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# Response of the catchable Largemouth Bass population to long-term water level reductions in Lake Perris, Riverside County, California

Quinn Granfors*

*California Department of Fish and Wildlife, 26229 Jefferson Ave, Murrieta, CA 92562, USA*

**Correspondent: Quinn.Granfors@wildlife.ca.gov*

Most of the Largemouth Bass (LMB) fisheries in California are within reservoirs that fluctuate annually. These reservoirs can experience prolonged reductions to the water level if cultural demands exceed the supply of water that normal climatic conditions can replace. These extended periods of reduced capacity may impact the fisheries by eliminating critical littoral habitat and limiting carrying capacity within the affected reservoirs. Lake Perris, California experienced a prolonged mandatory drawdown due to a dam remediation project exacerbated by drought conditions that eliminated nearly half of the water volume in the reservoir for over a 14-year period. Annual mark-recapture population estimates of catchable LMB (>305 mm TL) were conducted to monitor the response of the bass population and compared with the water levels over the duration of the 14-year dam remediation project. The estimated number of catchable Largemouth Bass responded in nearly synchronous decline along with the water level over the duration of the altered hydrology.

Key words: California, drawdown, drought, Lake Perris, Largemouth Bass, *Micropterus salmoides*, population estimate

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Largemouth Bass (*Micropterus salmoides;* LMB) are one of the most popular and economically important freshwater sportfish in California. Of the 1.35 million freshwater anglers in California, 33% spent 6.69 million days pursuing LMB and other black bass species (U.S Fish and Wildlife Service 2013). Like many of the reservoirs in North America, the majority of the LMB fisheries in California reside within reservoirs which are utilized for water storage, flood control and generation of hydroelectric power in addition to recreational uses (Sammons and Bettolli 2000). Utilized mostly for non-fishery related purposes, many of these reservoirs fluctuate annually to accommodate the primary objectives of the reservoir. These fluctuations are typically annual and seasonally repetitive. However climatic or anthropogenic causes can alter the regular hydrological regime. Changes to the hydrology have been found to affect year-class strength of various sport fish species: high water levels in spring have been found to improve year-class strength and low water levels have been found to negatively affect year-class strength. These studies have documented year-class strength based on age-0 fish (Heman et al. 1969, Aggus and Elliot 1975, Martin et al. 1981, Miranda et al. 1984, Willis 1986, Fisher and Zale 1991, Sammons et al. 1999, Jackson and Noble 2000, Sammons and Bettolli 2000); however, the age-0 year class may not correlate with the recruitment to catchable size after several years of influence from abiotic and biotic factors (Durocher et al. 1984, Maceina and Bettolli 1998, Allen et al. 1999, Tate et al. 2003). While modeling has been developed to predict LMB population trends (Orth 1979), models for predicting biological consequences of drawdowns have been considered inadequate. Primarily due to the lack of expensive long-term data documenting effects of water level drawdown on LMB populations (Ploskey 1986).

In July 2005, the California Department of Water Resources (DWR) identified potential seismic safety problems with the foundation of the Lake Perris Dam. DWR determined a portion of the dam's foundation would liquefy in the event of a magnitude 7.5 earthquake (Richter scale), which has the potential of a catastrophic dam failure. Based on these findings, DWR lowered the water level in Lake Perris from its maximum operating elevation of 484 m (1,588 ft) above mean sea level by 7.62 m (25 ft) until repairs to the dam's foundation are completed. The project was to be completed in 2012 (DWR 2007). However, delays extended the project until the end of 2017. This prolonged drawdown, resulting in a 41% reduction of the water volume and loss of much of the existing littoral habitat, was expected to severely reduce the LMB population. Mitigation measures, including changing the angling regulations and installing fishery habitat in the new drawn down littoral zone, were instituted to attempt to minimize anticipated reductions to the LMB population.

