Lake Havasu
Fisheries Management Plan
2019-2029

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Location

Lake Havasu is located immediately upstream of Parker Dam on the Colorado River. It is an impoundment created by Parker Dam that is approximately 26 miles long. Lake Havasu City is located on its eastern shore (Figure 1). The U. S. Bureau of Land Management, U. S. Bureau of Reclamation, Arizona State Land Department, Arizona State Parks, and the U. S. Fish & Wildlife Service; Bill Williams and Havasu National Wildlife Refuges cooperatively manage resources and recreation on Lake Havasu and the surrounding area (Figure 2).

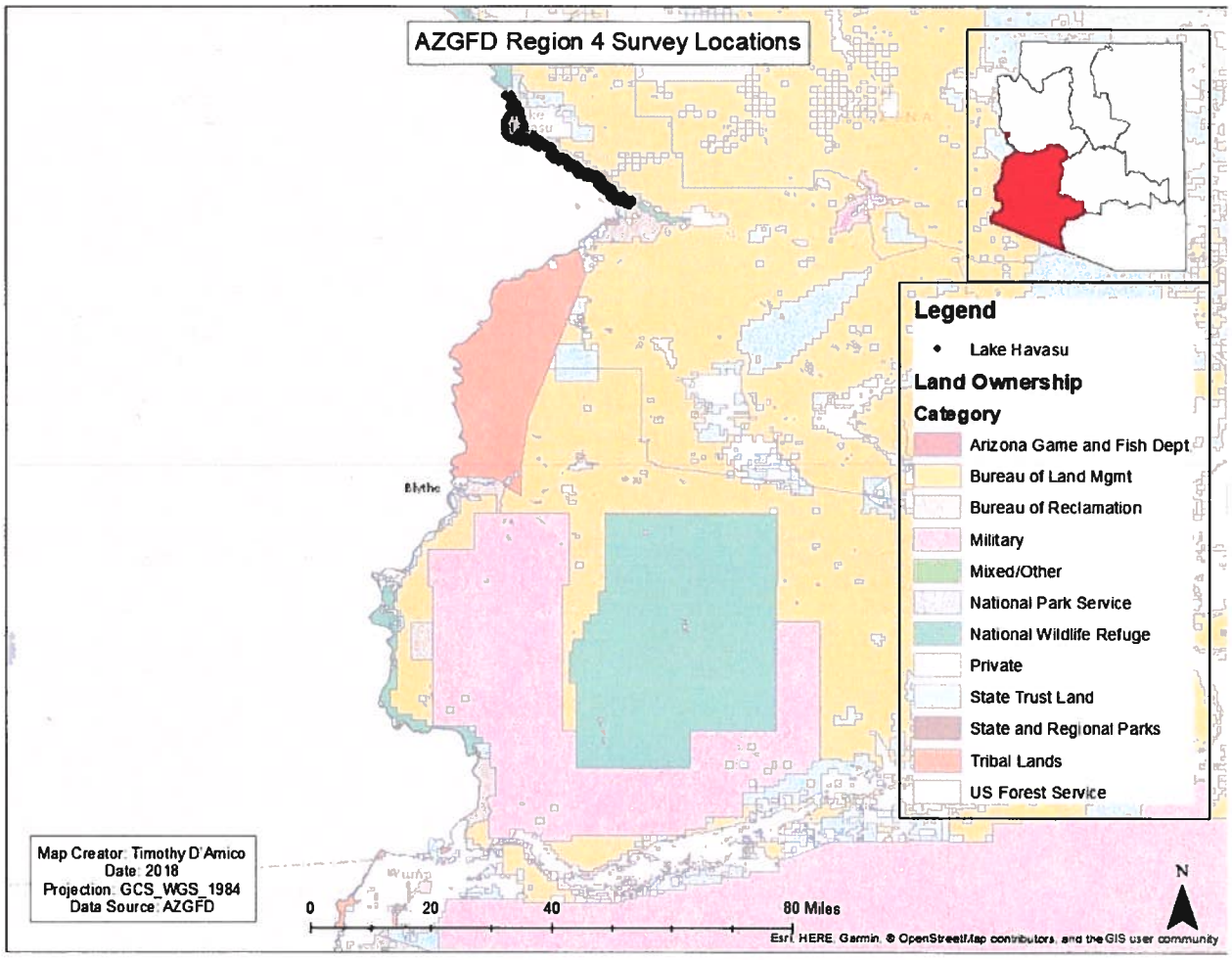

Figure 1. Location Map for Lake Havasu.

Management Prescription

The Arizona Game and Fish Department (AGFD, Department) has developed concepts under a Strategic Vision Document (AGFD 2017) to help guide warmwater fisheries management in Arizona. Using these concepts, fisheries management at Lake Havasu will focus primarily on a high-quality Largemouth Bass *Micropterus salmoides* and Smallmouth Bass *Micropterus dolomieu* fisheries, secondarily for Redear Sunfish *Lepomis microlophus* as a featured species and thirdly as a general opportunity fishery for Striped Bass *Morone saxatilis*. Bluegill *Lepomis macrochirus*, Channel Catfish *Ictalurus punctatus*, and Flathead Catfish *Pylodictis olivaris* can be locally abundant and will provide angling opportunities.

Native fish species management, conservation, and recovery will be in partnership with the U. S. Fish and Wildlife Service, Lower Colorado River Multi-species Conservation Program (LCRMSCP) and other partners. Actions related to the management, conservation, and recovery of native fish species in Lake Havasu will be mostly driven by existing conservation and recovery plans and will not be addressed in this plan.

Objective 1: Maintain the Largemouth Bass population to meet or exceed High Quality Concept standards.

Objective 2: Maintain the Smallmouth Bass population to meet or exceed High Quality Concept standards.

Objective 3: Maintain the Redear Sunfish population to meet or exceed the Featured Species Concept standards.

Objective 4: Maintain the Striped Bass population to meet or exceed General Opportunity Concept standards.

Objective 5: Maintain angler satisfaction at 80%.

Objective 6: Work within the Lake Havasu Fisheries Improvement Program to maintain or improve fish habitat and shoreline angling facilities.

Monitoring activities, including community-wide or species-specific electrofishing surveys and angler creel surveys will be used to determine if aforementioned management objectives are being met. Management strategies to meet objectives are identified in Table 1.

Table 1. Lake Havasu Objectives and Adaptive Management Strategies:

Objective 1: Maintain the Largemouth Bass population to meet or exceed High Quality standards as listed in the Warmwater Sportfisheries Strategic Vision Document.			
Parameters	**Objective Guideline**	**Trigger point to address unmet objectives**	**Strategies if Objectives are not met**
Electrofishing Catch Rates	Spring electrofishing CPUE ≥ 100 fish/hour of electrofishing.	Average CPUE drops below 100 for three consecutive samples.	• Reevaluate survey method and/or equipment • Potential Stocking • Potential Regulation Changes
Relative Weight	Average relative weight 90 < Wr < 105.	Average relative weight drops below 90 for three consecutive samples.	• Potential Prey Stocking • Potential Regulation Changes
Stock Density	PSD between 40-70, PSD-P between 10-40.	Three consecutive sampling events showing population below management guideline.	• Potential Stocking • Potential Regulation Changes
Angler Catch Rates	Largemouth Bass angler CPUE of no less than 1 fish per hour for anglers targeting Largemouth Bass.	Overall CPUE drops below 1 Largemouth Bass per hour for two consecutive creel surveys.	• Potential Stocking • Potential Regulation Changes • Potential Outreach/Education

Objective 2: Maintain the Smallmouth Bass population to meet or exceed High Quality standards as listed in the Warmwater Sportfisheries Strategic Vision Document.			
Electrofishing Catch Rates	Spring electrofishing CPUE ≥ 50 fish/hour of electrofishing.	Average CPUE drops below 50 for three consecutive samples.	• Reevaluate survey method and/or equipment • Potential Stocking • Potential Regulation Changes
Relative Weight	Average relative weight 90 < Wr < 105.	Average relative weight drops below 90 for three consecutive samples.	• Potential Prey Stocking • Potential Regulation Changes
Stock Density	PSD between 40-70.	Three consecutive sampling events showing population below management guideline.	• Potential Stocking • Potential Regulation Changes
Angler Catch Rates	Smallmouth Bass angler CPUE of no less than 1 fish	Overall CPUE drops below 1 Smallmouth	• Potential Stocking • Potential Regulation

	per hour for anglers targeting Smallmouth Bass.	Bass per hour for two consecutive creel surveys.	Changes • Potential Outreach/Education

Objective 3: Maintain the Redear Sunfish population to meet or exceed the Featured Species concept standard as listed in the Warmwater Sportfisheries Strategic Vision Document.			
Angler Catch Rates	Redear Sunfish angler catch rates no less than 1 fish per hour for anglers targeting Redear Sunfish.	Overall CPUE drops below 1 Redear Sunfish per hour for two consecutive creel surveys.	• Potential Stocking • Potential Regulation Changes • Potential Outreach/Education
Stock Density	PSD between 20-40, PSD-M+ greater than 10.	Three consecutive sampling events showing population below management guideline.	• Potential Stocking • Potential Regulation Changes
Size Structure	Multiple age classes captured during sampling events	Three consecutive sampling events showing population below management guideline.	• Reevaluate survey method and equipment • Potential Stocking • Potential Regulation Changes

Objective 4: Maintain the Striped Bass population to meet or exceed General Opportunity Concept standards as listed in the Warmwater Sportfisheries Strategic Vision Document.			
Electrofishing Catch Rates	Spring electrofishing CPUE $\geq$ 50 fish/hour of electrofishing.	Average CPUE drops below 50 for three consecutive samples.	• Reevaluate survey method and/or equipment • Potential Stocking • Potential Regulation Changes
Angler Catch Rates	Striped Bass catch rates no less than 1 fish per hour for anglers targeting Striped Bass.	Overall CPUE drops below 1 Striped Bass per hour for two consecutive creel surveys.	• Potential Stocking • Potential Regulation Changes • Potential Outreach/Education
Size Structure	Multiple age classes captured during sampling events	Three consecutive sampling events showing population below management guideline.	• Reevaluate survey method and equipment • Potential Stocking

			• Potential Regulation Changes

Objective 5: Maintain an overall angler satisfaction at 80%			
Angler Satisfaction	Angler Satisfaction > 80%; management trigger,	Angler satisfaction drops below 80% for two consecutive creel surveys.	• Potential Stocking • Potential Regulation Changes • Potential Outreach/Education

**** Objective 6: Work within the Lake Havasu Fisheries Improvement Program Partnership to maintain or improve fish habitat and shoreline angling facilities.***			
Maintain or Improve Shoreline Fishing Facilities	Maintain, replace, or improve the six existing fishing docks and associated facilities. Evaluate opportunities to construct additional fishing docks. Replace the Havasu Springs dock.	No maintenance, replacement, or improvements have been made by 01/01/2021. Havasu Springs Dock has not been replaced by 01/01/2024.	• Increase/provide funding and/or manpower as needed
Semi-Permanent Fish Habitat Structures	Evaluate and start placing semi-permanent fish habitat structures to replace existing structure that have degraded.	No new semi-permanent fish habitat structures have been placed by 01/01/2021	• Increase/provide funding and /or manpower as needed
Create short and long-term management plans for Lake Havasu fish habitat program	Create short and long-term management plans for the Lake Havasu fish habitat program to increase efficiency in labor, funding, and ability to add habitat to the lake.	No short or long-term management plans for Lake Havasu fish habitat program have been created before 01/01/2021	• Increase/provide funding and /or manpower as needed

[1] CPUE=Catch Per Unit Effort (fish per hour) [2] PSD=Proportional Size Distribution

* Trigger for this objective are to only be applied when other objectives guidelines are not being met

Background

Land, water, fish, and wildlife resources in, and around the lake are managed by multiple authorities. The Arizona Game & Fish Department is the primary management agency for fish and wildlife in the state of Arizona. The California Department of Fish and Wildlife (CDFW) manage fish and wildlife for the state of California. Water and dam operations are managed by the U. S. Bureau of Reclamation (BOR). The U. S. Bureau of Land Management (BLM) manages large amounts of land surrounding the lake. The U. S. Fish and Wildlife Service (USFWS) manages threatened and endangered species in the area and two wildlife refuges that border the lake. The Arizona State Land Department (ASLD) and Arizona State Parks (ASP) manage state land that borders the lake and the Chemehuevi Tribe manages tribal land that borders the lake. A small percent of the land that borders the lake is owned and managed by the City of Lake Havasu and other private entities (Figure 2).

Lake Havasu is a storage and diversion reservoir created with the completion of Parker Dam in 1938. The lake is located on the Colorado River upstream of Parker Dam approximately 25 miles to Catfish Bay. Lake Havasu is bordered by Arizona and California. It is approximately 20,000 acres in size at a surface elevation of 448 feet, and has a shoreline length of more than 100 miles. The water surface elevation typically does not drastically fluctuate. The purpose of the dam is to divert water for municipal use in southwest California, Phoenix, Tucson and other municipalities.

