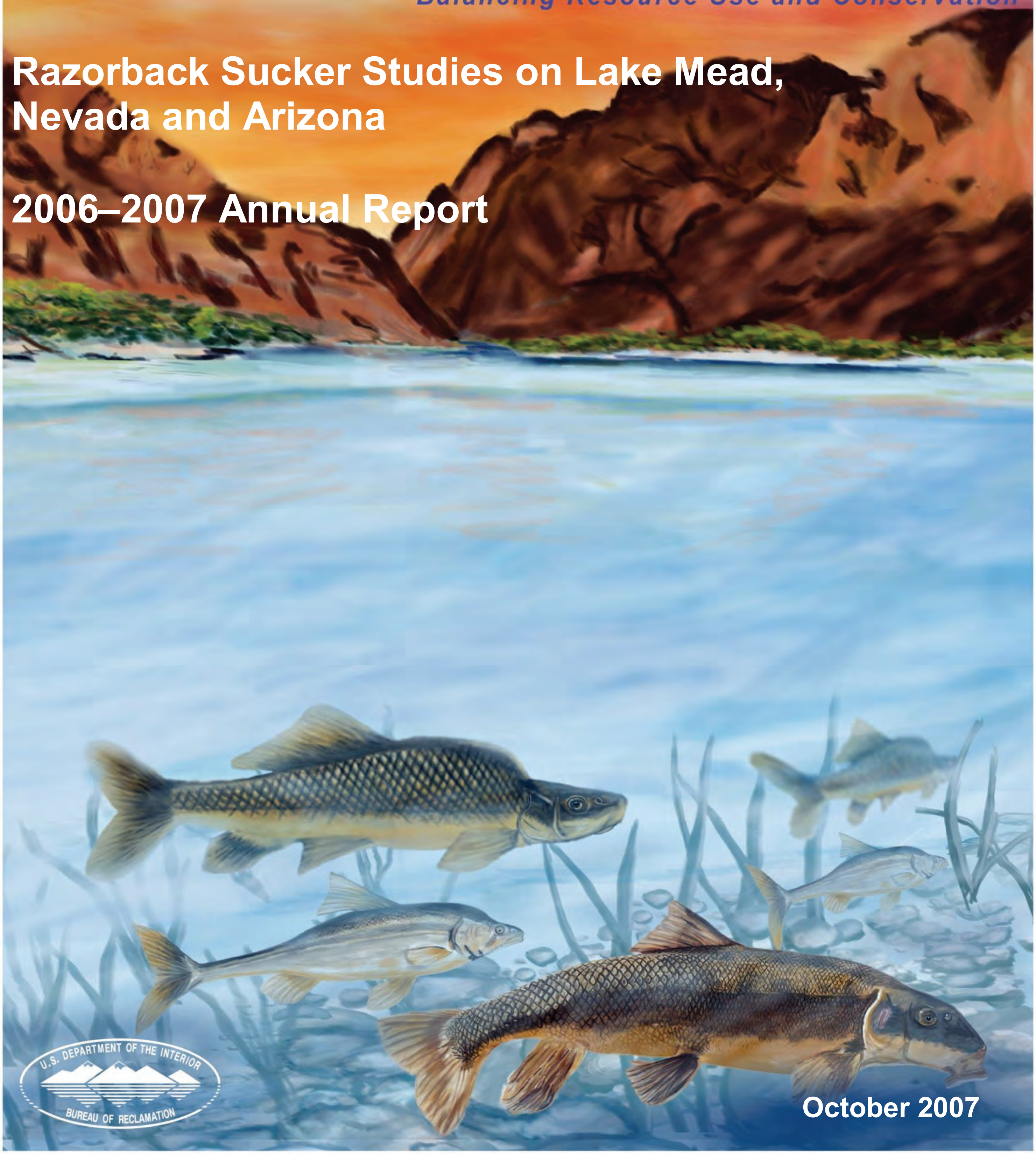
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Razorback Sucker Studies on Lake Mead, Nevada and Arizona

2006–2007 Annual Report



U.S. Department of the Interior
Bureau of Reclamation

October 2007

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Lower Colorado River Multi-Species Conservation Program

Razorback Sucker Studies on Lake Mead, Nevada and Arizona

2006–2007 Annual Report

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Multi-Species Conservation Program
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EXECUTIVE SUMMARY

In 1996 the Southern Nevada Water Authority and the Colorado River Commission of Nevada, in cooperation with the Nevada Department of Wildlife, initiated a study to develop information about the Lake Mead razorback sucker (*Xyrauchen texanus*) population. BIO-WEST, Inc., under contract with the Southern Nevada Water Authority, developed the study design and had primary responsibility for conducting the study. The Nevada Department of Wildlife provided equipment, technical support, and field support for the project. Other agencies that joined as cooperators at the beginning of the study included: the U.S. Bureau of Reclamation, which provided funding for equipment, storage facilities, and technical support; the National Park Service, which provided residence facilities in their campgrounds; and the U.S. Fish and Wildlife Service, which assisted with permitting issues. This report provides information and observations from the 11th (2006–2007) monitoring season.

During the 11th study year, the habitat use and movements of nine sonic-tagged fish were monitored, which provided a total of 127 separate location points. One of the fish was a residual tagged fish (code 222) from the 2004–2005 tagging event, while the remaining eight fish were individuals from the 2005–2006 tagging event. By using the data gathered from sonic-tagged fish, in conjunction with trammel netting and larval sampling data, spawning location shifts were once again documented during 2007 in all three study areas (Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area) of Lake Mead. Along with providing information on spawning locations, sonic- tagged fish provided valuable data on movement patterns within and amongst Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area. Sonic-tagged fish were documented moving between the Muddy River/Virgin River inflow area and Echo Bay, and between the Muddy River/Virgin River inflow area, Echo Bay, and Las Vegas Bay. In fact, one sonic-tagged individual (fish 447) was the first fish observed during the 11-year study moving between the northern portions of the Overton Arm and Las Vegas Bay (doing so twice). Sonic-tagged fish continue to provide invaluable data regarding the movement patterns and habitat use of razorback sucker in Lake Mead.

Trammel netting for juvenile/subadult and adult fish during the spawning period continued, and 88 razorback sucker—including 39 from Las Vegas Bay, 33 from Echo Bay, and 16 from the Muddy River/Virgin River inflow area—were captured. Interestingly, 10 of the razorback sucker collected (one from Las Vegas Bay, five from Echo Bay, and four from the Muddy River/Virgin River inflow area) were subadult fish (greater than 300 millimeters in total length, yet sexually immature). Of the 88 total razorback sucker collected, 50 were recaptures; this recapture rate falls within the range reported for previous years. More fish were captured this season than during any other season to date.

In addition to the capture of 16 razorback sucker at the Muddy River/Virgin River inflow area, another highlight of the 2006–2007 field season was the capture of two larval razorback sucker at the same location. The information obtained from sonic telemetry, trammel netting, and larval sampling suggests that the Muddy River/Virgin River inflow area of Lake Mead is yet another important area for razorback sucker production and recruitment. Furthermore, according to data collected during the 2007 spawning period and trammel netting and sonic telemetry data collected since 2004, it appears that the Echo Bay and Muddy River/Virgin River spawning aggregates are indeed one aggregate. Since the fish have been observed intermixing since 2004, these two groups of razorback sucker should be considered the same population.

Average growth during this study year, as determined from 23 recaptured fish, was 8.1 mm. Mean annual growth was 12.2 mm for Las Vegas Bay fish and 5.2 mm for Echo Bay fish. Growth rates from fish captured near the Muddy River/Virgin River inflow were not calculated due to lack of recaptures in this area. Growth rates of Lake Mead razorback sucker continue to be substantially higher than those recorded from other populations, suggesting that the Lake Mead razorback sucker populations are able to maintain a fairly strong cohort of young fish.

Fin ray sections were removed from 41 razorback sucker for age determination during the 11th study year which, when combined with the 91 fish aged during previous study years, brings the total number of fish aged during the study to 132. Of particular interest was the documentation of recent (2000–2004) recruitment. Past collections and analyses identified recruitment through 1999; however, fin ray material obtained during the last two field seasons indicates continued, recent recruitment in Lake Mead. Age-determination techniques continue to show that recruitment pulses in Lake Mead are associated with relatively high, stable lake elevations; however, this year we saw pulses in recruitment that coincided with low, declining lake elevations. This observation has prompted a need to review the overarching hypothesis concerning recruitment events on Lake Mead, which to date has tied recruitment to high lake elevations. This report highlights the need to further our understanding of the conditions that promote the highly unique recruitment of razorback sucker in Lake Mead. We recommend initiating an investigation of the factors enabling recent pulses in recruitment, despite lowered lake elevations, in the near future.

In addition to the efforts and findings reported above, BIO-WEST, Inc., also worked collaboratively with biologists from the Nevada Department of Wildlife, the U.S. Bureau of Reclamation, and the Southern Nevada Water Authority in a continued effort to collect additional larval razorback sucker for Lake Mead repatriation efforts. Hopefully these fish will allow for increased razorback sucker presence in Lake Mead, additional research opportunities to test our hypotheses concerning lake levels and cover, and increased understanding of recruitment patterns during future study years.

The 2007 study year marks the second documentation of the Las Vegas Bay population spawning at any location other than its historical Blackbird Point site. Spawning again occurred along the southwestern shoreline of Las Vegas Bay, as indicated by large numbers of juvenile/subadult and adult captures, relatively abundant larval densities, and heavy utilization of these habitats by residual sonic-tagged fish along this particular shoreline. It appears that the Las Vegas Bay razorback sucker population is able to shift spawning locations as needed to cope with reservoir elevation fluctuations, similar to observations of the spawning plasticity displayed by the Echo Bay population during the majority of past study years. How this shift in spawning habitat use at Las Vegas Bay relates to future year-class recruitment remains to be seen.

Similarly, during the last four spawning periods (2002–2005) at Echo Bay, the spawning site used the previous year was dry because of declining lake levels; however, each year this population found other suitable spawning sites in other portions of Echo Bay. During the 2007 spawning period, adult captures, larval concentrations, and the habitat use of residual sonic-tagged fish indicated that the Echo Bay population spawned primarily along the northern shoreline west of the Echo Bay Marina, approximately 85 m east of the location used during the 2004–2006 spawning periods. This shift, similar to that observed at Las Vegas Bay, is presumptively an artifact of low and declining lake elevations. Likewise, spawning near the Muddy River/Virgin River inflow area was successfully documented again in 2007 near Fish Island.

In addition to this annual report, we are in the process of preparing a review report that outlines and summarizes our efforts on Lake Mead during the past decade. The purpose of this document is to condense data collected to date into a user-friendly format that describes the study from its inception to current status. Furthermore, it is our hope that the review document will be useful for various user groups, audiences, and other parties–those interested in the questions, methodologies, results, and lessons learned while studying this unique species in Lake Mead.

