Willow Springs Lake
Fisheries Management Plan
2019-2029

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Aquatic Wildlife Branch Chief

Location

Willow Springs Lake is located on Willow Springs Creek in the headwaters of the Chevelon Creek watershed in the Little Colorado River basin. It is located in game management unit 4B in Coconino County at an elevation of 7,513 feet. The lake sits on the edge of the Mogollon Rim, approximately 30 miles east of Payson and 22 miles west of Heber-Overgaard on the Apache-Sitgreaves National Forests at UTM Zone 12-NAD 83 511215E, 3796927N (Figure 1). It is one of several lakes collectively known as the Rim Lakes.

Figure 1. Willow Springs Lake

Management Prescription

The primary management approach will follow the Intensive Use concept per the Coldwater Vision (AGFD 2019) for Rainbow Trout *Oncorhynchus mykiss* and secondary management approach will follow the Featured Species concept for Tiger Trout *Salmo trutta x Salvelinus fontinalis*. These concepts will be supported by frequent stocking of Rainbow Trout and occasional stocking of Tiger Trout each year. The Intensive Use coldwater sport fishery emphasis is based on the suitable water quality conditions for trout in Willow Springs Lake, the continued (and growing) high demand for coldwater angling at this lake and general area, and the presence of other valuable coldwater fisheries and sensitive aquatic species downstream of the lake.

Current angling regulations at Willow Springs Lake fall under the statewide regulations for gear and bag limits for trout, which allow bait, lures, flies, including treble hooks, and a 6 trout (in aggregate, not per species) daily bag limit. Bag limits are unlimited for bass and catfish to emphasize the management focus on a coldwater fishery for trout only and discourage illegal fish introductions of warmwater species. The use of live baitfish is not permitted at Willow Springs Lake. Management strategies for meeting Objectives are listed in Table 1.

Objective 1: Maintain an Intensive Use Rainbow Trout fishery during summer months when fishing pressure is high.

Objective 2: Maintain a Featured Species concept fishery for Tiger Trout.

Objective 3: At least 80% of the anglers interviewed during creel census rate the fishing as fair, good or excellent.

Table 1. Willow Springs Lake Objectives and Adaptive Management Strategies:

***Objective 1:* Maintain an Intensive Use Rainbow Trout fishery during summer months when fishing pressure is high.**			
Parameters	**Objective Guideline**	**Trigger point to address unmet Objectives**	**Strategies if Objectives are Unmet**
Angler Catch Rates	Maintain angler catch rates of at least 0.50 fish/hour through the summer months and overall average catch rate of 1.0 fish/hour.	When trout catch rates drop below 0.50 fish/hour average through the summer months, or below 1.0 fish/hour overall as determined by a season-long angler creel survey.	• Increase number of Rainbow Trout stocked to 1 per angler use day. • Increase size of stocked trout to 2.0 fish per pound (or larger) to improve catchability and to minimize predation by illegally introduced warmwater fish species. • Place signs highlighting the prohibition of use and possession of live baitfish and stocking of

			any live fish without a permit at Willow Springs Lake (and other lakes throughout the Region). • Conduct mechanical removal to control or eliminate undesirable fish species. • Consider chemical treatment of entire lake to eliminate undesirable species if mechanical control is not effective.
Objective 2: Maintain a Featured Species concept fishery for Tiger Trout.			
Tiger Trout persistence	Multiple age classes of Tiger Trout are caught by anglers.	Tiger Trout caught by anglers are only from that years stocking.	• Explore regulations changes. • Stock more Tiger Trout annually. • Investigate forage enhancements.
Objective 3: At least 80% of the anglers interviewed during creel census rate the fishing as fair, good or excellent.			
Parameters	**Objective Guideline**	**Trigger point to address unmet Objectives**	**Strategies if Objectives are Unmet**
Angler Satisfaction	A minimum of 80% of anglers rate fishing as fair, good or excellent.	Creel census shows less than 80% of anglers rate fishing as fair, good or excellent.	• Increase size of trout stocked. • Increase or modify efforts for angler education, preferably at the lake. Increase size of stocked trout. • Improve boat ramp and boat docks. • Provide fishing pier or jetty. • Maintain diversity of trout species in the lake and consider other species of trout.

Background

Willow Springs Lake is an artificial reservoir constructed by the Arizona Game and Fish Department in 1967 for recreation, fish, and wildlife. The lake is 158 surface acres in size, with a maximum depth of 80 feet. The Arizona Game and Fish Department (Department) has management and maintenance authority for the dam through a Special Use Permit with the Apache-Sitgreaves National Forests and also owns the water rights for 4,120 acre-feet of storage within Willow Springs Lake for aquatic recreation with a priority date of February 25, 1963. The water right allows for an annual release of 750 acre-feet of water.

Willow Springs Lake has a relatively small watershed, draining approximately 3.48 square miles (2,225.7 acres) of mixed conifer forest. There are no permanently flowing streams entering the lake and the lake level is maintained through winter snowmelt, with little influence from summer monsoon rains.

Willow Springs Creek downstream of the lake flows perennial for part of its 5.2 kilometer (3.2 miles) course before joining with Woods Canyon Creek to form Chevelon Canyon Creek (Lopez et al 1998a). Chevelon Canyon Creek flows perennially for 17.4 kilometers (10.8 miles) to Chevelon Canyon Lake, then downstream of Chevelon Lake for 110.2 kilometers (68.5 miles) to the confluence with the Little Colorado River (Lopez et al 1998b).

Productivity/Water Quality

From water quality samples taken over the last 30 years, water quality parameters such as temperature, pH, and dissolved oxygen (DO) are extremely reliable to meet trout stocking standards year-round.

Observations and routine water quality checks by Department biologist have shown the lake ices over in the winter, generally from December into late March or early April. Once the ice melts off the lake in the spring, water temperatures, pH, and dissolved oxygen are in the optimal range for trout and fairly consistent throughout the entire water column. Department Regional biologists did an intensive limnological survey in 2002. This survey showed a thermocline develops in the summer as surface water temperatures increase, developing at about 6 meters (20 feet) in June, July, and August, 9 meters (30 feet) in September, 14 meters (46 feet) in October, then breaks up by November. Optimal conditions are again consistent through the entire water column in late fall and winter. Colder water temperatures exist below the thermocline in the summer, but the water is anoxic due to a lack of mixing below the thermocline and lack of oxygen production at those depths. Thus, trout suspend in a very narrow layer on top of the thermocline during the summer months. The narrow layer develops because of the lack of oxygen below the thermocline, and warm water temperatures close to the surface.

During the summer months, pH stays within good levels rarely exceed 8.5 and typically measuring below 8.0. Conductivity is low, ranging from about 5-45 µmhos through most of the water column through the year. Turbidity is generally low, resulting in fairly clear water, with Nephelometric Turbidity Unit (NTU) measurements in single digits. Willow Springs Lake has not experienced fish kills due to water quality, even during the winter under substantial ice cover.

Primary productivity is a challenge at this lake. The level of nutrients available to provide a quality forage base and grow trout in Willow Springs Lake is low. Limnological surveys conducted by Department biologists in 2002 found ammonia, nitrites, nitrates, and total phosphorus to be below detection limits on nearly all survey trips (Table 2). Total nitrogen was within detection limits, but were relatively low on all dates surveyed (<0.50 mg/l). Total dissolved solids were also low, measuring <40 mg/l on all survey trips. The extremely low level of total phosphorus is likely the main limiting nutrient in the system. These nutrients form the basis for primary production in the lake. The relative low amounts limit algae, and other microscopic plants and animals from thriving in large concentrations.

Meyer and Dreyer (2012) found that catchable size Rainbow Trout stocked into Willow Springs Lake generally lost weight in the weeks after they were stocked, resulting in poor body condition. Measured condition factors of trout caught in Willow Springs Lake in 2011 were all below 80, except in late fall when conditions increased into the 80's.

This low productivity is due to the sandstone geology of the area, which is extremely insoluble, and the small watershed at Willow Springs Lake, similar to what was described at nearby Woods Canyon Lake (Ercole 1968). The low productivity has existed since the lake was constructed in the 1960's. A project was conducted by the Department in 1966-1970 in an effort to increase the productivity of nearby Woods Canyon Lake by adding commercial fertilizers (Kemmerer 1967; Ercole 1968; Ercole 1969; Ercole 1970; and Ginnelly 1971). The project was initially successful in increasing nutrient levels and primary productivity with certain mixtures of fertilizers, but these increases declined throughout the project even as they added more nutrients, and did not increase the general size of trout as expected. One of the reasons why the project didn't help grow trout to larger sizes was due to an expanding population of Golden Shiner *Notemigonus crysoleucas* that benefitted from the productivity and competed directly with trout for food resources (zooplankton). The project was abandoned at Woods Canyon Lake when the Golden Shiner population reached significant levels and trout growth continued to decrease.

Artificial fertilization of Willow Springs Lake to boost productivity is not recommended based on the failure of the project implemented at nearby Woods Canyon Lake in the 1960s-1970s and presence of illegally stocked and undesirable warmwater species in this lake. Warmwater species should be completely removed and an objective for larger trout initiated before fertilization can be considered. If fertilization were attempted under current conditions, the undesirable warmwater species would likely benefit before stocked trout could utilize an increase in nutrients.

The low productivity of Willow Springs Lake continues to influence the fishery, even when stocking only catchable size trout. Although the stocked trout are not expected to grow in the lake after stocking, their condition generally decreases through the fishing season after they are stocked (Meyer and Dreyer 2012), influencing the length of time they persist in the lake.

