Striped bass (*Morone saxatilis*)			X[k]							
Hybrid bass					X		X			
Centrarchidae										
Bluegill (*Lepomis macrochirus*)	X	X	X	X	X	X	X			X
Redear sunfish (*Lepomis microlophus*)	X			X			X			X
Green sunfish (*Lepomis cyanellus*)	X	X								X
White crappie (*Pomoxis annularis*)	X?									
Black crappie (*Pomoxis nigromaculatus*)	X?	X	X	X	X	X		X		X
Largemouth bass (*Micropterus salmoides*)	X	X	X	X						X
Cichlidae										
Tilapia	X									
Poecilidae										
Mosquitofish (*Gambusia affinis*)										X

Table 6-1. Fish Species Observed in Fish Surveys: 1984-2019 (adapted from Table 2-19, EIP Associates 2005)

Fish Taxa	Year of Record									
	1984[a]	1993[b]	2002[c]	2003[d]	2008[e,f]	2009[f]	2010[f]	2014[g]	2015[h]	2019[i]
Atherinopsidae										
Silverside minnows (*Menidia spp.*)										X

[a] Reported in Lake Elsinore State Recreation Area General Plan (California Department of Parks and Recreation 1984)
[b] Electrofishing data from the California Department of Fish and Game
[c] Electrofishing and gill net data from the California Department of Fish and Game
[d] EIP Associates seining data, 2008
[e] Anderson (2008)
[f] Ewing (2010a, b)
[g] Fish (2014)
[h] Anderson (2016b
[i] Current Study (2019)
[j] Although not recorded during 2009-2010 surveys, Threadfin Shad were observed in fish kills that occurred during those years
[k] Newspaper documentation of angler harvest (cited in EIP Associates 2005)

Table 6-2. Recent Lake Elsinore Fish Population Survey Methods

Year	Gear	Depth	Whole Lake Population Analysis	Reference
2002	Gill Net	Unknown	Species Abundance (%)	CDFW 2002
2002	Electrofish	Shoreline	Species Abundance (%)	CDFW 2002
2003-2008	Beach Seine (Mark-recapture)	Shoreline	Carp Biomass and Biomass Density	City of Lake Elsinore 2008
2008	Electrofish	Shoreline	Species Abundance (%)	Ewing 2010a; Ewing 2010b
2008	Hydroacoustic	Whole Water Column	Species Abundance (%), Density	Anderson 2008
2009	Electrofish	Shoreline	Species Abundance (%)	Ewing 2010a; Ewing 2010b
2010	Electrofish	Shoreline	Species Abundance (%)	Ewing 2010a; Ewing 2010b
2014	Electrofish	3 - 7 ft	None	Fish 2014
2014	Gill Net	8 - 20 ft	None	Fish 2014
2014	Minnow Traps	2 - 7 ft	None	Fish 2014
2015	Hydroacoustic	Whole Water Column	Species Abundance (%), Density	Anderson 2016b

Taking into account differences in habitat, season or collection methods into how fish may be distributed in the whole lake is critical when interpreting fish survey results. For example:

- Whole lake carp estimates from beach seines in 2003 to 2008 were likely biased high because sampling occurred in the spring, when carp spawn near the shore, and fall, when carp move near shore to avoid anoxic water. Furthermore, the methodology included baiting the seining area to attract more carp (City of Lake Elsinore 2008).
- Acoustic surveys conducted in 2008 and 2015 covered much of the moderate and deep-water areas of Lake Elsinore but did not include very shallow water or the top 1-m of the water column (Anderson 2008, 2016b).

The 2019 fish survey differed from many of these previous surveys in that it sampled multiple habitat types (which included various depth layers), using methods appropriate for each habitat type. This survey clearly demonstrates that fish populations are not equally distributed, which is critical for developing a more accurate estimate of fish density and biomass in Lake Elsinore. For example, the 2019 survey results show that Bluegill, Common Carp, Channel Catfish, and Largemouth Bass were predominantly found in shallow (0 - 8 ft) depth water. However, these species were either observed at much lower densities or not observed at all in deeper lake habitats; thus, scaling up the abundance of these species to the whole lake based solely on their abundance in the shallow water habitat would significantly overestimate actual abundance.

The one habitat feature that is not fully represented in the current 2019 study is areas of the lake with heavy structure habitat, including brush, tree stumps, and rock piles some of which are found in the extreme southeastern and northern portion of Lake Elsinore. The high potential for damage of gear used for the 2019 survey prevented sampling these habitats. As a result of this, some fish which typically prefer these habitats may be under-represented, including some Centrarchids (i.e. Largemouth Bass, Crappie, Sunfish), although these were observed during the 2019 collections. Performing electrofishing in these areas would provide a better estimate of fish abundances in these hard to sample locations.

6.1.3 Fish Population Analysis

Table 6-3 provides survey findings by fish species for each survey conducted since 2002. In some years the information is limited. For example, surveys from 2004-2007 only provide information on Common Carp populations and in 2014 the fish survey report only provides information on the species observed with no quantification. In most other years with fish surveys information is mostly limited to percent of catch or abundance (%) rather than characteristics such as fish size, weight, density or biomass. Thus, the ability to compare Lake Elsinore fish communities over time is somewhat limited.

The 2019 fish survey is the most comprehensive survey to date given that it included data collection from multiple habitats and depth layers. The 2019 survey analysis does not assume even distribution and fish survey results were weighted according to depth strata. This approach is very different from previous surveys, but it provides a more accurate representation of the fish community in Lake Elsinore. The more comprehensive nature of the 2019 survey also provided the opportunity to calculate a number of fish population metrics that could not be calculated from other surveys (see Tables 3-5 and 3-6).

Because of the differences in how data have been collected over time, an approach was needed to allow direct comparison between 2019 survey data and data collected in other years. Accordingly, the 2019 data were recalculated to provide results in two formats (Table 6-3):

- *Weighted (Wt)* – Weighted values provide the fish survey findings based on weighting the fish metrics by habitat (i.e. depth strata) area within Lake Elsinore. This approach provides the most accurate way to characterize the Lake Elsinore fish community.
- *Non-weighted (NWt)* – These values are 2019 values recalculated using only the beach seining data (Table 3-3) and then scaling up the result to the whole lake assuming equal distribution of fish. This modified result provides a means to compare the 2019 results with previous survey findings which are based on similar habitat-collected data. For the most part, the non-weighted whole lake abundance estimates (fish/acre) were greater than their respective weighted values since fish numbers tend to be higher in the beach-seined areas and extrapolation of these numbers to the whole lake assume the fish numbers observed in shallower areas are representative of the lake as a whole. An exception to this expectation is where fish are more common in deeper strata.

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]
All Fish												
Density (fish/acre)	--	--	--	--	--	--	18,090 (a)	--	2,867 (b)[2] 27,720 (b)[2]	--	56,600 (c)	491 (Wt)[3] 443 (NWt)[4]
Black Crappie												
Lake Abundance Estimates (%)	5 (d)[2] 9 (d)[2]	0.4 (e)	--	--	--	--	7 (i) < 0 (j) 5 (a)	2 (i) 2 (j)	--	Present (k)[5]	--	0.3 (Wt) 0.0 (NWt)
Density (fish/acre)	--	--	--	--	--	--	899 ± 180 (a)	--	--	--	--	1.5 (Wt) 0.0 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	12 (Wt) 0.0 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.002 (Wt) 0.0 (NWt)
Average (Avg) Total Length (mm)	276 (d)[2] 281 (d)[2]	--	--	--	--	--	312 (i) 263 (j)	325 (i) 91 (j)	--	--	--	18
Avg Weight (g)	404 (d)[2] 439 (d)[2]	--	--	--	--	--	--	--	--	--	--	0.5
Bluegill												
Lake Abundance Estimates (%)	5 (d)	0.02 (e)	--	--	--	--	37 (i) 85 (j)	9 (i) 75 (j)	3 (i) 44 (j)	--	--	0.3 (Wt) 1.4 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	2.3 (Wt) 6.4 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	1,113 (Wt) 732 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.18 (Wt) 0.25 (NWt)
Avg Total Length (mm)	114 (d)	--	--	--	--	--	116 (i) 113 (j)	122 (i) 117 (j)	112 (i) 137 (j)	--	--	92
Avg Weight (g)	--	--	--	--	--	--	--	--	32 (i) 49 (j)	--	--	28
Carp												
Lake Abundance Estimates (%)	20 (d)[2] 48 (d)[2]	88.5 (e) (f)	--	--	--	--	15 - 43 (h) 43 (i) 4 (j)	76 (i) 14 (j)	89 (i) 37 (j)	Present (k)	--	1.3 (Wt) 6.8 (NWt)

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]
Lake Abundance Estimates (# of fish)[5]	--	800K - 1.7M (e)	--	--	--	--	--	--	--	--	--	47.8K (Wt) 88.4K (NWt)
Density (fish/acre)	--	250 - 500 (e) Avg. 375 (h)	--	--	--	--	25 - 138(h) Avg. 82 (h) 138 ± 28 (a)	--	--	--	< 6 (c)	8.9 (Wt) 29.9 (NWt)
Lake Biomass Estimate (lbs)[5]	--	1.6M (g)[2] 1.0M (g)[2] 660K (g)[2]	782K (f)[2] 1.1M (f)[2]	453K (g)	679K (g)	299K (g)	196K (g)	--	--	--	--	83K (Wt) 163.5K (NWt)
Lake Biomass Density (lbs/acre)[6]	--	530-1.1K (e) 533 (g)[2] 359 (g)[2] 236 (g)[2]	279 (g)[2] 430 (g)[2]	128 (g)	199 (g)	93 (g)	62 (g)	--	--	--	--	15.6 (Wt) 55.3 (NWt)
Avg Total Length (mm)	375 (d)[2] 421 (d)[2]	370 (e)	--	--	--	440 ± 23 (a)	506 (i) 477 (j)	463 (i), 458 (j)	468 (i), 339 (j)	--	--	373
Avg Weight (g)[6]	855 (d)[2] 1.1K (d)[2]	900 (e)	--	--	--	125 ± 26 (a)	--	--	1,229 (i) 557 (j)	--	--	827
Channel Catfish												
Lake Abundance Estimates (%)	24 (d)[2] 19 (d)[2]	8.7 (e)	--	--	--	--	2 (i)	6 (i) 2 (j)	4 (i) 7 (j)	Present (k)	--	<0.01 (Wt) <0.05 (NWt)
Density (fish/acre)	--	4 (e)	--	--	--	--	--	466 (i)	--	--	--	0.09 (Wt) 0.21 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	269 (Wt) 1,030 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.07 (Wt) 0.35 (NWt)
Avg Total Length (mm)	295 (d)[2] 211 (d)[2]	--	--	--	--	--	442 (i)	550 (j)	560 (i) 647 (j)	--	--	318
Avg Weight (g)	219 (d)[2] 96 (d)[2]	--	--	--	--	--	--	--	2,506 (i) 2,963 (j)	--	--	529
Goldfish												
Lake Abundance Estimates (%)	--	0.2 (e)	--	--	--	--	1 (j)	--	--	--	--	--
Avg Total Length (mm)	--	--	--	--	--	--	334 (j)	--	--	--	--	--

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]
Green Sunfish												
Lake Abundance Estimates (%)	--	~0.01 (e)	--	--	--	--	--	--	--	--	--	<0.002 (W) 0.02 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	0.02 (Wt) 0.1 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	0.15 (Wt) 0.67 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	<0.0001 (Wt) 0.0002 (NWt)
Avg Total Length (mm)	--	--	--	--	--	--	--	--	--	--	--	49[7]
Avg Weight (g)	--	--	--	--	--	--	--	--	--	--	--	1[7]
Hybrid Bass												
Lake Abundance Estimates (%)	--	--	--	--	--	--	< 1 (1)j	--	2 (j)	--	--	--
Avg Total Length (mm)	--	--	--	--	--	--	566 (j)	--	489 (j) 1,652 (j)	--	--	--
Koi												
General										Present (k)		
Largemouth Bass												
Lake Abundance Estimates (%)	2 (d)[1] 17 (d)[1]	~0.02 (e)	--	--	--	--	11 (i) 9 (j)	8 (i) 7 (j)	4 (i) 11 (j)	--	--	<0.01 (Wt) 0.1 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	0.07 (Wt) 0.41 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	55 (Wt) 240 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.01 (Wt) 0.08 (NWt)
Avg Total Length (mm)	328 (d)[1] 257 (d)[1]	--	--	--	--	--	363 (i) 221 (j)	364 (i) 359 (j)	385 (i) 292 (j)	--	--	180

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]
Avg Weight (g)	760 (d)[2] 418 (d)[2]	--	--	--	--	--	--	--	974 (i) 556 (j)	--	--	89
Mosquitofish												
Lake Abundance Estimates (%)	--	--	--	--	--	--	--	--	--	--	--	11.9 (Wt) 36.6 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	68.6 (Wt) 162 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	441 (Wt) 940 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.08 (Wt) 0.32 (NWt)
Avg Total Length (mm)	--	--	--	--	--	--	--	--	--	--	--	36
Avg Weight (g)	--	--	--	--	--	--	--	--	--	--	--	1
Rainbow Trout												
Lake Abundance Estimates (%)	--	~0.01 (e)	--	--	--	--	--	--	--	--	--	--
Redear Sunfish												
Lake Abundance Estimates (%)	--	~0.01 (e)	--	--	--	--	--	--	< 0.5 (i)	--	--	< 0.002 (Wt) 0.02 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	0.02 (Wt) 0.10 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	1.86 (Wt) 8.1 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	< 0.001 (Wt) 0.003 (NWt)
Avg Total Length (mm)	--	--	--	--	--	--	--	--	125 (i)	--	--	90[7]
Avg Weight (g)	--	--	--	--	--	--	--	--	43 (i)	--	--	12[7]

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]
Mississippi Silverside												
Lake Abundance Estimates (%)	--	--	--	--	--	--	--	--	--	--	--	86.2 (Wt) 54.9 (NWt)
Density (fish/acre)	--	--	--	--	--	--	--	--	--	--	--	409 (Wt) 243 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	8,950 (Wt) 4,588 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	1.20 (Wt) 1.55 (NWt)
Avg Total Length (mm)	--	--	--	--	--	--	--	--	--	--	--	75
Avg Weight (g)	--	--	--	--	--	--	--	--	--	--	--	3
Threadfin Shad												
Lake Abundance Estimates (%)	43 (d)[2] 3 (d)[2]	1.9 (e)	--	--	--	--	20 (a)	--	--	Present (k)	96 (c)	< 0.002 (Wt) < 0.02 (NWt)
Density (fish/acre)	--	--	--	--	--	--	3,550 ± 710 (a)	--	--	--	54,100 (c)	0.02 (Wt) 0.1 (NWt)
Lake Biomass Estimate (lbs)[6]	--	--	--	--	--	--	--	--	--	--	--	5.27 (Wt) 22.9 (NWt)
Lake Biomass Density (lbs/acre)[6]	--	--	--	--	--	--	--	--	--	--	--	0.001 (Wt) 0.008 (NWt)
Avg Total Length (mm)	137 (d)	--	--	--	--	--	--	--	--	--	--	135[7]
Avg Weight (g)	26 (d)	--	--	--	--	--	--	--	--	--	--	34[7]
Large Fish (> 200 mm)												
Density (fish/acre)	--	--	--	--	--	--	1,050 (a)	--	6 (b)[2] 273 (b)[2]	--	12 (c)	55
Lake Abundance Estimates (%)	--	--	--	--	--	--	5.8 (a)	--	0.2 (b)[2] 1.0 (b)[2]	--	0.02 (c)	11.2

Table 6-3. Fish Population Metric Values for Surveys Conducted from 2002 to 2019 (see table notes for source)

Species/ Metrics	2002	2003	2004	2005	2006	2007	2008	2009	2010	2014	2015	2019[1]

Table Notes

[1] As noted in Section 6.1.3, the NWt information is only provided to provide a means to compare the 2019 survey results with data collected in previous years. Non-weighted (NWt) results are based only on data collected from beach-seining surveys. Weighted (Wt) results are based on the average of data collected from all three strata using different survey methods. The 2019 NWt and Wt data are not intended to be directly compared to each other since the difference between NWt and Wt results can be influenced by the degree to which a particular species or group of species was present in the shallow waters surveyed by beach seining. For example, the percent lake abundance estimate for Black Crappie is 0 in NWt results because Black Crappie were only captured at deeper depths and thus not captured by beach seining.

[2] Results reported from separate surveys conducted in the same year

[3] Estimate weighted by habitat type

[4] Estimate not weighted by habitat type.

[5] Only presence/absence reported; not quantified

[6] K = Thousand; M = Million

[7] Average based on only a single individual fish

Table References

(a) - Anderson (2008)
(b) - Anderson et al. (2011)
(c) - Anderson (2016b)
(d) - CDFW (2002)
(e) - EIP Associates (2005)
(f) – City of Lake Elsinore (2008)
(g) - City of Lake Elsinore (2008)
(h) - EIP Associates (2008)
(i) - Ewing (2010a)
(j) - Ewing (2010b)
(k) - Fish (2014)

Apart from differences in fish survey methodologies, which temper comparisons among survey results, the following is a summary of general observations regarding changes in the composition of the fish community over time (2002–2019) (Note: Non-weighted 2019 fish data were used as the basis for this evaluation):

- *Overall Observation* - There has been a significant shift in the most abundant fish species (%) observed during Lake Elsinore surveys as evidenced by the following:
  - *2002* – Four fish species dominated the fish community with Common Carp (34%), Threadfin Shad (23%), Channel Catfish (22%) and Largemouth Bass (10%) comprising almost 90% of the observed abundance of fish during the survey.
  - *2003* – Fish community abundance was dominated by Common Carp with this fish species representing approximately 88% of the fish observed during that year's survey. Channel Catfish represented the second most common fish comprising 8.7% of observed abundance.
  - *2008-2009* – Fish community was dominated by Common Carp and Bluegill, combined comprising about 80% of the community. Threadfin Shad were common in 2008 but were not observed in the 2009 survey.
  - *2015* – Threadfin Shad dominated the fish community comprising about 96% of the fish observed during that survey.[3]
  - *2019* – The fish community has shifted significantly with silverside minnows (*Menidia spp.*) and Mosquitofish comprising more than 90% of fish abundance. These species were not collected in previous surveys. Carp represented only about 7% of the abundance of fish in this latest survey.

Overall non-weighted fish density in 2019 (fish/acre) was much lower than estimated in previous years which indicates that fewer fish were present in Lake Elsinore than previously found. This difference may be attributed at least in part to the fish kill (see Section 6.3.3) that occurred earlier in 2019 or simply due to differences in survey methods, e.g., some previous surveys were conducted through implementation of hydroacoustic whole lake transects and did not include beach seining.

- Species-specific observations over time include the following:
  - *Common Carp* - Non-weighted whole lake density, biomass, and biomass density all generally decreased as a result of the 2003 to 2008 carp removal effort. These metrics, along with abundance (No. of carp and % abundance) were much lower in 2019 than in 2003. The 2003 to 2008 carp removal effort was considered successful in meeting its goal of reducing the Common Carp population to roughly 10% of the 2003 population (City of Lake Elsinore 2008). This effort resulted in reducing the density of carp from 375 carp/acre to 26 to 55 carp/acre or a remaining total population in the lake of 80,000 to 165,000 fish (EIP Associates 2005). A total of

[3] The 2015 data were collected through a hydroacoustic survey (Anderson 2016b). It is assumed that the small fish observed during the survey (mean size – 1.8 cm) were all Threadfin Shad, because the Silverside and Mosquitofish had never been previously observed in the lake. However, given the high density of these fish species observed in 2019, it is possible that some of the small fish observed in 2015 were Silverside and/or Mosquitofish.