Given the decline in lake levels projected to occur during the 2007–2008 field season, perhaps achieving the lowest levels observed during the study period, general research objectives for the 2006–2007 study year include continuing to monitor the two populations of razorback sucker at Echo Bay and Las Vegas Bay, continuing to age individual razorback sucker from Lake Mead, and continuing to study razorback sucker use of the Overton Arm of Lake Mead. In addition to the general long-term data collection and monitoring effort, we also recommend that efforts be made to gather, investigate, and evaluate other information that may help us understand recruitment pulses observed on Lake Mead to date and re-evaluate the overarching hypothesis regarding Lake Mead razorback sucker population sustainability in light of the changing physical and biological conditions on Lake Mead. Efforts could be directed at finding, evaluating, and incorporating data collected on Lake Mead by other groups, particularly data that tracks/monitors changes in the physical, limnological, and/or water quality conditions in Lake Mead. Special attention could be given to evaluating changes (if any) of turbidity levels in Lake Mead, especially data collected near known spawning locations. In all, the goal would be to investigate whether physical conditions in Lake Mead have changed in recent years, with the intention of relating this information to years of rather strong recruitment based on our aging results. Depending on literature and data review findings, this effort may be expanded to include trends in nonnative fish species that may have predatory or competitive impacts on razorback sucker recruitment. In general, the goal of the review would be to investigate questions similar to those questions posed/inferred in the discussion section of this report.

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INTRODUCTION

The razorback sucker (*Xyrauchen texanus* [Abbott]) is an endemic fish species of the Colorado River Basin. It was historically widespread and common throughout the larger rivers of the Colorado River Basin (Minckley et al. 1991). The distribution and abundance of the razorback sucker are greatly reduced from historic levels, and it is one of four endemic, large-river fish species (Colorado pikeminnow [*Ptychocheilus lucius*], bonytail [*Gila elegans*], humpback chub [*Gila cypha*]) presently considered endangered by the U.S. Department of the Interior (USFWS 1991). One of the major factors causing the decline of razorback sucker and other large-river fishes has been the construction of mainstem dams and the resultant cool tailwaters and reservoir habitats that replaced a warm, riverine environment (Holden and Stalnaker 1975, Joseph et al. 1977, Wick et al. 1982, Minckley et al. 1991). Competition and predation from nonnative fishes that are successfully established in the Colorado River and its reservoirs have also contributed to the decline of these endemic species (Minckley et al. 1991). Razorback sucker persisted in several of the reservoirs that were constructed in the lower Colorado River Basin; however, these populations were comprised primarily of adult fishes that apparently recruited during the first few years of reservoir formation. The population of long-lived adults then disappeared 40 to 50 years following reservoir creation and the initial recruitment period (Minckley 1983). The largest reservoir population, estimated at 75,000 in the 1980s, occurred in Lake Mohave, Arizona and Nevada, but it had declined to less than 3,000 by 2001 (Marsh et al. 2003). Mueller (2005, 2006) reports the wild Lake Mohave razorback sucker population to be approaching 500 individuals, while the most recent estimate of Lake Mohave razorback sucker determined there are approximately 218 wild fish remaining (Marsh 2007).

Adult razorback sucker are most evident in Lake Mohave from January through April when they congregate in shallow shoreline areas to spawn, and larvae can be numerous soon after hatching. Today, the Lake Mohave population is largely supported by periodic stocking of captive-reared fish (Marsh et al. 2003, Marsh et al. 2005). Predation by bass (*Micropterus* spp.), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), sunfish (*Lepomis* spp.), and other nonnative species appears to be the primary reason for lack of razorback sucker recruitment (Minckley et al. 1991, Marsh et al. 2003).

The Lake Mead population appeared to follow the trend of populations in other lower Colorado River Basin reservoirs. Lake Mead was formed in 1935 when Hoover Dam was closed and razorback sucker were relatively common lake-wide throughout the 1950s and 1960s, apparently from reproduction soon after the lake was formed. Their numbers became noticeably reduced in the 1970s, approximately 40 years after closure of the dam (Minckley 1973, McCall 1980, Minckley et al. 1991, Holden 1994, Sjoberg 1995). From 1980 through 1989, neither the Nevada Department of Wildlife (NDOW) nor the Arizona Game and Fish Department (AGFD) collected razorback sucker from Lake Mead (Sjoberg 1995). This trend may have been partially due to changes in the agencies' lake sampling programs; however, there was a considerable decline from the more than 30 razorback sucker collected during sportfish surveys in the 1970s. These results are not surprising and fit well within the pattern of razorback sucker population declines approximately 40–50 years following reservoir development, as was seen in other lower Colorado River Basin reservoirs.

After receiving reports in 1990 from local anglers that razorback sucker were still found in Lake Mead in two areas (Las Vegas Bay and Echo Bay), NDOW initiated limited sampling. From 1990 through 1996, 61 razorback sucker were collected, 34 from the Blackbird Point area of Las Vegas Bay and 27 from Echo Bay in the Overton Arm (Holden et al. 1997). Two razorback sucker larvae were collected by an NDOW biologist in 1995 near Blackbird Point, confirming suspected spawning in this area. In addition to the captures of these wild fish, NDOW also stocked subadult razorback sucker into Lake Mead. A total of 26 razorback sucker were stocked into Las Vegas Bay in 1994, and 14 were stocked into Echo Bay in 1995. All of these stocked fish were tagged with passive integrated transponder (PIT) tags, and all originated from the Dexter National Fish Hatchery 1984 year-class that was reared at Floyd Lamb State Park in Nevada. Collection of razorback sucker in the 1990s raised many questions about Lake Mead razorback sucker: How large is the population? Are the Las Vegas Bay and Echo Bay groups separate populations? Does razorback sucker recruitment occur in the lake? How old are the fish in Lake Mead, and are the two groups different in age structure? In 1996 the Southern Nevada Water Authority (SNWA), in cooperation with NDOW, initiated a study to attempt to answer some of these questions. BIO-WEST, Inc. (BIO-WEST), was contracted to design and conduct the study with collaboration from the SNWA and NDOW. Other cooperating agencies included: the U.S. Bureau of Reclamation (Reclamation), which provided funding, storage facilities, and technical support; the U.S. National Park Service (NPS), which provided residence facilities in their campgrounds; the Colorado River Commission of Nevada; and the U.S. Fish and Wildlife Service (USFWS).

At the start of the project in October 1996 the primary objectives were to:

- determine the population size of razorback sucker in Lake Mead,
- determine habitat use and life history characteristics of the Lake Mead population, and
- determine use and habitat of known spawning locations.

In 1998 Reclamation agreed to contribute additional financial support to the project to facilitate fulfillment of Provision #10 of the Reasonable and Prudent Alternative generated by the USFWS's Final Biological and Conference Opinion on Lower Colorado River Operations and Maintenance-Lake Mead to Southerly International Boundary (USFWS 1997). In July 1998 a cooperative agreement between Reclamation and the SNWA was completed, specifying the areas to be studied and extending the study period into 2000.

Additional study objectives added to fulfill Reclamation's needs included the following:

- search for new razorback sucker population concentrations via larval light-trapping outside the two established study areas, and

- enhance the sampling efforts for juvenile razorback sucker at both established study sites.

If new populations were tentatively located by finding larval razorback sucker, trammel netting would be used to capture adults and sonic tagging would be used to determine the general range and habitat use of the newly discovered population. In 2002 Reclamation and SNWA completed another cooperative agreement to extend Reclamation funding into 2004. In 2005 a new objective of evaluating the lake for potential stocking options/locations was added to the project as a response to a growing number of larval fish that had been and were slated to eventually be repatriated to Lake Mead. Also in 2005 Reclamation requested that a monitoring protocol be established to ensure the success and continuity of the long-term, growing database that is maintained by BIO-WEST and stems from Lake Mead collections made during its decade-long course of studies. In response, BIO-WEST developed a monitoring protocol that should help maximize the amount of information gained from studying various life phases of razorback sucker during future monitoring and/or research efforts on Lake Mead. Reclamation and SNWA recently decided to complete another cooperative agreement, tentatively extending monitoring efforts for the next several years.

This Annual Report presents the results of the 11th study year (July 2006–June 2007). Information and data from previous years (October 1996–June 2006) are included as applicable.

SUMMARY OF EARLIER STUDY RESULTS, 1996–2006

Since the Lake Mead Razorback Sucker Study began in 1996, netting efforts have resulted in nearly 700 total razorback sucker capture and/or stocking events, represented by nearly 400 unique individuals. The PIT tags proved valuable in assessing growth and movement patterns of this razorback sucker population. In 1997 four subadult razorback sucker were captured in Echo Bay, indicating that recent, natural recruitment had occurred within the Lake Mead population. Seventeen additional wild subadult razorback sucker were captured in the Blackbird Point area of Las Vegas Bay through 2005. Beginning in 1999 small sections of fin rays were removed from wild razorback sucker for age determination purposes, and through 2006 91 razorback sucker had been aged. Collected adult fish ranged in age from approximately 8–35 years, and subadult fish were between 3–6 years. It has been hypothesized that lake-level fluctuations that promote growth and then inundation of shoreline vegetation are largely responsible for the pattern of recruitment observed in Lake Mead's razorback sucker population. The inundated vegetation likely serves as protective cover that, along with turbidity, allows young razorback sucker to avoid predation by nonnative fishes.

During the last several years, declining and low lake elevations have affected razorback sucker spawning sites at Echo Bay and the Colorado River inflow area of Lake Mead. At Echo Bay from 1997–2001, aggregations of sonic-tagged adults, redd locations, and larval concentrations indicated that spawning was occurring at the back of Echo Bay along the south shore. Specifically, it appeared that adult razorback sucker were spawning at the base of a 50-foot-high cliff. At the end of the spawning season in May 2001, this site was dry. As the lake level continued to decline during the last several years, the Echo Bay population continued to find new spawning sites in Echo Bay as sites from previous years dried, moving down the wash with the declining lake. At Las Vegas Bay during the first 9 years of this study, most razorback sucker larvae were captured along the western shore and tip of Blackbird Point. This suggests that the same portion of Blackbird Point was used for spawning every year, but the depth in this area changed dramatically as lake levels dropped. In the late 1990s, at a high lake elevation, the spawning location was thought to be near a depth of 80 ft. By 2003 the spawning depth was closer to 20 ft, and by the end of 2004 the area was completely desiccated. As a result spawning was not observed at the Blackbird Point spawning area during the 2003–2004 study year, and only four larval razorback sucker were captured during the entire season at Las Vegas Bay, a site that harbored the largest razorback sucker population in Lake Mead. However, during 2005 spawning (January through April), Lake Mead elevations rose more than 20 ft, allowing access to the Blackbird Point spawning site during the ninth study year. In 2006, in response to lowered lake conditions, the spawning aggregate at Las Vegas Bay shifted spawning habitat use from Blackbird Point to the southwestern shoreline of Las Vegas Bay. This was the first time that the Las Vegas Bay population was documented to move its spawning location due to changes in habitat availability.

In 2000 and 2001 larval razorback sucker were captured in the Colorado River inflow region of Lake Mead. During the 2002 and 2003 spawning periods, no larval razorback sucker were captured in this area. This population either did not spawn, or spawning took place outside of our sampling area. Alteration of spawning sites resulting from lake elevation changes may be responsible for the apparent absence of spawning in the Colorado River inflow region. In 2003–2004 larval sampling was conducted at the Muddy River/Virgin River inflow areas and throughout the Overton Arm of Lake Mead. Despite having habitat characteristics similar to Echo and Las Vegas Bays (in terms of turbidity, vegetation, and gravel shorelines), no larval razorback sucker were captured in the Overton Arm north of Echo Bay on any of the sampling occasions. However, after following movements of a single, sonic-tagged fish in 2005, adult and larval sampling was reinitiated at the Muddy River/Virgin River inflow areas. The result of this effort was the documentation of spawning activities in this relatively understudied area of Lake Mead. In 2006 razorback sucker were again documented spawning successfully near the Muddy River/Virgin River inflow area.