After the completion of Parker Dam, Lake Havasu filled to capacity between 1940 and 1942. Historically, the lower Colorado River contained large-bodied native fishes, including Colorado Pikeminnow *Ptychocheilus lucius*, Razorback Sucker *Xyrauchen texanus*, and Bonytail Chub *Gila elegans*. With water development and diversion, these historic species declined to extirpation. A number of species have been unsuccessfully stocked into Lake Havasu, including Rainbow Trout *Oncorhynchus mykiss* and White Sturgeon *Acipenser transmontanus*. In 1954, Threadfin Shad *Dorosoma petenense* were introduced into Lake Havasu to improve the forage base. In 1959, Striped Bass were stocked to increase sportfishing opportunities. Currently, Lake Havasu offers one of the most speciose fishing opportunities. Other species of interest to anglers include Channel Catfish, tilapia *Oreochromis spp.*, and several species of sunfish *Lepomis spp.*

In the 1980s, managers and local interest groups noticed a decline in Lake Havasu's fisheries, which lead to the foundation of the Lake Havasu Fisheries Improvement Program (LHFIP). The LHFIP was established in 1992 through the development of a partnership with state, federal and private organizations that held a common interest in improving the fisheries in Lake Havasu. Current partners in the program include the BLM, BOR, USFWS, U.S. Geological Survey (USGS), AGFD, ASP, CDFW, Anglers United (AU), and the Lake Havasu Marine Association (LHMA). The major goals of the program are to improve sport fish populations and fishing through habitat improvement and augmentation as well as shoreline angling opportunities by developing fishing docks.

Productivity & Water Quality

The Clean Colorado River and Sustainability Coalition is a new partnership of agencies which has centralized water quality data collected along the lower Colorado River. The BOR and Arizona

Department of Environmental Quality (ADEQ) conduct most of the water quality testing on Lake Havasu. Water quality data has been collected sporadically since 1991.

Of the common parameters measured, pH usually ranges from 7.5 to 8.5, surface water temperature usually ranges from a low of about 50 degrees Fahrenheit (°F) in the winter to 90°F in the summer, conductivity usually ranges from 937 to 1,030 microsiemens per centimeter, and surface dissolved oxygen usually ranges from 6 to 10 parts per million. Secchi disk readings ranged from 3 feet to about 40 feet with an average of around 25 feet during the last six years. Based on these measurements, there is no indication of severe or chronic water quality issues in Lake Havasu at this time.

ADEQ has tested fishes in Lake Havasu and concluded that mercury levels are low enough to allow unlimited consumption. California has different fish consumption advisories depending on species, including four servings per week of carp, or three servings per week of catfish or sunfish species, or two servings per week of black bass species or Striped Bass. This advisory is the result of elevated levels of mercury found in the flesh of these species. Details of the advisories can be found at either ADEQ or California Environmental Protection Agency.

Blue-green algae blooms have become a recent concern. Phytoplankton documented in the lake includes various species of Bacillariophyta, Chlorophyta, Cryptophyta, and various species of Cyanobacteria including *Microcystis aeruginosa*. Blooms of *M. aeruginosa* have recently occurred in Lake Havasu and are being monitored. To the best of our knowledge, *M. aeruginosa* blooms have not caused wildlife or fish mortality in Lake Havasu. Zooplankton detected during monitoring include various species of Rotifera, Cladocera, Ostracoda, Copepoda, and the only bivalve during this monitoring detected were Quagga Mussel *Dreissena bugensis* veligers.

Very little is known about nutrient levels in Lake Havasu. A better understanding of nutrient inputs, specifically phosphorus and nitrogen, into the lake under different conditions and the corresponding changes in primary productivity of Lake Havasu could help managers understand trophic connections and the associated effect on sportfish populations. Lake Havasu City is working with Arizona State University: Lake Havasu to study nutrient flow, particularly orthophosphates in the lake. They are also working to create a benthic map of the lake. The Department will coordinate with the other agencies to acquire water quality measurements and determine if additional sampling is necessary.

Water clarity in Lake Havasu has improved during the last ten years, due to the infestation of Quagga Mussels. The growth of submerged vegetation appears to have increased along with the improved water clarity. This increase in the growth of submerged vegetation can provide additional fish habitat. The occurrence of submerged vegetation is generally greatest in late summer and varies from year to year. Vegetation mats predominantly occur at the upper end of the lake, in the Bill Williams River inlet area, and along shorelines. Mississippi State University completed a vegetation study on Lake Havasu in 2011. They reported that submerged vegetation could persist to a depth of 30 feet due to the water clarity and that the vegetation mats consisted mostly of Sago Pondweed *Stuckenia pectinata*, Southern Naiad *Najas guadalupensis*, and Spiny Naiad *Najas marina*. They also reported finding 17 different plants species in Lake Havasu.

Habitat

The Department will continue the partnership with the LHFIP that began in 1992. Within the first ten years, the LHFIP had put approximately 875 acres of fish habitat in 42 coves. As with many reservoirs along the lower Colorado River, Lake Havasu was very limited in natural habitat available to fish. The LHFIP has been very successful in helping to make Lake Havasu a premier fishery.

Types of habitat used included bundles of plastic pipe, rolled snow fence, PVC frames covered with snow fence, commercially produced plastic "trees", and brush bundles. Approximately 140,000 individual structures were put in the lake over the first ten years. The program is mostly in a maintenance mode now with a goal of placing a minimum of 800 brush bundles per year to replace deteriorating bundles. The program will also be evaluating types of more permanent habitat to replace deteriorating plastic habitat.

Forage/Prey

Management of forage fishes in Lake Havasu should focus on maintaining a diverse forage base to support healthy predatory fish populations. Bluegill Sunfish, Redear Sunfish, Threadfin Shad, and Gizzard Shad contribute the most to the forage base in Lake Havasu. Populations of Threadfin Shad, a mostly pelagic fish in Lake Havasu, can vary annually. The underlying biological causes for variability in the Lake Havasu Threadfin Shad population is unknown at this time.

Surveys conducted prior to 2014 were species-specific surveys, primarily targeting Largemouth Bass. Community-wide surveys have been conducted since 2014 to collect data on relative abundance and species composition in the lake, which will help to better quantify forage fish abundance. Forage fish have comprised at least 50% of the total catch during fall electrofishing since 2014 (Figure 5). In 2018, the Region IV Aquatic Wildlife Program began to measure total length (mm) and wet weight (g) of Threadfin and Gizzard Shad sampled to gain a better understanding of the population. With additional community-wide surveys, managers hope to better understand the connection between the abundance of shad and other forage fish, as well as lake conditions, both biotic and abiotic.

If after several years of community-wide surveys, biologists are still unable to understand the connections between lake conditions and forage abundance, alternative survey methods may be required. One possible alternative survey method to assess pelagic fish populations is hydroacoustic sonar, which has been utilized nationwide to accurately assess abundance of pelagic fishes. We recommend research the efficacy and efficiency to establish standard sampling through the use of hydroacoustics to better assess forage base moving forward.

The Department is unaware of any data collected on non-fish forage sources (i.e. plankton, macrophytes, crayfish, invertebrates, etc.) in Lake Havasu. An increased understanding of the links between aforementioned forage sources could help better inform fisheries management in Lake Havasu. Quagga mussels became established in the lake in 2007 and Redear Sunfish are known to feed on them. Since Quagga Mussels became established, world record Redear Sunfish have been caught in the lake.

Species

Largemouth Bass

Annual fall electrofishing surveys have been conducted for many years to assess fish populations by the Department and CDFW. Prior to 2014, these surveys have primarily targeted Largemouth Bass. The national standard for assessing Largemouth Bass populations requires spring nighttime sampling however, so future population sampling will switch over to the spring months. Fall sampling is still valuable and spot check type surveys to assess relative reproductive success of Centrarchids will still occur.

The Largemouth Bass fishery in Lake Havasu is managed for the High Quality concept. This concept has metrics for spring electrofishing CPUE, Relative weight (W_r), Proportional Size Distribution (PSD) and angler Catch per Unit Effort (CPUE). Average Lake Havasu Largemouth Bass CPUE for electrofishing surveys from 2014 to 2018 was 33.1 fish per hour (Figure 6). This is below the objective for the management concept (CPUE > 100 fish per hour of electrofishing).

The length frequency distribution for Largemouth Bass caught during the 2014 - 2018 surveys are shown in Figure 7. The 2018 distribution is similar to 2014 - 2017 and indicates multiple size classes in Largemouth Bass sampled from Lake Havasu. The PSD for Largemouth Bass caught during the 2014 survey was 64 (Table 2), which is similar to estimated PSD for 2014 – 2017 and meets management objectives. Gablehouse (1984) indicated that PSD values of 40-70 for Largemouth Bass generally indicate a balanced population.

The mean estimated W_r of Lake Havasu Largemouth Bass caught during electrofishing surveys from 2014 to 2018 was 92 (Figure 8). This meets the Department's Warmwater Sportfisheries Strategic Vision estimated mean relative weight objectives for the High Quality fishery.

Smallmouth Bass

Lake Havasu is capable of producing some of the largest Smallmouth Bass in the southwest. This fact was validated in 2017 when Lake Havasu produced the most recent Colorado River record for Smallmouth Bass in 2017 of 6.28 pounds, but the population is little understood by fisheries managers at this time largely due to low samples sizes during fall electrofishing surveys.

The Smallmouth Bass fishery in Lake Havasu is also managed according to the High Quality concept. This also has metrics for spring electrofishing CPUE, W_r, PSD and angler CPUE. Lake Havasu Smallmouth Bass CPUE from 2014 to 2018 was 10.3 fish per hour (Figure 9). This is below management objective for the concept. While sample sizes are small, Smallmouth Bass proportional length frequency from 2014 to 2018 surveys indicate multiple size classes (Figure 10). Smallmouth Bass PSD was not calculated in 2018 due to the low sample size. The mean estimated W_r of Lake Havasu Smallmouth Bass caught during electrofishing surveys from 2014 to 2018 was 89 (Figure 11) which is slightly below management objective ($90 < W_r < 105$). Smallmouth Bass habitat preference may be limiting the efficacy of shoreline electrofishing surveys in the fall. To better assess the Smallmouth Bass population, the Region IV Aquatic Wildlife Program may need to create a species-specific survey in the future.

Redear Sunfish

Lake Havasu is also managed as a featured species water for Redear Sunfish, which has metrics for age distribution, PSD and angler CPUE. Lake Havasu offers a unique opportunity for anglers targeting trophy-sized Redear Sunfish, in fact the current all tackle world record as certified by the IGFA was caught in Lake Havasu in 2014 and weighed in at 5.8 pounds. As an index of age class distribution, Lake Havasu electrofishing surveys show multiple size classes, indicating multiple age classes (Figure 12). Management of Redear Sunfish will strive to maintain a PSD value of 20 - 40 with a PSD-M+ >10, which should provide anglers the chance to catch large Redear Sunfish, yet provide small fish for anglers to catch into the future. PSD-M+ can be defined as all fish greater than memorable size. During the 2018 fall electrofishing sample, the Redear Sunfish met objectives for PSD with a PSD of 27 with a PSD M+ of 11 (Table 2).

Striped Bass

Finally, Lake Havasu is managed as a general opportunity water for Striped Bass which has metrics for age distribution and angler CPUE. General opportunity objectives include multiple age classes, as well as CPUE goals of greater than 50 fish per hour and angler CPUE no less than one fish per hour. The 2018 survey yielded an estimated mean CPUE of Striped Bass of 185.3 fish per hour, which was above management objectives (Figure 13). As an index of age class distribution, Lake Havasu electrofishing surveys show multiple size classes of Striped Bass, indicating multiple age classes (Figure 14). While the 2018 survey met management objectives, Striped Bass are a pelagic species, and as such are difficult to target in a typical shoreline electrofishing survey. To better assess the Striped Bass population, the Region IV Aquatic Wildlife Program may need to create a species-specific survey in the future.

Undesirable or Invasive Species

There was a large fish kill in 2009 which only involved Common Carp *Cyprinus carpio* and was attributed to the Koi Herpes Virus (Cyprinivirus: Cyprinus herpesvirus 3). Subsequent outbreaks have been mild. Bacterial outbreaks (e.g. *Escherichia coli*) have historically caused localized concerns. These have not caused concern recently.

Quagga Mussel, Asian Clam *Corbicula fluminea*, Bullfrog *Lithobates catesbeiana*, Golden Algae, *Prymnesium parvum*, Northern Crayfish *Orconectes virilis*, Gizzard Shad *Dorosoma cepedianum*, Curly Pondweed *Potamogeton crispus*, and Eurasian watermilfoil *Myriophyllum spicatum*, have all been documented in Lake Havasu. Of these, Quagga Mussel and Golden Algae are the only ones that are currently listed on the state Aquatic Invasive Species (AIS) list. The Department has an active AIS program at Lake Havasu mostly associated with Quagga Mussels. The Department provides education, outreach, and decontamination services for Quagga Mussels. The Department also assists with monitoring and surveillance for other AIS in Lake Havasu. However, coordinated surveillance, reporting, impact evaluation, and response need to be improved. Currently, no effect to the fish has been noted with the presence of Golden Algae likely due to water conditions that are incompatible for Golden Algae to thrive. Gizzard Shad is the most recent species to invade Lake Havasu and its full impacts are not yet known.

Access

Lake Havasu has many access points. The majority of vehicular access occurs on the Arizona side of the lake from Highway 95. Boat ramps at Lake Havasu include ramps located at Take-Off Point, Havasu Springs Resort, Cattail Cove State Park, Lake Havasu Marina, Islander Resort, Beachcomber Resort, Site Six, Crazy Horse Campground, Havasu State Park, Black Meadow Landing, Havasu Palms, and Havasu Landing Resort (Figure 3).