626,190 individual Common Carp equating to 1,316,650 lbs (or 88% of that species biomass) were removed (City of Lake Elsinore 2008) from the lake during this time. Estimates of actual population reduction ranged from 45-72% (Anderson 2008) or 45%-95% (City of Lake Elsinore 2008). Subsequent surveys have estimated a carp density of < 6 carp/acre in 2015 (Anderson 2016b) and (29.9 carp/acre, non-weighted) in 2019. Both of these density estimates still fall within the original 2003 90% reduction goal which indicates that the benefits achieved from the earlier carp removal effort have been maintained.

- *Silverside Minnows (Menidia spp.), Mosquitofish and Threadfin Shad* –Silverside (86% of total fish abundance), and to a much lesser extent Mosquitofish (12% of total fish abundance), which have not been previously observed in fish surveys, were by far the most abundant (%, non-weighted) fish species in 2019. These species have effectively replaced Threadfin Shad. Previous surveys found Threadfin Shad was an abundant fish species (43% 2002; 20% 2008; 96% 2015[4]). However, in 2019 this species represented < 0.02% of fish abundance (non-weighted) in Lake Elsinore.
- *Gamefish (Largemouth Bass, Black Crappie, Channel Catfish and Bluegill)* – These gamefish species have been periodically stocked in Lake Elsinore (see Section 6.3.2 below). For each species the non-weighted abundance (%) in 2019 was much less than what has been observed in previous surveys (Note that Black Crappie was only observed in deeper waters in 2019; thus, its non-weighted abundance was zero for 2019). In 2019, gamefish accounted for 0.6% of the population in Lake Elsinore, compared to 9.5% of fish in 2003 and 57% in 2008 (at the end of the carp removal effort (EIP Associates 2008)). Although abundance is lower, the diversity of gamefish species remains about the same as observed in 2008 (Anderson 2008), especially if the small number of Green and Redear Sunfish collected in 2019 are included.
- *Other Species* - Assessment of trends or patterns in metrics for other fish species cannot be evaluated for Redear Sunfish, Green Sunfish, Rainbow Trout (stocked prior to 2002), Hybrid Bass (stocked in 2004 and 2005), Goldfish and Koi. Observations of these species has been limited since 2002. In particular, Goldfish, Koi, Rainbow Trout, and Hybrid Bass all appear to no longer be present in Lake Elsinore (or they are present in extremely low numbers).

6.2 Plankton Community

6.2.1 Zooplankton

The 2019-2020 zooplankton density and biomass varied by season (Table 6-4). Density and biomass were much greater in October than in other seasons. In general, the lowest densities are observed in the winter and the highest densities are observed in late summer or fall. Estimates of zooplankton biomass were not available from previous surveys.

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4 See footnote 2 in Section 6.1.3 for comment regarding assumption that small fish observed during hydroacoustic survey data were all Threadfin Shad.

Table 6-4. Comparison of Zooplankton Community Metrics, 2003-2020 (~ Indicates value is an estimate based on information provided in the documented source; Indiv/L – Individuals/Liter)

Zooplankton	2003 - 2004						2009 - 2010[b]							2015[c]	2019-2020		
	Feb	May	Aug	Nov	Feb	May	Nov	Feb	Apr	Jun	Aug	Oct	Dec	Mar	Jul	Oct	Feb
All Taxa																	
Density (Indiv/L)	152	6,156	25,567	25,912	7,978	5,242	71.6 ± 38.2	~137	142.7 ± 44.4	56.7 ± 11.4	125.2 ± 50.5	376.2± 133.8	60	NR	996	8,515	444
Richness	7	10	9	9	5	9	~4-5	8-9	~5.1 - 6.2	3-4	~4-5.2	6.3-8	4.2-7	NR	7	9	9
Simpson's Diversity	0.54	0.55	0.62	0.59	0.67	0.57	~0.13	~0.47	~0.52	~0.49	~0.41	~0.43	~0.53	NR	0.68	0.73	0.78
Cladocerans																	
Density (Indiv/L)	2	96	9	8	39	35	0	~1	1.3 ± 0.9	0	0	0	~1	NR	2.2	24	2.3
Density (%)	1	2	0	0	0	1	0	0.14	6	0	0	0	0	< 0.01	0.2	0.3	0.5
Rotifers																	
Density (Indiv/L)	25	4,416	24,783	24,146	1,702	3,995	6.1 ± 6.9	~50	~70	~33	104.0 ± 42.9	~365	~22	NR	494	5,137	213
Density (%)	16	72	97	93	21	76	8	44	34	52	83	98	38	< 0.01	49.7	60.3	48.1
Total Copepods																	
Density (Indiv/L)	125	1,644	775	1,759	6,237	1,212	66 ± 33	~90	136 ± 49	~24	~21	~12	~43	NR	499	3,353	228
Density (%)	82	27	3	7	78	23	92	56	65	48	17	2	62	99	50.1	39.4	51.5
Juvenile Copepods																	
Density (Indiv/L)	83	1,045	447	1,280	3,904	837	~36	~67	~60	~4	~12	~9	~13	NR	318	2,697	74
Density (%)	55	17	2	5	49	16	~55	~74	~44	~17	~57	~75	~30	15	31.9	31.7	16.6
Adult Copepods																	
Density (Indiv/L)	42	600	328	479	2,333	376	~30	~23	~76	~20	~9	~3	~40	NR	181	657	155
Density (%)	28	10	1	2	29	7	~45	~26	~56	~83	~43	~25	~93	84	18.2	7.7	34.9

Table Notes:

[a] Veiga-Nascimento and Anderson (2004)
[b] Anderson et al. (2011)
[c] Anderson (2016b) - limited survey compared to other years; NR = Not recorded

A review of previous zooplankton surveys dating back to 2003 shows that total zooplankton density can vary by season, but when the highest density is observed has varied (Veiga-Nascimento and Anderson 2004; Anderson et al. 2011; Anderson 2016b) (see Table 6-4). Total zooplankton density as well as the densities of major zooplankton groups were generally lower in 2009 and 2010 (as much as an order of magnitude in some seasons), than zooplankton densities observed in 2003, 2004, and 2019 (Table 6-4). Some differences in zooplankton density among surveys may be the result of differences in the mesh size of the collection net. Mesh size for the surveys in 2009 and 2010 was 80 microns (µm); the mesh size for the surveys conducted in other years including 2019 was 63 µm.

Richness of zooplankton taxa has ranged from about 3 to 10 per survey date over the period of record. The richness observed during the most recent survey tends toward the higher richness values observed over time with a range of 7 to 9 taxa (see Table 6-4). Diversity (SDI) has ranged from approximately 0.13 to 0.78 over the period of record with the highest diversity being recorded in the most recently completed surveys: 0.73 in October 2019; 0.78 in February 2020.

The following is a summary comparing the current zooplankton community (2019-2020 survey) with findings from previous surveys conducted in 2003-2004 and 2009-2010 (Table 6-4):

<u>Copepods</u>

- Copepods were the dominant zooplankton group (in terms of density (%)) in winter (February) of 2020 which is consistent with the 2003, 2004, 2009, and 2010 surveys (December and February; Anderson et al. 2011, Veiga-Nascimento and Anderson 2004).
- Juvenile copepods, or nauplii, were the dominant form of copepods observed in most seasons and years. Only on a few occasions has the density of adult cyclopoid copepods exceeded the density of nauplii (e.g., during April, June and December of 2010 and 2015 and February 2020).
- The adult copepod populations are dominated by cyclopoid copepods rather than calanoid copepods (e.g., see Anderson et al. 2011). This observation is not unexpected as cyclopoid copepods are often more abundant in eutrophic waters (e.g., similar to conditions in Lake Elsinore; calanoid copepods are best adapted to oligotrophic conditions (Gannon and Stemberger 1978)).

<u>Rotifers</u>

- Rotifers were typically the dominant zooplankton taxonomic group in summer and fall (e.g., 2003-2004 (Veiga-Nascimento and Anderson 2004), 2009-2010 (Anderson et al. 2011) and 2019 (current survey)). In the current study, three genera (six total species) were observed: three *Brachionus* spp. (*B. angularis, B. caudatus, B. plicatilis*), two *Filinia spp.* (*F. longiseta*, *F. terminalis*) and *Keratella valga*. Only *Brachionus spp*. were present in July and they dominated the rotifer community in February. In contrast, *K. valga* dominated the community in October.

- In comparison to other survey years, the richness of the rotifer community in 2019-2020 is less than observed in surveys in 2003-2004 (five or six genera) and 2009-2010 (eight genera with multiple *Brachionus spp.*). This increased richness in prior surveys may in part reflect that samples were collected during more months over a one-year period than in the current survey. In the 2009-2010 survey period, the dominant rotifer taxon often changed from one sample event to another. Of the taxa observed in the most recent survey, *Brachionus* spp. were the only species observed in July and the dominant species in February. *Keratella valga*, while common in February, was the most common species during the October sample event. The shift to dominance by *Keratella* sp. was also observed during the 2003-2004 surveys when *Keratella* became the most abundant genus (species was not identified) during the fall sampling in November 2003 (Veiga-Nascimento and Anderson 2004). A very different pattern was observed during the 2010-2011 surveys. *Brachionus spp*. were dominant only during the October sample event. *Keratella sp.* was observed in Lake Elsinore, but only during the April sampling event. Other rotifer species dominated at other times including *Hexarthra sp*. in August and *Polyarthra sp.* in the spring (Anderson et al. 2011).
- Anderson et al. (2011) surmised that during periods when *Brachionus* or *Hexarthra genera* dominate, this may indicate poor water quality conditions (e.g., periods with high cyanobacterial biomass or highly brackish conditions); however, it was noted that additional studies would be needed to confirm this. Anderson et al. (2011) also noted that based on the rotifer genera findings from the 2009-2010 survey rotifer genera in Lake Elsinore tended to be dominated by taxa more indicative of mesotrophic to eutrophic conditions. For example, in that survey the mesotrophic assemblage (*Synchaeta*, *Keratella*, and *Polyarthra)* was more common in cooler months of the year with more rain (Mäemets 1983). In contrast, *Brachionus spp.,* which dominated the zooplankton community in the fall, was indicative of eutrophic conditions (Gannon & Stemberger 1978; Mäemets 1983) and/or more brackish conditions. In the most recent survey, *Brachionus spp*. are again abundant during the fall, but *Kertella* was actually the dominant species – at a different time of year than observed in previous surveys.

<u>Cladocera</u>

- Cladocerans were collected at very low densities in 2019-2020; similar to what has been observed in previous studies (Table 6-4). *Diaphanosoma sp.* was the only cladoceran collected during the October and February surveys. *Daphnia sp*., including *Daphnia rosea*, was collected along with *Diaphanosoma sp*. during the July survey.
- Other *Daphnia* species have been collected during previous surveys: *D. exilis* (2003-2004) (Veiga-Nascimento and Anderson 2004); *D. lumholtzi* and *D. ambigua*. The highest density (indiv./L) of cladocerans (*Daphnia lumholtzi*, representing 6% of the zooplankton community) was observed in April 2010. This survey occurred soon after heavy rainfall resulted in a spillover of Canyon Lake into Lake Elsinore (LESJWA 2018).
- Others have provided lengthy discussions of factors that may be influencing the cladoceran community in Lake Elsinore. In general, Veiga-Nascimento and Anderson (2004) concluded that the high salinity of Lake Elsinore is likely a key factor impacting

populations of *Daphnia* population. In addition, Threadfin Shad predation and poor algal food quality were also noted as likely important factors. Based on findings from the literature, Anderson et al. (2011) concluded that a rotifer-dominated zooplankton community, "can be expected for warm, shallow, eutrophic waters with planktivorous fish and large abundances of cyanobacteria." Anderson et al. (2011) also noted that many *Daphnia* species do not do well in waters with these types of conditions and that rotifers and other small zooplankton, "tend to be more tolerant of warm eutrophic conditions and less negatively affected by cyanobacterial filaments and toxins…and are less subject to predation by visually hunting fish species…than the large *Daphnia* species."

6.2.2 Phytoplankton

Table 6-5 summarizes the findings from the current phytoplankton survey and provides phytoplankton community data from previous surveys (Anderson et al. 2011; Anderson 2016b). Unfortunately based on how data have been analyzed over the years, limitations exist with regards to what community metrics can be compared between surveys. A detailed survey conducted from 2009-2010 reported results as biomass in milligrams/cubic meter (mg/m^3) while the results from the most recent survey reported sample results as cells/mL or units/mL (which considers that some algae have multiple cells per organism). Therefore, the only direct comparisons that can be made between survey events is richness and diversity and algal group dominance.

Section 4 provides a summary of the species observed during the current survey and provides summaries of the relative density of each algal group. Following is summary of key findings:

- Many species of phytoplankton prefer warm water and populations are often largest during warm months. Accordingly, as would be expected the highest algal densities were observed in July and October.
- Blue-green algae populations tend to grow more in summer when water residence times are longer (Wetzel 2001) which leads to increased water temperatures. Given this generality coupled with Lake Elsinore being a terminal lake with no outlet (under typical conditions), the outcome is an advantageous setting for dominance by blue-green algae.
- Blue-green algae were dominant during all sample events in 2019-2020. This finding is consistent with previous surveys (Table 6-5): March 2015 (Anderson 2016b) and during four of six sample events in 2009-2010 (Anderson et al. 2011). Although Veiga-Nascimento and Anderson (2004) did not estimate biomass or density of phytoplankton in their Lake Elsinore study, they did note the dominance of blue-green algae in the lake, with *Oscillatoria* being the dominant species. This filamentous species, which is now known as *Pseudanabaena*, was the dominant blue-green algal species during the 2009-2010 survey, comprising more than 95% of the algal biomass observed. *Pseudanabaena* continued to be present in the most recent survey, but it is not possible to compare dominance because of differences in how data are reported (i.e., density vs. biomass). However, it is assumed that *Pseudanabaena* is not as dominant as it was previously given that the dominance of blue-green algae species shifted by season (see Section 4.1.2 for summary of dominant species by sample event).

- A number of the blue-green algae taxa observed in the current survey have the potential to be harmful because they have the ability to produce cyanotoxins. For example, three relatively common species in Lake Elsinore - *Microcystis aeruginosa, Planktothrix agardhii, and Raphidiopsis spp* - can all produce cyanotoxins of various types. The abundance (units/mL) of these species changed by season: *P. agardhii* was among the most dominant species in February (30.3%), *M. aeruginosa* was very common in August (11%) and *Raphidiopsis sp. 2* (straight) was common in August (12.9%) and was the most dominant species in October (61.4%). Not only is there a potential human health concern from these species, but both *M. aeruginosa and P. agardhii* can produce microcystins which are toxic to zooplankton (Landsberg 2002).
- Many other blue-green algae that were relatively abundant during various seasons in the 2019-2020 survey are not known to be harmful, e.g., *Aphanocapsa delicatissima, Chroococcus disperses, Eucapsis parallelepipedon*, *Planktolyngbya minor*, and *Pseudanabaena acicularis*.
- *Cylindrospermopsis catemaco*, *Pseudanabaena limnetica* (formerly known as *Oscillatoria limnetica*), and *P. acicularis* were the dominant blue-green algae in 2010 with the former two species being considered harmful. In addition, *P. limnetica* is a poor food resource for filter-feeding Daphnia and other large-bodied Cladocera due to its large filaments (Anderson 2016b). *P. agardhii and C. raciborskii* were also collected in this study.
- The 2009-2010 survey documented a seasonal succession pattern from a dominance of diatoms in the winter and spring to a community dominated by blue-green algae in the summer and fall (dominated by *Pseudanabaena*, formerly *Oscillatoria*). A previous study in 2003 also found diatoms to be a significant component of the phytoplankton community during February through mid-spring and observed a shift to cyanobacteria dominance (almost entirely of the genus *Pseudanabaena*) that was evident by June (Oza 2003). These patterns were not observed in the current study.
- Highest taxonomic richness and diversity were observed during the July 2019 sample event. Richness was reduced by about 50% in October and February; diversity was reduced about 25-30%. In general, phytoplankton richness was higher during the recent survey than that observed during much of the 2010-2011 survey. Variability in diversity from one sample event to the next was also observed in the last comprehensive survey in 2010-2011.

Table 6-5. Comparison between 2019-2020 Phytoplankton Community Characteristics and Previous Phytoplankton Surveys

Community Metric	2010 – 2011[a]						2015[b]	2019 - 2020		
	February	April	June	August	October	December	March	July	October	February
Biomass (mg/m^3)	5,000	~5,100	20,000	~22,200	2,000-3,000	~8,700	--	--	--	--
Dominant Group (% biomass)	Diatoms	Diatoms	Blue-Green Algae	Blue-Green Algae	Blue-Green Algae	Blue-Green Algae	--	--	--	--
Density (cells/mL)	--	--	--	--	--	--	--	2,077,866	2,051,591	1,641,113
Dominant Group (% density)	--	--	--	--	--	--	Blue-Green Algae	Blue-Green Algae	Blue-Green Algae	Blue-Green Algae
Richness	36	29	12	10	12	~16	--	42	21	20
Simpson's Diversity[c]	0.79	0.71	0.20	0.34	0.60	0.80	--	0.89	0.50	0.60

Table Notes:
[a] Anderson et al. (2011)
[b] Anderson (2016b)
[c] Diversity calculated from data reported in units of mg/m^3 in 2010-2011 surveys; calculated from cells/mL in 2019-2020 surveys

6.3 Factors that Affect the Lake Elsinore Aquatic Community

As noted in Section 1.1.1, Lake Elsinore is a dynamic lake with fluctuating water levels such that the lake periodically undergoes drying cycles that greatly reduce the volume of the lake. These fluctuations greatly influence water quality, especially with regards to lake salinity. In addition, excess nutrient inputs have resulted in the need to establish lake-specific regulatory requirements (i.e. TMDLs) to manage nutrients in the lake. Variations in lake level and water quality coupled with management actions to improve the fishery for recreational purposes all impact the characteristics of the aquatic community of the lake. Anderson et al. (2011) noted this dynamic stating, "*considering the changes that have occurred in the communities of Lake Elsinore since the beginning of the decade and the variability in conditions each year, it is unlikely that any of the lake's communities will follow the exact same pattern from one year to another.*" The following sections discuss some of the key factors that have the potential to affect aquatic community conditions of Lake Elsinore. These factors must be considered when evaluating potential lake management alternatives for implementation in the future.

6.3.1 Carp Removal

EIP Associates (2005) conducted an in-depth analysis of the Common Carp population of Lake Elsinore through analysis of 2002 and 2003 fish surveys conducted by California Department of Fish and Wildlife (CDFW) and EIP Associates, respectively (see Table 6-3 above for carp population metrics from these surveys). Based on these data, it was determined that the carp population in 2003 had a: (a) high density (about 250-500 fish/acre); and (b) "record setting" biomass (about 530-1,100 lbs/acre). The existing population was the result of a very successful spawning event in spring 1995 when Lake Elsinore was full and overflowing. Since then, based on age class data, carp had not consistently reproduced successfully, likely due to density-dependent competition for the limited food supply, intraspecific reproductive interference, and poor water quality.

Based on the findings of the 2002-2003 surveys, the City of Lake Elsinore implemented an aggressive carp removal program from June 3 through September 11, 2003. By the end of this period the estimated carp biomass had declined from 530-1,100 lbs/acre to only 236 lbs/acre (City of Lake Elsinore 2008). These efforts to manage the carp population continued until 2008. By the end of that year, the estimated carp population was 138 fish/acre (City of Lake Elsinore 2008) and the carp removal program was suspended because the density was so low that carp could no longer be captured efficiently. EIP Associates (2008) provided the following summary of the outcome of carp removal efforts:

- 2003 carp density ranged from 250 to 500 fish/acre, with an average of 375 fish/acre; however, based on recent surveys, carp density has declined to range from 25 to 138 fish/acre with an average of 82 fish/acre.
- Since its initiation in 2002 and end in 2008, an estimated 626,190 carp with a total biomass of 1,315,000 lbs was removed from the Lake.