Water quality profiles of basic parameters (pH, temperature, dissolved oxygen) will be measured monthly through the year every 5 years. A detailed nutrient analysis will be measured every 10 years.

Forage/Prey

Forage for trout in Willow Springs Lake consists of zooplankton, benthos invertebrates (including crayfish), aquatic and terrestrial insects, and small fish species. As mentioned above, these potential forage organisms are affected by the low productivity of the lake.

Zooplankton were surveyed in Willow Springs Lake by Department Regional biologists in 2002. This zooplankton survey found relatively low densities of zooplankton available to trout. Generally, only the larger zooplankton in the Cladocera group (primarily *Daphnia*) are large enough to contribute significantly to the diet of a catchable size trout, however, the densities of Cladocera in Willow Springs Lake were relatively low, ranging from 20 to 96 individuals per plankton tow (Figure 3). Rotifers were fairly numerous in April and May, but are generally too small to sustain catchable size trout. Copepods, which are generally moderate in size between rotifers and Cladocera, also had moderately low densities all year, ranging from 21 to 71 Copepods per plankton tow.

Benthic invertebrates in Willow Springs Lake were surveyed by Department Regional biologists in 2002. *Chaoborus* (phantom midge) larvae and other Chironomid larvae were the only benthic invertebrates collected in 10 ponar dredge samples. Chironomids were not abundant, ranging from 1 to 74 Chironomid larvae (mean=26) per dredge sample. *Chaoborus* were even less abundant, ranging from 0 to 38 *Chaoborus* larvae (mean=9) per dredge sample. Overall, the low abundance of zooplankton and benthos invertebrates presents a fairly poor food base and indicates that the lake is moderately oligotrophic.

Willow Springs Lake has an abundant population of Northern Crayfish *Orconectes virils* which are not native to Arizona. No surveys have been conducted by the Department to determine densities of crayfish in the lake.

Willow Springs Lake has a relatively low abundance of small bodied forage fishes, consisting mostly of illegally introduced Green Sunfish *Lepomis cyanellus* and Fathead Minnows *Pimephales promelas*. The sunfish are not a quality forage fish for Rainbow Trout, but Fatheads Minnows may occasionally be utilized. Golden Shiners were once abundant in Willow Springs Lake, but have been rare since Largemouth Bass *Micropterus salmoides* were illegally introduced in the 1990s. Golden Shiners have been known to overpopulate in nearby Woods Canyon Lake and compete directly with stocked trout for zooplankton forage (Ercole 1969, Ercole 1970, Ginnelly 1971). It is likely similar competition occurred in Willow Springs Lake when the shiner population was booming in the 1970's and 1980's. Threadfin Shad were stocked into nearby Woods Canyon Lake as an experimental forage fish in 1961, but establishment was unsuccessful (Bruce 1961). Cold water temperatures and low plankton densities are likely the reasons a population did not persist. Shad would likely be unsuccessful in Willow Springs as well for the same reason. Reproduction of shad was documented in the first year in Woods Canyon Lake, but the species did not persist therefore little predation by trout was documented.

The addition of new forage fishes into Willow Springs Lake is not recommended since stocked Rainbow Trout would not utilize them effectively, but the undesirable and illegally stocked

warmwater species (Largemouth Bass, Smallmouth Bass *Micropterus dolomieu* Green Sunfish, Black Crappie *Pomoxis nigromaculatus*) would. It is expected that stocked Tiger Trout will prey on available forage fishes more than Rainbow Trout.

Zooplankton and benthos invertebrates surveyed on a 10 year interval to detect largescale changes in species and abundance is recommended.

There are no records of Director's Order listed aquatic invasive species at Willow Springs Lake. However, Willow Springs Lake does contain Northern Crayfish and illegally introduced Largemouth Bass, Smallmouth Bass, Green Sunfish, Black Crappie, and White Sucker *Catostomus commersonii.* None of these species are considered invasive species, but are undesirable for this lake and the watershed. Though not found in recent surveys, previous surveys have found Golden Shiner, also considered undesirable for this lake. The risk of illegal introduction of additional warmwater species is high because of the lake's history of illegal introductions and its proximity to other Rim Lakes. Confirmed illegal introductions of the following undesirable species has occurred the following waters: Green Sunfish and Golden Shiner in Woods Canyon Lake; Largemouth Bass and Green Sunfish in Black Canyon Lake; Yellow Bullhead *Ameiurus natalis*, Green Sunfish, and Largemouth Bass in Blue Ridge Reservoir; Largemouth Bass, Bluegill, and Golden Shiner in Long Tom Tank; and Green Sunfish at Bear Canyon Lake.

Habitat

There is some structure in Willow Springs Lake, including a rocky shoreline, numerous submerged stumps and snags in the upper end of the east arm, and some aquatic vegetation in the upper end of the west arm.

Rainbow Trout are not known to require structural habitat to do well, therefore habitat is not considered to be a limiting factor in Willow Springs Lake for Rainbow Trout. Recent electrofishing surveys seem to indicate Tiger Trout use cover to some degree. Structural habitat is, however, contributing to the undesirable success of illegally introduced warmwater fishes.

A bathymetric map will be developed for Willow Springs Lake by the end of fiscal year 2020 to determine current sedimentation levels.

Species

Rainbow Trout

Rainbow Trout have been intensively stocked from 1968 to the present and are the primary species in Willow Springs Lake. Brown Trout *Salmo trutta*, Brook Trout *Salvelinus fontinalis* and Cutthroat Trout *Oncorhynchus clarkii* were routinely stocked from 1972-1995, but are no longer found in the lake. Brown Trout were last detected in 2008 and Brook Trout were last detected in 1996.

Trout do not reproduce in Willow Springs Lake, which is consistent with other trout lakes in Arizona. Regular stockings are required to maintain this coldwater sportfishery.

Fish population surveys are scheduled once every 10 years with standardized gill nets for trout (AGFD 2004). Willow Springs Lake is an intensive use trout fishery with no natural reproduction and little carryover of Rainbow Trout from previous stocking years, thus, it is not necessary to survey the trout population regularly. The last regular gill netting survey was conducted in April 2011 just before the stocking season. This survey found primarily Rainbow Trout, ranging in size from 9.0 to 13.1 inches (Figure 4), but also caught moderate numbers of illegally introduced Largemouth Bass, Smallmouth Bass, and Green Sunfish.

Tiger Trout

Tiger Trout were first stocked in May 2016 to increase the diversity of angling opportunity. Approximately 8,000 subcatchable sized Tiger Trout were brought in from the State of Utah to increase the diversity of trout in Willow Springs. Another 8,000 catchable sized Tiger Trout were stocked in 2017. Angler reports have documented Tiger Trout being caught in consistent numbers, and electrofishing sampling in 2018 documented several size classes. Stockings occur in May and July annually.

Largemouth Bass, Smallmouth Bass and other warmwater species

Current fish composition in the lake consists of stocked Rainbow Trout and Tiger Trout, as well as illegally introduced Largemouth Bass, Smallmouth Bass, Green Sunfish, Black Crappie, White Sucker, and Fathead Minnow. Golden Shiner had been abundant in the past, but are now rare after the illegal introduction of Largemouth Bass. Golden Shiner (n=1) were last collected in 2011. Largemouth Bass were first detected in netting surveys in 1993, Green Sunfish in netting surveys in 1998, while Smallmouth Bass were first detected by boat electrofishing survey in 2008.

Largemouth Bass, Smallmouth Bass, Green Sunfish, Black Crappie, and Fathead Minnow are known to reproduce well in Willow Springs Lake. Golden Shiner had been known to overpopulate and compete directly with stocked trout, and the Department has taken action to eliminate them in the past. The lake was drained and chemically treated with chlorine in November 1971 and with rotenone in April 1972 to eradicate Golden Shiner, which was believed to be successful. However, Golden Shiner reappeared shortly after, despite the prohibition of live baitfish at this lake.

Current catch rates for trout are not meeting objectives, and have not met objectives for some time. Warmwater fish species have some impact on the catch rates of stocked trout in Willow Springs Lake, but primarily are a concern that they could severely impact fisheries resources downstream of the reservoir if they were to escape when the lake spills. When Willow Springs Lake spills, the water flows down into Willow Springs Creek, upper Chevelon Canyon Creek, then into Chevelon Canyon Lake. Below Chevelon Lake, Chevelon Canyon Creek continues until it joins the Little Colorado River. The greatest concern is that Smallmouth Bass might escape and become established in these downstream areas, much of which is very suitable habitat for Smallmouth Bass. Smallmouth are known to take over small streams in Arizona when they become established, displacing other species by predation and competition.

Fisheries resources in these downstream areas that are threatened by the Smallmouth Bass if they were to escape Willow Springs Lake include:

- Wild Brook Trout and Brown Trout in Willow Springs Creek – there are very few wild Brook Trout populations in Arizona, making this a rare featured species fishery.
- Trophy wild Brown Trout in upper Chevelon Canyon Creek – there are very few Trophy trout fisheries in Arizona, again making this a rare and valuable resource.
- Quality wild Brown Trout and stocked Rainbow Trout fishery in Chevelon Canyon Lake.
- Quality wild Brown Trout and stocked Rainbow Trout tailwater fishery in lower Chevelon Canyon Creek below Chevelon Lake dam.
- Sensitive native fishes in upper Chevelon Canyon Creek, Chevelon Canyon Lake, and lower Chevelon Canyon Creek, including:
    - Little Colorado Spinedace – threatened
    - Little Colorado Sucker – sensitive and Conservation Agreement species
    - Bluehead Sucker – sensitive and Conservation Agreement species
    - Roundtail Chub – sensitive and Conservation Agreement species
    - Speckled Dace – sensitive species

The combination of below target catch rates for trout and because the threat to downstream aquatic resources is significant, actions should be taken to prevent warmwater species, particularly Smallmouth Bass, from becoming established downstream of Willow Springs Lake. The safest solution would be to completely remove all warmwater species from Willow Springs Lake by treating the entire lake with rotenone and restocking with only trout. However, this action would be extremely controversial for numerous reasons, including the tremendous loss of angler and boater use on the lake during and after the treatment. A lesser intrusive action of mechanically reducing the Smallmouth Bass population was implemented to reduce the probability that some might escape the lake.