There are also seven improved fishing piers open to the public on Lake Havasu (Figure 4). There are three piers located on the Havasu National Wildlife Refuge (Mesquite Bay North and Mesquite Bay South), one at Site Six, two at the Bill Williams National Wildlife Refuge, one at Contact Point, and two at Take-Off Point. These piers were mostly developed through the Lake Havasu Fisheries Improvement Program. Additionally, most of the land adjacent to the Lake Havasu on the east side is public land and open for fishing. Even though public land is relatively abundant on the lakeshore of Lake Havasu, the thickly vegetated nature of the riparian area makes fishing access difficult or even impossible in many areas. In the areas where access is easier due to more thin vegetation, the lake bottom tends to be more shallow and sandy in nature leading to poor fishing success. Due to these facts, there is a need to develop more fishing areas on Lake Havasu. The Department should work with partners of the Lake Havasu Fisheries Improvement Program to increase the number of fishing piers or shoreline access areas on Lake Havasu to help provide anglers with increased angling opportunities and hopefully increased angling success.

The current condition of fishing piers on Lake Havasu are good with no known large scale issues. Several docks do have small maintenance issues (e.g. solar powered lights that are not working or railings that have been slightly damaged). The partners of LHFIP should work together to rectify these small issues before they become large. BOR attempts to perform dive surveys of each fishing pier or structure every two or three years to provide partners with general condition and to determine if repairs are required to keep the fishing piers operating in a safe manner. If after one of these dives the docks are reported to need large scale repairs, the Department should attempt to work with partners to help repair them in a timely manner.

Submerged vegetation can cause minor, temporary, and localized problems for boat and angling access. This is not currently considered a problem and local management agencies currently deal with any issues.

Catch

Lake Havasu is the most speciose sport fishery in Region IV. During the 2017 - 2018 Lake Havasu creel survey, anglers were asked what species they targeted during their fishing day. The majority of anglers interviewed declared they were targeting multiple fish species (i.e. if an angler declared they were targeting Largemouth Bass, Smallmouth Bass, and Striped Bass all species were recorded as targeted). Due to this majority of anglers declaring that they were fishing for multiple fish species, the final percentage of anglers targeting individual fish species may exceed 100 percent.

The fish species most targeted by Lake Havasu anglers was Smallmouth Bass (61.8%) (Table 3). The next most targeted species categories were: Largemouth Bass (61.2%), Striped Bass (28.1%), Anything (15.1%), Redear Sunfish (6.2%), Any Sunfish species (0.9%), Channel Catfish (0.8%), and Flathead Catfish (0.7%).

From July 2017 - June 2018, there were an estimated 67,076 angler use days on Lake Havasu (Table 4). An estimated total of 293,926 fish were caught, including an estimated 119,292 Striped Bass, 86,920 Largemouth Bass, 51,441 Smallmouth Bass, 25,011 Redear Sunfish, 6,951 Bluegill, 594 Channel Catfish, and 20 Flathead Catfish (Table 6). Overall harvest of Lake Havasu's fisheries was estimated at 18.7%. Estimated total harvest of fish was 55,045 fish, including 44,201 Striped Bass, 8,621 Redear Sunfish, 1,445 Bluegill, 376 Channel Catfish, 357 Largemouth Bass, 25 Smallmouth Bass, and 20 Flathead Catfish (Table 6). The average angler CPUE for all fish at Lake Havasu was estimated at 0.74 fish per hour (Table 5).

While lake-wide catch and harvest rates can provide a large-scale overview of the fishery, species-specific angling catch rates may be more useful in assessing specific fisheries. Lake Havasu anglers targeting Largemouth and Smallmouth Bass (bass) had a species-specific catch rate of 0.49 bass per hour. Anglers who declared they were not attempting to catch bass had a species-specific catch rate of 0.04 bass per hour (Table 7). Anglers targeting Striped Bass had a species-specific catch rate of 0.96 Striped Bass per hour while anglers not attempting to catch Striped Bass had a catch rate of 0.05 Striped Bass per hour (Table 8). Anglers targeting sunfishes had a genus-specific catch rate of 0.62 sunfishes per hour while anglers not attempting to catch sunfishes had a catch rate of 0.01 sunfishes per hour (Table 8). (Table 9). All the aforementioned catch rates were below the individual management objectives. The Region IV aquatic wildlife program will continue to monitor angler catch rates with future creel surveys. If management objectives are not met in future creel surveys, some management action may be taken, including public education on lake-specific fishing techniques for Lake Havasu, regulation changes, or stockings.

In addition to the creel survey of Lake Havasu, the Region IV Aquatic Wildlife Program has been using angling tournament results from 2010 – 2019 as an index to assess bass populations. Indices include the winning 5-fish tournament bag weights, largest fish, number of fish caught per team, and the average number of Largemouth and Smallmouth Bass caught in each tournament. As angling tournaments are held throughout the year, the data provides additional temporal resolution to evaluating Lake Havasu's sportfisheries. Furthermore, utilizing angling tournament data can be used as indices for angler CPUE and satisfaction management objectives. Dolman (1991) found that though angling tournaments may concentrate fishing pressure for brief periods, direct comparisons showed that tournament anglers and non-tournament anglers were equally successful and thus in the absence of creel surveys, tournament results can be a good method to track fishing success at a waterbody. Furthermore, Willis & Hartmann (1986) found that data collected from angling tournaments could be successfully used to monitor Largemouth Bass trends both statewide and in individual water bodies. Most metrics (i.e. 5-fish tournament bag weights, largest fish, and mean number of fish caught per team) have not significantly changed in the last nine years (Figure 15, 16, and 17). However, average number of Smallmouth Bass per bag has decreased significantly since 2010 ($df = 210$, $p < 0.05$) (Figure 18) while average number of Largemouth Bass per bag has increased significantly since 2010 ($df = 210$, $p<0.05$) (Figure 19). The Region IV Aquatic Wildlife

Program will continue to monitor angling tournament results as an indicator of the Lake Havasu fishery.

Satisfaction

During the 2017 - 2018 creel survey, anglers were asked to rate their fishing experience at Lake Havasu (Figure 20). Of the people interviewed, 64.4% rated their fishing experience as "fair" or better, which is below management objective of 80% for quality fisheries outlined in the Warmwater Sportfisheries Strategic Vision Document. While the exact reasons are unknown, this could be attributed to low catch rates. The Department may benefit from public education on lake-specific angling techniques. Two other areas that can influence higher catch rates includes placement of fish habitat and development of new access points. If we can increase fishing success we can improve angler satisfaction. The Department will attempt to perform creel surveys on a five-year basis.

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Tables

Table 2: Species, total number of fish caught (n), number of stock-size fish, proportional size distribution (PSD) of Largemouth Bass and Redear Sunfish sampled during fall 2018 Lake Havasu electrofishing surveys.

Species	#	No. of Stock-Size Fish[a]	PSD[b]	PSD S-Q[c]	PSD Q-P[c]	PSD P-M[c]	PSD M-T[c]	PSD T[c]
Largemouth Bass	265	141	75	25	31	39	5	0
Redear Sunfish	874	643	27	73	6	9	7	4

[a] Stock-size Fish = Largemouth Bass >199 mm, Smallmouth Bass >179mm, and Redear Sunfish >99mm.
[b] PSD = Percent of stock-size fish: Largemouth Bass >299 mm, Smallmouth Bass >279mm, and Redear Sunfish >179mm
[c] PSD = Proportional size distribution: S-Q=Stock to Quality, Q-P=Quality to Preferred, P-M=Preferred to Memorable, M-T=Memorable to Trophy.

Table 3. Summary of species preference question for all anglers interviewed during the creel survey of Lake Havasu from July 2017 - June 2018.

All Anglers		
Species	**Number of Anglers Attempting to Catch**	**Percent of Total Anglers Attempting to Catch**
Smallmouth Bass	521	61.8
Largemouth Bass	516	61.2
Striped Bass	237	28.1
Anything	127	15.1
Redear Sunfish	52	6.2
Any Sunfish Species	8	0.9
Channel Catfish	7	0.8
Flathead Catfish	6	0.7

Table 4. Estimated angler hours, estimated angler use days, and average hours fished for anglers of Lake Havasu during creel survey.

Angler Type	Estimated Angler Hours	Estimated Angler Use Days	Average Hours Fished
Boat	332,285	62,402	5.32
Shoreline	16,856	4,674	3.61
Total:	349,141	67,076	5.21

Table 5. Estimated catch and harvest with percent harvested by season and angler type.

	Boat Anglers			Shore Anglers			Overall (Boat+Shore)		
Season	**Estimated Fish**	**Season %**	**Mean* Fish/hr.**	**Estimated Fish**	**Season %**	**Mean* Fish/hr.**	**Estimated Fish**	**Season %**	**Mean* Fish/hr.**
Catch									
Summer	180,069	61.26%	0.90	3,996	38.39%	0.62	184,065	60.48%	0.82
Winter	113,858	38.74%	0.68	6,413	61.61%	0.84	120,271	39.52%	0.72
Total:	*293,926*	100.00%	*0.73*	10,410	100.00%	*0.79*	304,336	100.00%	*0.74*
Harvest									
Summer	18,335	33.31%	0.08	876	46.06%	0.11	19,211	33.73%	0.09
Winter	*36,710*	66.69%	0.14	1,025	53.92%	0.11	37,735	66.26%	0.13
Total:	*55,045*	*100.00%*	0.13	*1,902*	100.00%	*0.11*	56,947	100.00%	*0.12*
% Harvested									
Summer	10.18%			21.92%			10.44%		
Winter	32.24%			15.99%			31.38%		
Overall:	18.73%			18.27%			18.71%		

** Based on the mean of individual angler fish/hour rates, not number of fish divided by angler hours.*

Table 6. Estimated catch and harvest with percent harvested by species and angler type.

	Boat Anglers			Shore Anglers			Overall (Boat+Shore)		
Species	**Estimated Fish**	**Species %**	**Mean* Fish/hr.**	**Estimated Fish**	**Species %**	**Mean*Fish/hr.**	**Estimated Fish**	**Species %**	**Mean* Fish/hr.**
Catch									
Striped Bass	119,292	40.59%	0.27	7761	74.55%	0.61	127,053	41.75%	0.35
Largemouth Bass	86,920	29.57%	0.24	606	5.82%	0.06	87,526	28.76%	0.2
Smallmouth Bass	51,441	17.50%	0.15	328	3.15%	0.03	51,769	17.01%	0.12
Redear Sunfish	25,011	8.51%	0.04	1,412	13.56%	0.05	26,423	8.68%	0.05
Bluegill Sunfish	6,951	2.36%	0.02	297	2.85%	0.02	7,248	2.38%	0.02
Channel Catfish	594	0.20%	0.00	249	2.39%	0.00	843	0.28%	0.00
Flathead Catfish	20	0.01%	0.00	0	0.00%	0.00	20	0.01%	0.00
Total:	***293,926***	***100.00%***	***0.73***	***10,410***	***100.00%***	***0.78***	***304,336***	***100.00%***	***0.74***
Harvest									
Striped Bass	44,201	80.30%	0.10	874	45.95%	0.06	45,075	79.15%	0.09
Largemouth Bass	357	0.65%	0.00	66	3.47%	0.00	423	0.74%	0.00
Smallmouth Bass	25	0.05%	0.00	0	0.00%	0.00	25	0.04%	0.00
Redear Sunfish	8,621	15.66%	0.01	658	34.60%	0.04	9,279	16.29%	0.02
Bluegill Sunfish	1,445	2.63%	0.00	68	3.58%	0.00	1,513	2.66%	0.00
Channel Catfish	376	0.68%	*0.00*	229	12.04%	0.01	605	1.06%	0.00
Flathead Catfish	20	0.04%	0.00	0	0.00%	0.00	20	0.04%	0.00
Total:	***55,045***	***100.00%***	***0.13***	***1,902***	***100.00%***	***0.11***	***56,947***	***100.00%***	***0.12***
% Harvested									
Striped Bass	37.05%			11.26%			35.48%		
Largemouth Bass	0.41%			10.89%			0.48%		
Smallmouth Bass	0.05%			0.00%			0.05%		
Redear Sunfish	34.47%			46.60%			35.12%		
Bluegill Sunfish	20.79%			22.90%			20.87%		
Channel Catfish	63.30%			91.97%			71.77%		
Flathead Catfish	100.00%			N/A			100.00%		
Overall:	***18.73%***			***18.27%***			***18.71%***		

** Based on the mean of individual angler fish/hour rates.*

+ Below the 1/1,000th level of precision.

Table 7. Results of analysis contrasting genera-specific catch rates between anglers targeting and not targeting bass.

CPUE	Shore Anglers Targeting Largemouth and Smallmouth Bass	Shore Anglers Not Targeting Largemouth and Smallmouth Bass	All Shore Anglers	Boat Anglers Targeting Largemouth and Smallmouth Bass	Boat Anglers Not Targeting Largemouth and Smallmouth Bass	All Boat Anglers	All Anglers Targeting Largemouth and Smallmouth Bass	All Anglers Not Targeting Largemouth and Smallmouth Bass	All Anglers
Largemouth Bass CPUE	0.26	0.01	0.11	0.31	0.03	0.25	0.31	0.02	0.20
Smallmouth Bass CPUE	0.12	0.01	0.05	0.19	0.02	0.15	0.18	0.02	0.12
Combined CPUE	0.38	0.02	0.17	0.50	0.05	0.40	0.49	0.04	0.32

Table 8. Results of analysis contrasting species-specific catch rates between anglers targeting and not targeting Striped Bass.