Based on these findings as well as additional surveys regarding improvements in the gamefish population, EIP Associates (2008) concluded that the carp removal program "played a key role in successfully restructuring the fishery," and the lake's fishery was substantially improved. They also noted that fish populations can vary quickly and that the fishery should be "closely monitored and managed to sustain and build upon the recent success."

While the carp removal program was ongoing, EIP Associates prepared a Fisheries Management Plan for Lake Elsinore (EIP Associates 2005). The proposed program included a range of potential implementation strategies, including additional carp removal, zooplankton enhancement and fish habitat/community structure improvement (including stocking of predator fish). Carp removal was highlighted as a high priority given the significant impact carp can have on water quality and habitat, including for example: (1) enhancing algal production, a potential outcome of increased nutrient loadings to the water column caused by resuspension of bottom sediments from bioturbation (caused by carp foraging behavior); (2) competing with desirable sport fish for food; (3) preventing many species of sport fish from successfully reproducing; and (4) preventing rooted aquatic vegetation from becoming established. Given these potential impacts, it was recognized that without carp population control, other management strategies might have limited success.

The most recent surveys continue to show a low density and biomass of carp in Lake Elsinore. Anderson (2016b) reported a low density of < 6 fish/acre and the findings from the most recent 2019 survey confirmed that carp density remained low at 29.9 fish/acre (non-weighted). Similar to density in fish/acre, biomass density (lbs/acre) also declined significantly as a result of the carp removal program (Figure 6-1). The 2019 survey provides the first estimate of carp biomass density in more than ten years. Study findings show that carp biomass density has not changed during the late summer/fall survey period since 2008 (62 lbs/acre in 2008 vs. 55.3 lbs/acre, non-weighted) in 2019 (Figure 6-1). Altogether, the findings from the 2019 fish survey strongly indicate that the need for additional carp removal as a near-term fish management strategy is not necessary at this time.

6.3.2 Fish Stocking

As noted above in Section 6.1.1.2 the composition of the Lake Elsinore fishery is greatly influenced through periodic efforts to stock gamefish in the lake to support area recreational activities. Historical records indicate when various species were originally stocked (e.g., see Appendix Table C-1). Table 6-6 provides the most recent fish stocking records for Lake Elsinore since the last fish survey was performed in 2015 (Anderson 2016b). Black Crappie, Bluegill, Channel Catfish, Largemouth Bass, and Redear Sunfish have all been stocked in Lake Elsinore each year from 2016 to 2019.

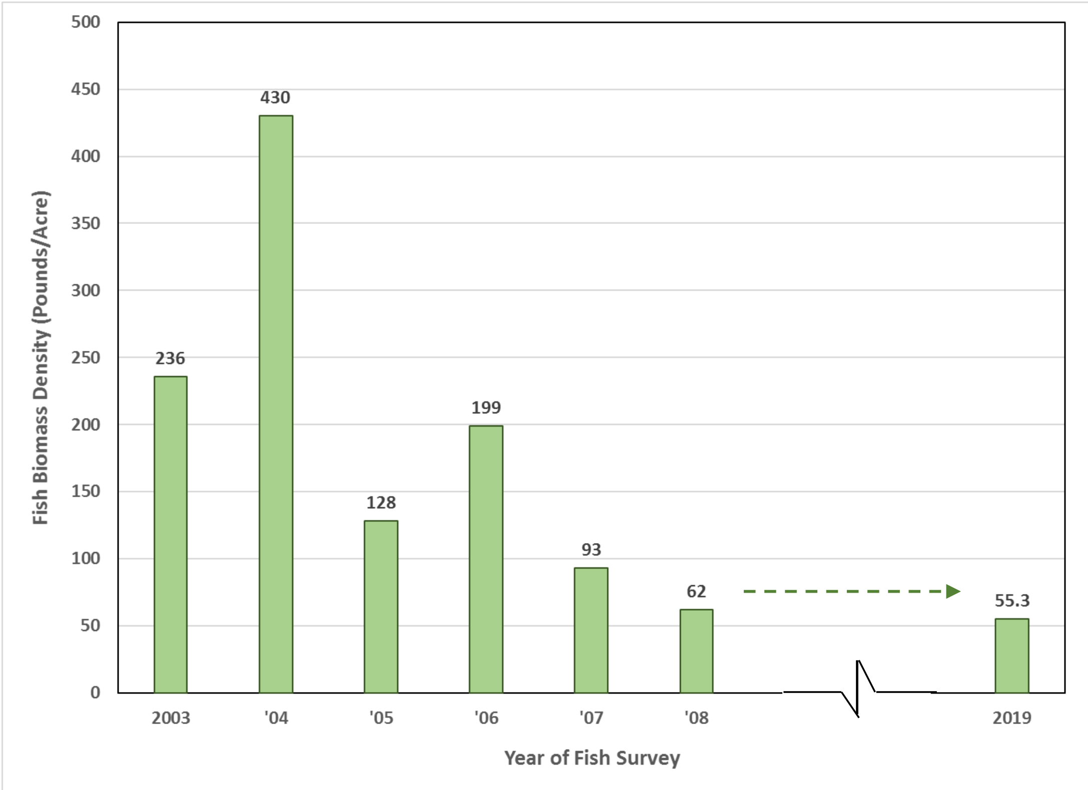

Figure 6-1. Carp Biomass Density (lbs/acre) during Late Summer/Early Fall Fish Surveys Since 2003 (Estimate for 2019 is Non-Weighted, see text).

Table 6-6. Recent Fish Stocking Records from Lake Elsinore

Fish Species	Year Stocked				Total	2019 Weighted Survey Results
	2016	2017	2018	2019		
Stocking Data Based on Abundance (# of Fish Stocked)						**Lake-wide Abundance (# of Fish)**
Black Crappie	3,000	4,000	975	2,000	9,975	11,020
Bluegill	2,000	2,850	2,225	1,560	8,635	12,266
Redear Sunfish	--	2,550	1,900	--	4,450	70
Stocking Data Based on Biomass (lbs)						**Lake-wide Biomass (lbs)**
Channel Catfish	4,863	6,282	8,150	8,600	27,895	269
Largemouth Bass	400	1,380	1,435	2,153	5,368	55

Using the 2019 estimated weighted abundance of stocked species (numbers of fish) it is possible to evaluate the success of these recent stocking activities. Comparing the 2019 survey findings for Black Crappie and Bluegill to the total number of these fish species stocked from 2016 to 2019 indicates that survival of these stocked fish has been good and reproduction is potentially occurring. In contrast, when comparing 2019 Channel Catfish and Largemouth Bass (estimated weighted biomass) and Redear Sunfish (abundance) survey results to the total stocked numbers in the previous years, the findings suggest that survival has been poor for these species. However, other explanations include (a) a significant proportion of the stocked fish have been successfully captured and retained by fisherman; (b) the abundance of species such as Largemouth Bass were likely under-represented in the 2019 catch simply because they can be more common in areas of the lake that the surveyors were unable to fish effectively, e.g., around submerged vegetation; or (c) some combination of all the above factors that can impact fish abundance estimates.

6.3.3 Fish Kill Events

The occurrence of fish kills has been well-documented throughout the history of Lake Elsinore. For example, EIP Associates (2005) stated (page 2-42):

> *"Fish kills have occurred periodically in Lake Elsinore for millennia due to adverse environmental conditions. Even under pristine conditions the lake would shrink and occasionally dry up completely. During these periods the fish fauna would be lost, only to recolonize the lake during more favorable hydrological conditions. Historically, fish kills have been reported at the lake even prior to any significant upstream diversions of water (principally the completion of Railroad Canyon Dam in 1928)."*

EIP Associates (2005) established the first comprehensive long-term record of known fish kill events in Lake Elsinore. LESJWA (2018) supplemented this record with records of fish kill events into 2018. Table 6-7 summarizes the fish kill events that have occurred since 2000 including the most recent event that occurred in winter 2019. All together there have been 39 recorded fish kill events from 1883 through 2019. EIP Associates (2005) noted that fish kills may occur under a variety of conditions and are not necessarily associated with low lake levels. For example, for those events where the lake elevation was known, EIP Associates (2005) noted that of 21 fish kills eight (38%) of them occurred when the lake level was equal to or greater than 1,240 ft – the targeted minimum lake level. The remainder of the recorded fish kill events occurred when the lake level was low or nearly dry.

Fish kill events have the potential to impact fish community composition, especially if the dominant species are significantly impacted by the event. For example, recent fish kills have noted the large number of Common Carp or Threadfin Shad impacted by the fish kill. The full effect of these periodic events is unknown, but previous surveys before and after fish kills suggest that the impacts can vary depending on what parameters are being evaluated. For example:

Table 6-7. Recorded Fish Kill Events in Lake Elsinore Since 2000 (adapted in part from LESJWA 2018)

Year	Dates	Lake Level (ft)	Event Description
2001	August	1,239	Carp
2002	August 22	1,236	Estimated 50 tons of fish - primarily Common Carp
2006	November 26	1,246	Estimated 20,000 fish - primarily Threadfin Shad and small minnows
2009	July 26 and August 14-16	1,241 and 1,240	For both events combined, estimated 116.3 tons primarily Threadfin Shad (1 million) and larger fish (6,000)
2010	August 4	1,243	Estimated 22.9 tons - primarily Threadfin Shad
2012	July(?)	1,244	Estimated 5.2 tons - primarily Threadfin Shad
2015	August 4-10 and August 17-19	1,236	For both events combined, estimated 23.3 tons - primarily Threadfin Shad and some Common Carp and sportfish
2017	August 3-5	1,238	Primarily Common Carp and Threadfin Shad
2018	May 28-30	1,237	Primarily Threadfin Shad and some Common Carp
2019	January	1,240	Estimated 150 tons - primarily Common Carp and Threadfin Shad; some Channel Catfish and Largemouth Bass

- *Fish Density Recovery* - The 2008 fish survey found a density of 18,090 fish/acre. After a large fish kill occurred in 2009 (116 tons removed), the spring 2010 hydroacoustic survey found a much lower fish density of 2,867 fish/acre. However, the next survey in December 2010, which was also a hydroacoustic survey, found a fish density of 27,720 fish/acre. These findings suggest that fish density can recover quickly following a fish kill event.
- *Modifications to Community Composition* – The 2015 hydroacoustic survey found that Threadfin Shad comprised 96% of the number of fish observed[5]. In the 2019 survey, Threadfin Shad were only rarely collected, representing < 1% of fish abundance. Fish kills recorded since 2015 noted a predominance of Threadfin Shad in the species recorded as impacted by the fish kill event. However, Threadfin Shad were not observed during the most recent fish kill in Winter 2019, corresponding with results of the fisheries survey soon after. The reduction in Threadfin Shad has likely benefited other species. Other small fish (i.e., Silverside and Mosquitofish) currently dominate the fish community. These species occupy a similar niche formerly occupied by Threadfin Shad.

[5] See footnote 2 in Section 6.1.3 for comment regarding assumption that small fish observed during hydroacoustic survey data were all Threadfin Shad.

Finally, of note is the fish kill event that occurred in January 2019 (see Table 6-7). Prior to this event the Holy Fire wildfire occurred in the Lake Elsinore watershed. This wildfire began on August 6, 2018 and was not fully contained until September 13, 2018. Approximately 23,025 acres (35.9 square miles) of the watershed was burned. During subsequent wet weather events beginning in October 2018, several large storm events occurred in the watershed including a December 2018 storm event that dropped approximately two inches of rain in the watershed. The Riverside County Flood Control & Water Conservation District, working with local agencies, led a coordinated effort to implement BMPs to prevent debris flows from fire-impacted slopes from entering Lake Elsinore. Even with this significant effort to manage fire impacts, a small percentage of the debris, primarily fines as suspended sediment, still entered the lake and potentially contributed to a fish kill that occurred January 2019. The fish kill event was attributed to a bloom of the golden algae, *Prymnesium parvum*, a species not previously observed in high concentrations in the lake. This species of algae was not observed during any of the 2019 and 2020 phytoplankton surveys. Roelke and Manning (2018) state that the conditions that support blooms of this algal species are poorly understood. Most blooms of this species have been observed in nutrient-enriched waters, but “usually develop under suboptimal conditions (i.e., lower temperatures and salinities).” A report investigating the potential link between the Holy Fire debris flows, *P. parvum* bloom, and the January 2019 fish kill was prepared by Wood for the City of Lake Elsinore (Wood, 2019). This report found that, while the fish kill was attributed to the golden algae, *P. parvum*, whether there is a direct link between the fire impacts to the watershed and the bloom of this species is unknown.

6.3.4 Water Quality

As noted in Section 1.1.2, a nutrient TMDL was adopted for Lake Elsinore in 2004. This TMDL established numeric targets for TP, TN, ammonia nitrogen, chlorophyll-*a* and DO. Based on many years of research, the 2004 TMDL is currently being revised with adoption expected in late 2020 or early 2021. The revised TMDL will have numeric targets for chlorophyll-*a*, DO and ammonia. The revised numeric targets are presented as cumulative distribution functions. This approach considers the highly variable nature of precipitation in the watershed and the extreme effects this has on nutrient loading, water levels and water quality not just in Lake Elsinore but in the upstream reservoir, Canyon Lake.

LESJWA (2018) provides a lengthy discussion of long-term water quality trends observed in Lake Elsinore through 2016, especially for water quality constituents with numeric TMDL targets. Recent annual monitoring reports provide water quality information for the Lake Elsinore up to near the time the current surveys were initiated in the summer of 2019 (e.g., LESJWA 2019b). Apparent from these various sources is that Lake Elsinore water quality is closely intertwined with lake level – especially for constituents such as salinity, DO and chlorophyll-*a*. LESJWA (2018) provided a synopsis of potential impacts of each of these constituents on the aquatic communities of Lake Elsinore. The following sections provide summary of those findings in the context of the current survey results.

6.3.4.1 Salinity

Salinity in Lake Elsinore undergoes significant fluctuations, a phenomenon closely tied to wet/dry climatic cycles and, thus, the surface water elevation of the lake (e.g., see Figures 2-14 and 2-15 in LESJWA 2018). Figure 6-2 illustrates how the concentration of total dissolved solids (TDS) has changed in Lake Elsinore from 2003 to 2019 – the same period which the best fish survey data are available.

The zooplankton population in Lake Elsinore has been dominated by copepods and rotifers since at least 2003. Elevated salinity has been identified as a likely stressor particularly to the zooplankton populations in the lake (e.g., Veiga-Nascimento and Anderson 2004; LESJWA 2018). LESJWA (2018) summarized the potential impacts of elevated salinity on zooplankton:

> *Elevated conductivity [or concentrations of TDS] acts as an osmotic stressor by interfering with the proper balance of salts and water within the body of an organism, which is necessary to maintain various physiological and biochemical processes. The fish and zooplankton that reside in Lake Elsinore are exposed to rising levels of conductivity during summers and particularly during extended drought periods when rainfall totals do not keep up with evaporation rates. The addition of recycled supplemental water to Lake Elsinore has helped to decrease spikes in conductivity during drought periods, but also elevates the long term mean conductivity.*

While some of the zooplankton taxa in Lake Elsinore are halophiles (organisms that can grow in and tolerate saline conditions), most species prefer low salinities of less than 1,000 mg/L TDS. Veiga-Nascimento and Anderson (2004) noted that the 10-day conductivity threshold effect level (LC_{50} - the concentration at which one would expect 50% mortality) for the most sensitive zooplankton observed in Lake Elsinore (Daphnid spp.) is 1,820 µS/cm. Given the generally accepted relationship between conductivity and TDS, the equivalent TDS threshold would be approximately 1,164 mg/L.[6] As seen in Figure 6-2, this threshold has been exceeded often since 2003 with the most significant exceedances observed since 2015. Other zooplankton, including some cladocerans, have been shown to have a relatively high sensitivity to elevated salinity, with LC_{50} values less than the highest TDS concentrations measured since 2003 (see LESJWA 2018, Appendix A, Table A-3).

In a healthy lake ecosystem, cladocerans, primarily Daphnia spp., are some of the most efficient algal feeders and heavily predate on phytoplankton. The grazing rates of Daphnia are high compared to other zooplankton (Moss 1998) and can account for as much as 80% of the community grazing rate (Porter 1977). The sparse population of cladocerans observed in Lake Elsinore is generally small-bodied and do not have efficient filtering capacities. However, even if a robust Daphnia population were present it may not be able to adequately graze the majority of phytoplankton present given the strong dominance of blue-

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[6] The relationship between electrical conductivity and TDS varies with the salinity composition of the water. Unless a site-specific study is done to determine the local relationship, a conversion factor of 0.64 is typically used to convert conductivity to TDS (TDS (mg/L = 0.64 * conductivity µS/cm).

green algae in Lake Elsinore. This algae group is a poor food resource and may be toxic to some filter-feeding Daphnia (Tobin 2011). Although the copepod and rotifer densities in Lake Elsinore are relatively high compared to cladocerans, these zooplankton taxa are not as effective at grazing phytoplankton populations as cladocerans (Veiga-Nascimento and Anderson 2004).

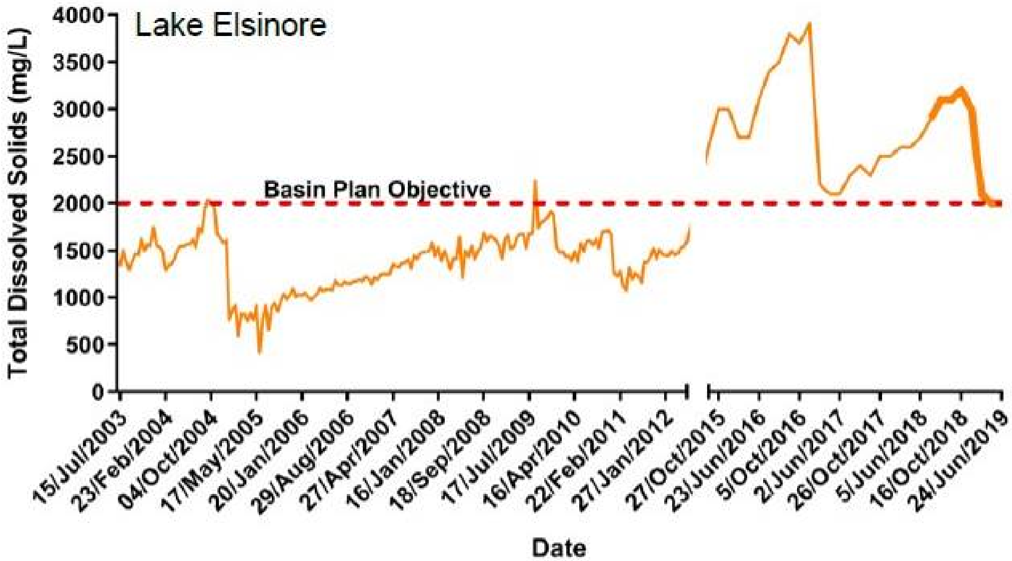

Figure 6-2. Total Dissolved Solids (mg/L) Observations in Lake Elsinore, July 2003 – June 2019 (gap indicates period with no lake measurements; bolded portion of data illustrates period of rapid TDS decline following a wet period in the winter of 2017-2018) (adapted from Wood 2019)

Many fish species in Lake Elsinore exhibit top down control on the zooplankton community. Threadfin Shad, abundant in Lake Elsinore during previous surveys (e.g., 2015), preferentially feed upon larger zooplankton such as cladocerans while copepods and rotifers were less likely to be consumed (Veiga-Nascimento and Anderson 2004). Accordingly, Veiga-Nascimento and Anderson (2004), hypothesized that the cladoceran community in Lake Elsinore was being impacted at least in part by excessive shad predation. Anderson et al. (2011) also noted that predation by Threadfin Shad likely had constrained development of a large *Daphnia* population in Lake Elsinore.