A mechanical removal project to control Smallmouth Bass numbers in Willow Springs Lake was implemented in 2015 and will follow methods outlined in a Willow Springs Lake Smallmouth Bass Removal Plan (Lopez 2015). A boat electrofisher is used in the spring and potentially fall to remove as many Smallmouth Bass from the lake as possible in a minimum of 3 complete passes around the lake. In 2015-2017, a total of 10,132 Smallmouth Bass were removed from the lake, with decreasing number collected each year. In the last 2 years (2016-2017), the vast majority of these bass were small fish. Over 77% were less than 6 inches long, 90% were less than 8 inches, and 96% were less than 10 inches in length. The latest efforts in 2018 confirm that most of the Smallmouth Bass in Willow Springs Lake are small, with very few large fish caught by electrofishing boat (Figure 6). The Largemouth Bass by comparison are fewer in number, but consist of a higher proportion of large fish.

Alternative methods to prevent Smallmouth Bass (and potentially other warmwater species) from escaping and establishing downstream should be considered to replace or supplement these mechanical removal efforts as they are costly both in labor and in public perception. Mechanical removal of other illegally introduced species may occur if considered a threat to aquatic resources in Willow Springs Lake or downstream in the watershed, including Largemouth Bass, Black Crappie, and others.

A chemical treatment of Willow Springs Lake will be considered if mechanical removal/control is not considered successful and the threats persist or increase.

Access

Access to Willow Springs Lake is via paved Forest Road 149 from Highway 260, or a short dirt road (Forest Road 148) to Sardine Point also coming off Highway 260 (Figure 2). There is one boat ramp located on the west shore at the end of FR 149. Boat motors are restricted to 10 horsepower motors or less.

Access to fishing along the shoreline is good on the west side from the paved Forest Road 149 to the boat ramp and day-use area, and along the shorelines of Sardine Point. Access to fishing along other shorelines is unrestricted to foot and boat traffic, but difficult to get to unless anglers have a boat. The shorelines are often rocky and steep, with few spots of flat and easy access for the physically challenged.

The nearby Sinkhole Campground has 26 campsites, which are extremely popular and fill quickly during the summer, due to its close proximity to the lake. The lake is generally accessible from April through December, with Forest roads in the area usually closed during the winter due to snow. The lake ices over for 3-4 months during the winter about the same time the roads are closed.

Challenges in access include:

- Crowded shorelines at access points,
- Crowded boat ramp during busy weekends due to a bottleneck where the single drive through lane enters the busy boat ramp area,
- Increasing use of non-motorized kayaks, paddleboards, and canoes, many who aren't fishing and often occupy the single boat ramp,
- Few spots of flat easily accessible shoreline and no ADA shoreline access,
- A public boat dock in poor condition due to damage during winter ice cover,
- Limited parking near the lake,
- Turning into and pulling out of Sardine Point from or onto the highway can be dangerous on busy weekends because of poor visibility of west-bound traffic coming around a bend in the highway.

Prioritized Access Strategies are:

1. Construct a second turn-around lane near the boat ramp to alleviate vehicle congestion at the boat ramp,
2. Replace the public boat dock at the boat ramp with one that can easily be removed during the winter and easily replaced in early spring,
3. Increase parking at Willow Springs Lake,
4. Install an ADA accessible fishing pier, jetty, or shoreline access,
5. Install a ramp or beach for launching non-motorized craft that is separate, but possibly adjacent to the boat ramp,
6. Support future plans for facilities improvements, including additional boat ramp, at Sardine Point after turning lanes are built into future highway widening projects.

Catch

Our target overall angler catch rate at Willow Springs Lake is 0.50 fish per hour (fish/hour) or greater during the stocking season from April through September, and angler satisfaction rate of at least 80% fair, good or excellent.

Angler catch rates at Willow Springs Lake fell short of the 0.5 fish/hour target rate, with an overall catch rate of 0.45 fish/hour from April through November, as determined by angler creel surveys conducted in 2011 (Figure 7). Only 3 months (June, July, and August) met the 0.5 fish/hour target catch rate with combined bank and boat anglers. However, catch rates for boat anglers (average 0.65 fish/hour) were approximately double the catch rates for shore anglers (average 0.33 fish/hour). For boat anglers, October was the only month that fell significantly below the 0.50 fish/hour target, with a catch rate of 0.28 fish/hour. Conversely, August was the only month that bank anglers met the .5 fish/hour catch rate target.

Over 45,000 stocked Rainbow Trout were caught and over 30,000 were harvested at Willow Springs Lake in 2011 (Figure 8). June and July are the peak catch and harvest months, which match the peak angler use. April and November have relatively low catch rates, catch numbers, and harvest numbers due to falling outside of the trout stocking season. August has low catch rates, catch numbers, and harvest numbers due primarily to warm water temperatures and a shallow thermocline, causing trout to suspend at the thermocline depth and become difficult for anglers to find. The Department should institute an education campaign to show novice anglers how to catch trout, including how to find trout suspended at the thermocline in the summer and how to minimize mortality of released fish when using bait. The declining catch rates in the fall months is undoubtedly tied to the Departments inability to stock after September even though trout may be available some years to stock during this time period. Restrictions by the U. S. Fish and Wildlife Service on trout stocking due to concerns over downstream impacts to threatened and endangered species prevents these stockings.

Angler use peaks in May, June, and July, with 20,327, 22,673, and 27,898 angler hours per month, respectively (Figure 9). The majority of use is by shore anglers, with 62% of anglers overall fishing from the bank (Figure 10). Total angler use at Willow Springs Lake was 84,357 angler days in 2013, as reported in a Statewide Angler Use Survey (Fisheries Branch 2015), ranking as the third highest use lake in Region I, with only Big Lake and Woods Canyon Lake receiving higher angler use.

Anglers heavily target trout at Willow Springs Lake. Of 2,162 anglers surveyed in 2016, 84% preferred to fish for trout only, while 15% wanted anything that bites, but only 0.7% preferred to catch bass (includes 0.2% that preferred to catch both trout and bass)(Figure 11). The management emphasis of a coldwater sportfishery and associated management approaches (Intensive Use Rainbow Trout and Feature Species Tiger Trout) supports the overwhelming preference for trout fishing at Willow Springs Lake. The removal of bass at Willow Springs Lake would impact a very small portion (<1%) of anglers at Willow Springs Lake while protecting other valuable aquatic resources within the Chevelon Creek watershed.

Catch rates for trout averaged 0.45 trout/hour from April through November, but catch rates for bass ranged from 0 bass/hour in the spring and fall to 0.05 bass/hour in August (Figure 12). Sunfish catch rates reached 0.14 sunfish/hour also in August when water temperatures were warmest.

Rainbow Trout made up 89.7% of the overall catch in 2011, while Smallmouth Bass and Largemouth Bass made up only 4.9% and 0.8% of the overall catch, respectively (Figure 13). Fish harvested was even more dominated by trout, consisting of 96.1% of all fish harvested in 2011. Smallmouth Bass and Largemouth Bass made up only 1.3% and 0.2% of all fish harvested (Figure 14).

Satisfaction

Satisfaction rates at Willow Springs Lake do not meet the target rate of 80% fair/good/excellent overall or in any single month, rating 34% good/excellent overall (Figure 15). The lowest satisfaction rates occurred in October (16%) and November (16%), and the highest satisfaction rates occurred in June (48%) and July (46%). This is attributed to the higher catch rates in June and July, and relatively low catch rates in October and November. The last stocking date in 2011 was September 14, resulting in lower catch rates in October and November.

Angler creel surveys will be conducted every 10 years to monitor angler use, catch rates, and satisfaction at this important fishery. It will be important to standardize how creel information is collected.

Literature Cited

Arizona Game and Fish Department. 2019. Coldwater Sportfisheries Strategic Vision Document. Arizona Game and Fish Department, Statewide Sportfish Program, Phoenix, Arizona.

Ercole, J.A. 1968. Fertilization of Woods Canyon Lake. Statewide Fisheries Investigations, Project F-14-R-2. Arizona Game and Fish Department.

Ercole, J.A. 1969. Fertilization of Woods Canyon Lake. Statewide Fisheries Investigations, Project F-14-R-3. Arizona Game and Fish Department.

Ercole, J.A. 1970. Fertilization of Woods Canyon Lake. Statewide Fisheries Investigations, Project F-14-4. Arizona Game and Fish Department.

Fisheries Branch. 2015. 2013 Arizona Angler User Days, Fishing Economics and Angle Demographics, Federal Aid Project FW-100-P-23. Arizona Game and Fish Department, Phoenix Arizona.

Ginnelly, G.D. 1971. Fertilization of Woods Canyon Lake. Statewide Fisheries Investigations, Project F-14-5. Arizona Game and Fish Department.