During the first 6 years of this study, 46 fish (42 wild and 4 hatchery reared) were equipped with internal or external sonic tags. Approximately half of these tags had a 12-month battery life (implanted in 1997 and 1998), and the other half had a 48-month battery life. Sonic telemetry showed a seasonal habitat use pattern within the lake. At Las Vegas Bay the fish concentrated in the Blackbird Point area during the spawning period but moved further out into the bay during the nonspawning period (June–November). Most of these fish were found using the north shore of Las Vegas Bay between Blackbird Point and Black Island. At Echo Bay a similar pattern was seen; fish left the Echo Bay spawning area and regularly used Rogers Bay and other points north of Echo Bay along the western shore of the Overton Arm. The four hatchery-reared fish implanted with sonic tags and stocked into the Colorado River inflow area early in the sixth study year (2002) were active in the Grand Wash area for several months after stocking. Two of the fish became stationary, and the remaining two fish were last contacted in the inflow area in April 2002. Despite numerous lake-wide searches, the missing fish were not located. In January 2003 (seventh study year) four razorback sucker (two at Echo Bay and two at Las Vegas Bay) were captured during standard trammel netting and implanted with 48-month sonic tags. One of the Las Vegas Bay fish was found stationary near Black Island in February 2003. The other fish and one of the Echo Bay fish were last contacted in 2003 (the eighth study year). The last fish from the 2003 telemetry implantation effort to be contacted was one of the Echo Bay fish, which was contacted several times during the early part of the 2004–2005 field season.

The drastic decline in larval fish abundance in 2004 spurred questions pertaining to whether/where the Las Vegas Bay population was spawning. Welker and Holden (2004) proposed tagging six razorback sucker from Floyd Lamb State Park as an experimental test, hoping that these fish would integrate with the wild population in Las Vegas Bay and help us identify new spawning areas. As a result, six fish from Floyd Lamb State Park were tagged during the 2004–2005 study year, and sonic surveillance of these individuals produced interesting results. All contact with the four fish introduced into the Las Vegas Bay area was lost within 1 month. It is most probable that the tags failed, as multiple and extensive searches of the lake for the missing fish were unsuccessful. However, two of the fish (experiencing the same surgery, handling, introduction, and monitoring protocols as the four Las Vegas Bay fish) were introduced at Echo Bay. In general, these fish appeared to integrate with the wild population and were followed throughout the 2004–2005 study year. One of these fish (code 344) spent the majority of the field season in the back of Echo Bay, while the other fish (code 222) displayed large movement patterns from Echo Bay and within the Overton Arm of Lake Mead. This report contains movement information for only one of the 2004–2005 tagged fish (code 222 from Echo Bay), which was contacted multiple times after its release and active during the 2006–2007 field season. In addition, this report also contains information from eight residual hatchery-reared (Floyd Lamb State Park) razorback sucker that were tagged and released during the 2005–2006 field season.

Overall, the sonic telemetry data collected during this study have provided valuable information on razorback sucker spawning, movement patterns, and shifts in habitat use and spawning site selection. Furthermore, it has been demonstrated that tracking even hatchery-reared, sonic-tagged razorback sucker can be highly effective in locating new spawning areas and monitoring known spawning locations used by wild razorback sucker populations. Hence using sonic-tagged fish can increase the efficiency of field efforts.

STUDY AREAS

All of 2006–2007 study year activities occurred at the locations used in the 1996–2006 portions of the study (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b, Holden et al. 2001, Abate et al. 2002, Welker and Holden 2003, Welker and Holden 2004, Albrecht and Holden 2005, Albrecht et al. 2006a, Albrecht et al. 2006b). The two most familiar areas sampled were Echo Bay and Las Vegas Bay (Figure 1). Razorback sucker activity was also studied at the Muddy River/Virgin River inflow area of Lake Mead, the part of Lake Mead near Fish Island in the northernmost portions of the Overton Arm (Figure 1).

Most areas of the lake, including the Overton Arm, Boulder Basin, Virgin Basin, and portions of Colorado River inflow areas, were searched using telemetry equipment. Larval sampling was performed in Echo Bay, Las Vegas Bay, and the Muddy River/Virgin River inflow area. Trammel netting was conducted at Las Vegas Bay, Echo Bay, and at the Muddy River/Virgin River inflow area (Figure 1).

Specific definitions for the various portions of the Las Vegas Wash/Bay in which the study was conducted were given in Holden et al. (2000b). The following definitions are still accurate for various portions of the wash:

- Las Vegas Wash is the portion of the channel with stream-like characteristics. This section is usually relatively narrow with obvious banks.

- Las Vegas Bay begins where the flooded portion of the channel widens and the velocity is reduced. Las Vegas Bay can have a flowing (lotic) and a non-flowing (lentic) portion. The flowing portion is typically short (200-400 yards) and transitory between Las Vegas Wash proper and Las Vegas Bay. Since lake elevation affects what is called the wash or bay, the above definitions are used to differentiate the various habitats at the time of sampling.

Throughout the text of this report, three portions of Las Vegas Bay may be referred to using the following terms:

- flowing portion (the area closest to, or within Las Vegas Wash);

- non-flowing portion (usually has turbid water but very little, if any, current); and

- Las Vegas Bay (the majority of the bay that is not immediately influenced by Las Vegas Wash and is lentic in nature).

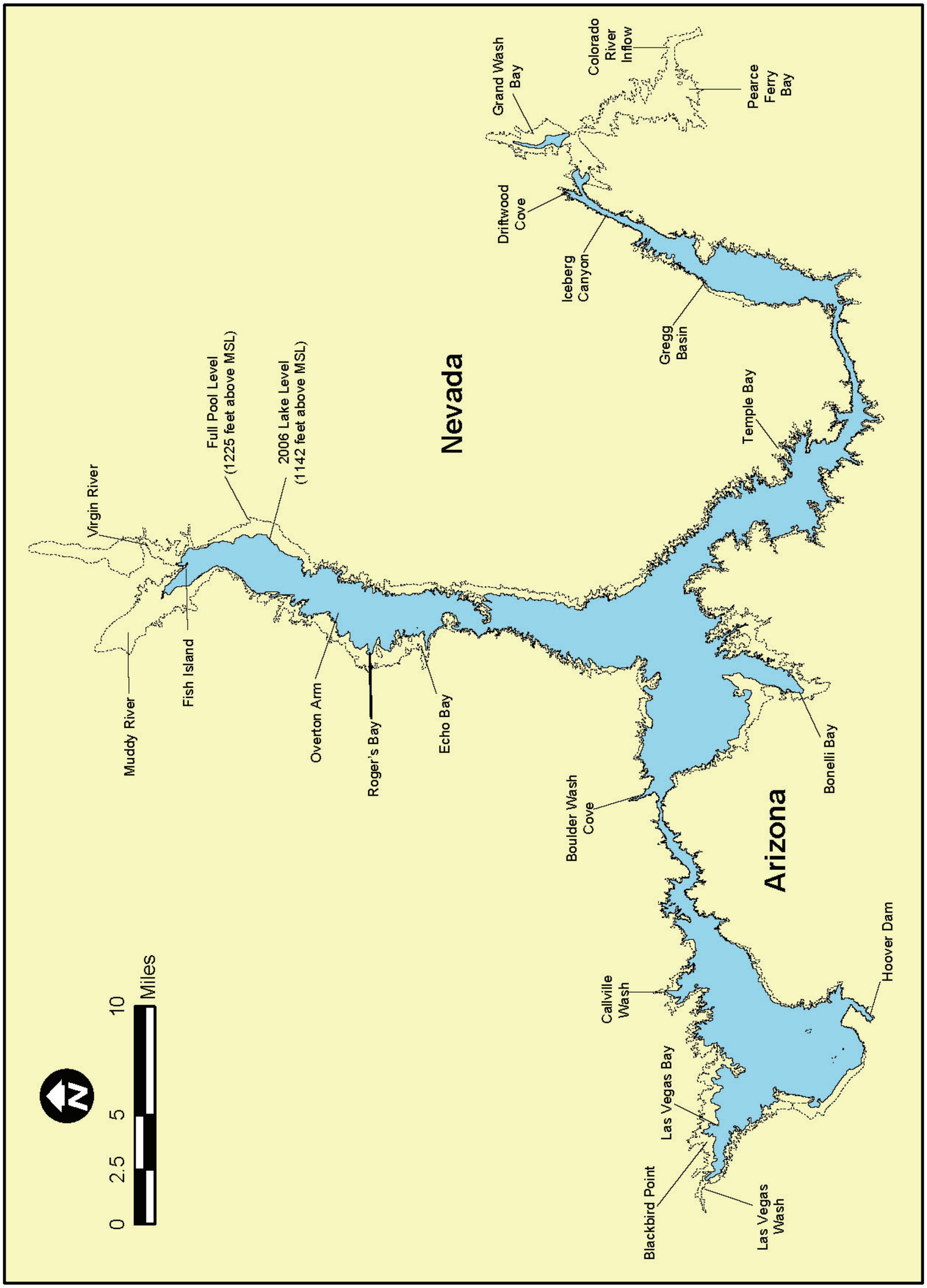

Figure 1. **Map of Lake Mead showing general study locations.**

Additionally, the location of wild adult and larval razorback sucker in the northern portion of the Overton Arm necessitates a description of these areas. These location definitions follow those provided in Albrecht and Holden (2005):

- Muddy River/Virgin River inflow area (the lentic and littoral habitats located between the Muddy River confluence and the Virgin River confluence with Lake Mead);

- Fish Island (located between the Muddy River and Virgin River inflows, bounded on the west side by the Muddy River inflow and on its eastern side by the Virgin River inflow. This area may or may not be an actual island depending upon lake elevation); and

- Muddy River and Virgin River proper, the actual flowing, riverine portions that comprise the Muddy and Virgin rivers.

METHODS

Lake Elevation

Month-end lake elevations for the 2006–2007 field season (July 1–June 30) were measured in ft above mean sea level (amsl) and obtained from Reclamation's Lower Colorado Regional Office website (Reclamation 2007). The effect of fluctuating lake levels on razorback sucker habitat was documented by written observations and/or photographs during sampling trips to each of the study areas.

Adult Studies

Trammel nets (300 ft long by 6 ft deep with an internal panel of 1, 1.5, or 2-inch mesh and external panels of 12-inch mesh) were the primary gear used to sample adult fish. Nets were generally set with one end near shore in 10–30 ft of water, with the net stretched out into deeper areas. All trammel nets were set in the late afternoon (just before sundown) and pulled the next morning (shortly after sunrise). Sampling was generally conducted weekly within each study area from January–April, with variable effort between months and locations. Netting locations for the three primary study sites were selected based on the locations used by sonic-tagged fish, the location of larval concentrations, and ancillary knowledge of historical spawning areas.

Fish were taken from nets, and live fish were held in large, water-filled containers. Razorback sucker were isolated from other fish species and held in separate containers. All but the first five common carp were enumerated and returned to the lake, while other species (including five carp) were identified, measured for total length (TL), weighed, and released at the location of capture. Razorback sucker were scanned for PIT tags, PIT tagged if they were not recaptured fish, measured (including standard length [SL] and fork length [FL]), weighed, and released at the point of capture. Razorback sucker were anesthetized with MS-222 and then placed dorsal side down on a padded surgical cradle for support during processing.