A key finding from the 2019 fish survey was that Threadfin Shad has essentially been replaced by silverside minnows (*Menidia spp.*) and Mosquitofish, species not observed in previous surveys. The success of these newly observed species has likely been assisted by recent fish kills that appear to have greatly impacted the Threadfin Shad population. Silversides confined to reservoirs will prey upon zooplankton, mostly cladocerans (e.g., *Ceriodaphnia sp*. and *Daphnia pulex*), but will also eat copepods, mysids, amphipods, isopods, veliqers (mollusk larval stage), and macroinvertebrates (as reviewed in Weinstein 1986). Mosquitofish are extreme generalists consuming a wide variety of food including zooplankton of all taxa, plant and detritus material, and other fish, including cannibalism (as reviewed in USFWS 2017 and Pyke 2005). Both of these species now fill the niche that Threadfin Shad once occupied. While all three of these species feed on zooplankton, the reduction in Threadfin Shad is likely beneficial to the plankton community because silverside minnows and Mosquitofish are much less efficient as feeders on zooplankton than Threadfin Shad. Threadfin Shad have two general modes of feeding: filter-feeding and hunt-and-peck; while Silversides and Mosquitofish are exclusively hunt-and-peck feeders. Filter-feeding, by which zooplankton, phytoplankton, and detritus are filtered through a fish's gill rakers as they swim through the water with their mouths open is a much more efficient way of collecting prey, compared to hunt-and-peck where the fish chase down individual zooplankters.

All of the observed fish species in Lake Elsinore have a relatively high tolerance to elevated salinity (Table 6-8). Moreover, the salinity threshold tolerances of silverside minnows and Mosquitofish is even higher than Threadfin Shad the species they replaced. Thus, salinity levels observed in Lake Elsinore since 2003 do not appear to be high enough to cause any significant stress to the fish community.

Table 6-8. Salinity Thresholds for Fish Species Observed in Lake Elsinore in 2019

Fish Species	Conductivity (µS/cm) (TDS in mg/L)	Endpoint	Source
Black Crappie	8,457 (5,412)	Presence	LESJWA (2018)
Bluegill	9,955 (6,371)	Maximum Tolerance	Stuber et al. (1982a)
	< 6,593 (4,219)	Preference	
Channel Catfish	13,855 (8,867)	Larval mortality	LESJWA (2018)
Common Carp	12,568 (8,043)	Lethality	LESJWA (2018)
	21,356 (13,668)	LD_{50}	LESJWA (2018)
Green Sunfish	9,955 (6,371)	Maximum Tolerance	Stuber (1982b)
	< 6,593 (4,219)	Preference	
Inland Silverside[1]	26,679 (17,074)	100% Larval mortality	Weinstein (1986)
	13,855 (8,867)	No adverse effect on Larvae	
Largemouth Bas	> 7,276 (4,657)	Decline in abundance	LESJWA (2018)
Mosquitofish	Tolerant of high salinity		USFWS (2017)
Redear Sunfish	> 26,191 (16,762)	Poor tolerance	Twomey et al. (1984)
	≤ 8,959 (5,733)	No Effect	
Threadfin Shad	23,437 (15,000)	Upper Tolerance	Anderson (2016b)

[1] Silverside minnows in Lake Elsinore are either Mississippi Silverside or Inland Silverside. Data for Inland Silverside in this table are assumed to be representative of both species of silversides.

6.3.4.2 Dissolved Oxygen

DO levels can serve as a measure of Lake Elsinore's response to nutrient loads. As described in LESJWA (2018), when algae decay in the water column and then settle, the lake bottom sediments become enriched with nutrients and oxygen demanding organic matter. The resulting sediment oxygen demand creates anoxic conditions in lake bottom waters. During periods of lake stratification, oxygen can become depleted in the hypolimnion, resulting in oxygen levels well below 5 mg/L. When destratification of the lake occurs (typically in October-November) oxygen-depleted bottom waters become mixed with oxygenated to waters. It is during this time that low DO conditions may occur throughout the water column which can rapidly impact the fish community.

Lake Elsinore is not consistently stratified due to its shallow depth and frequent wind mixing. Figure 6-3 illustrates DO observations from Lake Elsinore during the July 2018 to June 2019 monitoring year (LESJWA 2019b). Depth integrated results were typically above 6.0 mg/L; at 1-m above the lake bottom, DO concentrations varied around 4.0 mg/L. These recent observations are generally higher than what has been observed over time since 2002 (LESJWA 2018) (Figures 6-4 and 6-5).

Fish are typically more sensitive to low DO concentrations than zooplankton. They can often adapt to low DO concentrations if the decline is gradual (LESJWA 2018) and given their mobility are generally able to avoid low DO concentrations when necessary. Table 6-9 summarizes various DO thresholds for the Lake Elsinore fish community. Largemouth Bass are one of the more sensitive species in Lake Elsinore and can experience distress (e.g., increased respiration and reduced metabolic rate) when DO concentrations fall below the TMDL of 5.0 mg/L (Petit 1973). Mosquitofish and Inland Silverside can tolerate DO below 1.5 mg/L for at least some period of time with one study indicating tolerance as low as 0.18 mg/L (Ahuja 1964).

6.3.4.3 Nutrients and Related Constituents

Lake Elsinore was first listed as impaired due to low DO and excess algae growth in 1994. The listing cited elevated nutrients as the primary cause for these conditions. Respiration and decay of excess algae depresses DO levels which impacts the aquatic community. Manifestations of these conditions can be high turbidity, green color to the water, odors, all of which impact recreational use of the lake. Nutrients enter Lake Elsinore from the San Jacinto River watershed via Canyon Lake overflows, local watersheds surrounding the lake and release of nutrients that over time have built up in the lake bottom sediments. EIP Associates (2005) summarized these conditions, noting that (a) based on their analysis Lake Elsinore was currently a hypereutrophic lake; and (b) even if proposed efforts to control nutrient inputs and stabilize lake levees were implemented, only then would the lake at best become eutrophic. EIP Associates (2005) also found that the nutrient loading would continue to create conditions conducive to supporting a highly productive phytoplankton community dominated by blue-green algae. This condition would continue to impact the aquatic community into the foreseeable future until nutrient control and lake stabilization activities are able to be implemented.

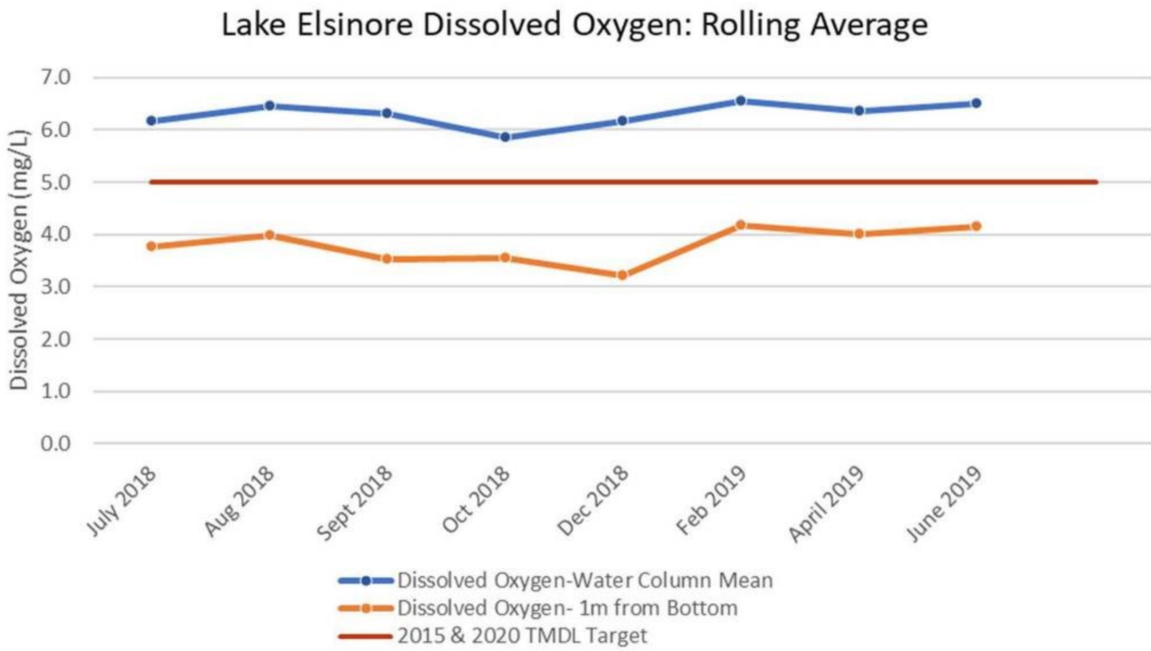

Figure 6-3. Dissolved Oxygen (mg/L) Observations in Lake Elsinore, 2018-2019 Monitoring Year (from LESJWA 2019b).

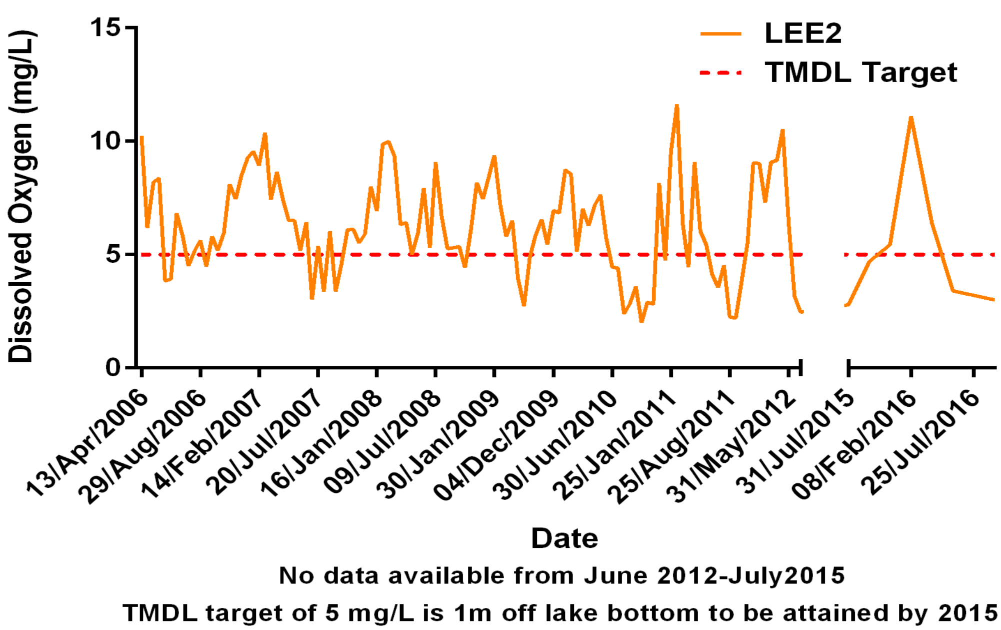

Figure 6-4. Depth-Integrated Average Dissolved Oxygen Concentrations in Lake Elsinore: 2006-2016 (Note discontinuous data record on x-axis) (from LESJWA 2019b)

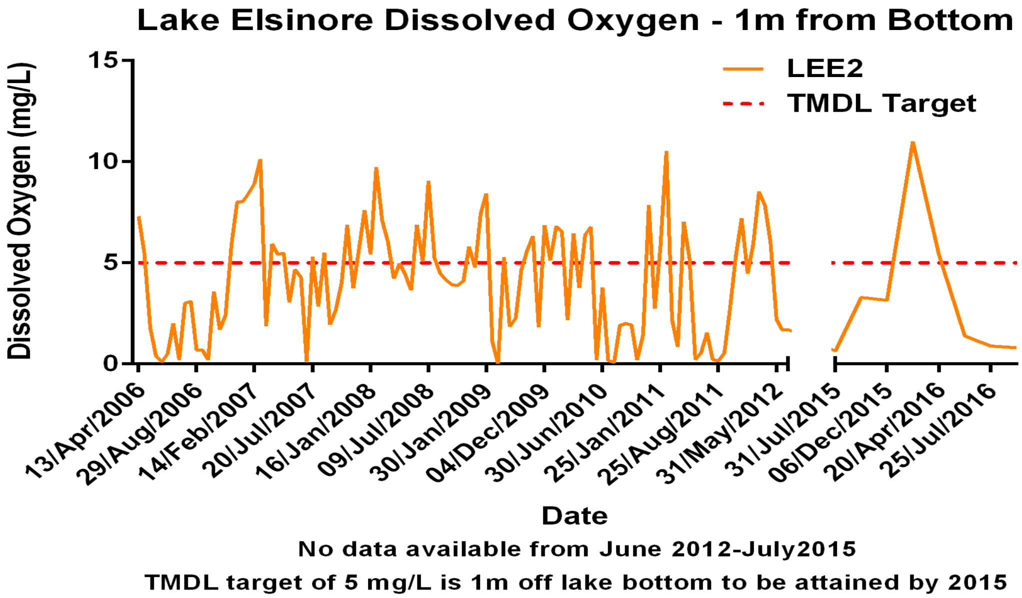

Figure 6-5. Dissolved Oxygen Concentrations (1-m from Bottom) in Lake Elsinore: 2006-2016 (Note discontinuous data record on x-axis) (from LESJWA 2019b)

Table 6-9. Dissolved Oxygen Thresholds for Fish Species Observed in Lake Elsinore in 2019

Fish Species	Threshold (mg/L)	Endpoint	Comment	Source
Black Crappie	4.3	Lethality	Caged at 26 °C	LESJWA (2018)
	1.4	Lethality	--	LESJWA (2018)
Bluegill	1.5	Avoidance	Adults	LESJWA (2018) Stuber et al. (1982a)
	0.9	LC_{50}	At 30 °C	LESJWA (2018)
Channel Catfish	3	Retarded growth	--	LESJWA (2018)
	0.9	Lethality	Juvenile at 25-35 °C	LESJWA (2018)
Common Carp	4.2	Increased respiration	At 10 °C	LESJWA (2018)
	3.4	Reduced metabolic rate	At 10 °C	LESJWA (2018)
	0.7	Lethality	Juveniles at 18 °C	LESJWA (2018)
Green Sunfish	1.5	Avoidance	Adults	Stuber et al. (1982b)
Inland Silverside[1]	1.3	LC_{50}	At 25 °C	FDEP (2013)
Largemouth Bass	5	Distress	Adults	LESJWA (2018)
	2.5	Lethality	Larval	LESJWA (2018)
	2.3	Reduced metabolic rate	Adults at 20 °C	LESJWA (2018)
	1.5	Avoidance	Adult	LESJWA (2018)
	1.2	Lethality	At 25 °C	LESJWA (2018)
Mosquitofish	0.18	Tolerate	--	USFWS (2017)
Redear Sunfish	3	Avoidance	Adults	Twomey et al. (1984)
Threadfin Shad	1	Lethality	16 °C (based on close relative Gizzard Shad)	LESJWA (2018)

[1] Silverside minnows in Lake Elsinore are either Mississippi Silverside or Inland Silverside. Data for Inland Silverside in this table are assumed to be representative of both species of silversides.

Given the water quality concerns first identified in 1994, the Santa Ana Water Board established a TMDL in 2004 due to impairment of the WARM, WILD, REC1 and REC2 beneficial uses. The TMDL established numeric targets to address the exceedances of the following WQOs (Santa Ana Water Board 2019):

- Narrative WQO for algae - Waste discharges shall not contribute to excessive algal growth in receiving waters.
- Numeric WQO for DO – Levels in Lake Elsinore were below 5 mg/L.

To address exceedances of the above WQOs, the 2004 TMDL included the following numeric targets (Santa Ana Water Board 2004):

- TP and TN levels (causal targets)
- DO and chlorophyll-*a* (response targets).

As noted above, control of nutrient inputs to Lake Elsinore was deemed necessary to reduce impacts to water quality from algal blooms. Chlorophyll-*a* levels, which are a measure of the phytoplankton population, have been as high as 400 µg/L since 2002. Concentrations have been cyclical. Concentrations decreased from 2002 to 2008, increased until 2016, and then again decreased through 2019 (LESJWA 2018, 2019b). Periods of increased concentrations correspond to dry climatic periods when Canyon Lake does not overflow and Lake Elsinore lake elevation is declining.

The 2004 TMDL also included numeric ammonia targets to prevent un-ionized ammonia toxicity to aquatic life. Fish are much more sensitive to elevated levels of un-ionized ammonia than are invertebrates (LESJWA 2018). Of the fish species found in Lake Elsinore since 2002, hybrid striped bass appears to be the most sensitive fish species to un-ionized ammonia. Bluegill are the next most sensitive species followed by Largemouth Bass, Channel Catfish, and Common Carp (LESWA 2018). For the zooplankton community, cladocerans are the most sensitive taxonomic group. LESJWA (2018) noted that historical concentrations of un-ionized ammonia in Lake Elsinore calculated using historical depth integrated total ammonia values, along with depth integrated mean pH, temperature, and salinity show that ammonia concentrations are generally below the levels expected to cause acute toxicity to fish and zooplankton observed in Lake Elsinore. Accordingly, the potential is low for un-ionized ammonia to be at concentrations toxic to aquatic species typically observed in Lake Elsinore. Given the right conditions (high pH and temperature) acutely toxic concentrations of un-ionized ammonia could occur locally, but not sufficiently to be detected during routine monitoring activities.

In 2016 stakeholders initiated a collaborative process with the Santa Ana Water Board staff to revise the existing TMDLs based on knowledge gained from many studies conducted since adoption of the 2004 TMDL. The revised TMDL will establish new targets for chlorophyll-*a*, DO and ammonia but not TP or TN. The new targets are based on the range of concentrations that Lake Elsinore is actually expected to be able to achieve under natural, pre-development reference conditions taking into account the natural long-term wet/dry hydrologic cycles that occur in the watershed. Compliance with these targets in Lake Elsinore is expected to ensure that the frequency, duration and magnitude of algae blooms do not exceed that which would have occurred under the natural, pre-development reference condition.

6.4 Lake Management Strategies

The findings from EIP Associates (2005) with regards to establishment of a successful sport fish community generally remain true in 2020. EIP Associates (2005) previously stated (page ES-2):

> *"In order to change the environment of Lake Elsinore in a direct way that will be more favorable to a sport fish community, these factors must be addressed: Lake level fluctuations; poor water quality; Carp predation and competition; poor food supply; poor feeding conditions; poor habitat; and poor reproduction. In terms of managing Lake Elsinore to support a viable sport fish community, control of the first two factors is imperative. The [Fishery Management Plan] acknowledges that without control of these factors, management to improve other conditions will not be successful."*

Notably, Carp predation and competition have likely been addressed through the long-term carp removal program implemented from 2002 to 2008. As noted in Section 6.3.1, Carp population density in 2019 remains about the same as it was when the carp removal program ended in 2008. In addition, water quality is improving through nutrient control activities linked to TMDL implementation. These water quality improvement activities will continue. However, even with these improvements, lake level fluctuations continue due to the cyclical nature of wet and dry weather periods. Both salinity and chlorophyll-*a* concentrations are closely linked to these cycles. With this as a backdrop, the following sections provide recommendations for continued efforts to manage the Lake Elsinore fishery.

6.4.1 Carp Removal

A key objective of the 2019 fish survey was to evaluate the Lake Elsinore Common Carp population. The Carp removal program was completed in 2008. Since then there has not been a comprehensive survey to determine if additional carp management was needed. Based on the findings from the 2019 survey, we provide the following recommendations:

<u>Recommendation No. 1</u>: Removal of Common Carp is not necessary at this time.