Hall, D.J., E.E. Werner, J.F. Gilliam, G. Mittelbach, D. Howard, C.G. Doner, J.A. Dickerman, and A.J. Stewart. 1979. Diel foraging behavior and prey selection in the golden shiner

(Notemigonus crysoleucas). Journal of the Fisheries Research Board of Canada. 36:1029-1039.

Kemmerer, A.J. 1967. Fertilization of Woods Canyon Lake. Statewide Fisheries Investigations, Project F-14-R-1. Arizona Game and Fish Department.

Lopez, M., R. Dreyer, and G. Gonzales. 1998a. Willow Springs Creek Fish Management Report. Statewide Fisheries Investigations, Survey of Aquatic Resources, Federal Aid Project F-7-M-40. Arizona Game and Fish Department. 22 pp.

Lopez, M., R. Dreyer, and G. Gonzales. 1998b. Chevelon Creek Fish Management Report. Statewide Fisheries Investigations, Survey of Aquatic Resources, Federal Aid Project F-7-M-40. Arizona Game and Fish Department. 53 pp.

Lopez, A. 2015. Willow Springs Lake Smallmouth Bass Removal Plan. Arizona Game and Fish Department. 8 pp.

Meyer, K. and R. Dreyer. 2012. Woods Canyon Lake and Willow Springs Lake stocking evaluation. Arizona Game and Fish Department, Pinetop Region.

Tables and Figures

Table 2. Nutrient and chlorophyll levels at Willow Springs Lake taken quarterly in 2002. NH4 is ammonia, TKN is Kendal nitrogen, NO2,3 is nitrites and nitrates, TotN is total nitrogen, TotP is total phosphorus, Chl a is chlorophyll a, and TDS is total dissolved solids.

Date Sampled	NH4 mg/l	TKN mg/l	NO2,3 mg/l	TotN mg/l	TotP mg/l	TDS mg/l
2/22/2002	-	0.42	<0.02	0.42	<0.01	29
5/22/2002	-	0.50	<0.02	0.50	0.01	38
7/16/2002	-	0.39	<0.02	0.39	<0.01	29
10/28/2002	<0.04	0.46	<0.02	0.46	0.01	27

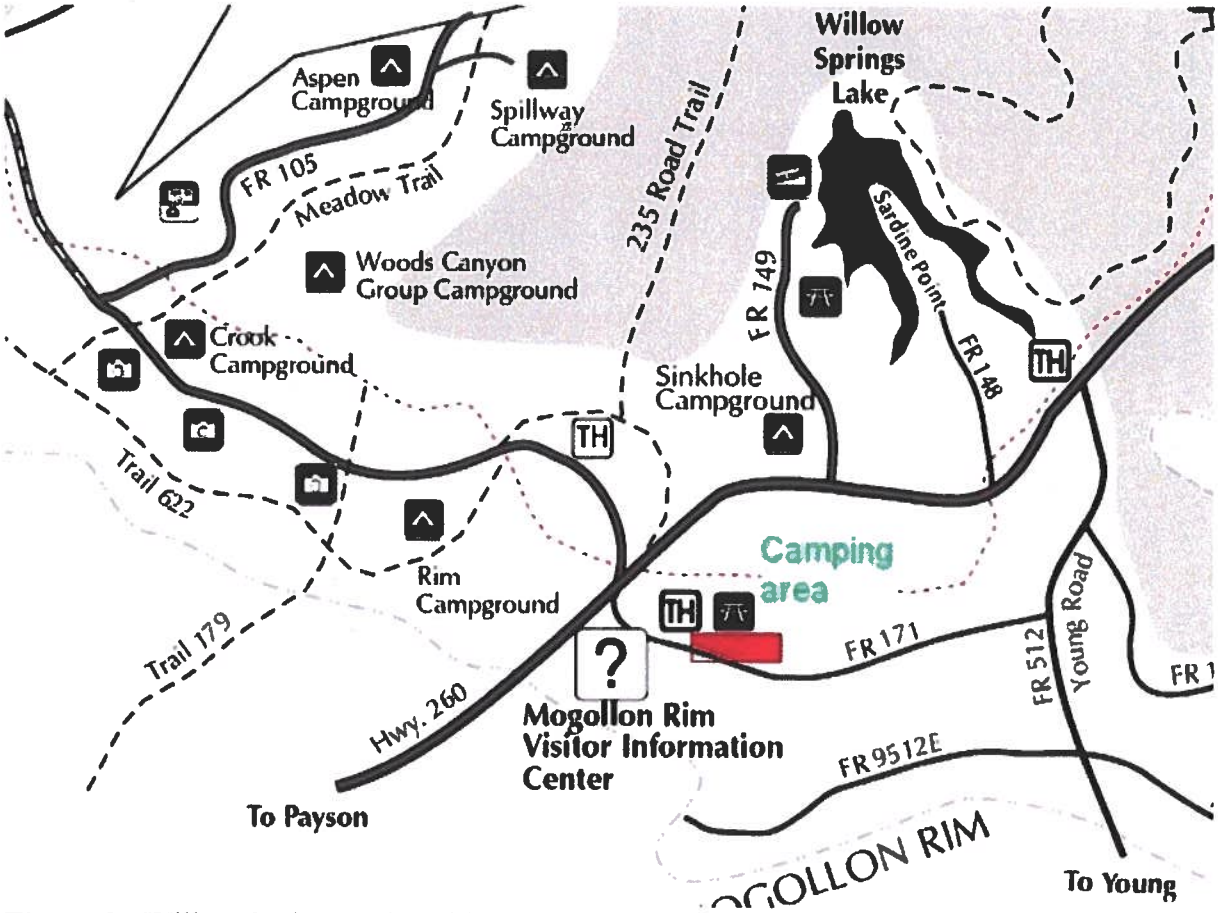

Figure 2. Willow Springs Lake with access routes and boat ramp.

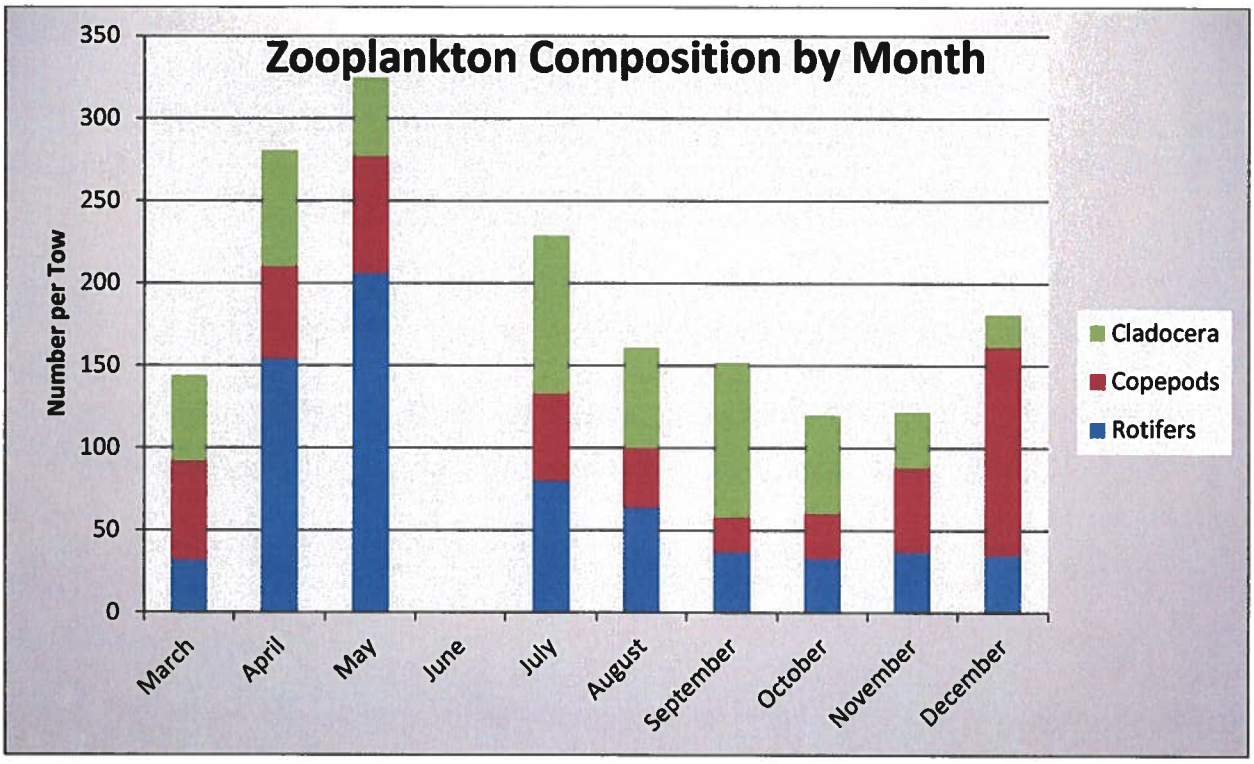

Figure 3. Number of zooplankton per vertical plankton tow in Willow Springs Lake in 2002.