CPUE	Shore Anglers Targeting Striped Bass	Shore Anglers Not Targeting Striped Bass	All Shore Anglers	Boat Anglers Targeting Striped Bass	Boat Anglers Not Targeting Striped Bass	All Boat Anglers	All Anglers Targeting Striped Bass	All Anglers Not Targeting Striped Bass	All Anglers
Striped Bass CPUE	1.26	0.06	0.87	0.84	0.05	0.27	0.96	0.05	0.36

Table 9. Results of analysis contrasting genera-specific catch rates between anglers targeting and not targeting sunfish.

CPUE	Shore Anglers Targeting Sunfish	Shore Anglers Not Targeting Sunfish	All Shore Anglers	Boat Anglers Targeting Sunfish	Boat Anglers Not Targeting Sunfish	All Boat Anglers	All Anglers Targeting Sunfish	All Anglers Not Targeting Sunfish	All Anglers
Redear Sunfish CPUE	0.03	0.03	0.02	1.81	0.03	0.04	0.47	0.01	0.04
All Sunfish CPUE	0.05	0.01	0.02	0.41	0.01	0.01	0.15	0.00	0.01
Combined CPUE	0.08	0.04	0.04	2.22	0.04	0.05	0.62	0.01	0.05

Figures

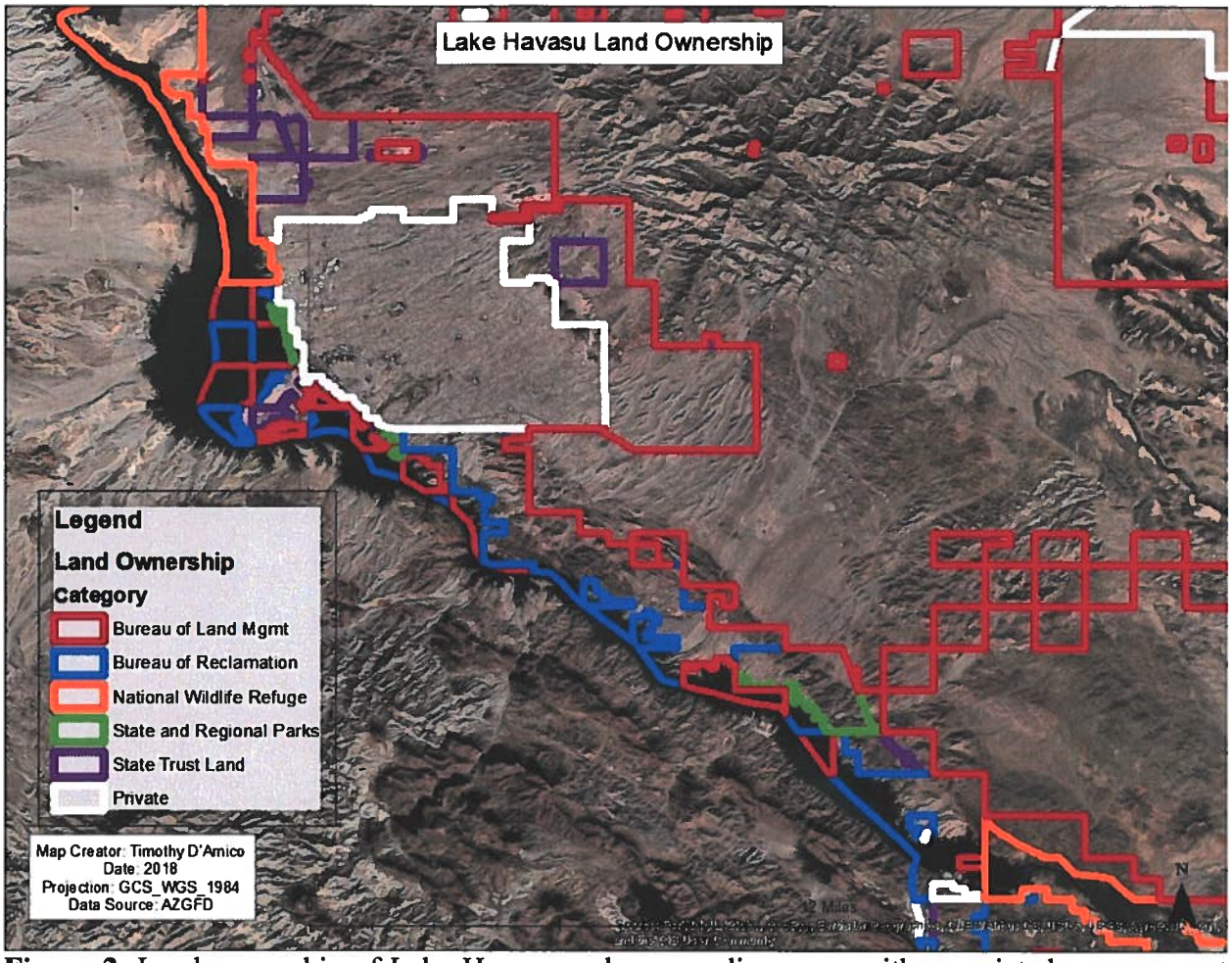

Figure 2. Land ownership of Lake Havasu and surrounding areas with associated management agencies.

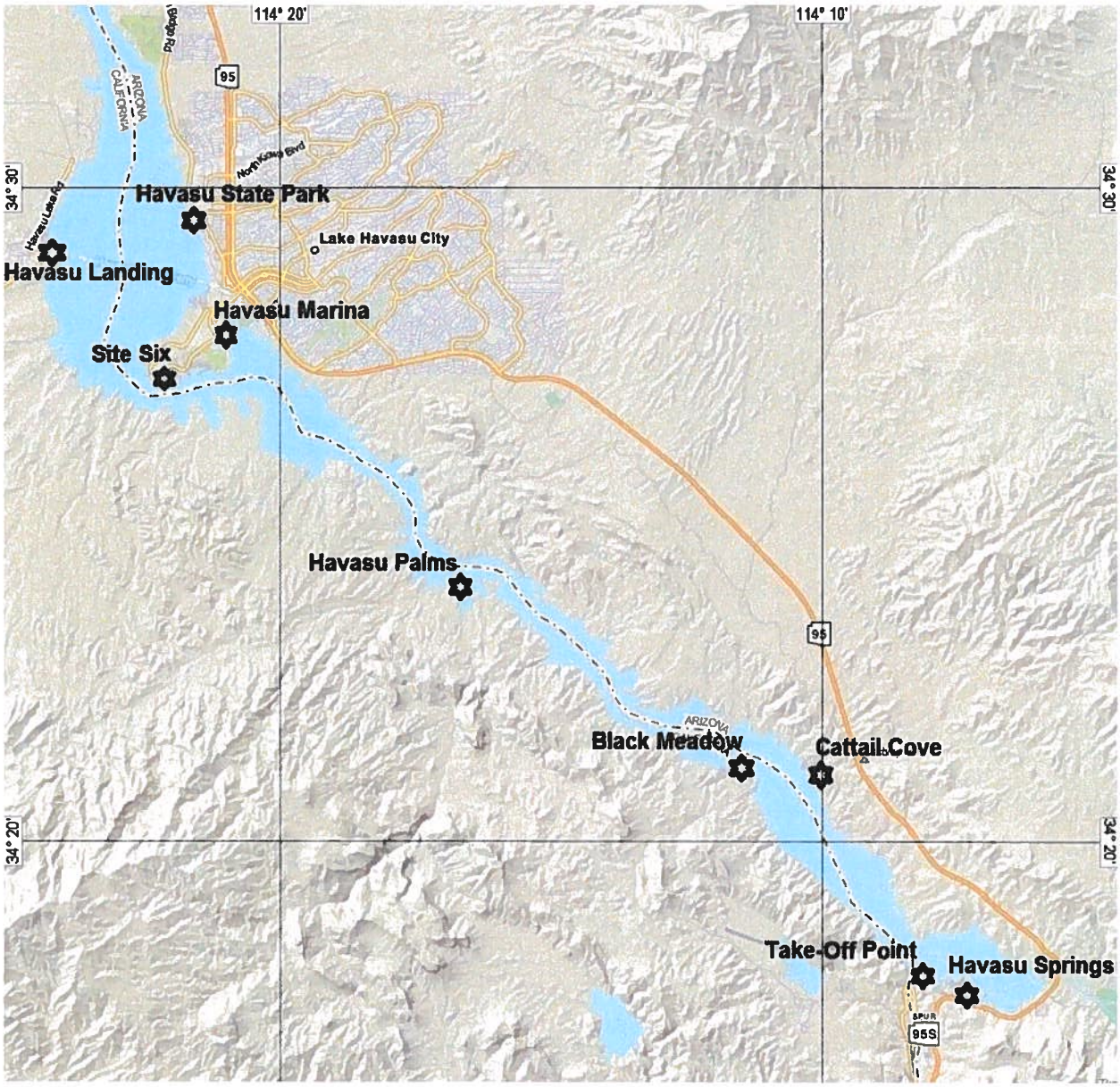

Figure 3. Location of main boat ramps at Lake Havasu.

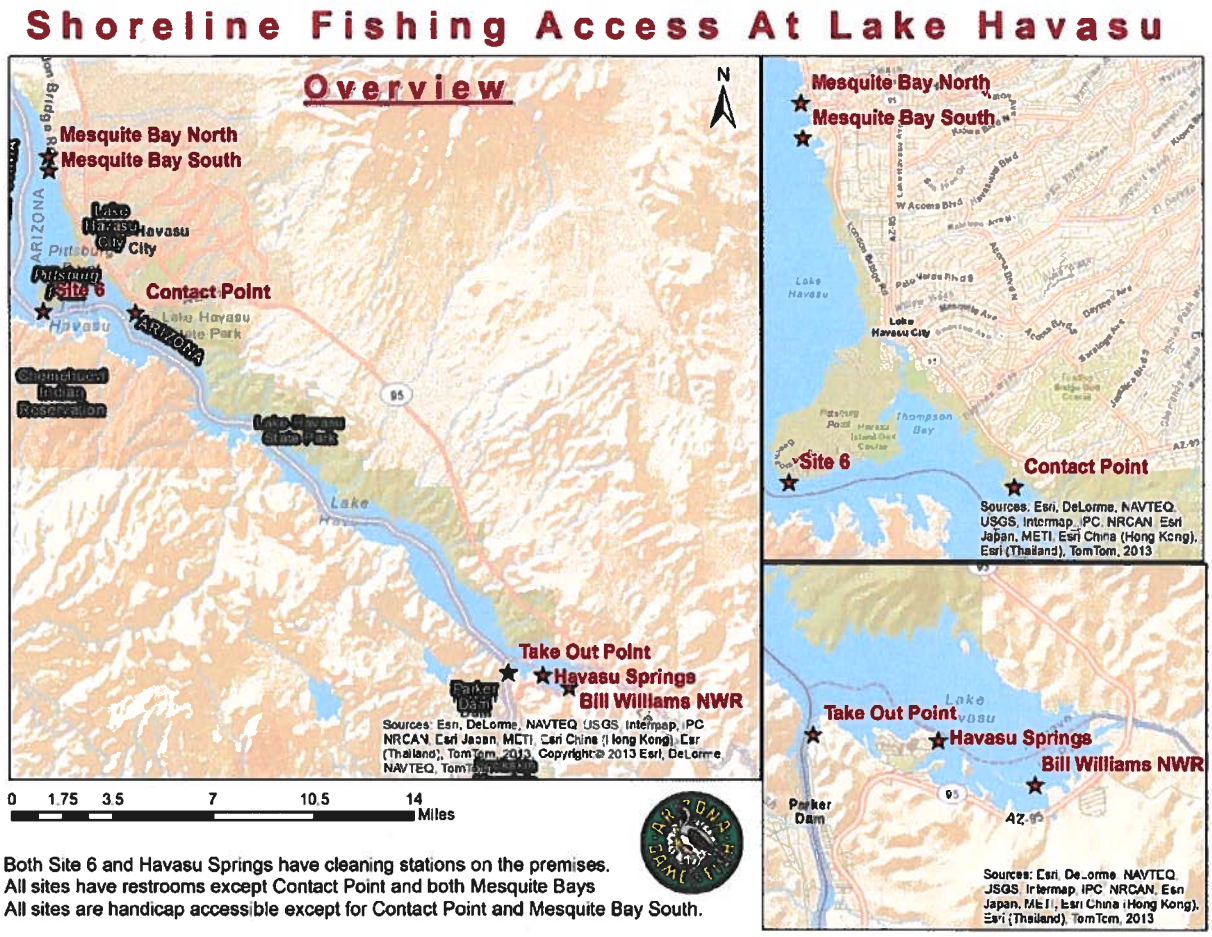

Figure 4. Location of public fishing piers and shoreline fishing access areas at Lake Havasu.