- The carp removal effort conducted from 2003 to 2008 was successful. EIP Associates (2005) recommended fishery management program included a goal to reduce the carp population to 10 percent or less of the 2003 carp biomass level. Based on assumptions of average carp size/weight, carp density needed to be reduced to 26 to 55 fish/acre or a total lake population of 80,000 to 165,000 carp to achieve this goal. EIP Associates (2005) estimated a 2003 carp biomass density of 503 to 1,100 lbs/acre. By 2008, the carp biomass density was estimated at 62 lbs/acre (City of Lake Elsinore 2008) (see Table 6-3, Figure 6-1).
- The less than six carp/acre estimated from the 2015 fish survey (Anderson 2016b) and the weighted and non-weighted density, abundance, and biomass of carp observed from

the 2019 survey results still represent an approximate 90% reduction in fish from what was observed in 2003.

- Carp biomass density in 2019 was below ~100 kilograms/hectare (89 lbs/acre). Detrimental effects caused by Common Carp in shallow lakes have been documented to occur above this density in lakes in the Midwest United States (Bajer 2009).

Recommendation No. 2: Periodically reassess the need for additional Common Carp removal.

- Recent fish kills in Lake Elsinore likely contributed to the low carp population density observed in the 2019 survey (see Table 6-7). Surveys should be conducted periodically to verify carp populations remain relatively low.
- If carp population density were to increase to a level that necessitated removal, two potentially low cost but effective methods could be considered for implementation: (a) fish bounty program which typically attracts anglers; or (b) use of box nets (manufactured by Common Carp Solutions) which are easily operated by minimal staff. If more traditional fish capture methods are employed, focus should be on use of the beach seining method which typically catches more carp than purse seine or otter trawl methods.

Lake Elsinore, 2019

6.4.2 Fish Stocking

Several recommendations are provided to support development of a sport fishery in Lake Elsinore.

Recommendation No. 1: Stock Striped/White Bass hybrids ("Hybrid Bass") (*Morone saxatilis* x *Morone chrysops*), also known as "Wipers",[7,8] "Palmetto Bass" (female *M. saxatilis* x male *M. chrysops*), or "Sunshine Bass" (female *M. chrysops* x male *M. saxatilis*).

- These species will provide top-down biomanipulation.

[7] The City of Lake Elsinore has previously requested on two separate occasions that CDFW stock Wipers in Lake Elsinore. Neither request was approved because the fish are non-native and there were concerns that if Lake Elsinore were to spill into Temescal Creek because of flooding, then these non-native fish could become established in downstream Lee Lake. However, the CDFW has supported recent technical findings that Wipers can provide benefits if stocked (information provided by City of Lake Elsinore via email, June 25, 2020).

[8] Since 2017 the City of Lake Elsinore has been working on a plan to stock Wipers in Lake Elsinore. The success of this effort was realized in July 2020 when more than 50,000 Wipers were stocked in Lake Elsinore (McAllister 2020; https://patch.com/california/lakeelsinore-wildomar/50-000-hybrid-striped-bass-restocked-lake-elsinore).

- Striped Bass, White Bass, and Hybrid Bass are all documented as eating silverside minnows (Mathews et al. 1992, Webb and Moss 1968; Olmstead and Kilambi 1971, Gilliland 1978) and White Bass are documented as eating Mosquitofish (Mathews et al. 1992).
  - Plentiful Silverside and, to a lesser extent Mosquitofish, exist in lake (~1.2 and 0.08 lbs/acre, respectively) and are available as prey.
  - Average lengths of Silverside and Mosquitofish were 75 mm (16-110 mm) and 36 mm (5-59 mm), respectively. Both species are the appropriate size for consumption by Hybrid Bass. For example, Hybrid Bass of less than 250 mm have been found to prefer shad < 40 mm in length (Dettmers et al. 1998) and seldom consumed shad > 65 mm in length (Ott and Malvestuto 1984). Surveys also indicate that Hybrid Bass must exceed a length of 500 mm to be able to swallow a shad measuring 150 mm total length and that a 900 mm Hybrid Bass could swallow a shad up to 260 mm in length (Dennerline and Van Den Avyle 2000).
  - Hybrid Bass are open water pelagic predators (Hodson 1989). Silverside lake biomass and biomass density estimates are also greatest in moderate (8.1-16 ft) depth water compared to shallow and deep water, increasing chances of them encountering each other.
- Hybrid Bass stocked at a size greater than 100-125 mm are much less likely to feed on zooplankton than smaller Hybrid Bass, especially those less than 50 mm in size. When greater than 100-125 mm the diet of Hybrid Bass shifts from zooplankton to fish (Hodson 1989).
- Hybrid Bass are large predatory fish that will reduce forage fish populations, specifically Silverside and Mosquitofish, which, in turn, will reduce predation on large zooplankton. With more large zooplankton, it is possible that predation on phytoplankton can increase and algal growth reduced. However, elevated salinity and the presence of blue-green algae species that are not consumable by zooplankton could be limiting factors to this benefit.
- If Hybrid Bass prey on other gamefish, such predatory pressure has been shown to enhance Bluegill, Redear Sunfish and Black Crappie size and quality (Neal et al. 1998).
- Hybrid Bass would also be expected to reduce the population of juvenile carp. Carp fecundity is very high and one successful spawn when conditions are correct can produce a large number of young.
- Hybrid Bass are unlikely to prey upon young sport fish (Dettmers et al. 1996; Jahn et al. 1987).

• Hybrid Bass life history is suitable for Lake Elsinore.
  - The possibility exists that Hybrid Bass could naturally reproduce to a limited extent in Lake Elsinore, particularly in the inlet channel when there is some late winter or spring inflow. Given that reproduction is expected to be limited for this species, the

risk of a growing population and extensive predation on other species, e.g., Largemouth Bass or Black Crappie, is likely minimal (EIP Associates 2005).

- Hybrid Bass grow quickly during their first two years of life (275 - 375 mm in length and 225 - 350 g in the first year and 450 - 550 mm in length and 2.2 – 3.2 lbs in the second year (Hodson 1989).
- Hybrid Bass can survive in water quality unfavorable to many other species. Table 6-10 summarizes their tolerance range for several key water quality constituents. While the preferred range is occasionally exceeded in Lake Elsinore, Hybrid Bass are more tolerant of such conditions than many other southern California sport fish.

- Successful stockings of Hybrid Bass have previously occurred in Lake Elsinore in 2004, 2005, and in July 2020.
- Hybrid Bass stocking would result in this species becoming the dominant sportfish in Lake Elsinore and would be readily fished for by anglers. The typical size of hybrids caught by anglers generally ranges from 2 to 5 lbs, but fish in the 10 to 15 lb range are not uncommon (Hodson 1989). This size of fish is currently absent from the lake.

Table 6-10. Water Quality Thresholds for Optimal Survival of Hybrid Bass[1]

Species	Parameter	Threshold	Endpoint (Threshold Basis)
Hybrid Bass	Temperature	4-33 °C, 25 to 27 °C is optimal	Range
Hybrid Bass	pH	7.0 - 8.5 is optimal, but wider range is tolerated with minimum of 2.5	Range
Striped Bass	Conductivity	Maximum of 34,981 µS/cm	LC_{50}
Hybrid Bass	Salinity	As part per thousand (ppt): 0 - 25; maximum of 35 ppt (seawater)	Range
Striped Bass		Conductivity > 34,981 µS/cm (> 22,387 mg/L TDS); = approx. 22 ppt salinity	LC_{50}
Hybrid Bass	Dissolved Oxygen	Minimum of 1 mg/L for short period, 6-12 mg/L optimal	Range
Striped Bass		Minimum 1.6 mg/L	Adult LC_{50}
White Bass		Minimum 2.0 mg/L	Distress at 24 °C
Hybrid Bass	Un-ionized Ammonia as N	Maximum 0.43 mg/L	Species Mean Acute Value (LC_{50})
Striped Bass		Maximum 1.78 mg/L	Species Mean Acute Value (LC_{50})

[1] Striped and White Bass thresholds are provided for comparison or to supplement unavailable data for Hybrid Bass (LESJWA 2018, Hodson 1989)

Recommendation No. 2: Discontinue stocking of Channel Catfish, Largemouth Bass, and Redear Sunfish. Population data from the 2019 survey indicate that survival of these species from 2016 to 2019 has been very poor (See Table 6-6).

Recommendation No. 3: Continue stocking Black Crappie and Bluegill. Population data from the 2019 survey indicates that survival of these species stocked from 2016 to 2019 has been good (See Section 6.3.2). However, only fish over the size of 150 mm in length should be stocked to avoid predation by Hybrid Bass. If the Black Crappie and Bluegill are reproducing in Lake Elsinore, their young may be predated on.

Recommendation No. 4: Do not stock any baitfish at this time. Silverside and Mosquitofish are already present in Lake Elsinore at high numbers. They appear to be reproducing and maintaining a viable population.

Lake Elsinore Sunrise, 2016

Recommendation No. 5: Continue to conduct periodic fish surveys to evaluate success of ongoing fish stocking activities, potential to modify the species stocked and evaluate populations of other species. In particular:

- Periodic re-stocking of Hybrid Bass will be necessary as this species is unlikely to reproduce. Periodic surveys will provide information on the status of the Hybrid Bass population in the lake.
- When water quality has improved, other game fish species may be stocked. As noted in Section 6.3.2, based on the number of Black Crappie and Bluegill observed in the 2019 survey survival of these species stocked from 2016 to 2019 has been good and reproduction is occurring at least to some extent given the small juveniles captured. In addition, Largemouth Bass could continue to be targeted for future stocking activities given they are generally more preferred by anglers than Hybrid Bass, however long-term survival for this species is unlikely as noted in Recommendation 2.
- Regular surveys provide the opportunity to determine if the Carp population remains in check and the availability of baitfish in the lake.

All subsequent surveys should rely on the use of consistent sampling and data analysis methods which will allow for more accurate comparisons of the characteristics of the fish community between years.

6.4.3 Habitat Improvements

It may be possible to improve fish habitat in Lake Elsinore. Ideally this would occur best through stabilization of lake levels, e.g., a minimum of 1,240 ft. Alternatively, it might be possible to improve habitat through projects to reconfigure the shoreline in selected areas to create peninsulas or small coves or even create islands. The outcome of any of these types of macro-habitat modifications would be to increase the amount of shoreline habitat where fish densities tend to be higher. If the conditions are right for implementation of habitat improvements either because of lake level stabilization or projects are implemented to increase availability of habitat, the following recommendations should be considered:

Recommendation No. 1: Plant rooted aquatic and emergent vegetation, as originally proposed in EIP Associates (2005). Increased vegetation would provide (a) spawning habitat for many fish species; (b) habitat for small fish; (c) ambush habitat for large fish; (d) shelter for zooplankton; and (e) nesting habitat and food for waterfowl. In addition, aquatic plants uptake nutrients otherwise used by algae and reduce resuspension of sediments due to wind and wave action. Considerations include:

- Recommended plants include: sago pondweed (*Stuckenia pectinatus*), which was once native to the lake; and cattail (*Typha latifolia*) and tule/bulrush (*Scirpus actutus*), which currently exist in small pockets around the lake and are therefore known to be able to grow in the area.
- Plants may need enclosures or restrictions to protect them from Common Carp, birds, wave action, and human activity while they are becoming established. For example, the wave action from one or more motorboats or personal watercraft per 25 acres can affect shoreline stability and sediment conditions in littoral zones (Wagner 1991) as well as reduce macrophyte growth (Asplund and Cook, 1997).

Recommendation No. 2: Until appropriate water levels are able to be maintained, a temporary alternative to planting shoreline vegetation is to consider installation of anchored floating vegetation mats. These mats, which will rise and fall with the water offer many of the same benefits as shoreline and submerged vegetation; however, they are not as aesthetically pleasing.

Recommendation No. 3: Create physical, non-plant structures to serve as fish habitat, as originally proposed in EIP Associates (2005). Example structures may include addition of gravel patches, rock piles, large woody materials, brush piles, or other fish attractors. These structures, which can be placed in deeper water where plants do not grow, can provide habitat for larger fish, such as Hybrid Bass (Kilpatrick 2003), that do not utilize shoreline vegetation. In addition, these structures are not as readily disturbed or subject to damage by Common Carp, birds, wave action, and human activity.

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APPENDIX A

PHOTOGRAPHS OF COMMON ZOOPLANKTON SPECIES OBSERVED IN 2019-2020 SURVEYS

A.1 Cladocera

Figure A-1. *Daphnia sp*. (100 times [X] magnification), Lake Elsinore, July 26, 2019.

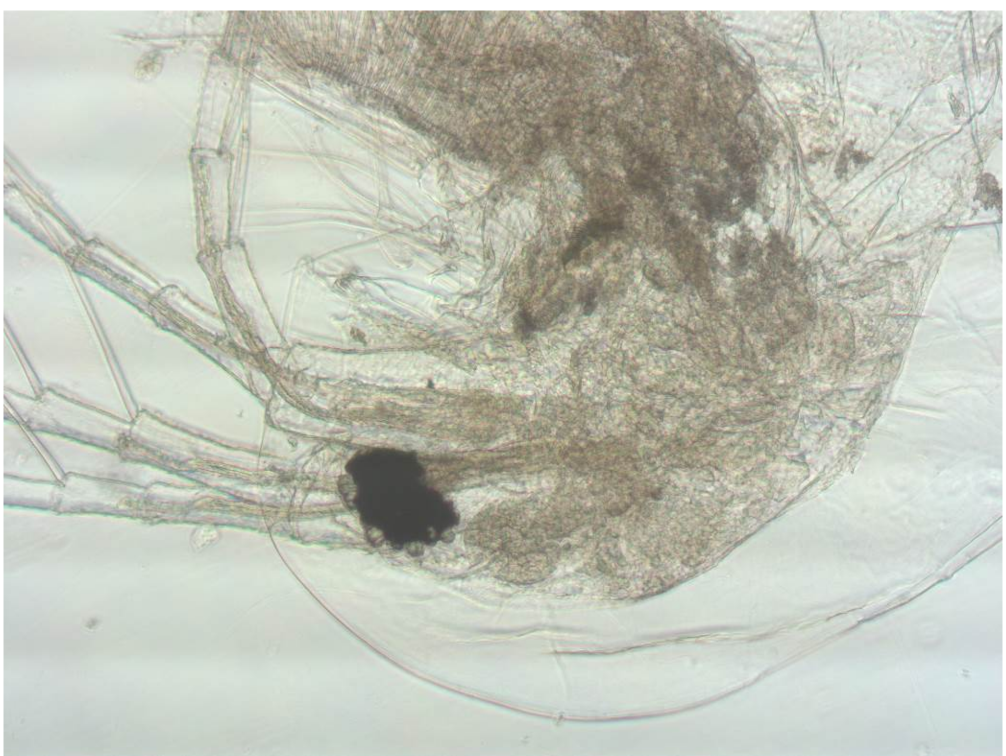

Figure A-2. *Daphnia rosea*, head view (100X magnification), Lake Elsinore, July 26, 2019.

Figure A-3. ***Daphnia rosea sp*****. abdominal view (100X magnification); Lake Elsinore, July 26, 2019.**

Figure A-4. ***Daphnia rosea*****, post-abdominal view (100X magnification), Lake Elsinore, July 26, 2019.**

Figure A-5. *Diaphanosoma sp.* (40X magnification); Lake Elsinore, July 26, 2019.

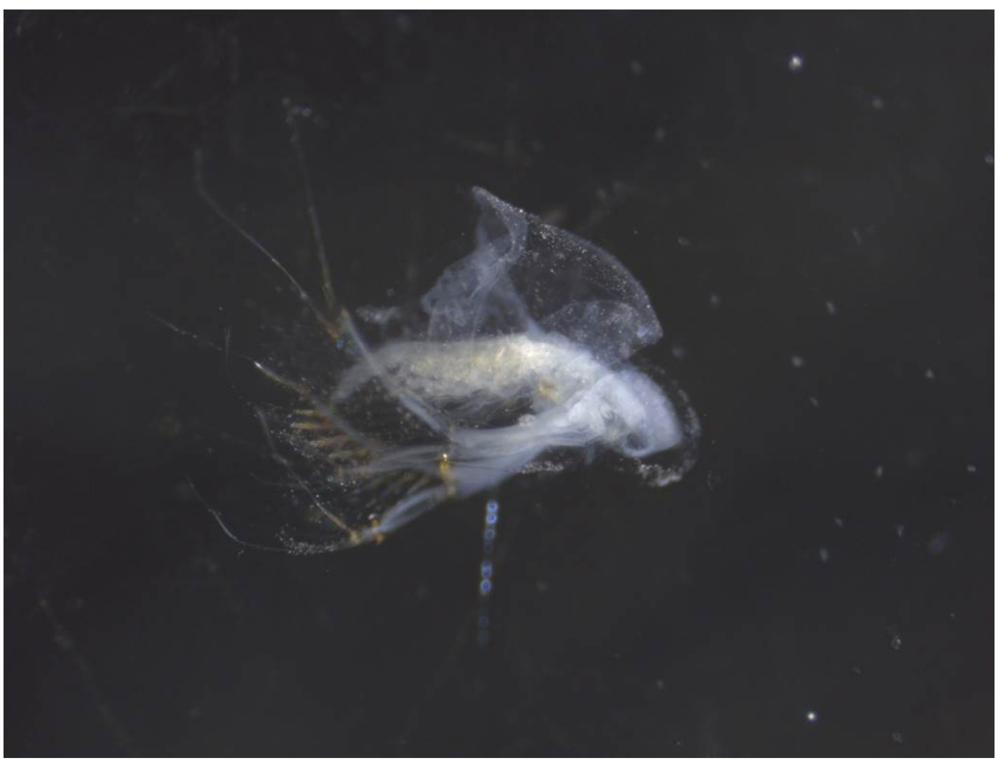

Figure A-6. *Diaphanosoma sp.* (100X magnification); Lake Elsinore, July 26, 2019

A.2 Copepoda

Figure A-7. Pair of *Acanthocyclops robustus* (40X magnification); Lake Elsinore, July 26, 2019.

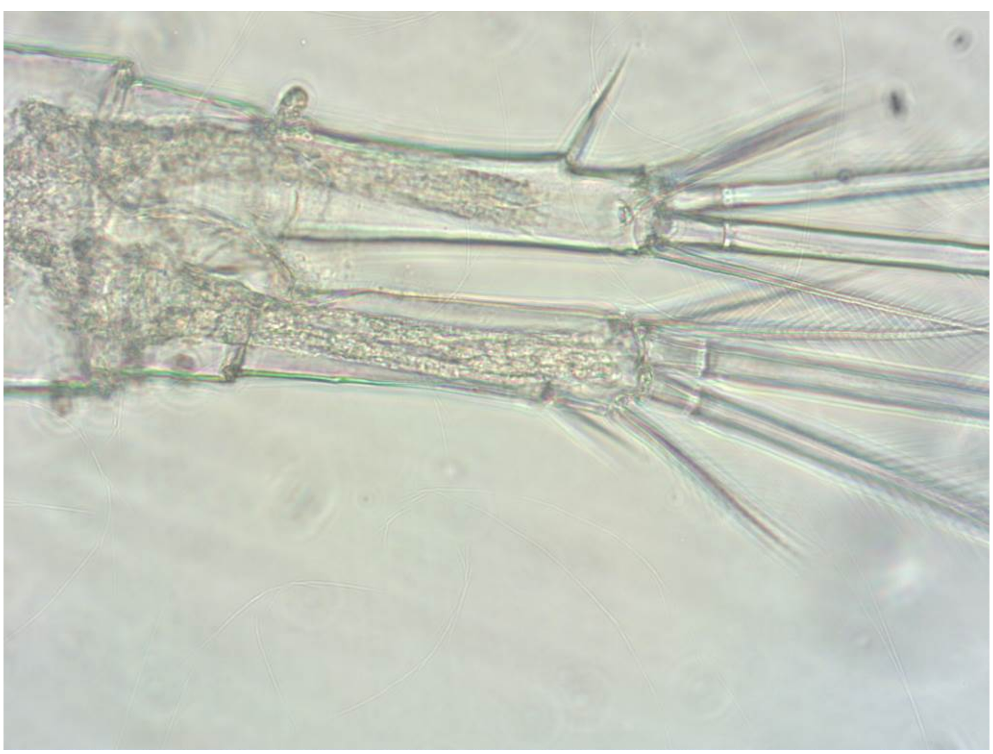

Figure A-8. *Acanthocyclops robustus*, caudal rami (400X magnification); Lake Elsinore, July 26, 2019.