To monitor the effects of the drawdown to the LMB fishery, annual population estimates were initiated prior to the drawdown in 2005 and conducted annually thereafter through 2018 upon completion of the dam remediation project. These population estimates were intended to provide insight into the status of the catchable LMB population while the lake water level was lowered for the project. Various methods have been used to estimate fish populations throughout the United States, including angler catch, (Gablehouse and Willis 1986) underwater surveys, (Davis et al. 1997) or catch depletion techniques (Maceina et al. 1995). The primary methods for LMB population estimates have relied on mark-recapture and catch per unit of effort (CPUE) studies (Cooper 1981, Hightower and Gilbert 1984, Miranda et al. 1996, Isley and Tomasso 1998, Kershner and Marschall 1998, McInerny and Cross 1999, Granfors and Giusti 2011). For this study, mark-recapture methods were utilized to monitor the response of the catchable LMB within Lake Perris to the reduced water levels over the 14-year period.

## Materials and Methods

*Study area*.— Lake Perris (33° 52' N, 117° 09' W) is the termination of the eastern branch of the State Water Project operated by DWR and was first filled in 1974. The lake is located approximately 16 km (10 miles) southeast of the city of Riverside and 105 km (65 miles) east of Los Angeles at an elevation of approximately 484 m (1,588 ft) in the Perris Valley. At maximum pool, the lake occupies 2,292 surface acres and has 127,000 acre-feet of water storage. The lake drawdown of 7.62 vertical meters (25 ft) resulted in around 1,882 surface acres and 74,500 acre-feet of storage (59% capacity) at maximum capacity while repairs occurred (DWR 2007). A statewide drought further impacted the lake 2014-2017, further reducing the water volume to 53,500 acre-feet (42% capacity). The lake began to slowly refill in February 2018 after repairs were completed

*Methods.*— Mark-recapture using electrofishing was conducted in spring using a Smith-Root SR-18 electrofishing boat. The primary objective was to determine the population of catchable LMB of 305 mm (12 inches) total length (TL) and larger. Pulsed DC current at 60 pulses per second (6-8 amps) was used to put the fish into electro-narcosis. The boat crew consisted of two forward netters and a boat operator. LMB were netted and placed in the boat holding tank for processing and released back into the lake.

LMB larger than 305 mm were marked using a combination of pelvic fin clips (removal) and hole punches in the anal or second dorsal fin, each combination distinct to a given year of sampling (Granfors and Giusti 2011, Pine et al. 2012). The dorsal and anal fins were divided into thirds: front, middle and rear, for placement of the hole punch mark if used. Each yearly estimate was independent of any other estimates. Fish were marked with the fin clip combination unique to a given year and subsequently recorded as recaptures for that given year. Any fish marked in prior years were treated as unmarked fish and the new unique mark applied. The population was considered to be "closed" to estimate the population (Krebs 1999). Monthly lake storage data (acre-feet) at Lake Perris were collected from the DWR California Data Exchange and converted to elevation from lake capacity curve information provided by DWR.

The LMB population was estimated 2005-2018 using either Schumacher-Eschmeyer (SEM) or Petersen (P) statistical methods (Seber 1982, Krebs 1999). The 2005 pre-drawdown estimate sampled locations that were selected by dividing the lake shoreline into forty-one 0.40 km (0.25 mile) transects and randomly selecting 15 transects (37% of the available shoreline) for each of the mark-recapture efforts that year. The resulting 2005 pre-drawdown estimate was extrapolated to account for the remaining shoreline area that was not sampled. The 2006-2018 post-drawdown estimates sampled the entire shoreline primarily by electrofishing. The 2006-2008 estimates used SEM multiple mark-recapture sampling utilizing only electrofishing. However, the estimates 2009 and 2010 also incorporated catch and release bass fishing tournaments as an additional mark-recapture method to electrofishing to replicate a similar sampling methodology undertaken at nearby Diamond Valley Lake at the time (Granfors and Giusti 2011). Tournament data was collected to potentially increase the sampling area beyond the shallow areas of the lake through angling practices in deeper areas of the lake. The loss of staff and boat mechanical issues in 2011, disabled the ability to conduct a SEM multiple mark-recapture effort. Therefore, a Petersen mark-recapture estimate using only electrofishing was conducted to arrive at a population estimate that year. The estimates 2012-2018 resumed using SEM multiple mark-recapture, sampling the entire shoreline with electrofishing only.