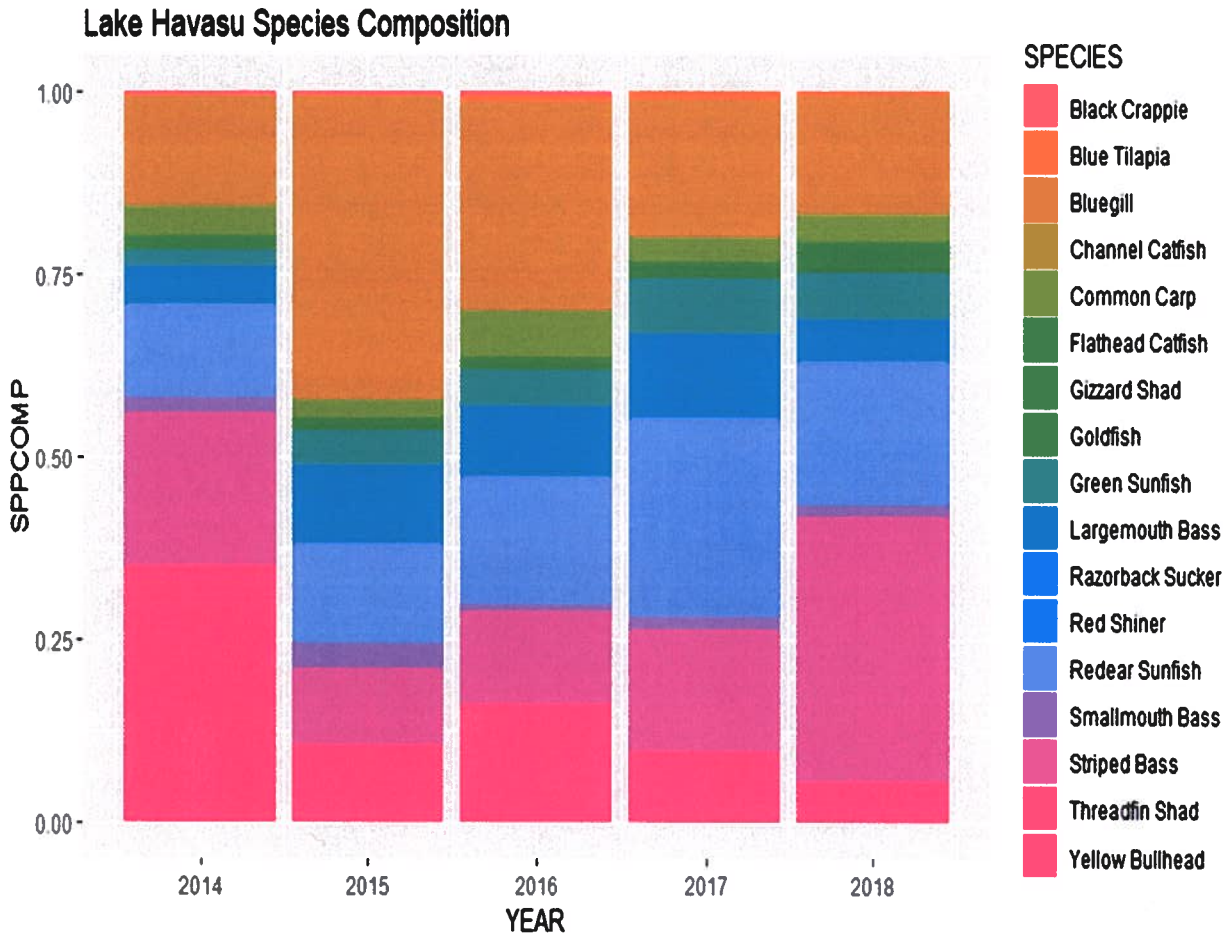

Figure 5. Relative species composition of fish caught at Lake Havasu during a fall electrofishing survey 2014-2018.

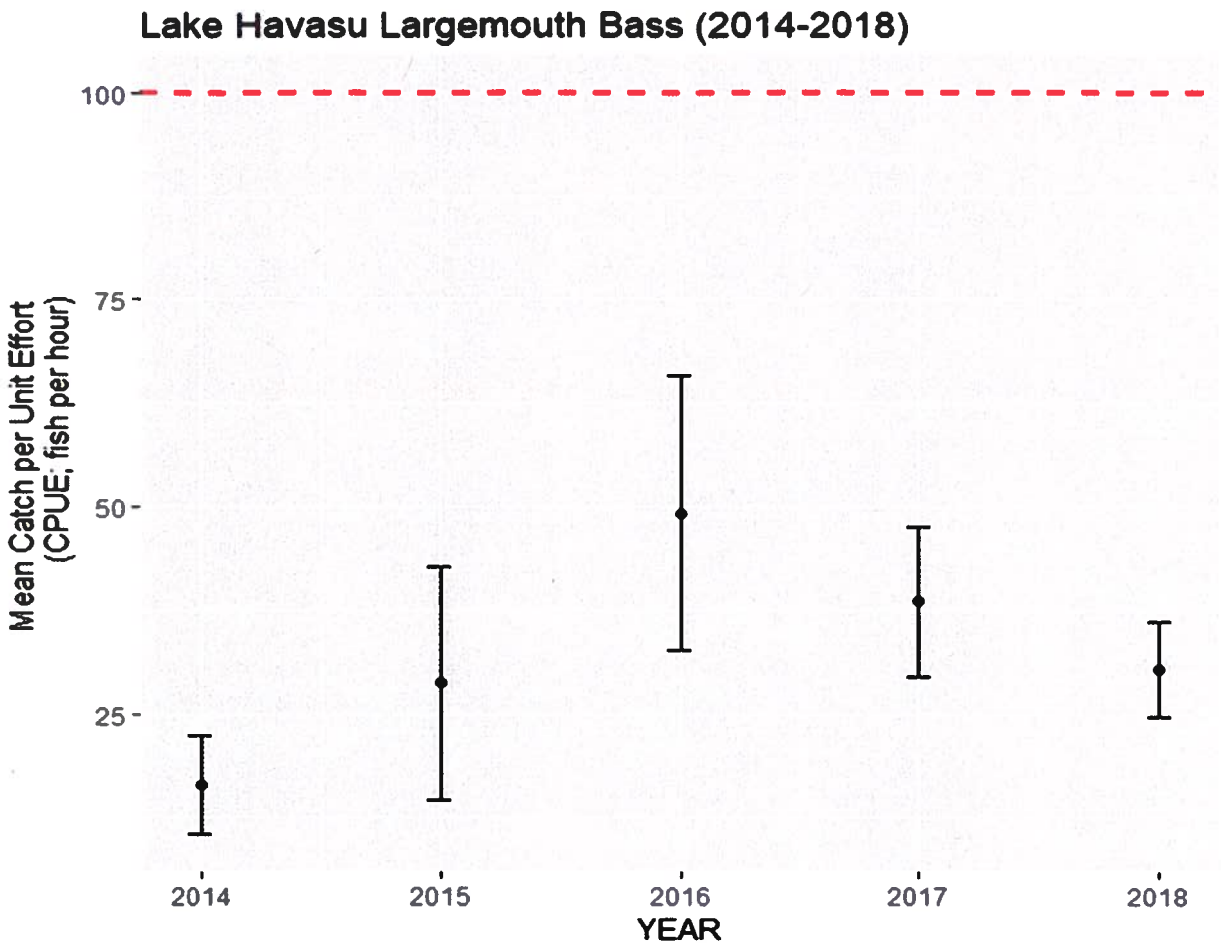

Figure 6. Mean catch per unit effort for Lake Havasu Largemouth Bass caught during fall electrofishing surveys (2014-2018).

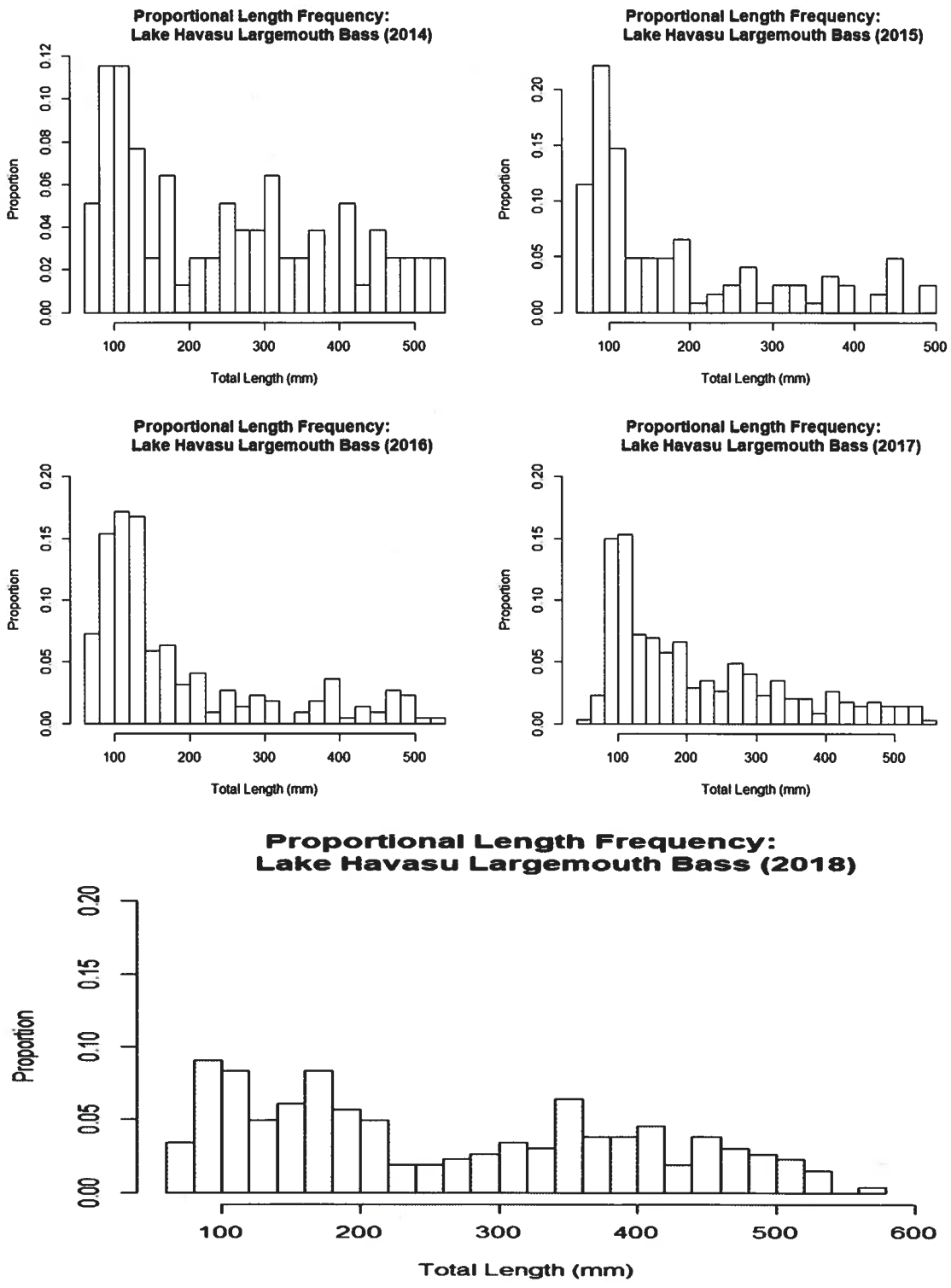

Figure 7. Length-frequency distribution of Lake Havasu Largemouth Bass sampled during fall electrofishing surveys (2014-2018).

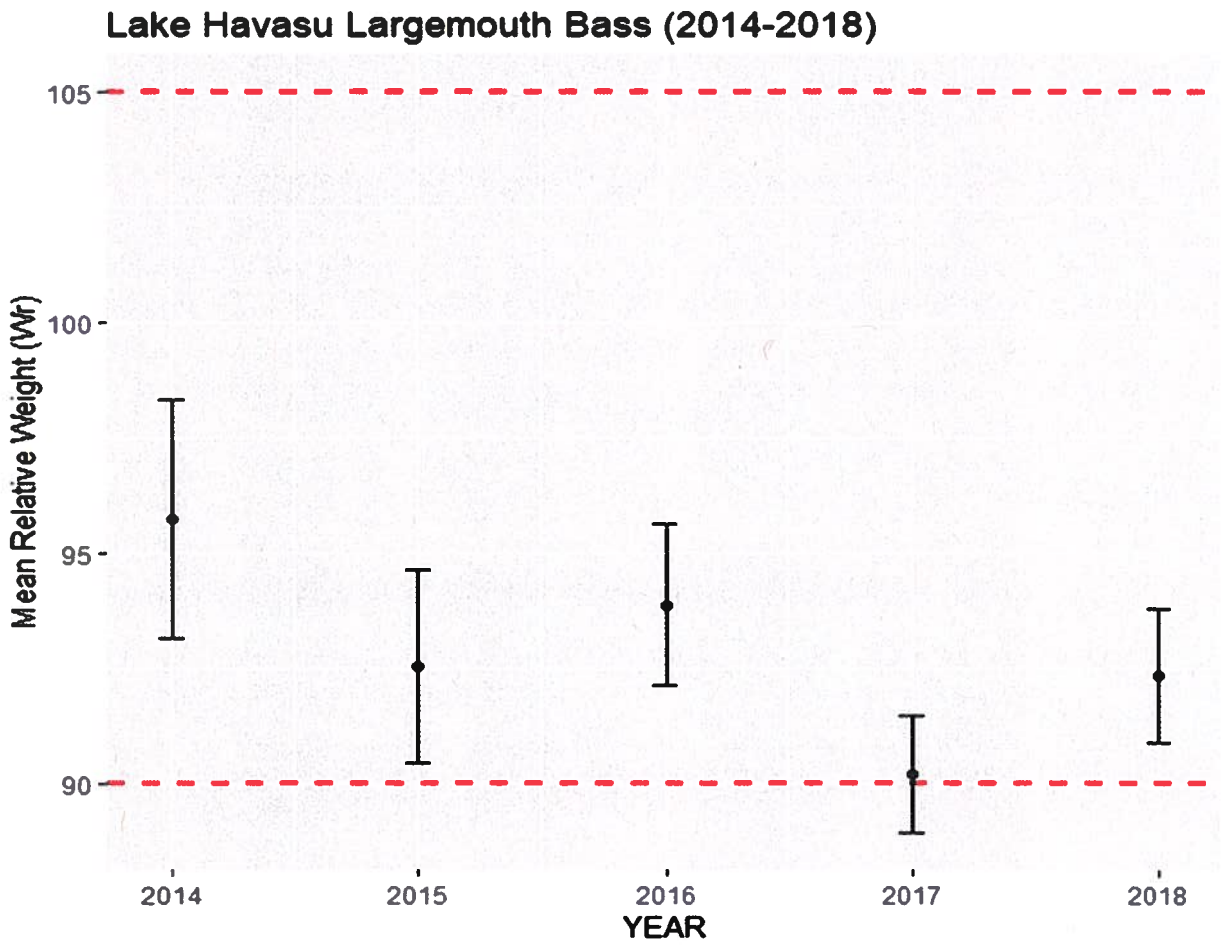

Figure 8. Mean relative weights of Lake Havasu Largemouth Bass caught during fall electrofishing surveys (2014-2018).