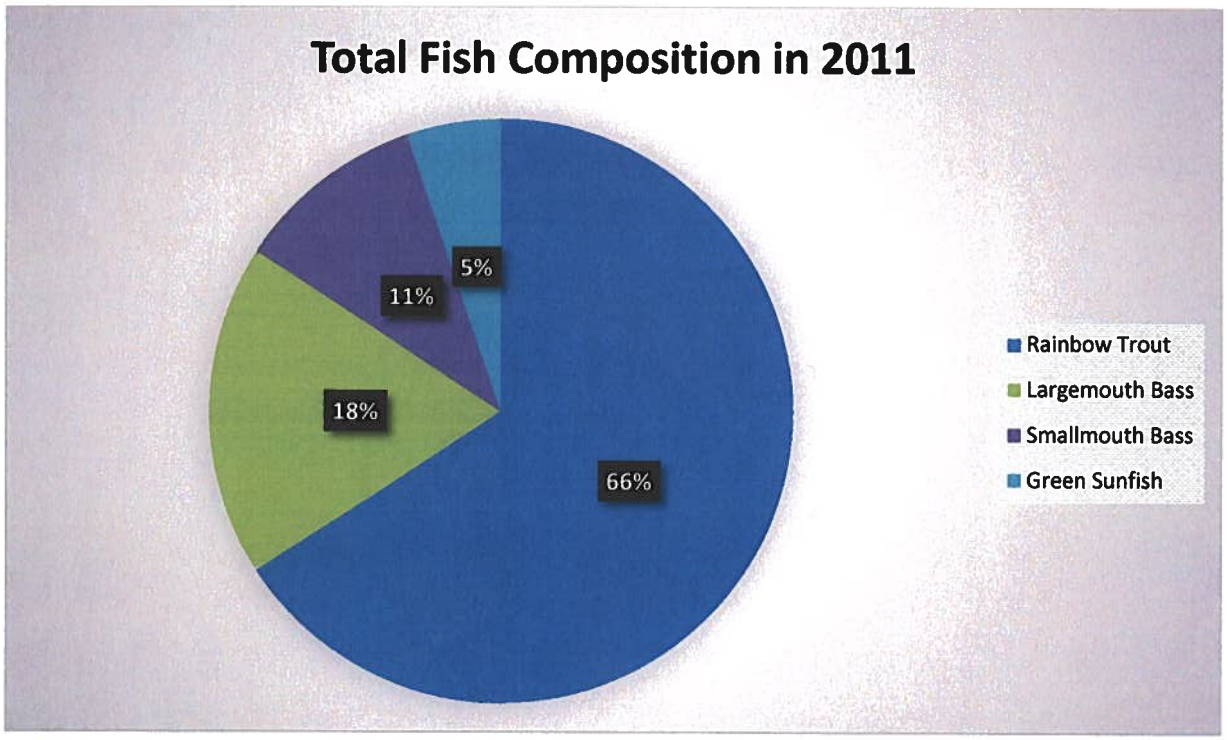

Figure 4. Fish species composition by percentage in Willow Springs Lake during gill net surveys in April 2011.

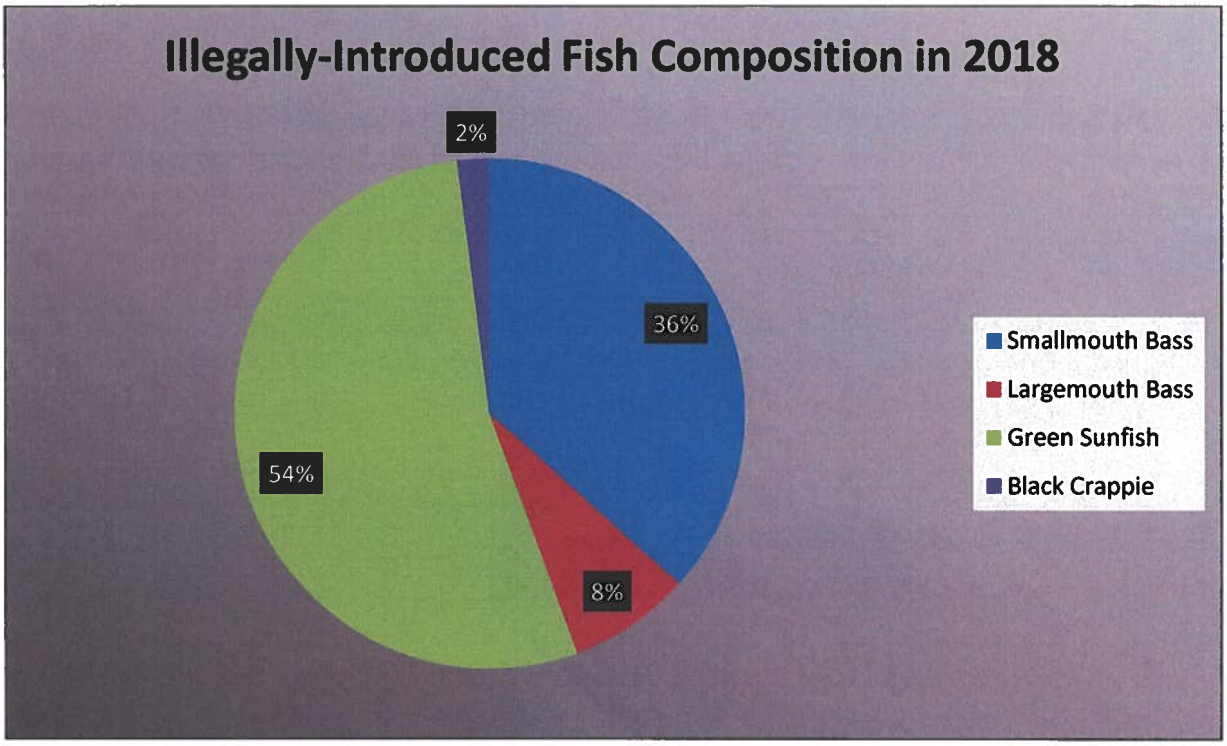

Figure 5. Percent composition of illegally introduced warmwater fish species caught in Willow Springs Lake during boat electrofishing surveys in May 2018. Trout were observed but not collected during these surveys.

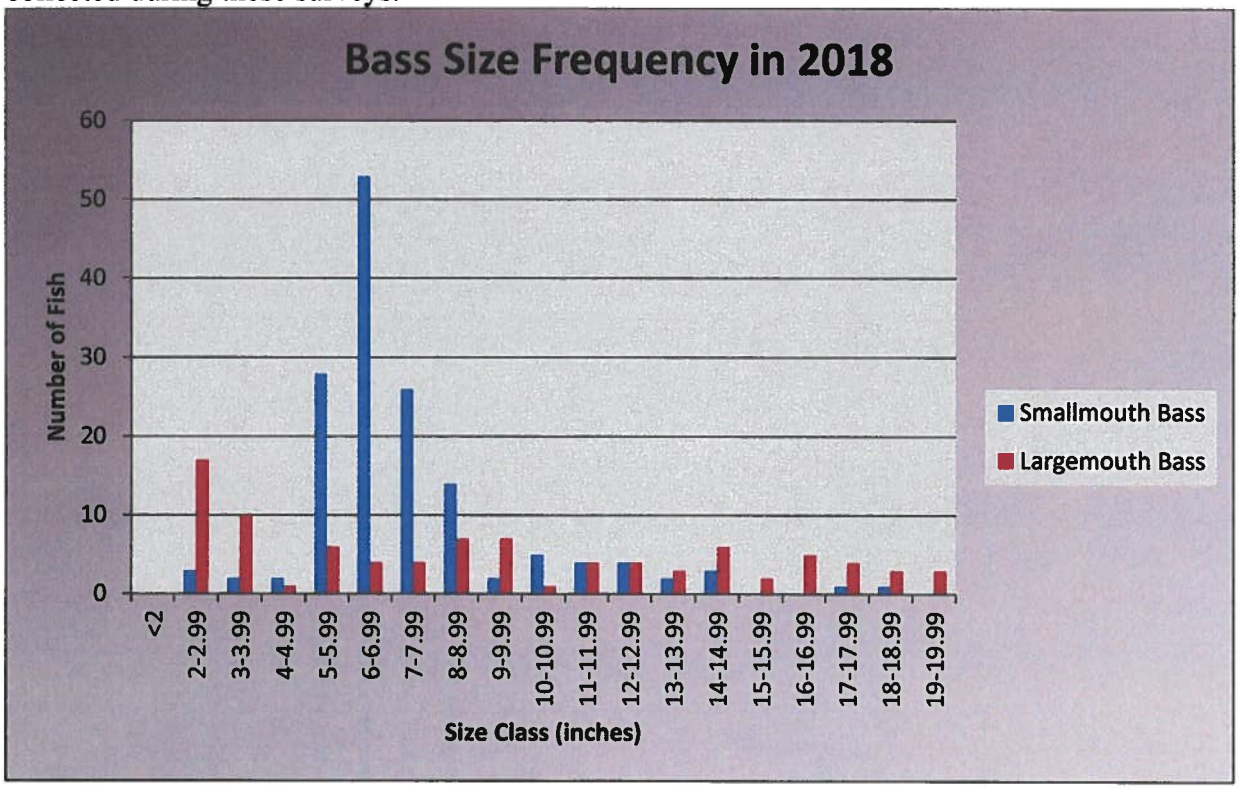

Figure 6. Size class distribution of illegally-introduced Smallmouth Bass and Largemouth Bass during electrofishing surveys in May 2018.