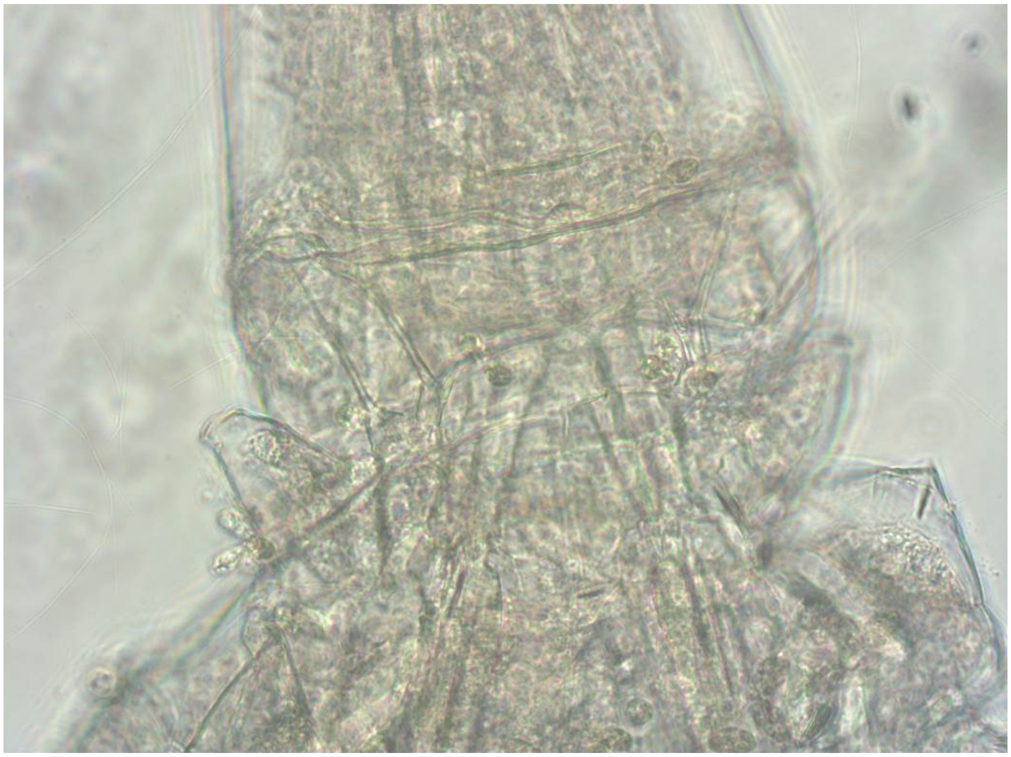

Figure A-9. *Acanthocyclops robustus*, fifth leg (400X magnification); Lake Elsinore, July 26, 2019.

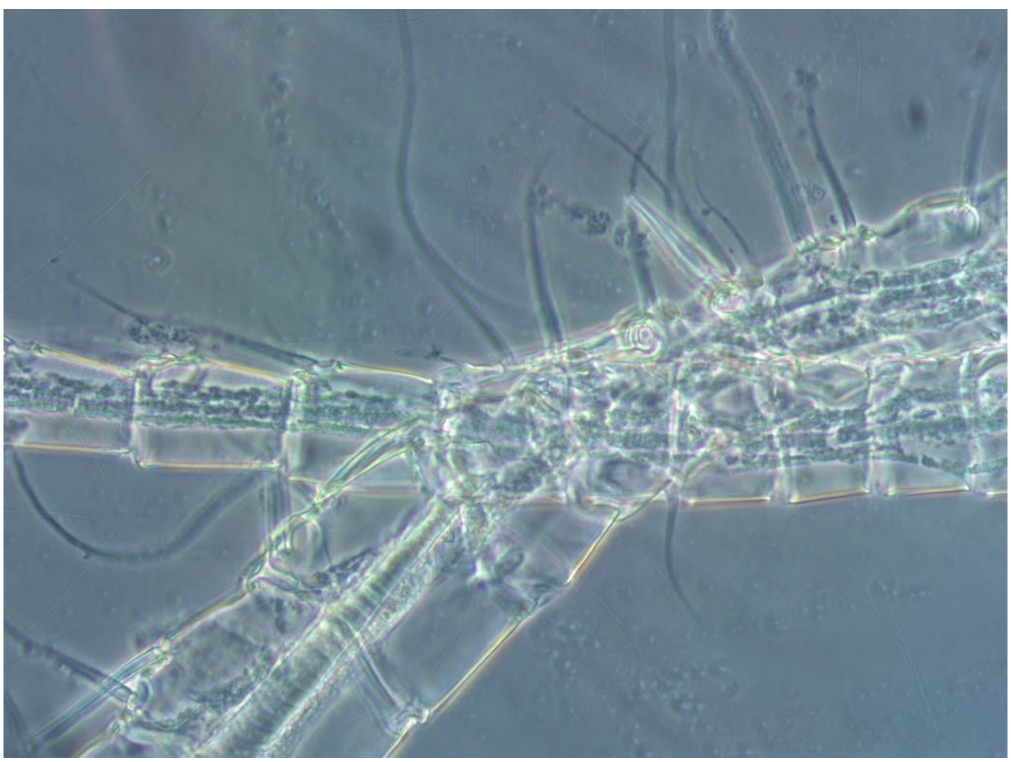

Figure A-10. *Leptodiaptomus siciloides,* right antenna segments 8-12 (400X magnification); Lake Elsinore, October 17, 2019.

Figure A-11. *Leptodiaptomus siciloides,* right antenna segment 19 (400X magnification); Lake Elsinore, October 17, 2019.

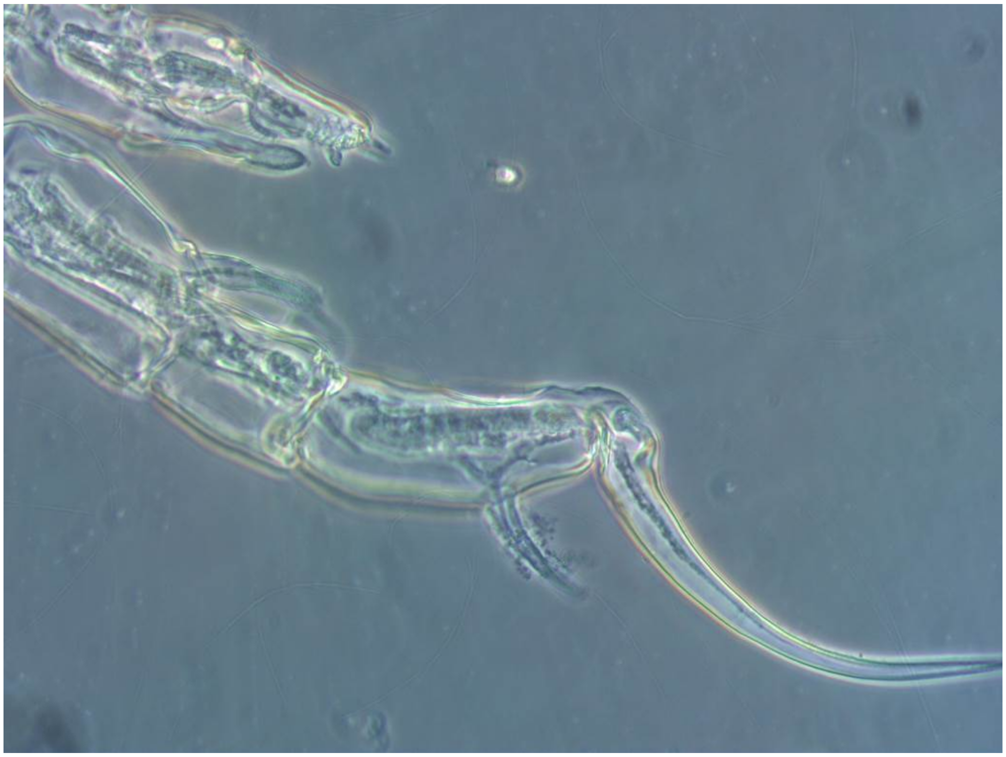

Figure A-12. *Leptodiaptomus siciloides, fifth leg* (400X magnification); Lake Elsinore, October 17, 2019.

Figure A-13. Calanoida - copepodite (100X magnification); Lake Elsinore, July 26, 2019.

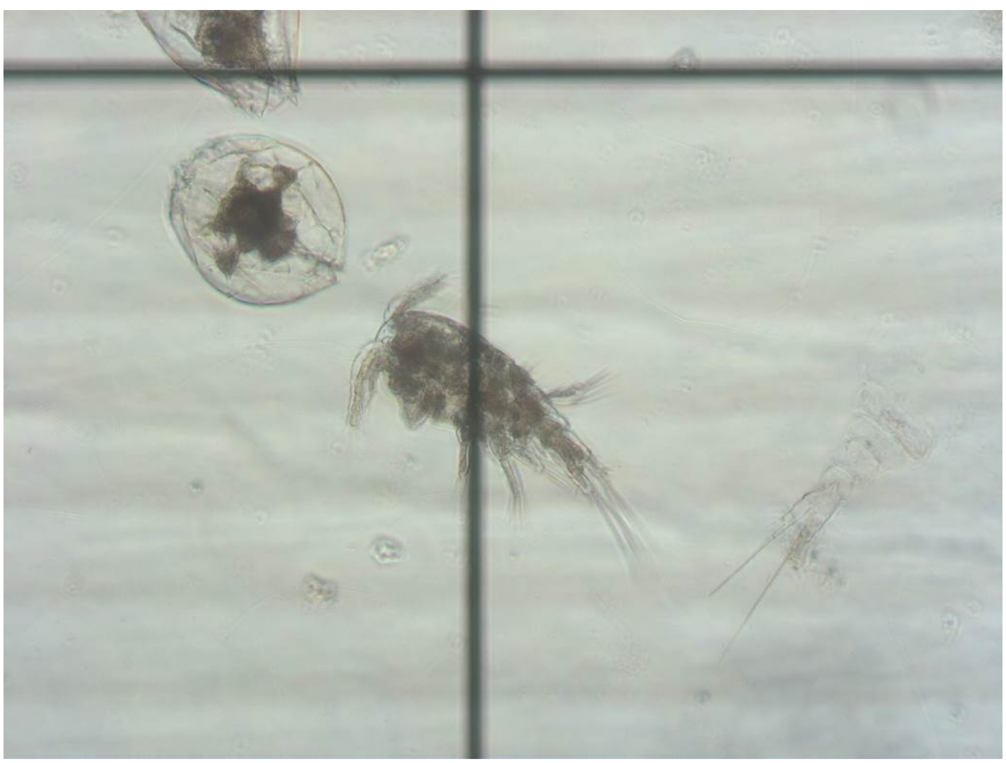

Figure A-14. Cyclopoida-copepodite (100X magnification); Lake Elsinore, July 26, 2019.

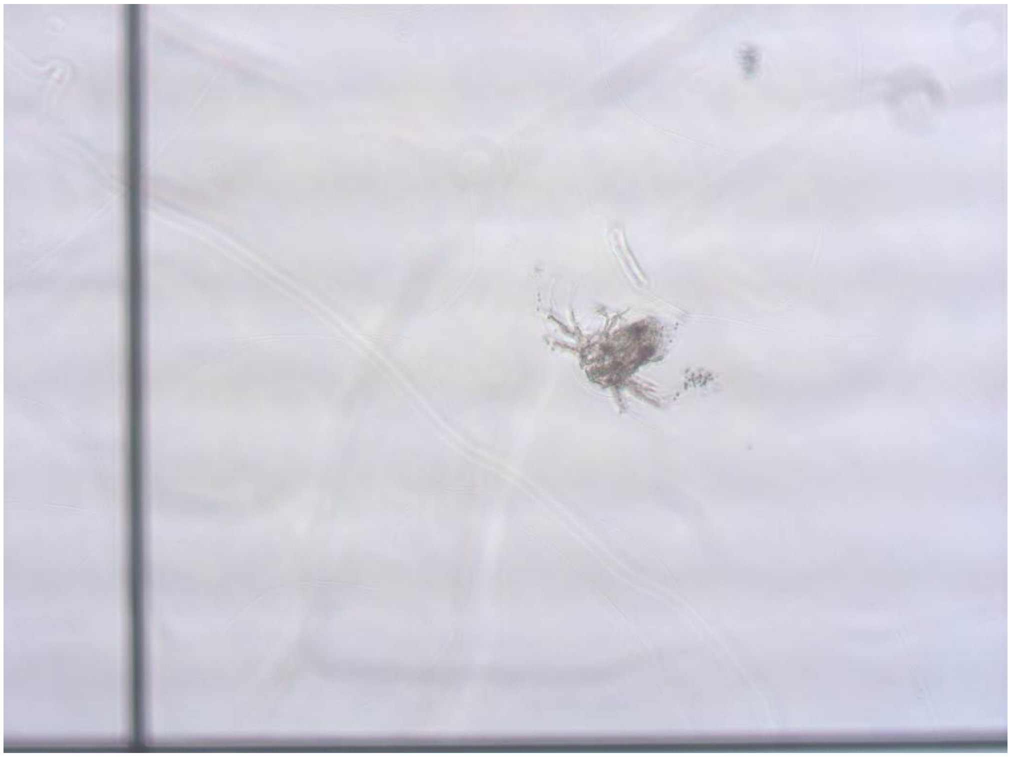

Figure A-15. Copepoda – nauplius (100X magnification); Lake Elsinore, July 26, 2019.

A.3 Rotifera

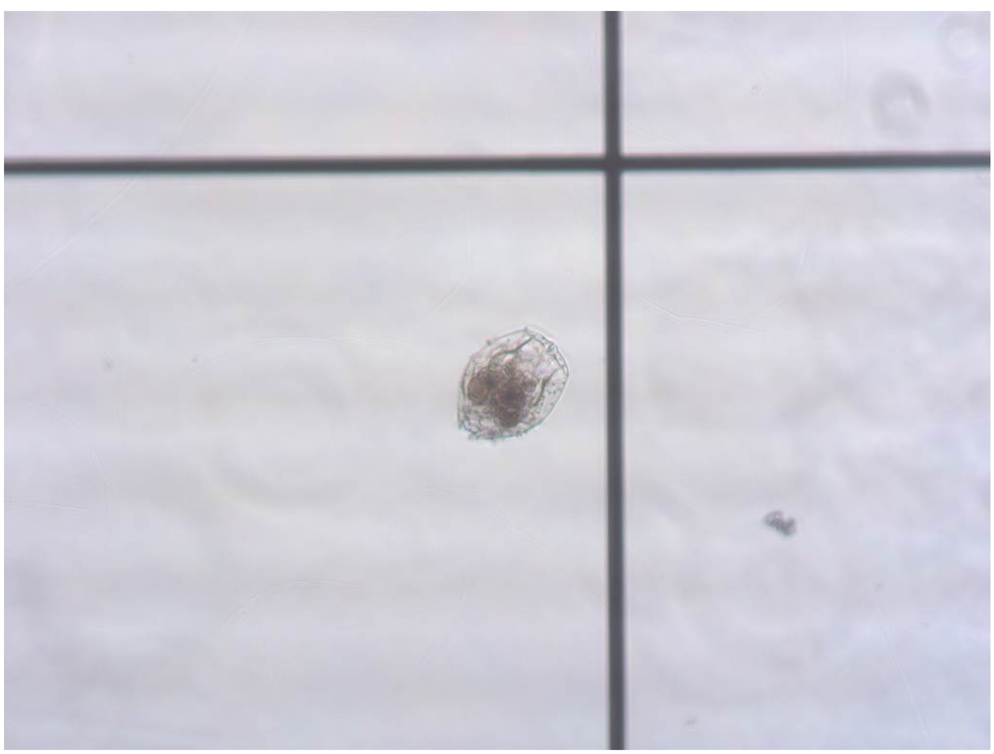

Figure A-16. *Brachionus angularis* (100X magnification); Lake Elsinore, July 26, 2019.

Figure A-17. ***Brachionus caudatus*** **(100X magnification); Lake Elsinore, October 17, 2019.**

Figure A-18. ***Brachionus plicatilis*** **(100X magnification); Lake Elsinore, July 26, 2019.**

Figure A-19. ***Filinia longiseta*** **(100X magnification); Lake Elsinore, February 18, 2020.**

Figure A-20. ***Filinia terminalis*** **(100X magnification); Lake Elsinore, October 17, 2019.**

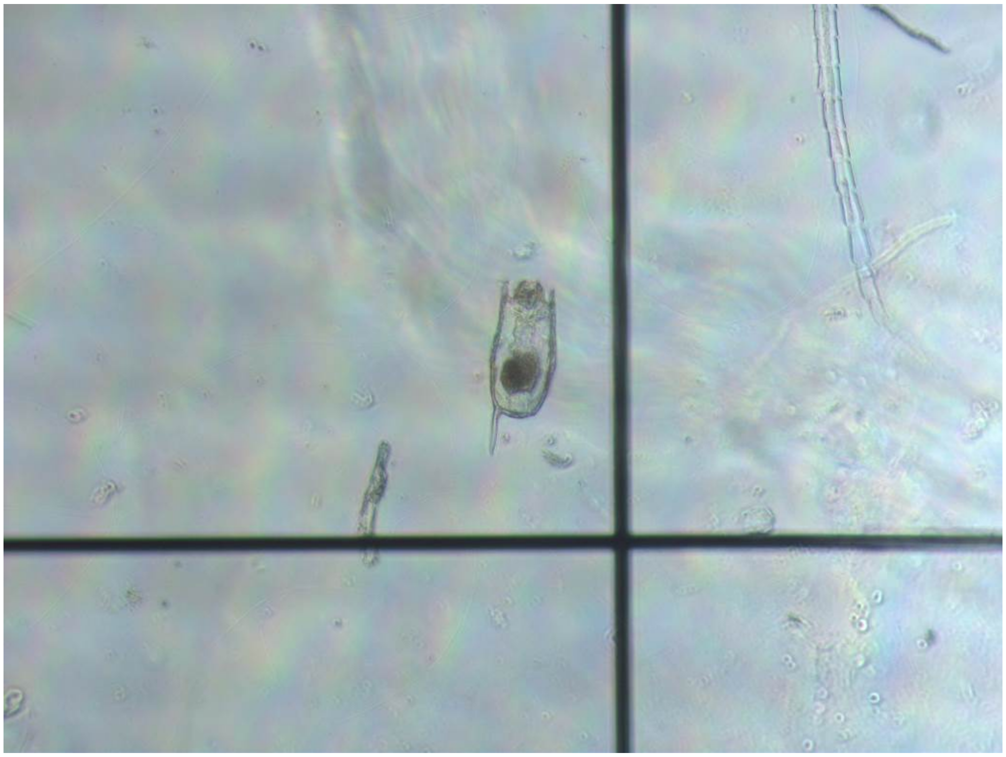

Figure A-21. *Keratella valga* (100X magnification); Lake Elsinore, October 17, 2019.

APPENDIX B

PHOTOGRAPHS OF COMMON PHYTOPLANKTON SPECIES OBSERVED IN 2019-2020 SURVEYS

Plates B-1, **B-2** and **B-3** illustrate the top ten most abundant algae (cyanobacteria and diatoms) recorded in the three surveys completed in Lake Elsinore, 2019-2020.