Larval Sampling

Larval sampling methods followed those developed by Burke (1995) and other researchers on Lake Mohave. The procedure uses the positive phototactic response of larval razorback sucker to capture them. After sundown two 12-volt "crappie" lights were connected to a battery, placed over each side of the boat, and submerged in 4-10 inches of water. Two "netters" equipped with long-handled aquarium dip nets were stationed to observe the area around the lights. Larval razorback sucker that swam into the lighted area were dip-netted out of the water and placed into a holding bucket. The procedure was repeated for 15 minutes at each location, and 6–12 sites were customarily sampled on each night attempted. Larvae were identified and enumerated as they were placed in the holding bucket and then released at the point of capture when sampling at a site was completed.

As a result of fluctuating lake levels, larval sampling during spring 2007 could not be conducted at the same 12 Echo Bay and Las Vegas Bay standard larval sites that were sampled in spring 1999, 2000, and 2001 (Holden et al. 2000a, 2000b, 2001). During 2002–2007 only some of the original sites were used, and others were assigned based on initial sampling. Additional larval sites were selected at random to help locate spawning areas. When possible, the locations of active, sonic-tagged fish and the previous week's adult netting results were also used to select larval sites over the course of the season. At Echo Bay, Las Vegas Bay, and the Muddy River/Virgin River inflow area, larval sampling sites changed throughout the course of the season due to the ever-changing desiccation and inundation of sites throughout the study year. As a result, the larval sampling strategy was a much more responsive, fluid, and adaptable protocol than in the past. This strategy was useful in coping with fluctuating lake elevations during the 2007 spawning period.

In addition to the standard larval sampling conducted this year, BIO-WEST also worked collaboratively with biologists from NDOW and Reclamation in an effort to collect additional larval razorback sucker for future repatriation efforts. The general collection protocol was essentially an extension of the larval sampling method BIO-WEST had developed (described above) with additional effort (time, boats, number of lights, etc.) spent collecting larval fish at specific sites, where catch per unit effort (CPUE) was elevated during a particular night. BIO-WEST worked under the direct supervision of agency biologists, and larval razorback sucker were immediately turned over to NDOW and Reclamation biologists upon capture for transport and hatchery provisions. Larval fish capture results stemming from the collaborative sampling efforts discussed above are not included as part of this report; they are retained by and available from NDOW upon request.

Annual Spawning Site Identification

We have found that multiple methods are needed to identify and pinpoint annual spawning sites. The basic, most effective spawning site identification procedure has been to track sonic-tagged fish, keying in on the most heavily frequented areas. Once a location was identified as an area of heavy use by sonic-tagged fish, nets were set in an effort to capture adult razorback sucker. These fish were then evaluated for signs of ripeness indicative of spawning. After the initial identification of a possible spawning site through sonic-tagged razorback sucker habitat use and other, untagged adult trammel net captures, larval sampling was conducted to validate whether successful spawning occurred. Examples of the effectiveness of these techniques are evident in the descriptions provided by Albrecht and Holden (2005) regarding the documentation of a new spawning aggregate near Fish Island.

Age Determination

Determination of Lake Mead razorback sucker age distribution was added to the project in 1998, when a subadult fish (381 mm TL) was collected and subsequently died (Holden et al. 1999). This initiated development of a nonlethal aging technique using fin ray sections beginning in 1999 (Holden et al. 2000a). As in past years, an emphasis of our 2006–2007 efforts involved collecting fin ray sections from razorback sucker for aging purposes.

During the 2007 spawning period, selected razorback sucker captured via trammel netting were anesthetized and a single, approximately 0.25-inch-long segment of the second left pectoral fin ray was surgically removed. Fish were anesthetized with a lake water bath containing MS-222, NaCl, and slime coat protectant to reduce surgery-related stresses, speed recovery, and avoid accidental injury to fish that may thrash about during surgical procedures. During the surgery standard processing was accomplished (weighing, measuring, PIT-tagging), and a sample was surgically collected using custom made bone snips developed by BIO-WEST. The surgical tool used to remove fin rays and developed by BIO-WEST consists of a matched pair of finely sharpened chisels welded to a set of wide-mouth Vise-Grips™ pliers. The connecting membrane between rays was cut using a scalpel blade, and the section was placed in a labeled envelope for drying. All surgical equipment was sterilized before use, and subsequent wounds were packed with antibiotic ointment to minimize post-surgical bacterial infections and promote rapid healing. All razorback sucker were immediately placed in a recovery bath of fresh lake water containing slime coat protectant, allowed to recover, and released as soon as the fish regained equilibrium and appeared recovered from the anesthesia. Vigilant monitoring of the fish was conducted during all phases of the procedure.

In the laboratory fin ray segments were embedded in thermoplastic epoxy resin and heat cured. This technique allowed the fin rays to be perpendicularly sectioned using a Buhler isomet low-speed saw. Resultant sections were then mounted on microscope slides, sanded, polished, and examined under a stereo-zoom microscope. Oil immersion techniques were also used on occasion to increase clarity and aide in proper specimen age identification. Each sectioned fin ray was aged independently by at least two readers. Sections were then reviewed by the readers in instances where the assigned age was not agreed upon. If age discrepancies remained after the second reading, the readers viewed the structure together and assigned an age. For further information regarding the evolution of our fin ray aging technique, please refer to Albrecht and Holden (2005), Albrecht et al. (2006a), as well as other, past annual reports.

Sonic Tagging

No sonic tagging occurred or was necessary during the 2006–2007 study year due to the number of residual sonic-tagged fish from the 2005–2006 tagging event. For those interested in the sonic-tag implantation methods we used during Lake Mead razorback sucker studies, please refer to Albrecht et al. (2006a) or other past annual reports.

Sonic Tracking

Sonic telemetry was used to assess adult habitat use and movement within and between spawning areas during the 2006–2007 study year. Four male and six female razorback sucker from Floyd Lamb State Park were sonic tagged during the 2005–2006 field season, and in 2006–2007 we continued to follow a single, residual fish from the 2004–2005 tagging event (Albrecht and Holden 2005, Albrecht et al. 2006a). Fish were located on a weekly or more frequent basis, depending on the field schedule and weekly project goals. Fish searches were generally conducted along shorelines with listening points every 0.5 mile or less, depending on shoreline configuration and other factors that could impact signal reception (sonic equipment is line-of-sight and any obstruction can reduce or block a signal). Once a signal was found, the directional capabilities of the hydrophone, volume of the transmitter, and triangulation techniques were used to pinpoint the actual location of the fish, which was then noted using a GPS unit.

Population Estimates

Capture data collected by BIO-WEST from 2005–2007 were used to calculate abundance estimates for razorback sucker populations at Echo Bay and Las Vegas Bay. Stocked fish were not used in the population estimates unless they had survived at least 1 year in Lake Mead. It was assumed that an adult stocked fish that had survived 1 year in the wild was able to reproduce and contribute progeny to the population (Albrecht and Holden 2005, Modde et al. 2005). Estimates for populations were derived from the most recent 3-year data collection period (2005–2007) of this study.

Two abundance estimators were used, Chao's M_h (Chao 1989) and Model M_o (Otis et al. 1978). The Model M_o typically produces the most reliable estimates for endangered western fishes (Dr. Ron Ryel, consultant, personal communication), but it assumes equal catchability of individuals. Chao's M_h is a good estimator for sparse data, but unlike Model M_o it assumes heterogeneity of capture probabilities. If the estimators gave very different numbers, then a reliable estimate was believed to lie somewhere between the two numbers. However, as shown in past reports, close agreement between the models indicated a fairly reliable estimate.

RESULTS

Lake Elevation

Similar to the 10th study year, lake elevations during the 11th study year diminished overall. From a starting elevation in January 2007 of nearly 1,130 ft amsl, lake levels dropped throughout the spawning period. Lake Mead elevation at the end of April 2007 was approximately 1,120 ft amsl. This translated to an overall loss of nearly 10 ft of depth during the spawning period (or approximately 3 ft of vertical drop per month [Figure 2]). We visually observed that the littoral shoreline habitat at Fish Island, near the Muddy River/Virgin River inflows, diminished 30–40 m during February–late April. Similar observations were made at both Echo and Las Vegas bays.

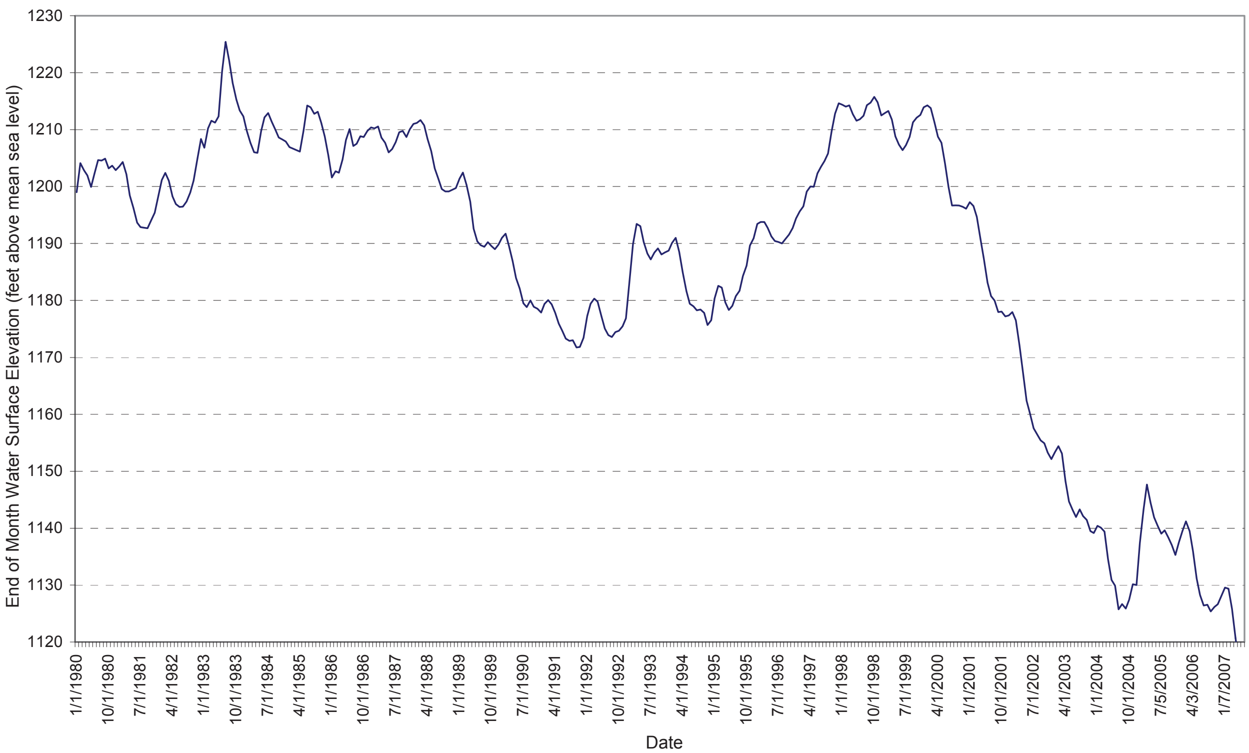

Figure 2. Lake Mead month-end elevations, January 1980–June 2007.