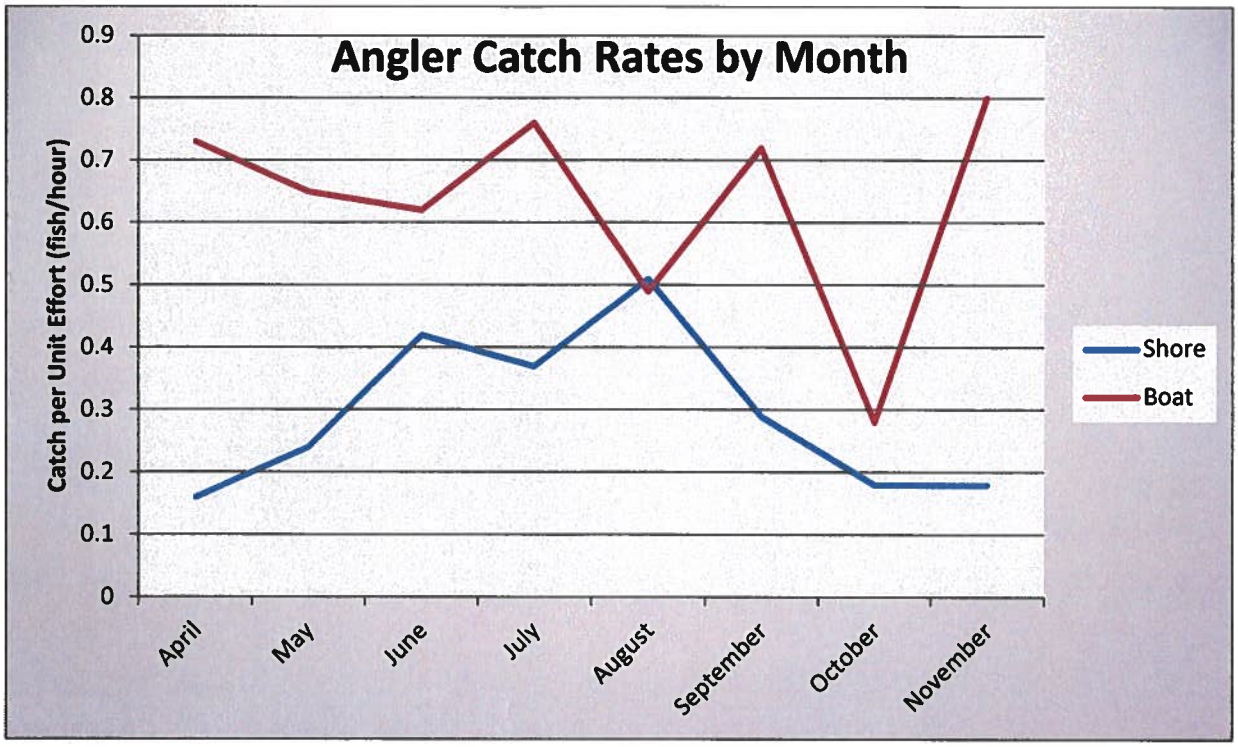

Figure 7. Angler catch rates (fish/hour) by month at Willow Springs Lake in 2011. Numbers in parentheses are standard errors.

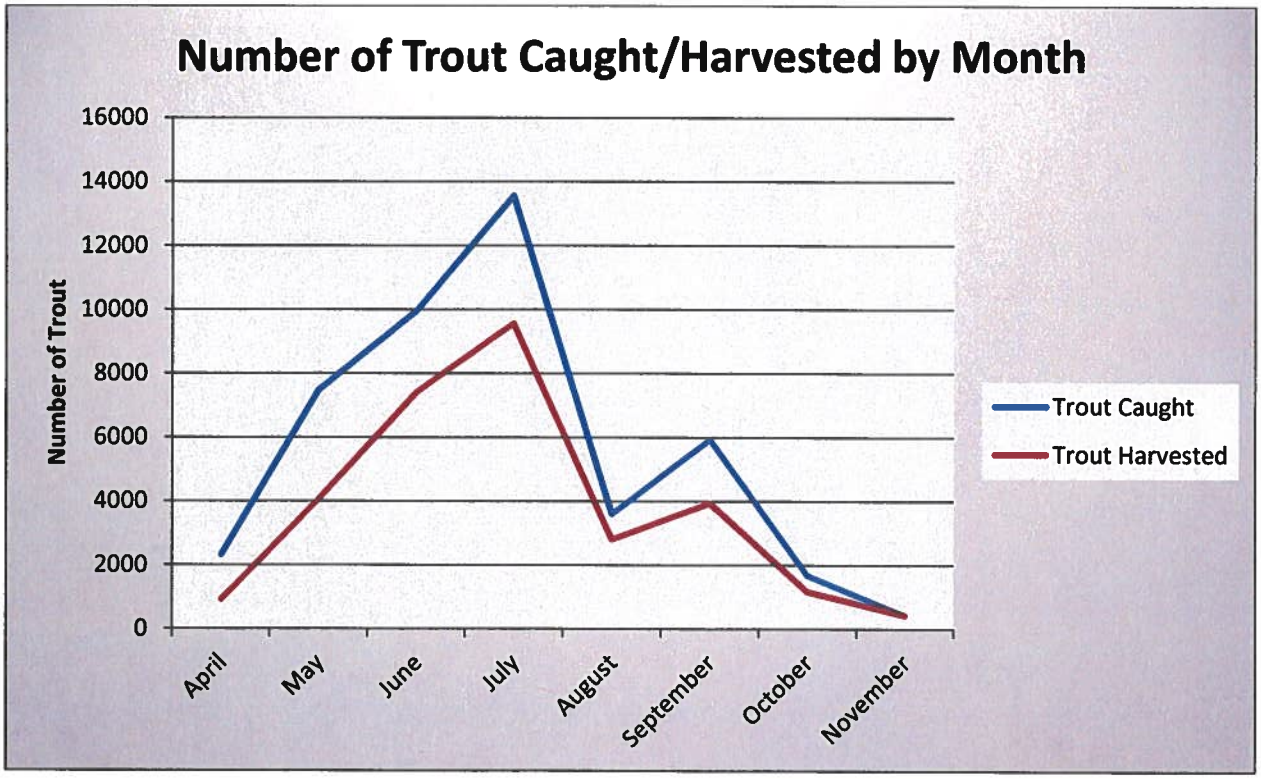

Figure 8. Trout caught and harvested per month at Willow Springs Lake in 2011.

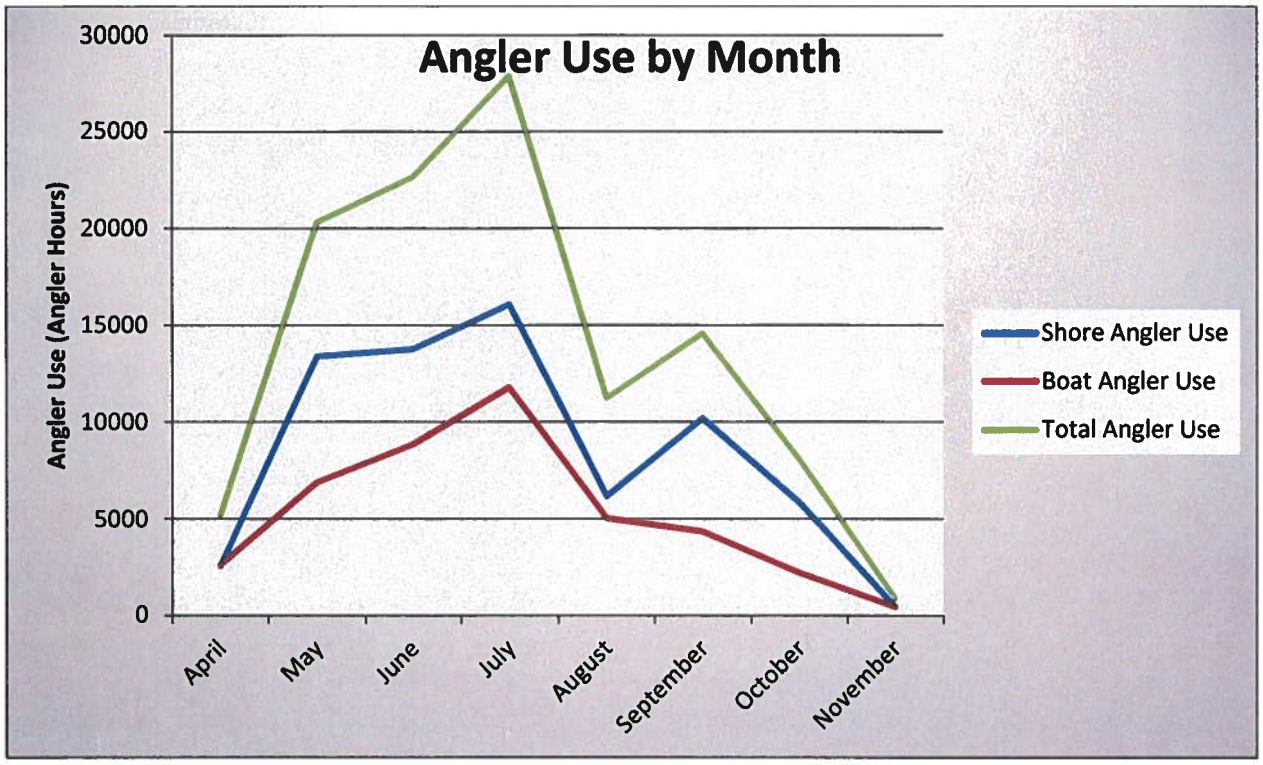

Figure 9. Angler use of shore and boat anglers by month at Willow Springs Lake in 2011.