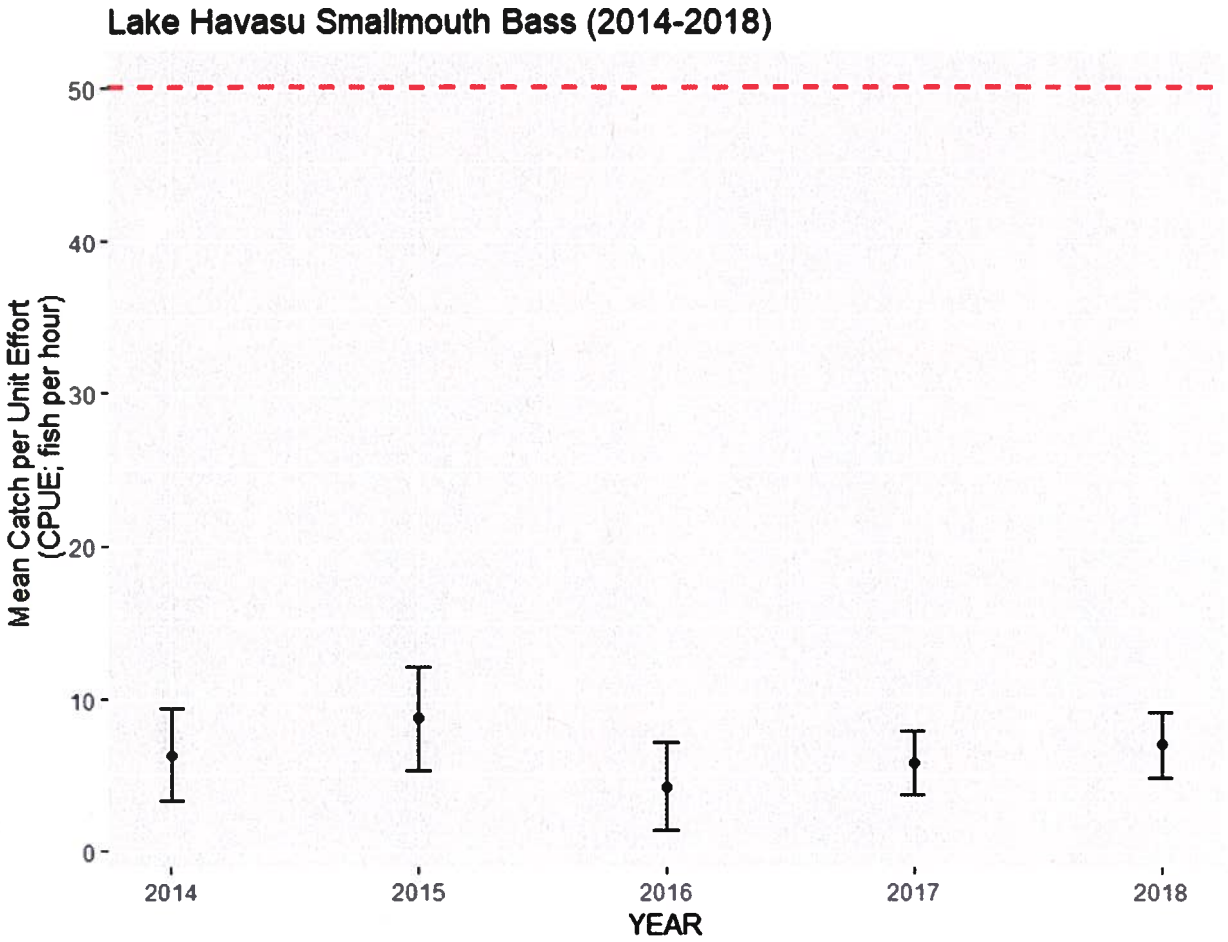

Figure 9. Mean catch per unit effort for Lake Havasu Smallmouth Bass caught during fall electrofishing surveys (2014 – 2018).

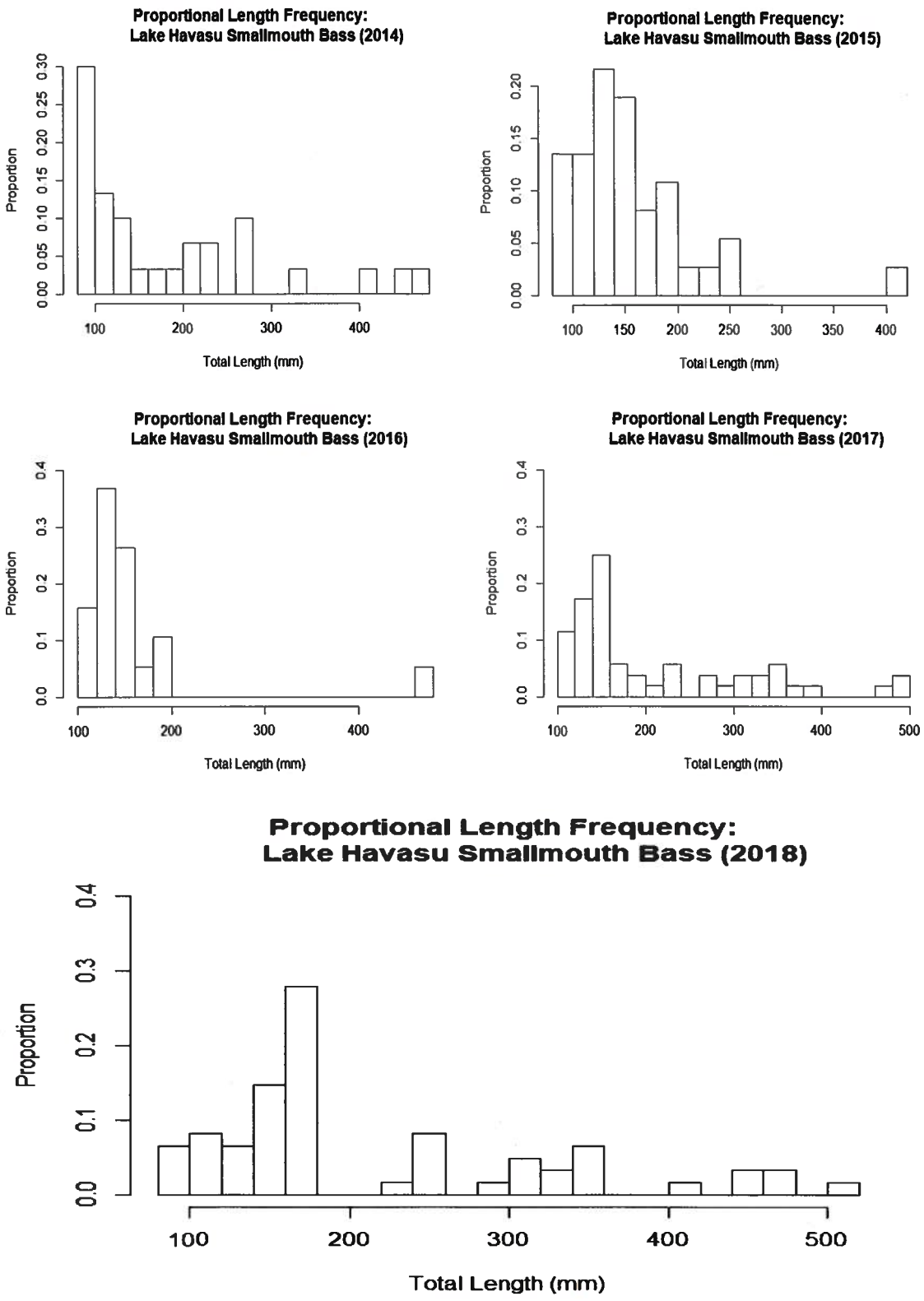

Figure 10. Length-frequency distribution of Lake Havasu Smallmouth Bass sampled during fall electrofishing surveys (2014-2018).

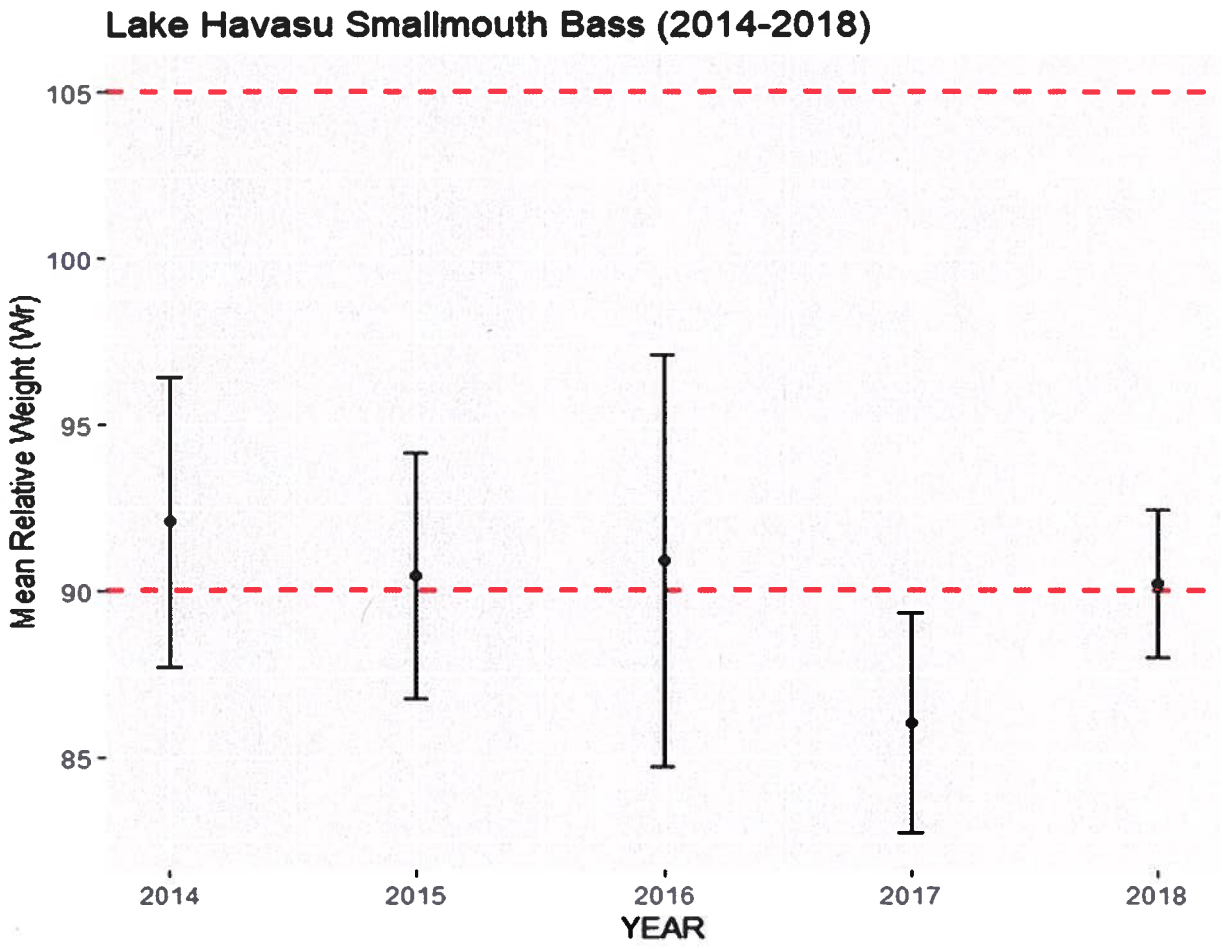

Figure 11. Mean relative weights of Lake Havasu Smallmouth Bass caught during fall electrofishing surveys (2014-2018).