Adult Sampling

<u>Trammel Netting</u>

Table 1 shows the trammel netting effort, expressed as net nights, that occurred from July 2006–June 2007. Figures 3, 4, and 5 show the locations of trammel net sets in the primary study

Table 1. Trammel netting effort (net nights) on Lake Mead during the 11th study year.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY	OVERTON ARM	TOTAL
January	4	6	4	14
February	16	10	8	34
March	11	16	14	41
April	5	8	6	19
May	2	0	0	2
Total	**38**	**40**	**32**	**110**

areas for the same period. One net night is comprised of a single net, set overnight. Trammel netting was conducted over 110 net nights during the 11th study year, with 38 net nights spent in the Las Vegas Bay/Boulder Basin area, 40 net nights spent in the Echo Bay area, and 32 net nights in the Muddy River/Virgin River inflow area. Trammel netting efforts were concentrated along the southwestern shoreline area in Las Vegas Bay, as well as within other Las Vegas Bay locations (Figure 3). Trammel netting was primarily conducted near the back of Echo Bay (Figure 4). In all cases, net sets were largely dictated by the location of sonic-tagged fish in each of the sampling areas.

Trammel netting at the Muddy River/Virgin River inflow was concentrated around the Fish Island shoreline, but efforts were designed to be flexible and were largely dictated by the habitat use and movements of sonic-tagged fish throughout the northern portions of Lake Mead (Figure 5). Most of the netting effort was expended from January–April (Holden et al. 1997, 1999; Albrecht et al. 2006a, 2006b). During the 2006–2007 field season, adult razorback sucker were captured at depths ranging from 3–64 ft, with a mean capture depth of 14 ft (averaged across all netting and razorback sucker capture locations). No trammel netting effort specific to razorback sucker was expended at the Colorado River inflow area during the 11th study year.

In accordance with previous study years (Holden et al. 2000a, 2000b, 2001; Abate et al. 2002; Welker and Holden 2003, 2004; Albrecht and Holden 2005, Albrecht et al. 2006a), the timing of trammel netting for the 11th study year was coordinated with seasonal differences in water and air temperature, and the spawning season. Netting during the first two study years revealed that warmer air and water temperatures encountered during summer netting efforts appeared to stress razorback sucker that were brought to the surface. Hence trammel netting was not conducted from June–October 2006. One change implemented during the 2001–2002 field season that was not a part of netting protocol during the previous three field seasons was netting during the razorback sucker spawning season (January–May). This practice was again employed during the 11th study year. Prior to the sixth study year, it was believed that netting during the spawning season was stressful to spawning razorback sucker and that this activity might disrupt spawning or influence adult survival. However, return rates for razorback sucker sampled by the USFWS in 2000 and 2001 were similar to return rates for fish captured outside of the spawning period.

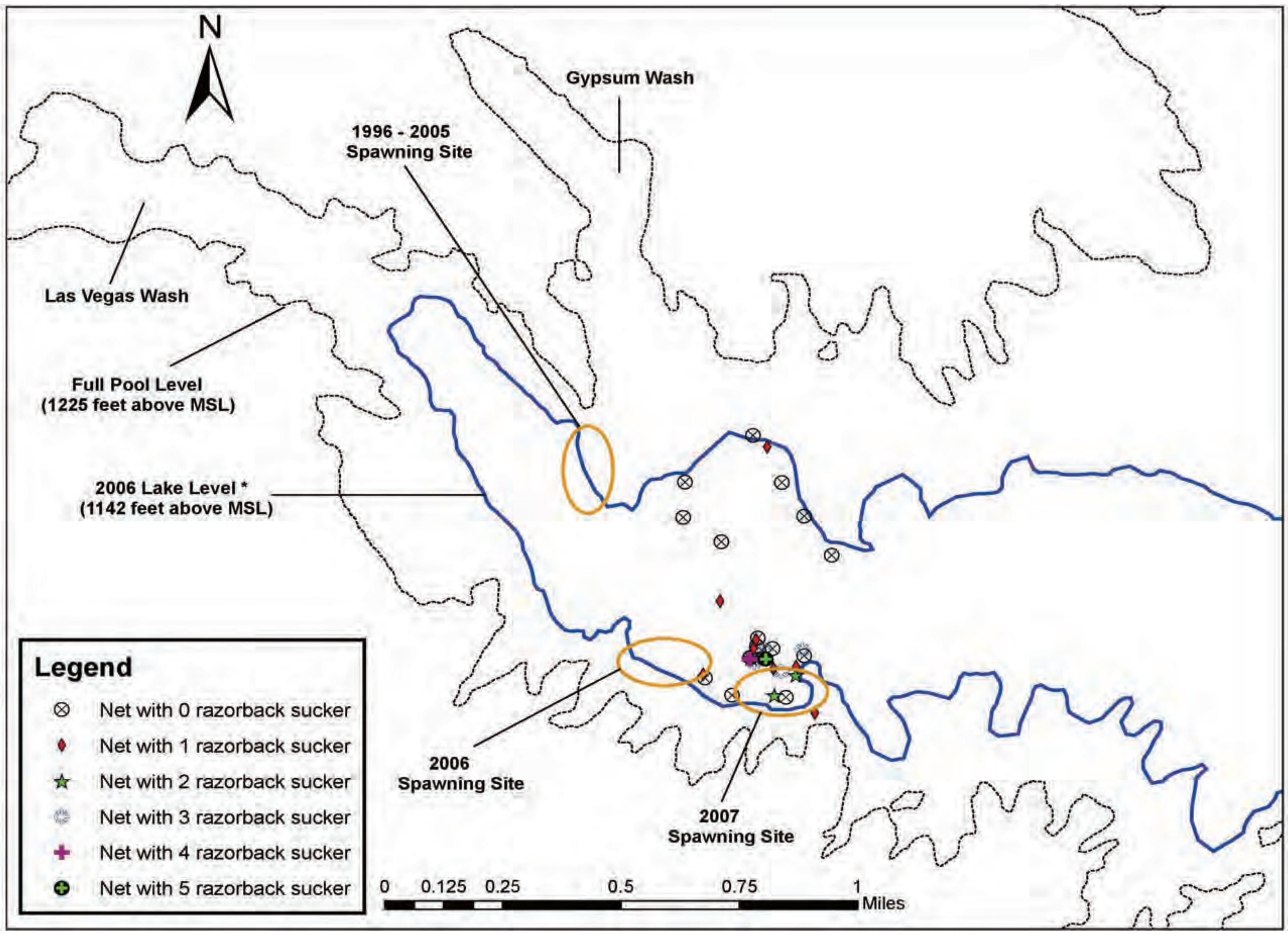

Figure 3. Las Vegas Bay study area showing locations of trammel netting and numbers of fish captured, July 2006–June 2007.

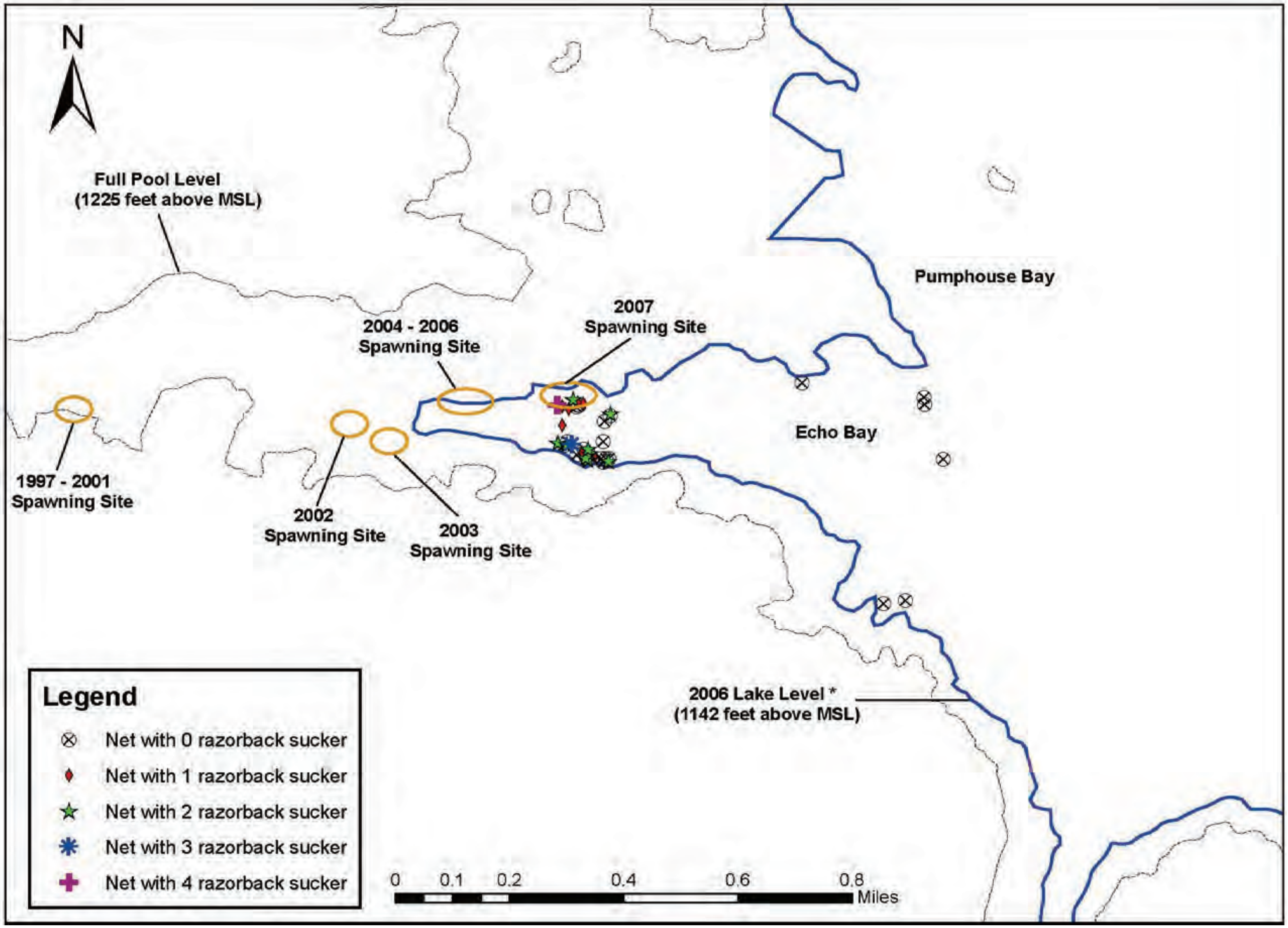

Figure 4. Echo Bay study area showing locations of trammel netting and numbers of fish captured, July 2006–June 2007.