LMB angling regulations were changed in 2006 to a two fish / 380 mm (15 inch) limit from five fish / 305 mm (12 inch) limit as a mitigation measure to limit harvest during the drawdown. Installation of 1,484 fishery habitat structures made of primarily citrus limbs were also placed in the lake from 2008 to 2016 as a mitigation measure for lost littoral habitat. These structures were placed into the drawn-down littoral zone to provide habitat for LMB and other sport-fish.

## Results

The 2005 pre-drawdown population estimate resulted in a SEM estimate of 21,726 LMB larger than 305 mm after extrapolation to shoreline area not sampled. The 2006 SEM analysis estimated a total of 13,472 LMB larger than 305 mm (62% of the 2005 reference population) and 5,802 LMB larger than 305 mm in 2008 (27% of the reference population) (Table 1). Catch and release tournament fishing was integrated into the sampling as a mark-recapture method in 2009. This additional sampling method accounted for 40% of the total fish collected that year and increased the estimate that year to 9,966 LMB. Tournament angling was again utilized as part of the 2010 mark-recapture efforts culminating in a population estimate of 5,642 LMB with tournaments accounting for only 20% of the total collected. The 2011 estimate relied upon a single mark-recapture Petersen method, resulting in an estimated 5,827 LMB larger than 305 mm. Estimates increased to 9,971 in 2012 and 11,169 in 2013, then decreased to 3,412 in 2015 and 3,631 in 2018 during drought years (Table 1).

**Table 1.**— Yearly catchable Largemouth Bass (*Micropterus salmoides*) population estimates, mark-recapture method, sampling methods and number of LMB collected from Lake Perris, CA 2005 -2018.

| Year | Estimate | Method | Sampling Method | LMB collected |
|---|---|---|---|---|
| 2005 | 21,726 | SEM | Shoreline Transects | 1,378 |
| 2006 | 13,472 | SEM | Entire Shoreline | 4,562 |
| 2007 | 9,596 | SEM | Entire Shoreline | 1,095 |
| 2008 | 5,802 | SEM | Entire Shoreline | 1,471 |
| 2009 | 9,966 | SEM | Shoreline w/ tournaments | 1,626 |
| 2010 | 5,642 | SEM | Shoreline w/ tournaments | 1,442 |
| 2011 | 5,827 | PETERSON | Entire Shoreline | 779 |
| 2012 | 9,791 | SEM | Entire Shoreline | 3,052 |
| 2013 | 11,169 | SEM | Entire Shoreline | 3,135 |
| 2014 | 7,518 | SEM | Entire Shoreline | 2,392 |
| 2015 | 3,412 | SEM | Entire Shoreline | 1,442 |
| 2016 | 4,678 | SEM | Entire Shoreline | 1,332 |
| 2017 | 5,447 | SEM | Entire Shoreline | 1,637 |
| 2018 | 3,631 | SEM | Entire Shoreline | 692 |

Lake Perris surface elevation was near full pool in 2005 averaging 483.4 m (1,586 ft; 96% capacity) until September when the mandated drawdown to 476.4 m (1,563 ft; 59% capacity) was initiated and was reached by November 2005 (Figure 1). Lake Perris elevation averaged 475.5 m (1,560 ft; 54% capacity) from 2006 to 2013. The 2014 statewide drought decreased the lake elevation to an average of 472.7 m (1,551ft; 42% capacity) from 2014-2017. Drought conditions ended in 2017, and water was available to refill the lake once the dam remediation project was completed in January 2018 (Figure 1).