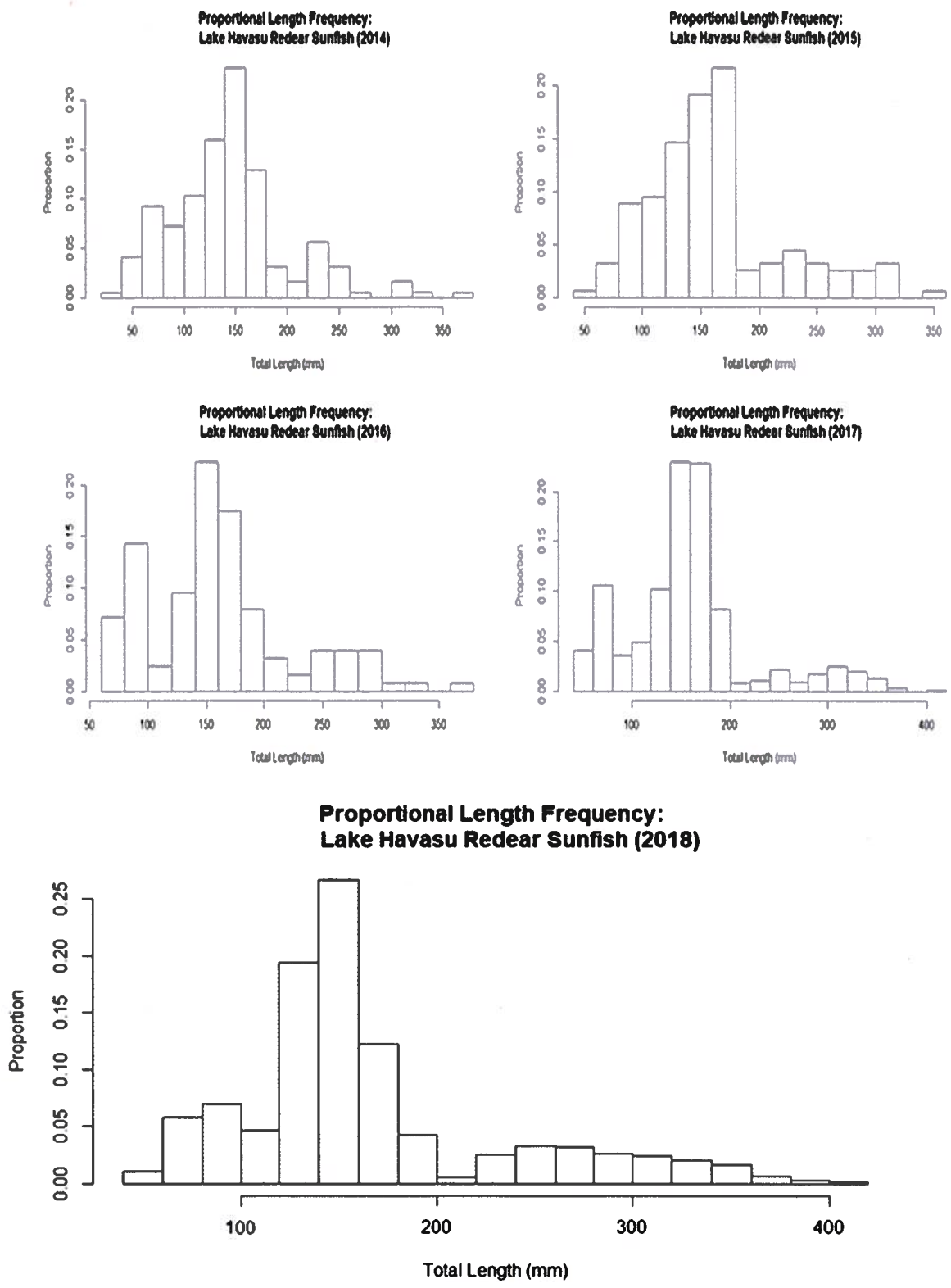

Figure 12. Length-frequency distribution of Lake Havasu Redear Sunfish sampled during fall electrofishing surveys (2014-2018).

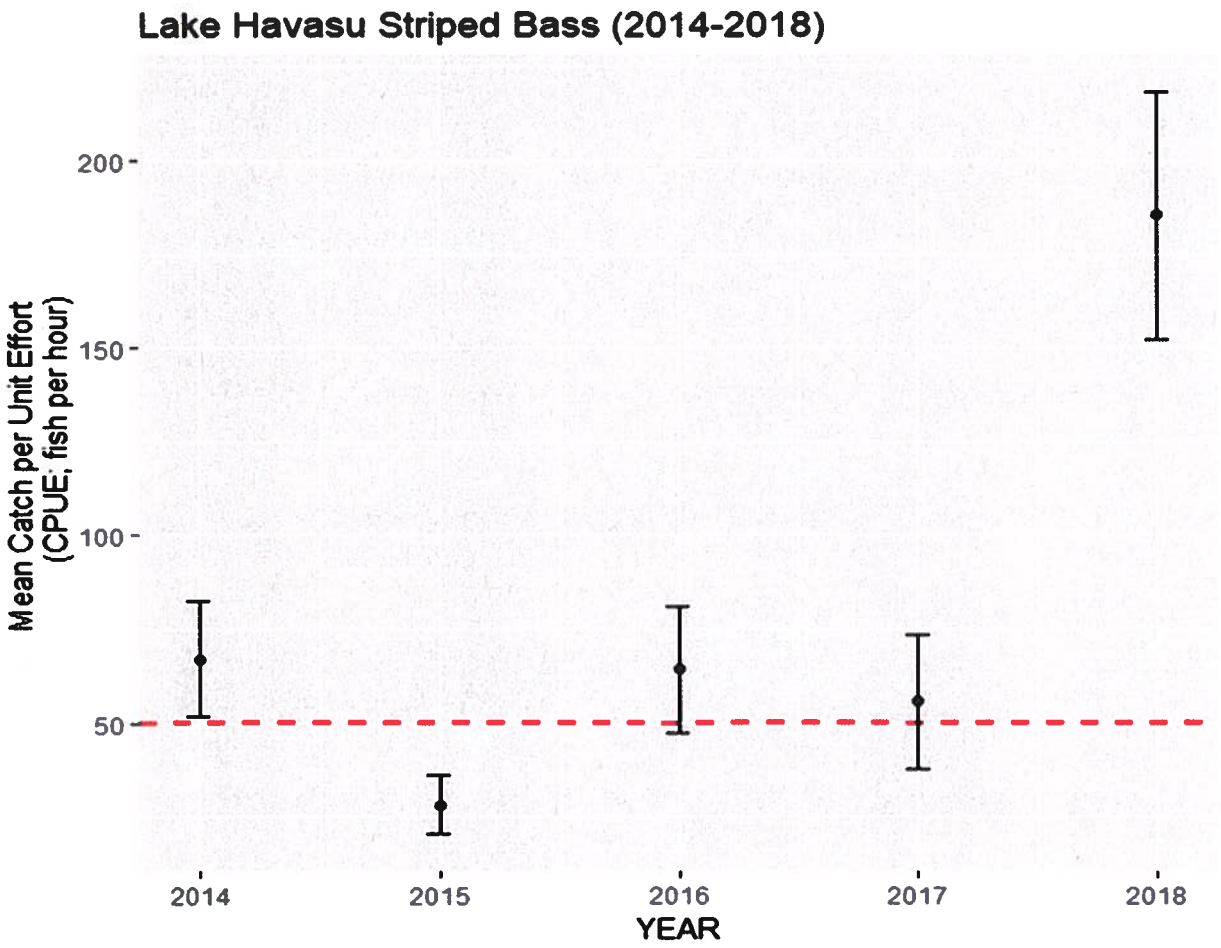

Figure 13: Mean catch per unit effort (CPUE = number of fish per hour) and associated 95% confidence intervals from Lake Havasu Striped Bass (2014-2018). AGFD Warmwater Vision objectives are represented by dashed horizontal red line.

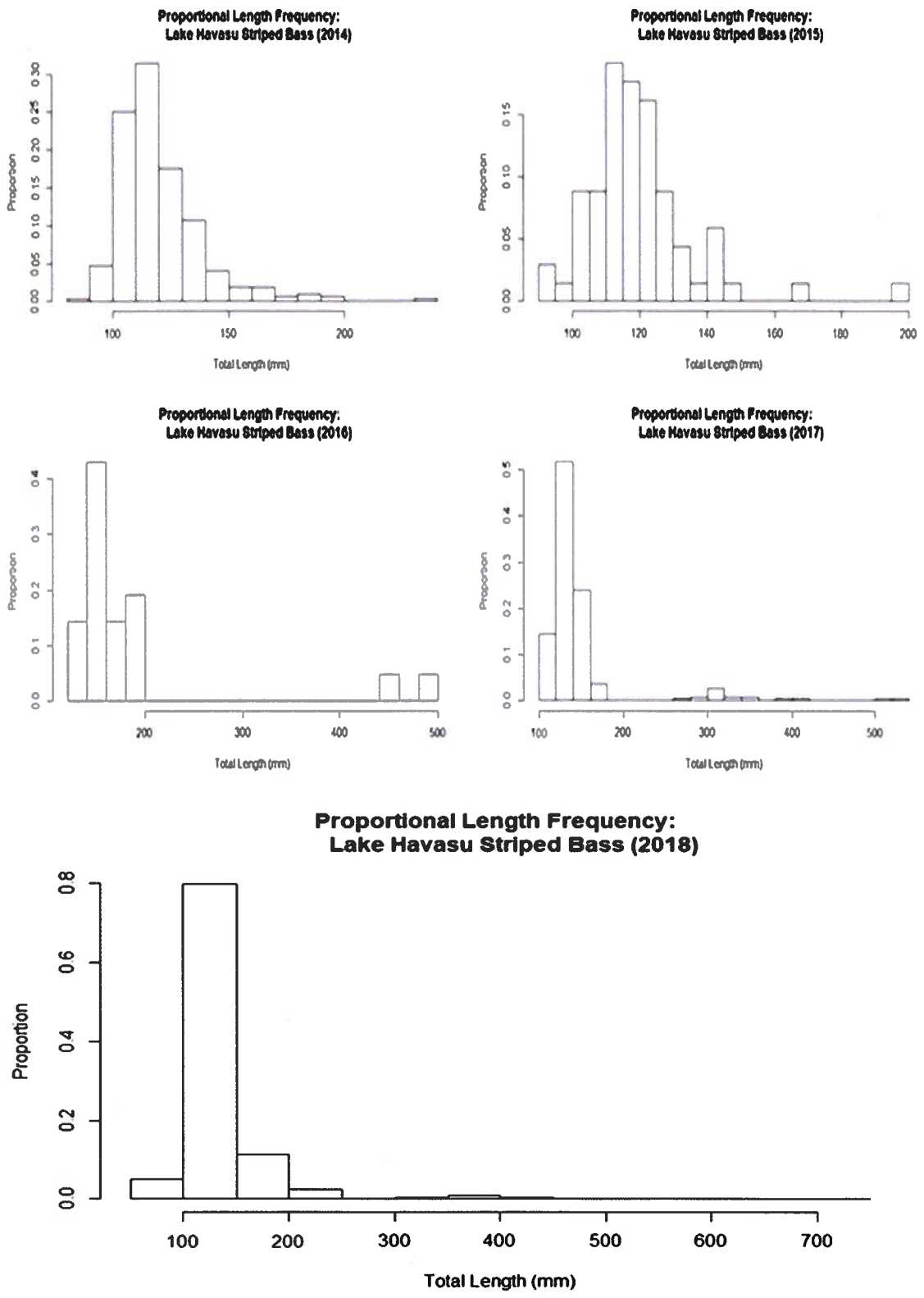

Figure 14. Lake Havasu proportional length frequency distribution of Striped Bass (2014-2018).

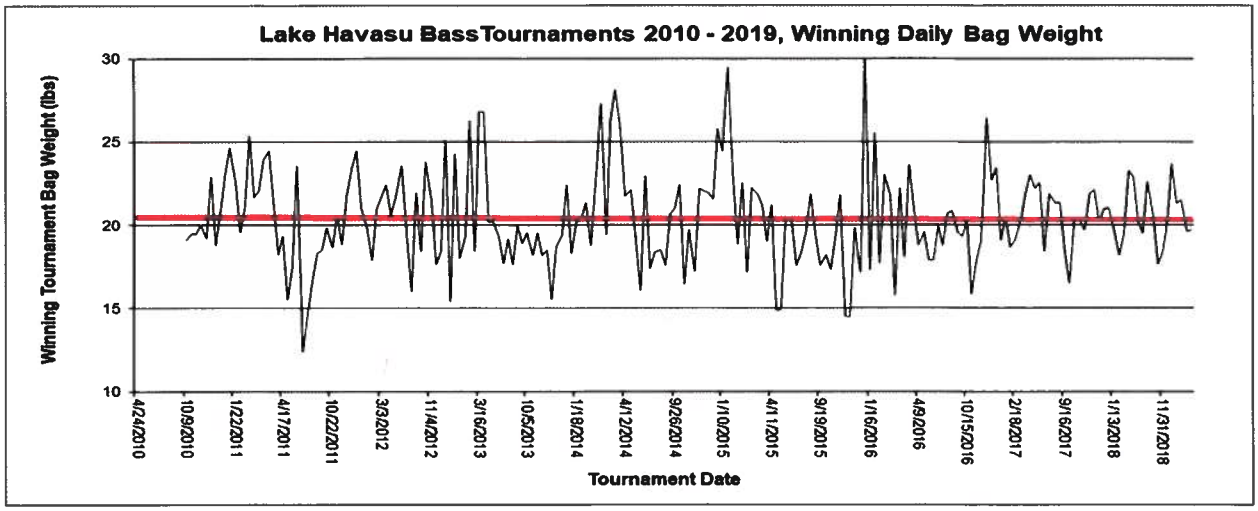

Figure 15. Winning Daily 5-Fish Bag for Bass Tournaments on Lake Havasu 2010 - 2019.