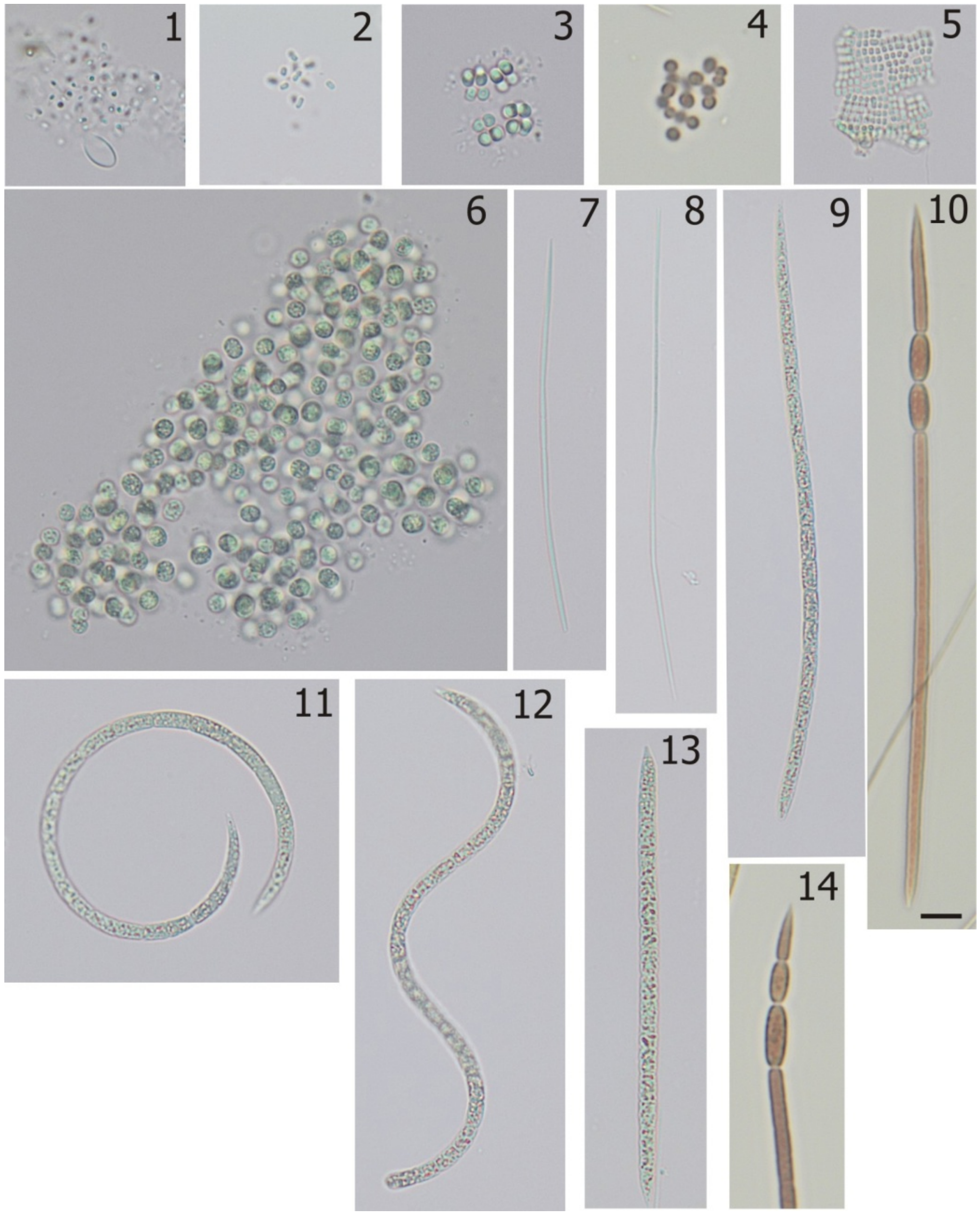

Plate B-1. Coccoid and Non-heterocystous Filamentous Cyanobacteria in Lake Elsinore, August 27, 2019. Fig. 1. *Aphanocapsa delicatissima*. Fig. 2. *Aphanothece minutissima*. Fig. 3. *Eucapsis parallelepipedon*. Fig. 4. *Merismopedia tenuissima*. Fig. 5. *Chroococcus dispersus*. Fig. 6. *Microcystis* cf. *aeruginosa*. Fig. 7. *Pseudanabaena* cf. *acicularis*. Fig. 8. *Planktolyngbya minor*. Figs 9, 13. *Raphidiopsis* sp. 2 (straight). Figs 11, 12. *Raphidiopsis* sp. 1 (spiral). Figs 10, 14. *Raphidiopsis* sp. 3 (akinetes). Scale bar = 10 µm for all images. Figs 4, 10, 14 from Lugol's-fixed samples. Other images from formalin-fixed samples. Collection location in Lake Elsinore - Figs 1-3, 6: LE01; Figs 5, 7-9, 11-13: LE02; Figs 4, 10, 14: LE03.

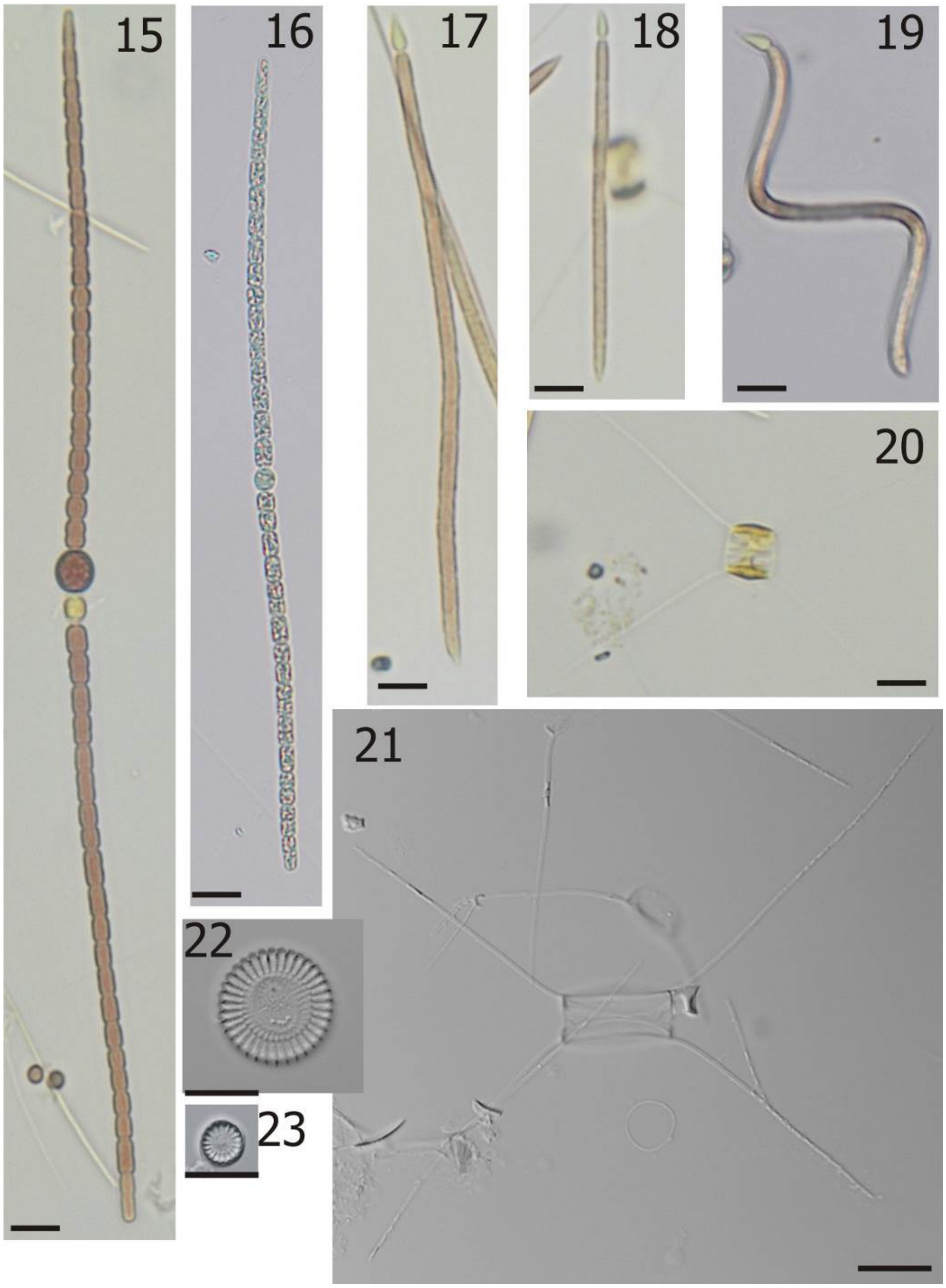

Plate B-2. Heterocystous Filamentous Cyanobacteria and Diatoms in Lake Elsinore, August 27, 2019. Fig. 15. *Sphaerospermopsis aphanizomenoides*. Fig. 16. S*phaerospermopsis* cf. aphanizomenoides. Figs 17-19. *Cylindrospermopsis raciborskii*. Figs 20, 21. *Chaetoceros muelleri*. Fig. 22. *Cyclotella meneghiniana*. Fig. 23. *Cyclotella atomus*. Scale bars = 10 µm. Figs 15, 17-20 from Lugol's-fixed samples. Fig. 16 from formalin-fixed sample. Figs 21-23 from samples cleaned for diatoms. Collection location in Lake Elsinore - Figs 19, 20, 23: LE01; Figs 16, 21, 33: LE02; Figs 15, 17, 18: LE03.

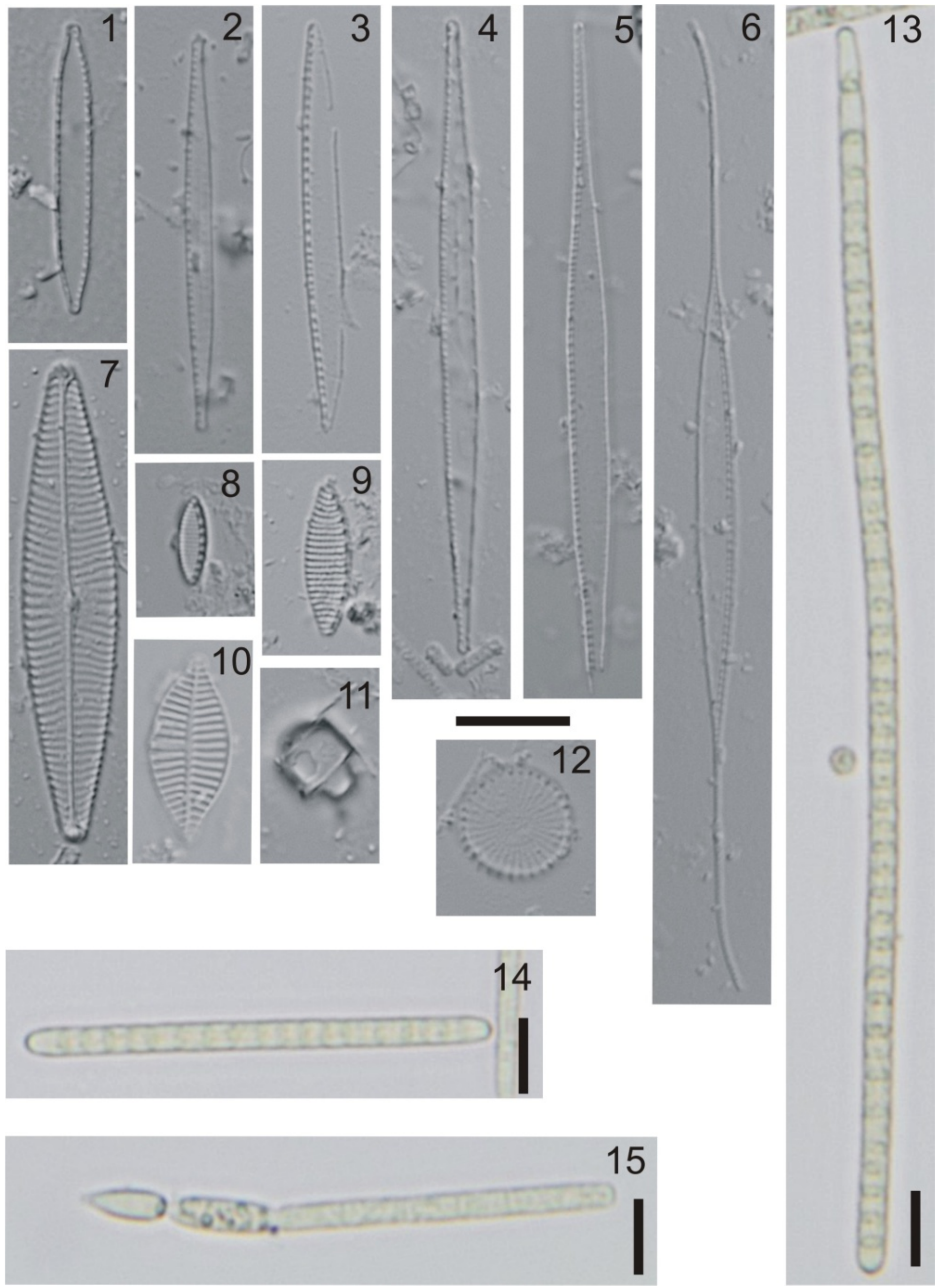

Plate B-3. Filamentous Cyanobacteria and Diatoms in Lake Elsinore, October 17, 2019. Fig. 1. *Nitzschia palea* var. *debilis.* Fig. 2. *Nitzschia palea* var. *tenuirostris*. Fig. 3. *Nitzschia palea* var. *tenuirostris*. Fig. 4. *Nitzschia gracilis*. Fig. 5. *Nitzschia subacicularis*. Fig. 6. *Nitzschia reversa*. Fig. 7. *Navicula erifuga*. Fig. 8. *Nitzschia incospicua*. Fig. 9. *Nitzschia amphibia*. Fig. 10. *Planothidium robustum*. Fig. 11. *Chaetoceros* spore. Fig. 12. *Stephanodiscus minutulus*. Figs 13, 14. *Sphaerospermopsis aphanizomenoides*. Fig. 15. *Cylindrospermopsis raciborskii* with akinete and terminal heterocyst. Scale bars = 10 μm, note the horizontal bar is the same for all diatom images. Figs 13-15 from Lugol's-fixed samples. Figs 1-12 from samples cleaned for diatoms.

Plate B-4 illustrates relatively uncommon phytoplankton algae, recorded with low abundance during the three sampling events in Lake Elsinore.

Plate B-4. Relatively Uncommon Phytoplankton Observed in Low Abundance in 2019-2020 Surveys. Figs 1, 2. *Closterium acutum* (LE02, 02/18/20), Fig. 3. *Cosmarium granatum* (LE03, 8/27/19), Fig. 4. *Actinastrum hantzschii* (LE01, 8/27/19), Fig. 5. *Monoraphidium griffithii* (LE01, 8/27/19), Fig. 6. *M. arcuatum* (LE01, 2/18/20), Fig. 7. *M. contortum* (LE01, 2/18/20), Fig. 8. *M. minutum* (LE01, 2/18/20), Fig. 9. *Desmodesmus intermedius* (LE02, 8/27/19), Fig. 10. *D. communis* (LE03, 10/17/19), Fig. 11. *Oocystis pusilla* (LE02, 8/27/19), Fig. 12. *Tetraedron minimum* (LE01, 8/27/19), Fig. 13. Green coccoid cell d. 5 (LE03, 8/27/19), Fig. 14. Green coccoid cell d. 7.5 (LE03, 8/27/19), Fig. 15. *O. parva* (LE02, 8/27/19), Fig. 16. *O. lacustris* (LE03, 8/27/19), Fig. 17. *Coelastrum microporum* (LE02, 8/27/19), Fig. 18. *Dictyosphaerium ehrenbergianum* (LE01, 8/27/19), Fig. 19. *Cryptomonas erosa* (LE02, 8/27/19), Fig. 20. *Cryptomonas* sp. 1 (LE03, 02/18/20), Fig. 21. *Phacus acuminatus* (LE03, 8/27/19), Fig. 22. *Colacium vesiculosum* (LE01, 8/27/19), Fig. 23. Dinoflagellate cell (LE02, 10/17/19), Figs. 24, 25. Chrysophyceae flagellate cell (LE02, 8/27/19). Algae illustrated above belong to Charophyta (Figs. 1-3), Chlorophyta (Figs. 4-18), Cryptophyta (Figs. 19, 20), Euglenophyta (Figs. 21, 22), Dinophyta (Fig. 23), and Chrysophyta (Figs. 24, 25). Scale bar = 10 µm for all images. Figs 2, 3, 7, 15, 18 and 22 from formalin-fixed samples. Other images from Lugol's-fixed samples.

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APPENDIX C

HISTORICAL FISH STOCKING ACTIVITIES

Table C-1. Key Fish Stocking Events in Lake Elsinore (adapted and summarized from EIP Associates 2005)

Year(s)	Fish Stocking Activity
1910	Several thousand “catfish,” probably brown bullheads, were salvaged from Lee Lake by local residents and moved to Lake Elsinore.
1911	“Bullheads” and “black bass” were again moved by local residents from Lee Lake to Lake Elsinore. In addition, the California Fish and Game Commission (CFGC) arrived in late October with a railroad car of “black bass” from the “Tulare River” (probably Tule River in the San Joaquin Valley). Forty large “cans” of fish weighing an estimated three tons were stocked.
1912	CFGC stocked another railroad car load of “black bass” in Lake Elsinore. Again, a “large” number of “fish” were removed from Lee Lake, which was being drained, and stocked in Lake Elsinore by local residents.
1915	CFGC stocked about 50 “sunfish,” also called “perch.” While these fish were probably green sunfish, it is possible that they were bluegill
1916	During the flood year 1916, Lake Elsinore overflowed and common carp were observed moving up Temescal Wash from the Santa Ana River into Lake Elsinore, thus supplementing the carp already in the lake. CFGC also stocked two “cans,” (i.e., several thousand) striped bass fry in the lake. The survivors of this plant were being caught in the sport fishery in the 1920s (One fish weighed 9 ¼ lbs and was 28 inches long.
1918	More “black bass” were stocked. James H. Gyger, a deputy Fish and Game warden, wrote that five species of fish occurred in Lake Elsinore in 1919: “black bass”, “bullhead catfish”, “sunfish”, many “German carp” (i.e., common carp or one of its varieties), and “minnows that are indigenous to this country,” (i.e., the arroyo chub).
1922	1922: Couch (1952) reports that Chamber of Commerce decided to send men to the lake on the E. E. Barnett ranch (Barnett Lake) near Temecula and collect striped bass for Lake Elsinore. Presumably these fish were stocked based on a February 18, 1926 Lake Elsinore Valley Press article which stated that “Private parties put striped bass in the lake some years ago, but so far as is known only 2 such fish have been caught”
1926	First documentation of Bluegill being stocked in Lake Elsinore, along with an unspecified number of other fishes. Most of the 98 cans of fish from the CFGC were stated to be bluegill; however, a 1927 newspaper report indicates that “crappies” and “bass” were included in the shipment. The “crappies” introduced at this time could have been either white crappie, black crappie or both; mixed-species shipments were common. At the time, white crappie was known to do well in San Diego County reservoirs, and it was more abundant in those waters than the black crappie.
1927	A “few black bass” were stocked in late July.
1930-1931	Over 40,000 “bass,” ranging from 6 to 8 inches, were stocked in the lake by the CFGC. These fish were obtained from the Sacramento River, Chatsworth Reservoir in the San Fernando Valley, and from Temescal Reservoir near Elsinore. The plantings also included “thousands of other game fish,” however, the species stocked were not identified.
1939	California Division of Fish and Game stocked over 60,000 “bass.”
1940-1964	Fish stocking not known to occur because lake was at very low levels or dry from 1955-1958 and again from 1959-1964

Table C-1. Key Fish Stocking Events in Lake Elsinore (adapted and summarized from EIP Associates 2005)

Year(s)	Fish Stocking Activity
1964 ff.	After very dry period, Colorado River water was shunted down the San Jacinto River through Canyon Lake into Lake Elsinore. Water transfer reintroduced common carp and perhaps some other species, that had been resident in Canyon Lake or the Colorado River. Additional Colorado River water was transferred to Lake Elsinore in 1965-1966; each water transfer may have also introduced fish to the lake. For example: • Threadfin shad were introduced into California waters for the first time in 1954. Their occurrence in Lake Elsinore is the result of either: (1) planting by the California Department of Fish and Game (CDFG) at an undetermined date; or, (2) introduction from the Colorado River during the water transfers to Lake Elsinore from 1964 through 1966. • Golden shiners have been documented in Lake Elsinore; these minnows were often used for bait or introduced as forage fish. Their occurrence in Lake Elsinore was most likely due to: (1) planting by the CDFG; or (2) an unauthorized bait bucket introduction by anglers. • Goldfish were probably introduced as the result of dumping by aquarium hobbyists; however, they may also be unauthorized bait bucket introductions by anglers. • Common carp, one of the first fishes stocked in the lake, is mostly likely to have recolonized the lake (after the lake dried up in the 1950s) during the addition of Colorado River water. The seed population origin was probably Canyon Lake. • Brown and black bullheads were stocked by the CDFG; however, neither species was collected during 2002 or 2003 surveys and not likely to currently occur in the lake. While the yellow bullhead may have been stocked by CDFG, no stocking record has been found. Instead, these fish probably came from the Colorado River, where they are common, during the water transfers. This species likely does not currently occur in Lake Elsinore. Channel catfish (*Ictalurus punctatus*) were stocked. • Rainbow trout do not survive in Lake Elsinore for more than short periods of time due to the unsuitable water quality and water temperature conditions. They have been stocked in the fall and spring to support a put-and-take fishery. • While striped bass have been stocked in the past; however, recent occurrences of this fish are attributed to unauthorized plantings by anglers. Very few, if any, striped bass occurred in the lake in 2003. In 2004, striped bass/white bass hybrids, known as “wipers” (*Morone saxatilis* x *Morone chrysops*) were stocked by the City of Lake Elsinore to control the threadfin shad population and to provide angling opportunities. • All of the members of the sunfish family (Centrarchidae) have been stocked at one time or another by CDFG. Green sunfish have not been stocked since 1964. It is likely this fish entered the lake from Canyon Lake or the San Jacinto River during Colorado River water transfers. Other species of sunfishes may have also entered the lake at this time, notwithstanding later stocking. • One or more species of tilapia (*Tilapia* spp.) were reported to occur in Lake Elsinore in 1984; this taxon is not currently known to occur in the lake. The historical occurrence of these fishes was likely the result of an unauthorized bait bucket introduction by anglers or aquarists.