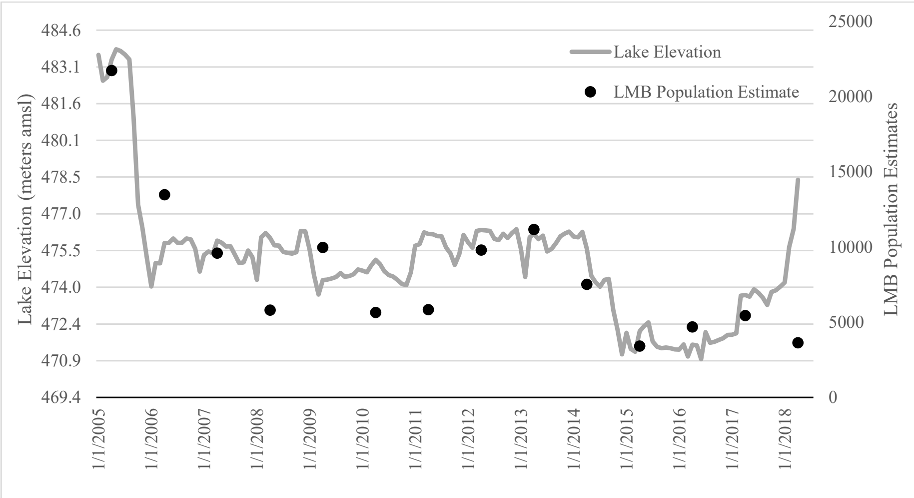


**Figure 1.**— Lake Perris Largemouth Bass (LMB; *Micropterus salmoides*) population estimates and lake elevation during a prolonged drawdown and drought 2005-2018.

## Discussion

Nationally there is a scarcity of quantitative data collected over many consecutive years on one waterbody which hinders testing of fisheries management hypothesis (Ploskey 1986). Because of this, effects of reservoir water level manipulation, as they relate to LMB recruited into the sport-fishery, are difficult to predict with any degree of confidence (Miranda et al. 1984, Ploskey 1986). Primarily due to the many biotic and abiotic variables that exist in reservoirs. Biotic factors such as spawning population size (Ricker 1954), suitable habitat availability (Durocher et al. 1984, Maceina and Bettoli 1998, Tate et al. 2003), body size (Aggus and Elliott 1975, Gutreuter and Anderson 1985, Miranda and Pugh 1997) and interspecific/intraspecific competition (Olson et al. 1995, Garvey et al. 2000) are known to affect recruitment. Abiotic factors, such as water level, are also important in understanding recruitment mechanisms of LMB, but the nature of its influence is not always obvious (Parkos and Wahl 2002). Reservoir hydrology plays a pivotal role in fish recruitment, as the amount of water in a reservoir regulates the potential for many underlying biotic variables to be exerted (Reinart et al. 1997, Sammons et al. 1999). This study documents 14 consecutive years of catchable LMB population estimates as they relate with drawn down water levels at Lake Perris, because the numbers and sizes of fish in a population determine the potential to provide benefits for recreational fisheries (Neumann et al. 2012).

Estimates of catchable LMB were chosen over monitoring age-0 or juvenile LMB, because of the recruitment variability that can occur with sport-fish to catchable size, even under normal hydrological conditions (Ploskey et al. 1996, Parkos and Wahl 2010). Ultimately, fisheries managers monitor species within a sport fishery by population size, angler catch rate, harvest rate, relative weights, and proportional size distribution (PSD) / relative size distribution (RSD) values of a fishery population. All these quantifiable attributes are taken from “adult” or “catchable” fish, not age-0, juveniles or sub-adults. Juvenile and subadult LMB may not recruit into a sport fishery and reach a size of maturity to sustain the population or provide recreational benefits sought by anglers. Inability to recruit is due to the vast number of biological, limnological and environmental variables; which are regulated largely by hydrology, that can affect recruitment success of juvenile year classes (Gutreuter and Anderson 1985; Ploskey al. 1996, Allen et al. 1999, Jackson and Noble 2000, Parkos and Wahl 2002, Parkos and Wahl 2010). The vast amount of uncertainty to whether juveniles or sub-adults will reach adulthood in a sport fishery prompted use of catchable population estimates to monitor the effect of the drawdown in Lake Perris.