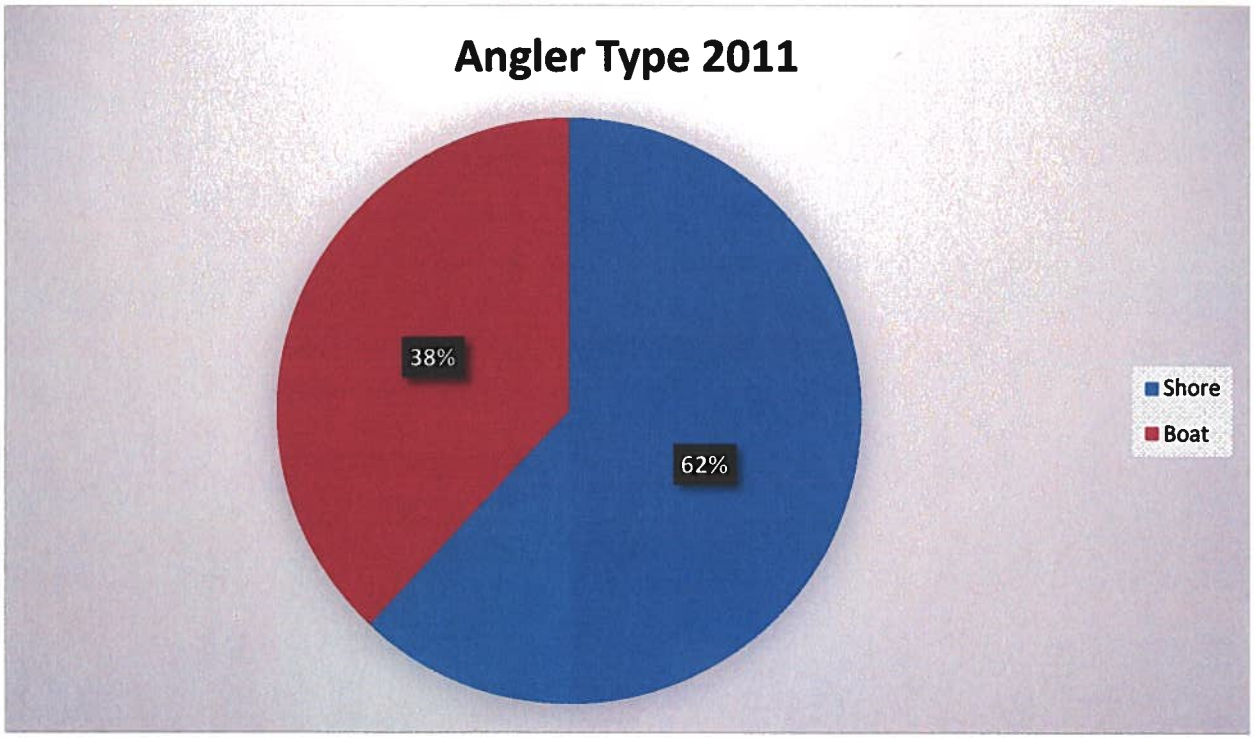

Figure 10. Angler type at Willow Springs Lake, April to November, 2011.

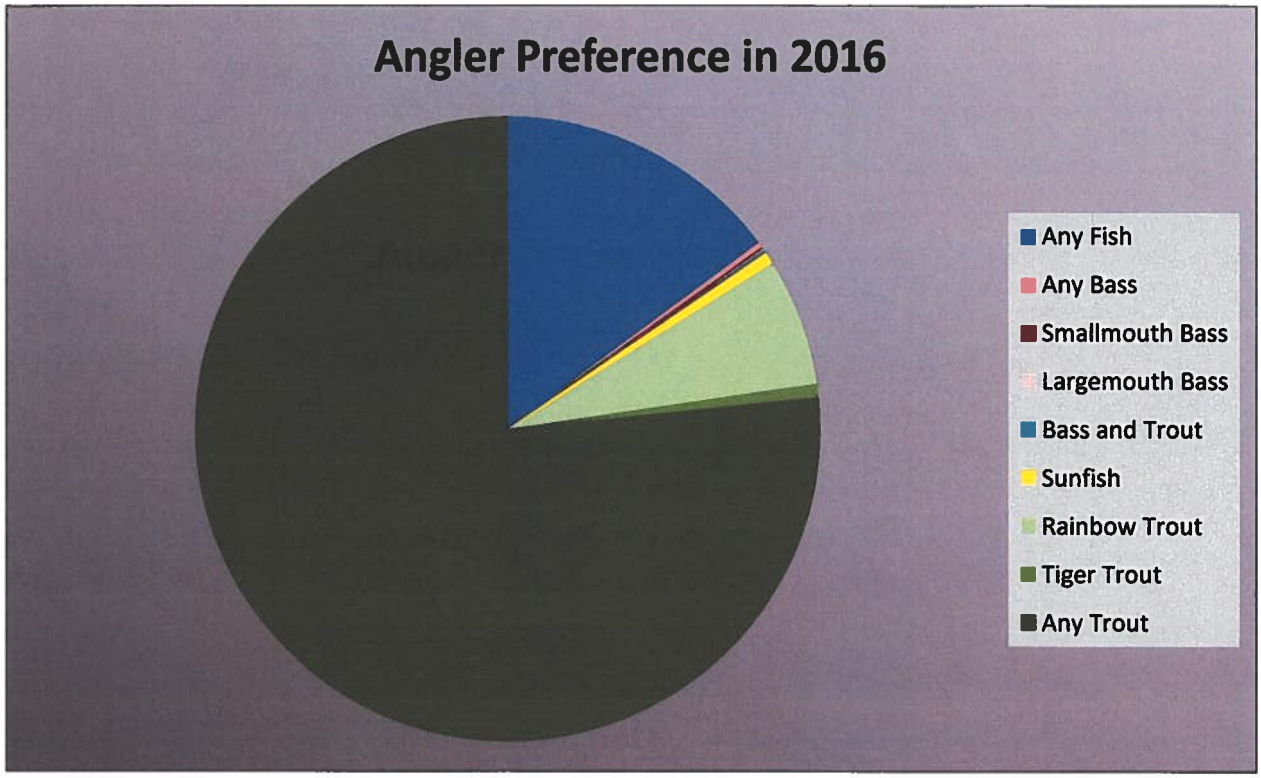

Figure 11. Angler preference at Willow Springs Lake in 2016.

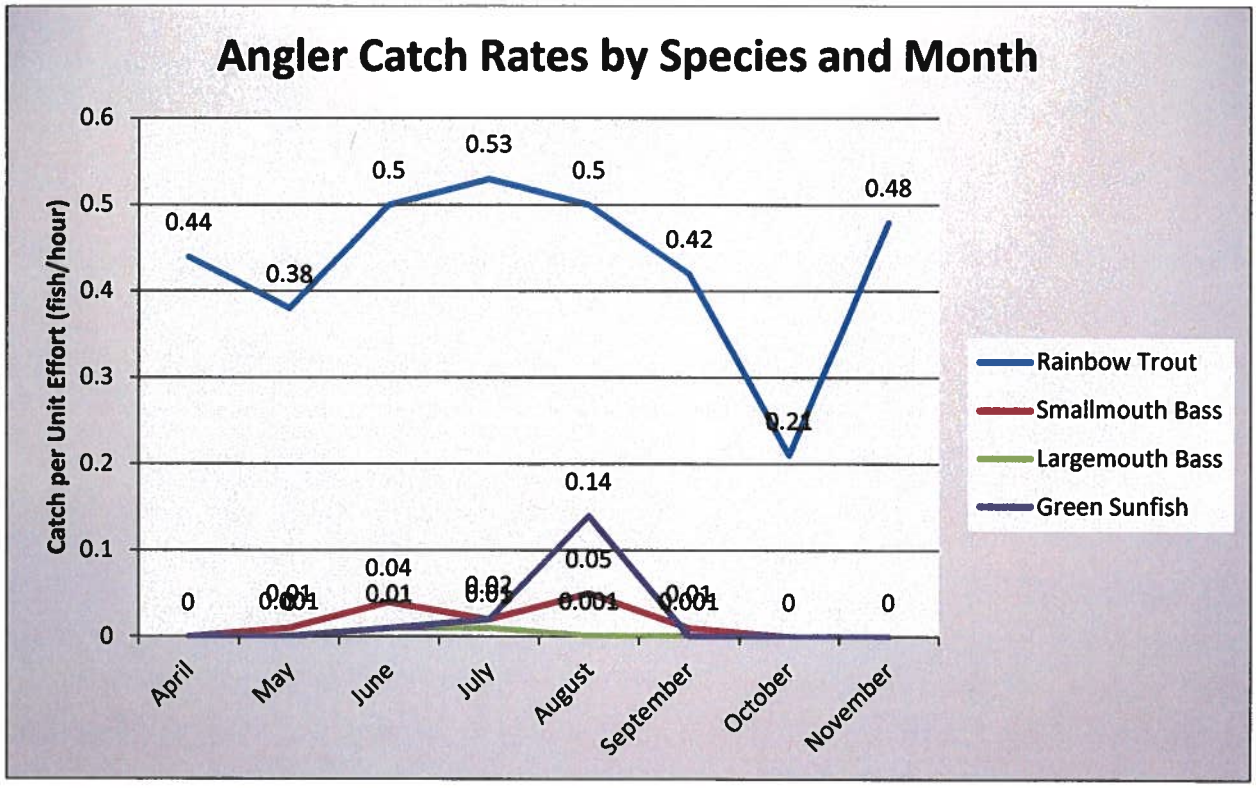

Figure 12. Angler catch rates (fish/hour) at Willow Springs Lake by species and month in 2011.