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No.	Commentor	Affiliation	Report Element	Comment	Response
1	Abigail Suter	Riverside County Flood Control & Water Conservation District (RCFC&WCD)	2.1.1.1 - Beach Seining	Re: "However, no tagged fish were collected during subsequent sample dates." - Does this lead to any changes in assumptions? Were any called in later by fisherman?	There were no tagged fish turned in by fisherman. The assumptions vary depending on the method employed to estimate the fish population. That is they vary depending on whether the estimates are based on Mark-Recapture or Density-Area method. Following are the assumptions applicable to each method to estimate population: Mark-Recapture Method: (1) marked and unmarked members of the population undergo the same mortality; (2) marked individuals do not lose their marks; (3) marked and unmarked members of the population are equally vulnerable to capture; (4) marked individuals must mix randomly with the population or the sampling effort must be proportional to the number of fish present in different portions of the body of water; (5) all recaptures must be recognized and reported; and (6) recruitment must be negligible. Density-Area Method: (1) within each depth zone sampled the fish are equally distributed; (2) all fish within the area being sampled are captured (i.e., they cannot avoid/escape the net); and (3) all types of fish are equally able to be captured.
2	Rebekah Guill	RCFC&WCD	2.1.1.2 - Otter Trawling	Is there a photo for this survey method?	Added a schematic
3	Rebekah Guill	RCFC&WCD	2.1.2 - Data Analysis	Can the combined count of tagged and untagged be used to represent a sample size for population extrapolation?	The number of fish we captured in comparison to the size of the lake made it unlikely that any tagged fish would be recaptured. We had anticipated capturing many more carp than we did (n = 311). The fish move around after being tagged/released, and redistribute into the lake, and it is likely that a few died after being released.
4	Rebekah Guill	RCFC&WCD	2.1.2 - Data Analysis	Is it assumed that the sample population previously counted has dispersed? Or could there have been some detrimental effect on those tagged? Interesting that they odds were that not a single one was caught again.	See responses to Comment Nos. 3 & 4
5	Abigail Suter	RCFC&WCD	2.1.3 - Fish Tissue Collections	This part of the sentence confuses me. I'm with you up until the parenthesis, the math makes sense. Is the minimum of 3 individual fish per composite what was done if less than 15 fish were collected in the first place? If so, this could be rephrased for clarity	Revised text to clarify. Note that the minimum of three fish comes from the CA EPA Office of Environmental Health Hazard Assessment general protocol for sport fish sampling and analysis. Unfortunately for some species we were not able to meet this goal. There is also a requirement for certain size lakes (e.g. small, medium, large) to meet a minimum number of locations sampled. Lake Elsinore is considered a medium lake according to the State Water Board, which requires at least two sample locations. So we had to group fish accordingly, even if less than three were captured in a specific location.

No.	Commentor	Affiliation	Report Element	Comment	Response
6	Abigail Suter	RCFC&WCD	2.1.3 - Fish Tissue Collections	Is there a reason this data is going into a separate report	After discussion with Tess Dunham and Rick Whetsel, we felt that the tissue analysis data for potential delisting of the lake served a different purpose than the fisheries report, and that due to its highly specific nature deserved to be highlighted seperately.
7	Abigail Suter	RCFC&WCD	2.2.3 - Data Analysis Methods	Confirmed with Wood, definition is incorrect and reversed. As the SDI increases, diversity increases.	Comment is correct; text revised
8	Abigail Suter	RCFC&WCD	3.1 - Fish Catch Summary	Re: "The majority of sampling occurred in the shallowest depth layer (0-8 ft), which represents about a quarter of the total lake acreage" - Was there a reason for this? Are most of the species known to live in shallower waters?	Yes. It was anticipated that the majority of the fish would live in the shallower areas of the lake due to higher oxygenation. This was confirmed based on the number of fish caught per unit area sampled, with the exception of the fish that are pelagic and typically live near the surface (e.g., silversides and mosquitofish).
9	Abigail Suter	RCFC&WCD	3.1 - Fish Catch Summary	Re: "The effectiveness of the three fish survey methods cannot be compared due to differences in area sampled and net mesh sizes..." - I'm a little confused by what you mean by 'effectiveness'. Generally I thought this would be a comparison of how well fish were caught in each method but given that we don't know the true sample size and no fish were re-caught, I'm wondering how this would be done even if the areas and mesh were equal in size. I didn't think evaluating method effectiveness was part of the goals for this study so is this statement needed?	Comparing method method effectiveness was not an objective of the study. To avoid confusion, text was removed
10	Abigail Suter	RCFC&WCD	3.3 - Fish Size	Please check this paragraph for consistency and clarity. 86% of all fish were between 11-100mm, and you list # of fish and fish/acre. Than you introduce small fish, defined as less than 200mm which means this percentage of 89% already includes the 86% of fish from the first group. So only 3% of fish were between 100-200mm? This seems like an overly-complicated way to present this data. Next you present fish greater than 200mm please make text consistent with either text 'greater/less than' OR symbols </> and the order of abundance / fish/acre.	Text revised to simplify message – lake dominated by “small fish”
11	Abigail Suter	RCFC&WCD	Table 4-2	You may want to add (SDI) as you use the acronym on the next page.	Edit made

No.	Commentor	Affiliation	Report Element	Comment	Response
12	Abigail Suter	RCFC&WCD	Table 4-3 - Zooplankton Richness and Diversity in Lake Elsinore	You summarize each of the three events but it would be helpful to have some information comparing the events. For example the SDI keeps increasing which, means the diversity is increasing. I was also curious about the benchmarks for the SDI as all three are described as on the upper range or a moderate to highly diverse community.	The "upper range" and "moderate to high" diversity was relative to the 2003-2004 and 2009-2011 studies by Veiga-Nascimento, Anderson, and Tobin. This is stated in the sections that follow. There are no official benchmarks for diversity indices, although in scientific literature if you are above approximately 0.6 for SDI it is generally considered good.
13	Abigail Suter	RCFC&WCD	6.1.3 - Fish Population Analysis	Re: "This difference may be attributed at least in part to the fish kill", were any comparisons done against the amount of dead fish removed by the city?	No change made - The referenced paragraph is only intended to provide potential reasons for differences in fish density. Two examples provided were 2019 fish kill and differences in survey methods. These are intended as speculation only; not possible to go beyond that speculation. Only data points we have are (a) fish kill data in Table 6-7 (states that approximately 150 tons of fish killed and they were primarily carp and shad.; (b) and a note regarding important differences in survey methods.
14	Abigail Suter	RCFC&WCD	6.3.2 - Fish Stocking	Re: "...the findings might suggest that survival has been potentially poor for these species." - This is an extremely passive sentence, is there any way to rephrase? Maybe take out either 'might' and/or 'potentially'	Text revised
15	Abigail Suter	RCFC&WCD	6.3.2 - Fish Stocking	Re: "...successfully captured and retained by fisherman", did anyone call in spotting the tagged fish	In the context of this paragraph dealing with stocking, stocked fish are not tagged, so fishermen would not have known if they captured a stocked fish. Of the carp we tagged, none were reported by fishermen as being caught.

No.	Commentor	Affiliation	Report Element	Comment	Response
16	Amy McNeil/ Abigail Suter	RCFC&WCD	6.3.3 - Fish Kill Events	Re: "During subsequent wet weather events beginning in October 2019, several large storm events occurred resulting in large debris flows entering the lake. The January 2019 fish kill event occurred about two weeks after a December 2018 storm event dropped approximately two inches of rain in the Lake Elsinore watershed area." - Here the report talks about large amount of debris flows reaching the lake. This seems contradictory to many other papers written discussing the gross amounts of nutrients collects through debris removal prior to reaching the lake. LE/CL Task Force has highlighted these efforts and looked/is looking for "credit" as it was costly maintenance effort. Should we have a disclaimer for consistency? Suggest "Even with great efforts for debris removal in place to prevent this material entering into the lake, a significant small percentage entered into the lake and possibly contributed to the fish kill in 2019."	Text signficantly revised to address comment.
17	Amy McNeil	RCFC&WCD	6.3.3 - Fish Kill Events	Re "The fish kill event was attributed to a bloom of the golden algae, Prymnesium parvum, a species not previously observed in high concentrations in the lake" - Golden algae linked to fire debris flows? Any other case where golden algae present a lakes after fire debris?	Very good question. A brief search of the literature shows little is known re what causes blooms of this species. That information has been added to the section along with a couple of additional references.
18	Abigail Suter	RCFC&WCD	6.4.1 - Carp Removal	Please review and revise for clarity. I think this is stating the prior densities and populations as well as the goal but it doesn't make sense as written.	Text revised
19	Abigail Suter	RCFC&WCD	6.4.2 - Fish Stockiing, First Recommendation	Re: "If Hybrid Bass are stocked at a size greater than 100 mm, they will unlikely target consumption of zooplankton (Hudson 1989) which could then be more available to consume phytoplankton and serve as prey for resident reproducing sport fish." - Please review and revise "they will unlikely target consumption of zooplankton" for clarity and grammar. I'm not sure what this statement is trying to convey.	Text revised
20	Barbara Barry	Santa Ana Water Board	Section 4	Pages 4-8, 4-9. Table 4-4, add “(continued)” in the title	"Continued" added to the table as needed
21	Barbara Barry	Santa Ana Water Board	Section 4	Table 4-5. It might be useful to explain how “Agal Units/ml” is defined.	Definition aldded (along with cells/mL)
22	Barbara Barry	Santa Ana Water Board	Appendix A	Appendix A. It would be nice to have scale bars for the photos.	Thank you for your comment; however, the report includes what was provided by the laboratory

No.	Commentor	Affiliation	Report Element	Comment	Response
23	Barbara Barry	Santa Ana Water Board	Section 2.2.3 - Data Analysis Methods	Page 2-9. Example for interpreting Simpson's diversity index seems odd. When one taxon completely dominates the community, community diversity would be the lowest and SDI=0 (based on the formula presented in the text). However, the text seems to indicate the opposite. Is this a typo?	Yes it was a significant typo. RCFC&WCD also noted that it was written backwards. Corrected.
24	Barbara Barry	Santa Ana Water Board	Section 2 General	Would there be potential sampling bias for the fish survey by avoiding the areas with LEAMS?	It is unlikely that this would be the case. The trawls represented by LE-T-1, LE-T-2, and LE-T-3 and purse seines cover the same depth strata that is present in the areas of the LEAMS aeration lines. Additionally, any benefit of the aeration increasing DO would certainly have been observed in the area of the LE-T-2 trawls and PS2 purse seine events. Furthermore, as noted in the report, the various different types of sampling gear utilized during this survey, which were not used in the previous 2005 EIP survey (i.e. trawls and purse seine), allowed a much better representation of the various habitat types in the lake.
25	Bob Magee	LESJWA Board, City of Lake Elsinore (Comments via Nicole Dailey, City of Lake Elsinore)	6.4.2 - Fish Stocking	Very pleased to see recommendation #1. However, to be technically accurate we should document that on at least two separate occasions CDFW refused our request to re-introduce Wipers because they were non-native and potentially an evasive species should flood waters ever reach Lee Lake (an event occurring twice in the last 101 years). They even support a bill in the State Assembly to outlaw the fish all together (it failed). Now the Scientists have shown the species to have value and we applauded the Department's support of this finding and our request to stock these fish!	Thank you for the background information. We have added a footnote to Section 6.4.2 to document the history; we also added a footnote to note the recent successful stocking of Wipers in July 2020.
26	Bob Magee	LESJWA Board, City of Lake Elsinore	6.4.2 - Fish Stocking	I am disappointed with recommendation #2, but it is subject to re-evaluation and if water quality improves we could restart the stocking of those fish.	Thank you for the comment
27	Bob Magee	LESJWA Board, City of Lake Elsinore	Table 6-7, Lake Levels	Table 6.7 lists the November 2006 elevation of Lake Elsinore at 1236. In March of 2005 the waters rose to 1254.5....almost flowing out the outflow channel. No way we lost 18 feet in 18 months. Please double check this data. Subsequently, Nicole Dailey (City of Lake Elsinore) commented that City records show the lake level was 1246.5 in November 2006.	Table 6.7 has been revised
28	Bob Magee	LESJWA Board, City of Lake Elsinore	Appendix C	Appendix table C-1 on the history of fish stocking is fascinating. It might be something that Ruth Atkins would be interested in seeing	Thank you for the comment

No.	Commentor	Affiliation	Report Element	Comment	Response
29	Bob Magee	LESJWA Board, City of Lake Elsinore	General	In the study, it mentions the Silverside minnows and mosquitofish make up 90% of our fish. But, there is not much about how these fish got into our lake. They have never been mentioned before. Do we know? Can we speculate Canyon Lake State Water?	From what we have seen in the literature, it is highly likely that silversides are in other lakes within the area as well. They have been found in the Santa Margarita and Santa Ana River watersheds. It has been documented that silversides entered the Diamond Valley Lake, just south of Hemet in Riverside County, in late 1999 or 2000 as the reservoir filled with water from the California Aqueduct and Colorado River. This Diamond Valley Lake has a potential hydrologic connnection to Canyon Lake during high flows through the San Diego Canal which intersects Salt Creek. It is thought (but not certain) that they came in through the State Water Project into Canyon Lake at some point, and then when the dam overflowed got transported to Lake Elsinore. It is reasonable to assume that they would be in Canyon Lake as well, but a targeted survey will be necessary to determine that.
30	Bob Magee	LESJWA Board, City of Lake Elsinore	General	In the study, it mentions the Silverside minnows and mosquitofish make up 90% of our fish. What is the impact of 90% of our fishery being bait fish?	This survey finding is actually not much different than Dr. Michael Anderson's (UC Riverside) 2015 survey which found that the fish community was dominated (95.6%) by small fish (< 3.5 cm in length). We do not think that they are going to be highly detrimental to Lake Elsinore, especially if the pattern that we saw of very low numbers of Threadfin Shad holds true for a while. Replacing Threadfin Shad with silversides, we believe is actually a benefit ecologically for the lake and water quality. Threadfin Shad are filter feeders, swimming through the water with their mouths open very efficiently filtering out the small zooplankton that we want to keep in the lake due to their ability to feed on phytoplankton (aka algae) and keep algae populations in check. While Silversides feed on the same zooplankton, they have a different, much less efficient feeding strategy of hunt-and-peck. They wait until they see a prey zooplankter, and then go after that one individual. So the thinking is that they will be much less detrimental to the zooplankton population, which will in turn help to keep the algae in check.
31	Bob Magee	LESJWA Board, City of Lake Elsinore	General	In the study, it mentions the Silverside minnows and mosquitofish make up 90% of our fish - How do we eradicate/control/change this? Stocking, yes, but how often? How much?	See response to Comment No. 30. We do not think they should be eradicated as they provide a better food source for Largemouth Bass, Wipers, Bluegill and other piscivorus fish due to their smaller size than Threadfin Shad.

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32	Bob Magee	LESJWA Board, City of Lake Elsinore	General	What is the hardiness of this fish (Silverside minnow)? Are they susceptible to fish die offs? Can you tell us more about them?	Silversides are a brackish/marine species, but can tolerate freshwater and can inhabit a wide range of salinities from highly saline to fresh. They are omnivorus feeding on zooplankton, benthic invertebrates, fish eggs and larvae, and diatoms. Although they would be impacted by low dissolved oxygen (DO) levels, they have the ability to stay near the surface where DO is typically higher.
33	Bob Magee	LESJWA Board, City of Lake Elsinore	Recommendations	Wipers – we are told these are VERY hard to get stocked in California. Hard to find. Only finding bait size. Do you know more about options to find and bring in more of the fish that will help us balance the fishery?	This will require some research; if any information is obtained it can be reported back to the LECL Task Force.
34	Bob Magee	LESJWA Board, City of Lake Elsinore	Recommendations	Catch Limits or Restrictions – was anything included in the document about the City limiting how many or what type of fish can be removed from the lake? i.e. take all the carp and bait fish you want, but catch and release only on Bass, Wipers, Crappie, etc? Or, maybe we do a catch and release only during mating seasons? A few months a year? Ideas here?	Initially we could recommend including a catch and release only program for wipers to allow time for establishment of a more mature population. The City of Lake Elsinore has a current published fishing regulation guide which includes wipers (Bag limit – 2; Size limit 18 inches). The published regulations also include bag and size limits for crappie, catfish, largemouth bass, redear sunfish, and bluegill. Other potential catch limits/restrictions could be considered in the future after wipers are routinely stocked.
35	Rick Whetsel	SAWPA	Cover	Please correct name of LESJWA on first page. Remove “Project” before “Authority”	Corrected
36	Rick Whetsel	SAWPA	Section 1	Page 1-3. Please correct name for LESJWA on next to last paragraph ("and" left out; "Watershed" should be plural	Corrected
37	Quinton Granfors	CDFW	General	Reviewed report and summarized findings and recommendations on behalf of City of Lake Elsinore	No revisions needed