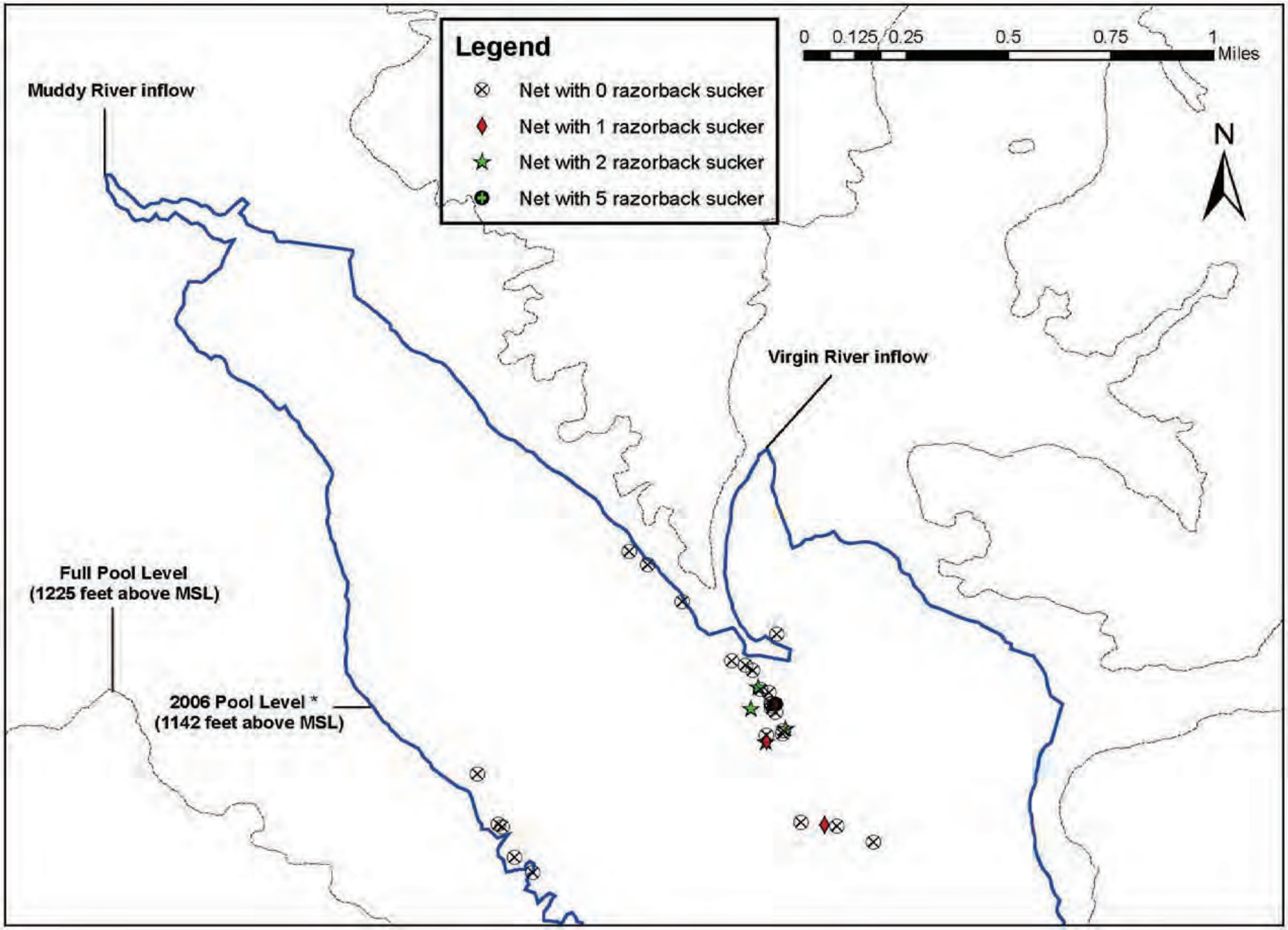

Figure 5. **Muddy River/Virgin River inflow study area showing locations of trammel netting and numbers of fish captured, July2006–June 2007.**

Furthermore, many of the fish captured by the USFWS were new individuals, indicating that BIO-WEST was not sampling the portion of the populations in both Las Vegas Bay and Echo Bay that moved into these areas late to spawn. Therefore, trammel netting was performed during the 2006–2007 spawning season in order to effectively sample the adult razorback sucker population.

In addition, most trammel netting effort occurred between February through the latter portion of April 2007. This change was implemented in order to opportunistically provide a test of the recommendations for long-term monitoring of Lake Mead razorback sucker as found in Albrecht et al. (2006b).

Thirty-eight adult and one subadult razorback sucker were captured at Las Vegas Bay (Table 2) during the 38 net nights expended during the 11th study year (Figure 3). As described in Albrecht et al. (2006a), most fish were captured near the southwestern shoreline of Las Vegas Bay, providing continued evidence the Las Vegas Bay razorback sucker population shifted spawning locations for the second year running. In the past, most of the razorback sucker captured in Las Vegas Bay were netted at Blackbird Point (Holden et al. 1997, 1999, 2000a, 2000b, 2001; Abate et al. 2002; Welker and Holden 2003, 2004; Albrecht and Holden 2005). During the 2006 and 2007 spawning periods, the majority of razorback sucker were captured in shallow water (7–34 ft deep) along a gravel section of shoreline off the southwestern side of Las Vegas Bay in net sets positioned perpendicular to the shoreline. Initially, efforts were increased along this particular shoreline due to the frequent presence of sonic-tagged fish that were introduced into Las Vegas Bay during the 2005–2006 field season, most of which were still active in 2007. In both 2006 and 2007, larval razorback sucker abundance confirmed this location as the primary spawning area. The razorback sucker catch rate for trammel netting at the Las Vegas Bay area was 1.30 fish/net night for the 11th field season. This rate is higher than the previous year's (0.30 fish/net night) and is the highest catch rate observed during our studies at this location (0.10–0.34 fish/net night) (Figure 6).

Throughout Echo Bay nets were set with greater emphasis placed on the back portion of the bay in areas where contacts with sonic-tagged fish were concentrated, larval razorback sucker were found in the highest concentrations, and razorback sucker were previously captured (Figure 4). Razorback sucker were collected from depths ranging from 3–64 ft. In all, 28 adult and 5 subadult razorback sucker were captured during 40 net nights (Table 2). The razorback sucker catch rate for trammel netting at Echo Bay was 0.83 fish/net night, which is higher than the rate obtained during the previous study year (0.59 fish/net night) (Figure 6). Similar to the comparison of 2005 and 2006 efforts at Echo Bay, it appears that the increase in CPUE during the 2007 spawning period may have been related to the presence of sonic-tagged fish at this location, which enabled more precise net set locations. Furthermore, the overall reduction in the size and topography of Echo Bay during 2006–2007 also likely increased the efficiency of net sets, particularly those sets near the back of Echo Bay where surface areas were constrained, depths were diminished, and we could nearly barricade the back portions of the bay with sampling gear.

Table 2. **Location, tagging, and size information for razorback sucker collected in Lake Mead from July 2006-June 2007.**

DATE	CAPTURE LOCATION [a]	PIT TAG NUMBER	SONIC CODE	DATE STOCKED OR ORIGINALLY CAPTURED	RECAPTURE	TL[b] (mm[f])	FL[c] (mm)	SL[d] (mm)	WT[e] (g[g])	SEX[h]
1/11/07	EB	53256C725A	-	-	NO	535	500	460	1,890	UI
1/11/07	EB	5325515754	-	2/01/06	YES	710	650	595	4,490	F
1/11/07	EB	53260F6232	-	-	NO	493	459	420	1,475	M
1/11/07	EB	53244B0648	344	12/01/04	YES	567	520	480	2,310	M
1/11/07	EB	7F7D2B2D5F	-	4/02/93	YES	606	558	515	2,850	M
1/11/07	EB	1F4A457C56	-	7/25/95	YES	556	517	475	2,440	M
1/30/07	LVB	532557480A	-	-	NO	514	478	435	1,805	M
1/30/07	LVB	5326000260*	447	11/29/05	YES	650	602	585	3,665	F
1/30/07	LVB	1F476B7936*	-	7/25/1995	YES	674	617	574	3,085	F
2/01/07	EB	53256C725A	-	1/11/07	YES	-	-	-	-	UI
2/01/07	EB	53257D1C30	-	-	NO	637	585	543	2,820	M
2/01/07	EB	7F7D2B2D5F	-	4/02/93	YES	-	-	-	-	M
2/01/07	EB	1F4A457C56	-	7/25/95	YES	-	-	-	-	M
2/06/07	LVB	532603134E	-	5/22/03	YES	584	542	490	2,165	M
2/06/07	LVB	53257D563B	-	-	NO	519	480	435	1,415	M
2/06/07	LVB	5325773752	-	-	NO	574	522	473	2,020	F
2/08/07	EB	532615681C	-	-	NO	609	568	531	2,590	M
2/08/07	EB	1F4A457C56	-	7/25/95	YES	-	-	-	-	M
2/08/07	EB	53256C725A	-	1/11/07	YES	-	-	-	-	UI
2/08/07	EB	7F7D16534B	-	2/27/02	YES	619	564	505	2,855	M
2/08/07	EB	1F48452C28	-	1/22/02	YES	649	606	573	3,585	F
2/13/07	LVB	1F476C5856	-	1/17/01	YES	580	530	485	2,310	M
2/13/07	LVB	5324566879	-	-	NO	526	490	455	1,915	M
2/14/07	EB	53256C725A	-	1/11/07	YES	-	-	-	-	UI
2/14/07	EB	5325646B16	-	-	NO	501	465	425	1,495	M
2/14/07	EB	1F50034140	-	12/02/03	YES	636	584	-	-	F
2/16/07	LVB	5325661333	-	-	NO	530	489	451	1,610	M
2/20/07	LVB	53256B2638	-	-	NO	534	492	455	1,835	M
2/21/07	LVB	532603134E	-	5/22/03	YES	-	-	-	-	M
2/21/07	LVB	5325773752	-	2/06/07	YES	-	-	-	-	F
2/21/07	LVB	5325736759	-	-	NO	358	332	302	495	UI
2/21/07	LVB	5325661333	-	2/16/07	YES	-	-	-	-	M
2/21/07	LVB	5324495232	-	-	NO	511	466	435	1,550	M
2/22/07	OA	5326051F79	-	-	NO	452	418	386	1,180	M
2/22/07	OA	53256B3E00	-	-	NO	542	506	471	2,125	UI
2/22/07	OA	532568047C	-	-	NO	476	441	410	1,275	M
2/22/07	OA	532578084C	-	-	NO	459	424	392	1,100	M