The term "catchable" is often interchanged with the term "harvestable" because of Statewide or lake specific regulations used to manage sport-fish populations. Lake Perris regulations included a daily limit of five LMB larger than 305 mm (12 inches) per angler prior to the drawdown in 2005. Lake Perris regulations were temporarily changed to a daily limit of two LMB larger than 380 mm (15 inches) per angler for the duration of the drawdown. This management action was implemented to mitigate against a potential fishery collapse through unsustainable harvest. Though harvest rates of LMB at Lake Perris for the duration of the drawdown are unknown, angler survey data collected from nearby Diamond Valley Lake 2009-2017 and Lake Skinner 2014-2017 showed LMB harvest rates ranged from <1%-4% at both lakes (Q. Granfors unpublished data). All three lakes are frequented by the same pool of anglers targeting LMB, indicating predominately catch and release practices in the area. Another mitigation was the addition of brush pile structures to create habitat that was lost following the water reduction. These brush pile additions placed 2008-2014 consisted of 1,154 structures and were placed in the shallow littoral zone adjacent to areas where habitat was lost. However, drought in years 2014-2017 caused most of these shallow brush piles to be exposed to the air and thus unusable to fish. Therefore, 330 additional brush piles were placed 2015-2016 (22% of the total 1,484) in the drought induced littoral zone making them available to fish between 2015-2017. Despite the additional habitat, fishery habitat was very limited during these drought years. Similar to other studies that observed congregations of bass near brush habitat (Paxton and Stevenson 1979, Wege and Anderson 1979, Allen et al. 2014), many of the LMB collected by electrofishing 2015-2017 were concentrated near these brush piles. Electrofishing near many of the few remaining habitats in the water may have affected the population estimated in those years. Electrofishing around the limited areas where LMB congregated could have increased recapture rates of previously marked LMB relative to prior surveys where habitat areas were more numerous and spread out. This would result in more conservative estimates. However, electrofishing near areas where LMB congregate, also potentially increases sample size, which could result in a more thorough population estimate.

The initial 2005 population estimate (N=21,726) resulted from an extrapolated estimate derived from randomly sampling of 37% of the lake's shoreline over five sampling efforts. At that time, Lake Perris was near full pool, making sampling the entire shoreline impossible given budgetary and personnel constraints at the time. Transects sampled were chosen at random for each sampling effort, maximizing the assumptions for a closed population (Krebs 1999) given the entire lake was not sampled. Grinstead and Wright (1973) conducted a population estimate at Lake Eufaula Reservoir, Oklahoma, using the same transect extrapolation sampling methodology, and they found the estimates were biased toward underestimation. They based their conclusion on sampling bias that assumed all bass would be located near the shallow littoral zone where electrofishing occurs, and all sample transects would be representative of the entire reservoir. Neither of these assumptions is accurate because bass populations are seldom evenly distributed due to environmental heterogeneity and behaviors regulated by competitive, predatory or reproductive actions (Miranda and Dibble 2002). Our 2005 estimate may also have underestimated the population size. However, underestimation is likely due to the same reasons identified in the Lake Eufaula study and not the sample size in general. The 2005 estimate collected, marked and examined 1,378 LMB over 305 mm (Table 1), indicating a sufficient number of LMB were collected if the population was near the assumed 20,000, based upon estimates conducted prior to 2005 (Robson and Reiger 1964, Krebs 1999). The 2006 estimate (N=13,472; Table 1) collected, marked and examined 4,562 LMB by sampling the entire shoreline. The 2006 sample size is exceedingly sufficient. Since the LMB population from 2007-2018 was likely never going to exceed the baseline 2005 population estimate of 21,726 fish at full pool or the 2006 estimate of 13,472 fish following initial drawdown, sample sizes of the remaining SEM multiple mark-recapture estimates should be considered adequate (Table 1). The much smaller sample size (n=779) of the 2011 single mark-recapture Petersen estimate (N=5,827) is well below all other sample sizes, however the estimate is similar to the preceding 2010 estimate (N=5,642).