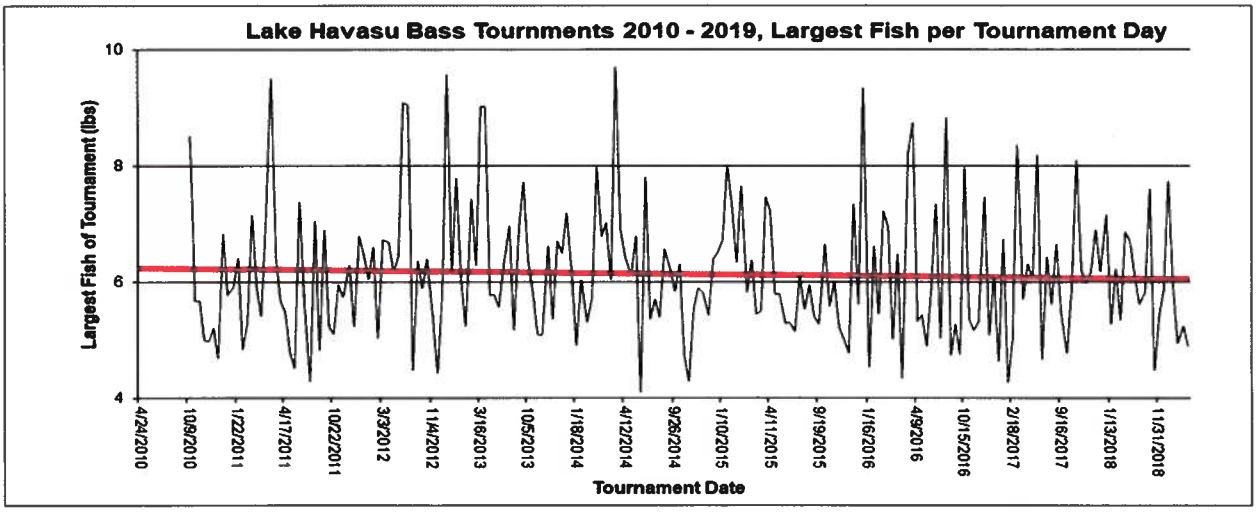

Figure 16. Largest Bass Weighed in for Bass Tournaments on Lake Havasu 2010 - 2019.

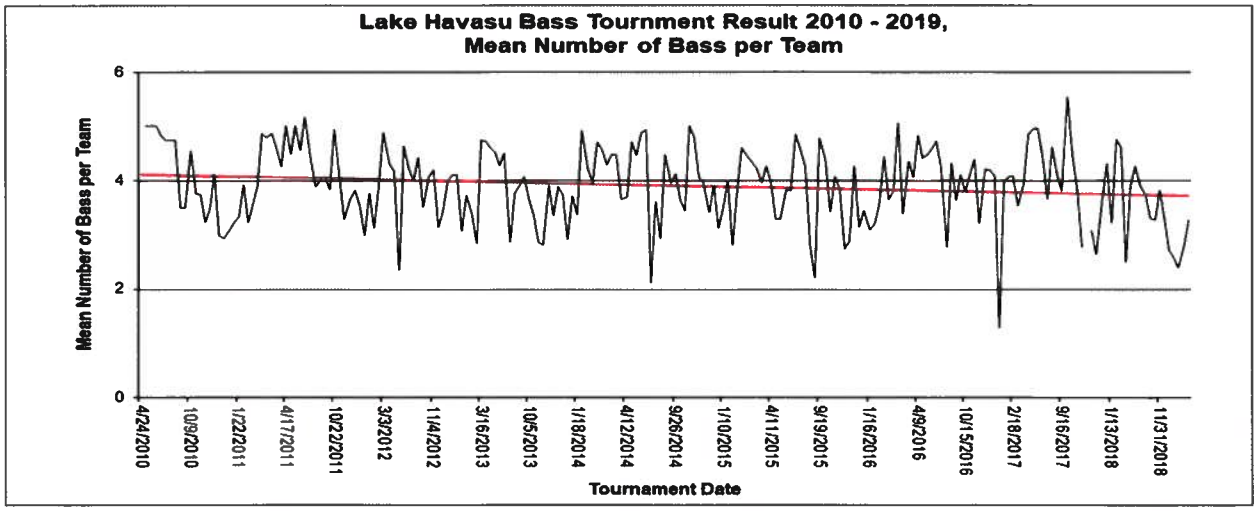

Figure 17. Mean Number of Bass Weighed in per Team for Bass Tournaments on Lake Havasu 2010 - 2019.

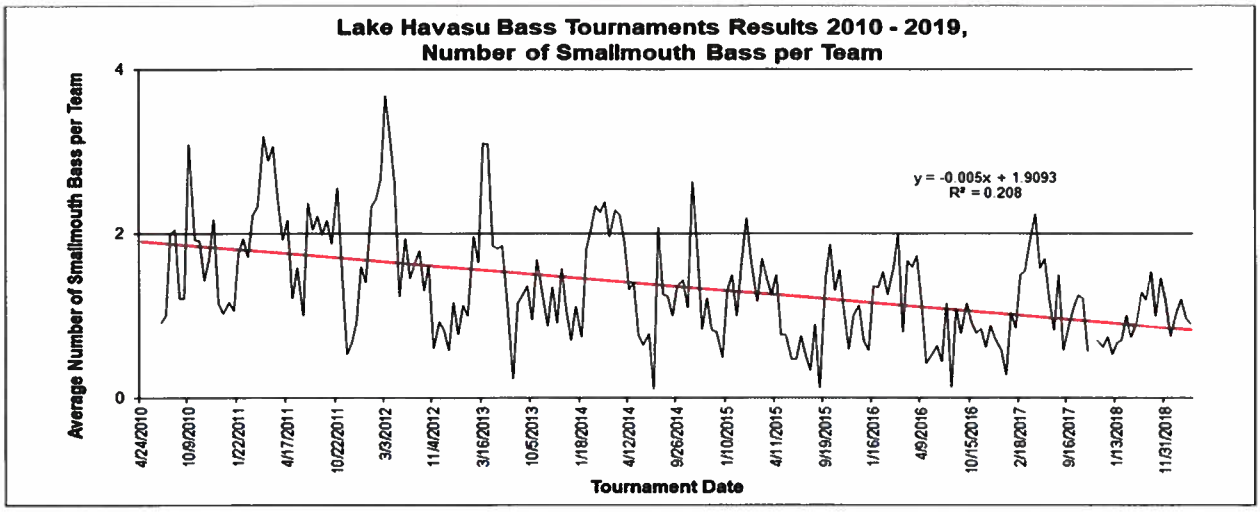

Figure 18. Mean Number of Smallmouth Bass Weighed in for Bass Tournaments on Lake Havasu 2010 - 2019.

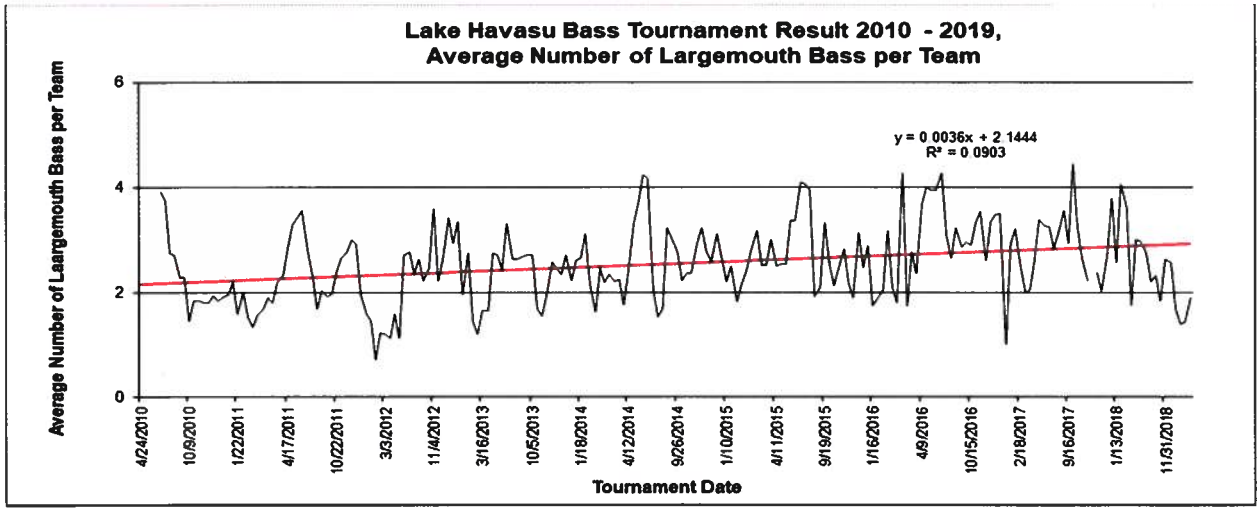

Figure 19. Mean Number of Largemouth Bass Weighed per team in for Bass Tournaments on Lake Havasu 2010 - 2019.

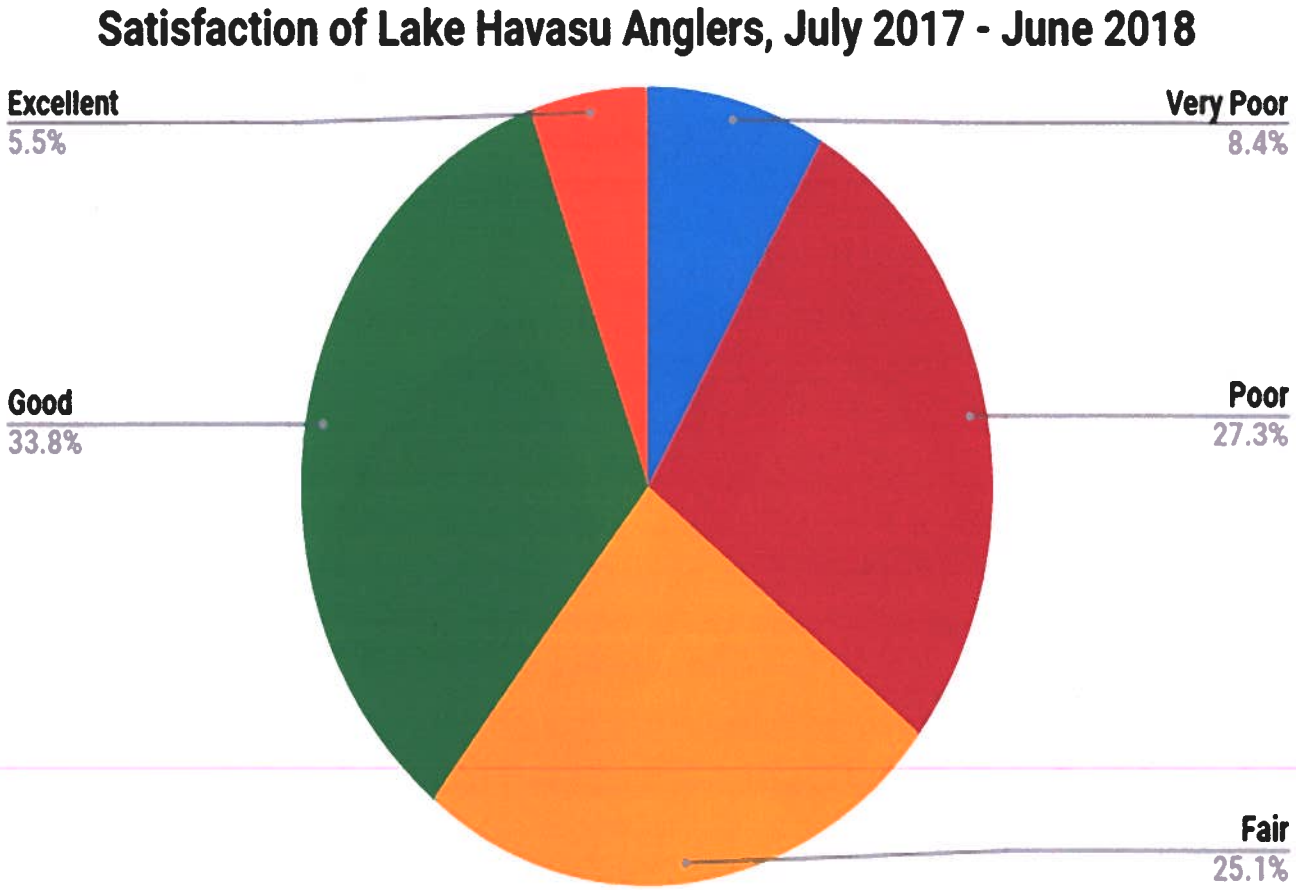

Figure 20. Summary of angler satisfaction during creel survey of Lake Havasu, July 2017 - June 2018. 64.4 percent of anglers were satisfied with their fishing experience on Lake Havasu.