DATE	CAPTURE LOCATION [a]	PIT TAG NUMBER	SONIC CODE	DATE STOCKED OR ORIGINALLY CAPTURED	RECAPTURE	TL[b] (mm[f])	FL[c] (mm)	SL[d] (mm)	WT[e] (g[g])	SEX[h]
2/22/07	OA	5326214434	-	-	NO	494	460	425	1,485	UI
2/23/07	EB	53263D264D	355	1/21/03	YES	617	565	526	-	M
2/23/07	EB	53257C0232	-	4/02/03	YES	586	540	510	-	M
2/27/07	LVB	5325661D5B	445	11/30/05	YES	538	495	459	1,988	M
2/27/07	LVB	5325661333	-	2/16/07	YES	-	-	-	-	M
2/27/07	LVB	5324495232	-	2/21/07	YES	-	-	-	-	M
2/27/07	LVB	201D5B2345	-	11/19/98	YES	645	588	559	3,392	M
2/27/07	LVB	5324223868	-	-	NO	586	541	505	2,365	M
2/27/07	LVB	53244A0917	-	-	NO	603	555	516	2,288	M
2/27/07	LVB	532574067F	-	-	NO	650	610	565	3,220	M
3/01/07	OA	53254B2122	-	-	NO	477	442	392	1,392	M
3/01/07	OA	5325570A47	-	-	NO	512	479	430	1,598	UI
3/02/07	EB	1F782D516B	-	12/07/98	YES	590	545	502	2,172	M
3/02/07	EB	5325515754	-	2/01/06	YES	706	645	591	3,880	F
3/02/07	EB	532624527C	222	12/01/04	YES	537	488	451	2,052	M
3/06/07	LVB	5324051E2D	446	11/30/05	YES	611	567	533	2,930	F
3/06/07	LVB	5325661333	-	2/16/07	YES	-	-	-	-	M
3/06/07	LVB	532F2B3C28	-	-	NO	515	474	436	1,875	F
3/06/07	LVB	5344304E63	-	-	NO	611	574	539	2,840	F
3/06/07	LVB	5325773752	-	2/06/07	YES	-	-	-	-	F
3/06/07	LVB	5325626218	-	-	NO	565	523	491	2,035	F
3/07/07	OA	53256C725A	-	1/11/07	YES	-	-	-	-	UI
3/08/07	OA	45137C607D	-	-	NO	463	432	391	1,075	M
3/08/07	OA	5325506C6C	-	-	NO	455	426	389	1,110	M
3/08/07	OA	53254B2122	-	3/01/07	YES	-	-	-	-	M
3/09/07	EB	53420B5001	-	-	NO	660	624	582	3,015	M
3/09/07	EB	53420B5001	-	3/09/07	YES	-	-	-	-	M
3/09/07	EB	532624527C	222	12/01/04	YES	-	-	-	-	M
3/13/07	LVB	532603134E	-	5/22/03	YES	-	-	-	-	M
3/13/07	LVB	532F43475C	-	-	NO	586	547	509	2,515	F
3/13/07	LVB	5325773752	-	2/06/07	YES	-	-	-	-	F
3/13/07	LVB	53336F552A	-	-	NO	636	587	538	3,205	M
3/13/07	LVB	5334475A6E	-	-	NO	524	485	459	1,925	M
3/15/07	OA	7F7D7C0675	-	-	NO	516	476	441	1,615	F
3/16/07	EB	53256C725A	-	1/11/07	YES	-	-	-	-	UI
3/16/07	EB	5326253212	-	-	NO	691	644	612	3,990	F
3/19/07	EB	53260F6232	-	1/11/07	YES	-	-	-	-	M
3/19/07	EB	5325786966	-	1/10/06	YES	631	584	534	3,100	M
3/19/07	EB	531F0A6332	-	1/21/03	YES	631	581	531	2,580	M

DATE	CAPTURE LOCATION [a]	PIT TAG NUMBER	SONIC CODE	DATE STOCKED OR ORIGINALLY CAPTURED	RECAPTURE	TL[b] (mm[f])	FL[c] (mm)	SL[d] (mm)	WT[e] (g[g])	SEX [h]
3/28/07	EB	7F7D7B2651	-	-	NO	564	524	485	1,850	M
4/02/07	LVB	533E7F092F	-	-	NO	704	655	603	4,885	F
4/03/07	OA	5330534B0F	-	-	NO	508	476	430	1,590	M
4/03/07	OA	1F500A3156	-	12/2/03	YES	560	510	473	2,050	M
4/04/07	EB	5325646B16	-	2/14/07	YES	-	-	-	-	M
4/09/07	LVB	7F7D312A1B	-	3/20/04	YES	644	598	550	2,835	F
4/09/07	LVB	1F7D790D5E	-	11/25/98	YES	656	605	548	3,550	F
4/09/07	LVB	5325773752	-	2/06/07	YES	-	-	-	-	F
4/09/07	LVB	532575245C	555	11/30/05	YES	632	580	533	3,080	F
4/11/07	OA	532578084C	-	2/22/07	YES	-	-	-	-	M
4/11/07	OA	7F7D3F0905	-	-	NO	498	466	422	1,440	F
4/30/07	LVB	532F2B3C28	-	3/06/07	YES	-	-	-	-	F

[a] Locations: EB = Echo Bay, FLDB = Floyd Lamb State Park, FI = Fish Island, LVB = Las Vegas Bay, OA = Overton Arm (Muddy River/Virgin River inflow area).
[b] TL = Total length.
[c] FL = Fork length.
[d] SL = Standard length.
[e] WT = Weight.
[f] mm = Millimeters.
[g] g = Grams.
[h] Sex: F = female, M = male, UI = sex not determined.

*Fish was originally stocked into Echo Bay. All subsequent captures have been in Echo Bay until this capture occasion at Las Vegas Bay.

-Please also note that when length and weight data are missing, the fish had been captured previously during the 2007 season and was therefore released quickly to avoid further and/or unnecessary stress.

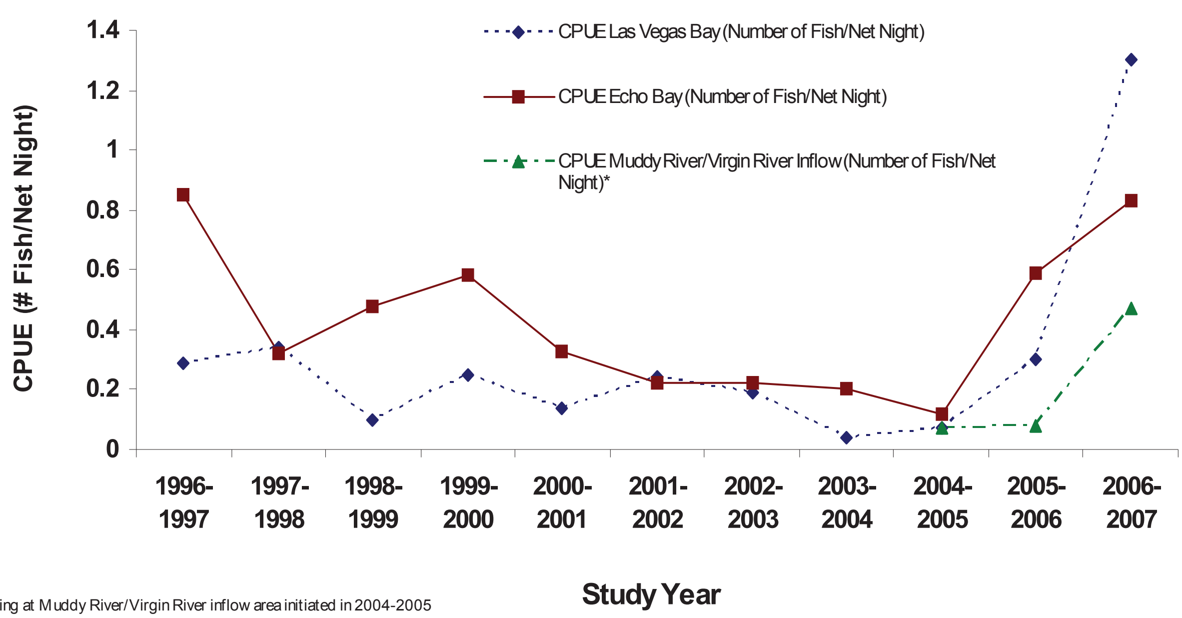

Figure 6. Trammel netting catch per unit effort (CPUE) during studies on Lake Mead razorback sucker, 1996-2007.

Razorback sucker were also captured at the Muddy River/Virgin River inflow area (Figure 5), marking the third consecutive spawning season in which we have documented successful spawning in this area of Lake Mead. Trammel netting efforts resulted in the capture of 12 adult razorback sucker. We also captured four subadult fish during the 2007 spawning period while trammel netting at the Muddy River/Virgin River inflow area. Capture depths ranged from 3–18 ft, and most fish were captured over gravel substrates near the Virgin River inflow at Fish Island. The razorback sucker catch rate for trammel netting at the Muddy River/Virgin River inflow area was 0.47 fish/net night, substantially higher than last year's catch rate of 0.08 fish/net night (Figure 6).

Albrecht and Holden (2005), as well as Albrecht et al. (2006a), discussed possible interactions and the potential for intermixing of the Muddy River/Virgin River spawning aggregate with fish known to use Echo Bay as a spawning location. Through the 2006 spawning period, we found that a hatchery-reared, repatriated fish stocked by NDOW in 2002 at Echo Bay was using habitats near the Muddy and Virgin River inflows. We also saw one of the sonic-tagged fish that had been stocked into Echo Bay extensively use habitats at the northern end of Lake Mead. However, prior to 2007, we had never observed a wild Lake Mead razorback sucker moving between locations. During this year, sonic-tagged fish continued to move between Echo Bay and the Muddy River/Virgin River inflows. We also captured another hatchery-reared razorback sucker that NDOW stocked in 2003 at Echo Bay using habitats near the Virgin River inflow.

Perhaps the most interesting capture in 2007 involved a subadult fish captured at Echo Bay and recaptured nearly a month later near the Virgin River inflow. This same subadult fish was then captured again in Echo Bay only 1 week later. Although the fish was immature, the capture of this wild, unmarked fish solidifies the idea that the Echo Bay spawning aggregate and the spawning aggregate documented near the Muddy River/Virgin River inflow area are more integrated than described in the past. Furthermore, if the two spawning aggregates are indeed the same population, then the Echo Bay population (as termed in past reports) may be much larger than previously thought. Additionally, the increase in young fish captured introduces more questions: For example, has something changed in Lake Mead that, in spite of diminished lake levels, favors natural recruitment? Is turbidity more important for recruitment of fish in Lake Mead than once thought, or has the lake become more productive? How have predators and nonnative fishes responded to lake level changes, and does this response shed any light on what appears to be increases in recent, natural recruitment of razorback sucker? Are young razorback sucker being stocked into Lake Mead, or are young razorback sucker entering the lake from an outside source such as one of the tributaries or a grow-out pond that is somehow connected to one of the tributaries and/or unknown to us at this time? At minimum, efforts this season continue to demonstrate that razorback sucker spawn outside of the two previously documented spawning locations, a phenomenon unknown until the ninth study year (2004–2005) (Albrecht and Holden 2005). Furthermore, this season shows that recruitment events continue despite lowered lake conditions. As more research is conducted in Lake Mead we are hopeful that the interactions and habitat use of razorback sucker in the Overton Arm will become better understood and that questions pertaining to continued razorback sucker recruitment events despite diminished lake conditions will also become more clear.

Another interesting pair of captures was two fish that had been stocked into Echo Bay and contacted one or more times in Echo Bay after stocking, and recaptured this season in Las Vegas Bay. The first fish was an active, sonic-tagged fish (code 447). This hatchery-reared (Floyd Lamb State Park) fish was sonic-tagged and released in November 2005, and it was consistently found near Echo Bay until this season. Sonic-tagged razorback 447 remained in Las Vegas Bay throughout the 2007 spawning period and was last located in Las Vegas Bay. The second fish, another fish stocked from Floyd Lamb State Park into Echo Bay by NDOW in 1995, was subsequently captured in Echo Bay in December 2003 and recaptured in Las Vegas Bay (along with sonic-tagged fish code 447) this year. Although we have documented stocked fish moving between spawning sites in the past, this is quite rare; in fact, we have only seen a fish move from one spawning site to another nine times during these studies. If the more regular movements between Echo Bay and the Muddy River/Virgin River inflow area are discounted, we have only observed the larger movement patterns on five occasions when fish moved between Echo and Las Vegas Bays, and two of these observations occurred during the 2007 spawning period. It should be noted that we have only witnessed a wild fish moving between spawning sites on two occasions: One was a wild male fish that went from Las Vegas Bay to Echo Bay (during the 2002 spawning period), and the other was a sexually immature fish that went from Echo Bay to the Muddy River/Virgin River inflow area and back to Echo Bay this spawning season (2007).