All estimates from 2006-2013 during the drawdown ranged from 5,642-13,472 (26-62% of the reference estimate) and averaged 8,908 LMB which is 41% of the reference estimate. During the drought there was a reduced capacity to only 42% of the water volume, and this reduction was reflected in estimates that ranged from 3,412-7,518, which was 15-35% and averaged 4,937 LMB, 23% of the reference estimate. The 2018 estimate had the smallest sample size (n=692) of the study and second smallest estimate (N=3,631). I believe this may be due to the rapid refilling of the lake following several years of drought (Figure 2). The expansion of the lake would have resulted in the LMB population being more widely distributed and more difficult to sample.

The monitoring at Lake Perris between 2005-2018 has documented the response of the catchable LMB population during a drastic and prolonged drawdown at Lake Perris. Anticipated losses in the fishery resulting from the change in the lake were realized. Unanticipated drought further amplified reductions observed to the catchable LMB population. The severity of the drought eliminated nearly all existing fishery habitat throughout the lake, likely contributing to a reduction of the carrying capacity within the lake (Figure 2). The addition of mitigated fishery habitat appears to have concentrated LMB during drought years in areas where habitat was placed and sampled where water still covered this habitat during the years of drought. Many of the LMB collected during drought years were around the limited fishery habitat, indicating LMB preference for those areas. Carrying capacity is influenced by the most limiting resource, typically habitat or food. Had habitat mitigation efforts not been instituted, it is possible the reduction to the catchable LMB population brought on by the drawdown would have been greater. Estimated population size of catchable LMB appears to decline consistently with the declining water level and lake capacity (Figure 2). Typically, negative feedback on population density often involves time lags that lead to oscillations around carrying capacity (Miranda and Dibble 2002). However, these population estimates show little time lag effect upon the abundance of catchable LMB, as they relate to the water levels. Studies have shown LMB populations exist in dynamic equilibrium where density of bass populations change temporally but fluctuate near a recurring level in stable water level and habitat conditions (Inskip and Magnuson 1983, Maceina and

Bettoli 1998). Temporal changes include irregular fluctuations, increases and decreases over long periods and cyclic oscillations regulated by complex density-dependent and density-independent factors (Miranda and Dibble 2002). Reductions to the population in Lake Perris most likely manifested from dynamic equilibrium selective pressures affecting recruitment and carrying capacity over the study period through density-independent regulations (e.g. habitat & water volume loss) and density dependent regulations (e.g. competition for food) as the water receded.

Although sampling was conducted in a consistent manner, annual variability among population estimates as they relate to changing lake levels, may be partially due to sampling bias, habitat availability, fluctuations inherent in stable LMB populations, the inherent under-estimation in the statistical analysis used in estimating the population, or all of them in combination (Robson and Reiger 1964, Swingle et al. 1966, Grinstead and Wright 1973, Edwards et al. 1997, Miranda and Dibble 2002, Parkos and Wahl 2010, Michaletz and Siepker 2013). Therefore, even relatively minor lake level fluctuations of up to seven feet that occurred within the drawdown period likely influenced estimates obtained and LMB populations year to year. However, since the methods used, and sample sizes collected to monitor the LMB population in Lake Perris were consistent throughout, estimates likely represent the trend of abundance that occurred. Studies that have evaluated water level effect on the abundance of LMB populations have done so by examining abundance of age-0 and/or juveniles with uncertain assumptions of translation to the catchable population. This study has shown the estimated abundance of LMB as they relate to water level reductions where the fish collected have direct recreational value in the sport-fishery as catchable fish. Our results show an extreme and prolonged drawdown negatively affected the abundance of catchable LMB within Lake Perris, confirming the anticipated losses to the recreational fishery.

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