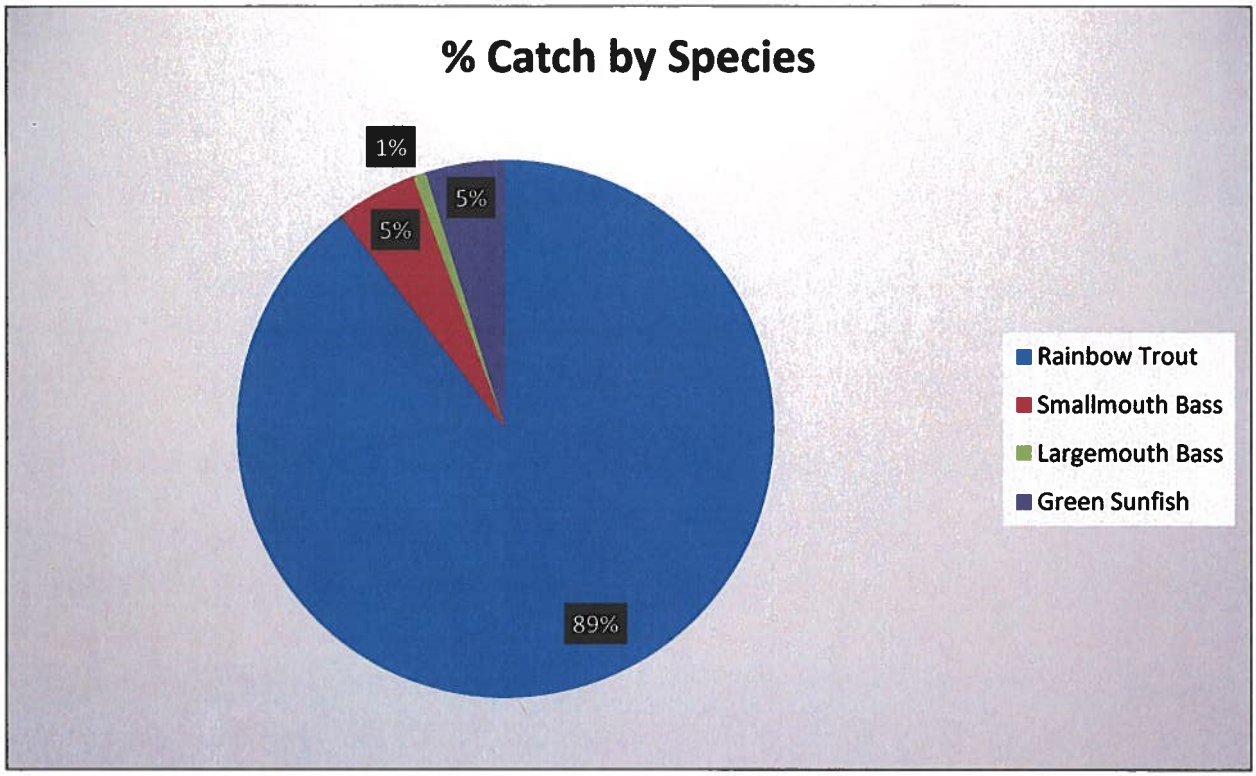

Figure 13. Percent of catch by species at Willow Springs Lake in 2011.

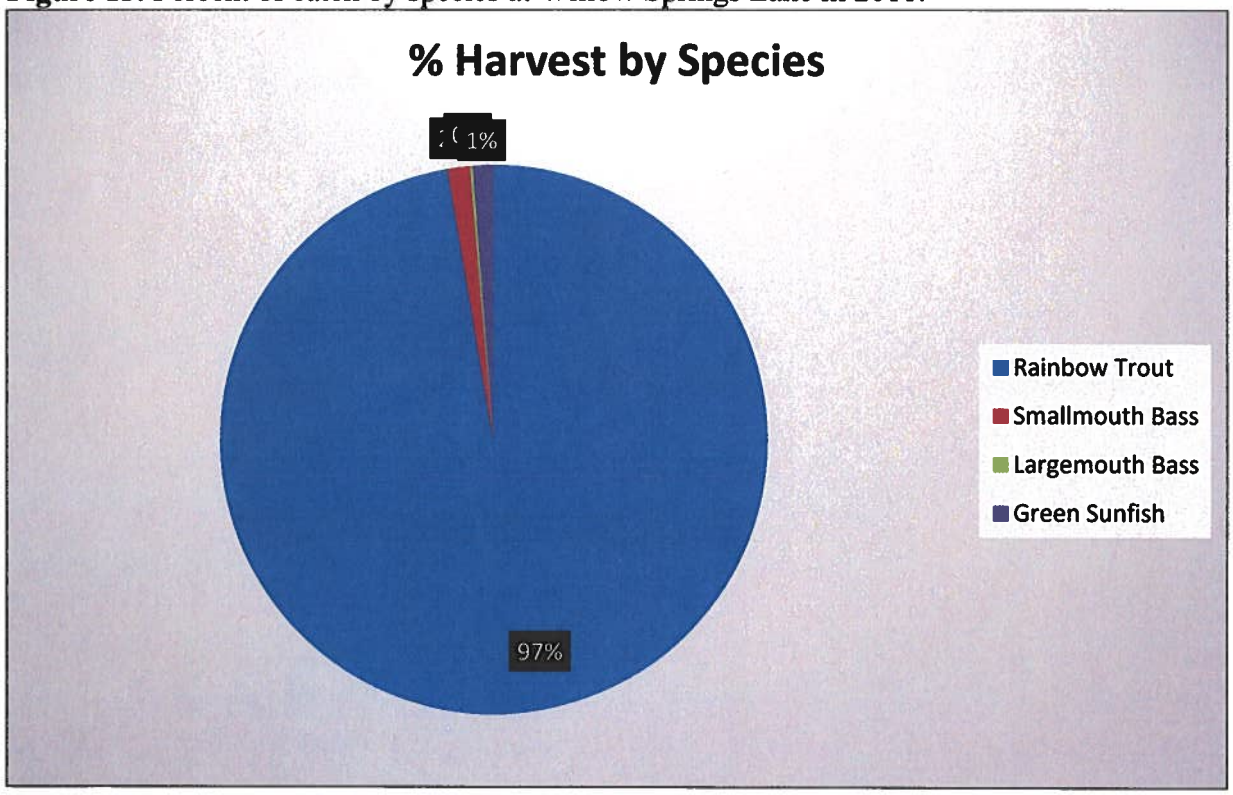

Figure 14. Percent harvest by species at Willow Springs Lake in 2011.

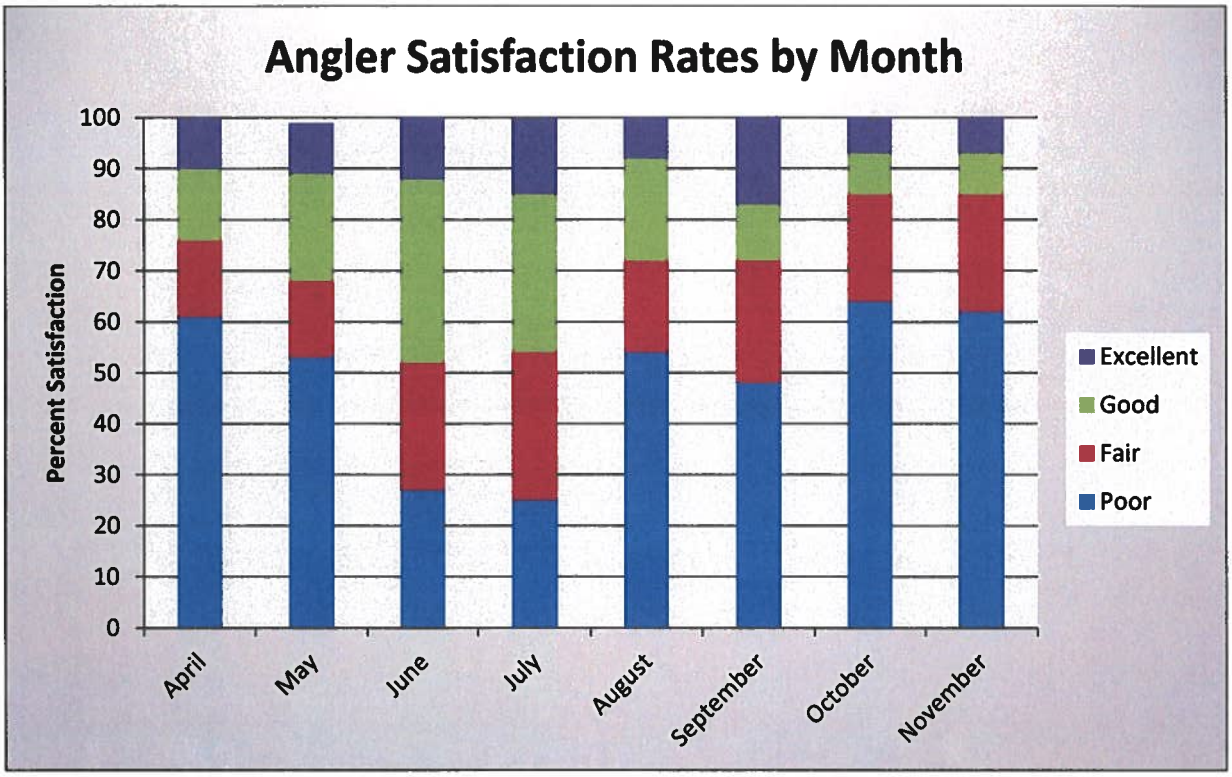

Figure 15. Satisfaction rates by month at Willow Springs Lake in 2011.