The other notable captures included several razorback sucker that were sonic tagged during past efforts. In total, seven different sonic-tagged fish were captured during 2007 netting efforts. Of these seven fish, five had active tags, were in great shape, and had completely healed surgical scars. One of the sonic-tagged fish (code 344) had been tagged and released in 2004, and one (code 355) had been tagged in 2003. Both fish (codes 344 and 355) had inactive tags, but the fish appeared physically fit and were apparently spawning. The fish tagged 344 was particularly interesting because its 4-year tag should have been active at capture. It is worth noting that this fish was part of the group of fish that were stocked in 2004 and lost within weeks to months of their release into Lake Mead. Albrecht and Holden (2005) speculated that tag failure was the most likely explanation for the loss of this fish group. Capture of this healthy fish suggests that tag failure, not surgical complications, resulted in our inability to locate fish tagged during the 2004-2005 season.

In all, the 2007 spawning season was unusual, not only in terms of large fish movement patterns, but also in terms of the overall numbers of adult and subadult fish captured. This is perhaps best exemplified in Figure 6, which demonstrates the uniqueness of the 2007 trammel netting CPUE. As shown, the last time CPUE was remotely similar to this season's was during the early study years when the lake was at or near capacity, and even then CPUE was only somewhat comparable at Echo Bay, while 2007 catch rates at Las Vegas Bay were nearly four times higher than the highest catch rate observed during the past decade.

The first male razorback sucker expressing milt was captured on January 11, 2007, and the first female razorback sucker expressing eggs was captured February 14, 2007. Both fish were captured at Echo Bay. Recapture rates varied between study locations in the 11th study year. At Las Vegas Bay, 21 of the 39 razorback sucker caught were recaptures (53.8%), and eight of those fish had been stocked by NDOW into Lake Mead. At Echo Bay 25 of the 33 razorback sucker caught were recaptures (75.8%), nine of which were stocked by NDOW during previous years. Finally, at the Muddy River/Virgin River inflow area, 4 of the 16 razorback sucker caught were recaptures (or 25%). Of the Muddy River/Virgin River recaptures, one fish had been stocked by NDOW into Echo Bay in 2003. This fish had not been captured since its release by NDOW. As indicated above, a fairly large number of fish captured at spawning sites were recaptured fish originally stocked by NDOW. This demonstrates that stocked fish are able to find and incorporate themselves into wild populations, a phenomenon also observed by Modde et al. (2005) in the Green River and similarly described in Albrecht and Holden (2005) and Albrecht et al. (2006a).

In summary, 126 unique individual razorback sucker from Echo Bay have been handled during the 11 study years, 104 of which were captured and PIT tagged by BIO-WEST personnel and 22 of which were PIT-tagged by NDOW. At Las Vegas Bay 135 unique razorback sucker have been handled, including 120 individuals PIT tagged by BIO-WEST personnel and 15 PIT tagged by NDOW. Finally, at the Muddy River/Virgin River inflow area, 19 unique razorback sucker have been captured, 15 of which were PIT tagged by BIO-WEST and 4 of which were PIT tagged by NDOW. The lake-wide total of unique individual razorback sucker handled during this study is now 280 individuals.

Growth

In all 50 razorback sucker were recaptured during the 2006-2007 field season, 25 from the Echo Bay area, 21 from the Las Vegas Bay area, and 4 from the Muddy River/Virgin river inflow area. However, annual growth information analyses were only performed using data from 23 of these fish. Reasons for not including all 50 recaptures in this analysis were that some of the fish were captured more than once during the 2006–2007 field season and in other instances a full year had not passed between the date of original capture or stocking event and the subsequent recapture. The difference in total length between capture periods was used to determine mean annual growth (Table 3). The combined, lake-wide, mean annual growth of razorback sucker recaptured from Lake Mead during the 11th study year was 8.1 mm. The combined mean annual growth of recaptured fish the previous study year was 10.6 mm (Albrecht et al. 2006a). Mean annual growth of fish recaptured at Echo Bay was 5.2 mm (for both stocked and wild fish) and ranged from 0.8 mm to 11.2 mm of growth per year. Razorback sucker recaptured at Las Vegas Bay had a mean annual growth of 12.2 mm (9.3 mm for stocked fish and 19.1 mm for wild fish) and ranged from -4.0 mm to 30.4 mm of growth per year. The growth of wild razorback sucker in the Muddy River/Virgin River inflow area is still non-reportable at this time due to a lack of recaptures. However, a Floyd Lamb State Park fish that was stocked in 2003 by NDOW and captured in 2007 had a mean annual growth rate of 0.9 mm per year.

Table 3. **Lake Mead recaptured razorback sucker growth histories for fish captured during the 2006-2007 field season.**

PIT TAG NUMBER	CAPTURE DATE [a]	TOTAL LENGTH (mm) [b]	RECAPTURE DATE	TOTAL LENGTH (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (mm/ 365 Days)
			LAS VEGAS BAY				
			Stocked Fish				
5326000260 [c]	11/29/2005	635	1/30/2007	650	15	427	12.8
1F476B7936 [c]	7/25/1995	541	1/30/2007	674	133	4,207	11.5
1F476C5856	1/17/2001	542	2/13/2007	580	38	2,218	6.3
1F7D790D5E	11/25/1988	574	4/9/2007	656	82	3,057	9.8
5324051E2D	11/30/2005	616	3/6/2007	611	-5	461	-4.0
5325661D5B	11/30/2005	528	2/27/2007	538	10	454	8.0
532575245C	11/30/2005	604	4/9/2007	632	28	495	20.7
Mean annual growth of Las Vegas Bay stocked fish							**9.3**
			Wild Fish				
201D5B2345	11/19/1998	645	2/27/2007	645	0	3,022	0.0
532603134E	5/22/2003	471	2/6/2007	584	113	1,356	30.4
7F7D312A1B	3/20/2004	562	4/9/2007	644	82	1,115	26.8
Mean annual growth of Las Vegas Bay wild fish							**19.1**
Mean annual growth calculated from Las Vegas Bay stocked and wild fish combined							**12.2**
			ECHO BAY				
			Stocked Fish				
1F48452C28	1/22/2002	631	2/8/2007	649	18	1,843	3.6
1F4A457C56	7/25/1995	488	1/11/2007	556	68	4,188	5.9
1F5003414D	12/2/2003	619	2/14/2007	636	17	1,170	5.3
53244B0648	12/1/2004	556	1/11/2007	567	11	771	5.2
532624527C	12/1/2004	524	3/2/2007	537	13	821	5.8
Mean annual growth Echo Bay stocked fish							**5.2**
			Wild Fish				
5325786966	1/10/2006	630	3/19/2007	631	1	433	0.8
1F782D516B	12/7/1998	498	3/2/2007	590	92	3,007	11.2
531F0A6332	1/21/2003	612	3/19/2007	631	19	1,518	4.6
53257C0232	4/2/2003	580	2/23/2007	586	6	1,423	1.5
53263D264D	1/21/2003	596	2/23/2007	617	21	1,494	5.1
7F7D16534B	2/27/2002	566	2/8/2007	619	53	1,807	10.7
7F7D2B2D5F	4/2/1993	574	1/11/2007	606	32	5,032	2.3
Mean annual growth of Echo Bay wild fish							**5.2**
Mean annual growth Echo Bay stocked and wild fish							**5.2**

OVERTON ARM (MUDDY RIVER/VIRGIN RIVER INFLOW AREA)							
			Stocked Fish				
1F500A3156 [c]	**12/2/2003**	**557**	**4/3/2007**	**560**	**3**	**1,218**	**0.9**
Mean annual growth of Overton Arm stocked fish							**N/A**
Mean annual growth of all Echo Bay, Las Vegas Bay and Overton Arm stocked fish combined							**7.1**
Mean annual growth of all Echo Bay, Las Vegas Bay, and Overton Arm wild fish combined							**9.4**
Mean annual growth of all recaptured fish during course of study year							**8.1**

[a] The date a fish was stocked into Lake Mead, or the date a fish was originally captured if wild.
[b] Total length in millimeters.
[c] Fish stocked originally into Echo Bay.

Negative growth values are thought to reflect measurement error between values recorded during the initial capture occasion and those values observed during the recapture date and may be a function of very old and/or slow-growing individuals. Alternatively, this observed change could be reflective of netting-related stress, stress associated with sonic tagging, or other unknown, naturally induced stressors (Holden et al. 2000b). In all, and as alluded to in past annual reports (e.g., Albrecht et al. 2006), growth rates for Lake Mead razorback sucker continue to be substantially higher than those of other razorback sucker populations, suggesting the overall youthfulness of Lake Mead razorback sucker populations (Modde et al. 1996, Pacey and Marsh 1998, Mueller 2006).

Sonic Telemetry

During the first 10 years of the study, 62 (38 wild and 24 hatchery-reared) fish were equipped with sonic tags. Throughout the 2006-2007 Lake Mead field season, contact was made with nine of these sonic-tagged fish. One of these tagged fish (code 222) was the lone remaining individual from the 2004 tagging event, while the remaining eight tagged fish were tagged in 2005 (Table 4). Two of the original 10 fish (codes 554 and 556) implanted with transmitters in 2005 were not located throughout the 2006-2007 Lake Mead field season; tag 554 was deemed a mortality near the end of the 2005-2006 season, while 556 was lost immediately following the tagging procedure (Albrecht et al. 2006a).

In all cases where sonic-tagged fish moved into and used habitats within the riverine portions of Las Vegas Wash, crews recorded the closest data point accessible by boat. As such, some of the figures below may not fully display the range of sonic-tagged fish movements into the shallow, flowing portions of Las Vegas Wash that were not accessible by boat.

The following dialog describes the history and habitat use of the eight individual razorback sucker implanted during 2005–2006 field season, and the movements of the single, residual fish (code 222) tagged in 2004–2005. Please refer to Table 4 for all origin, tagging, and current status information for sonic-tagged fish.

Table 4. Tagging and stocking information, location, and date of last contact, and current status of telemetered fish in Lake Mead from July 2006–June 2007.

CAPTURE LOCATION	DATE TAGGED	TAG CODE	TOTAL LENGTH (MM)	SEX	STOCKING LOCATION	LAST LOCATION	DATE OF LAST LOCATION	CURRENT STATUS
FDLB	12/1/04	222	524	M	EB	EB	3/7/07	Unknown
FDLB	11/29/05	444	610	F	OA/FI	OA/FI	6/12/07	Mortality
FDLB	11/30/05	445	528	M	LVB	Sand Island	6/12/07	Alive
FDLB	11/30/05	446	616	F	LVB	LVB	6/12/07	Alive
FDLB	11/29/05	447	635	F	EB	LVB	6/12/07	Alive
FDLB	11/30/05	448	515	M	LVB	LVB	6/12/07	Alive
FDLB	11/30/05	555	604	F	LVB	LVB	6/12/07	Alive
FDLB	11/29/05	557	545	M	OA/FI	OA/FI	2/28/07	Unknown
FDLB	11/30/05	558	662	F	OA/FI	EB	3/20/07	Unknown

[a] Locations: FDLB = Floyd Lamb State Park, EB = Echo Bay, OA/FI = Overton Arm/Fish Island (Muddy River/Virgin River inflow area), LVB = Las Vegas Bay.
[b] Sex: F = female, M = male.

Las Vegas Bay

Fish 445

Contact was established with fish 445 on 17 different occasions during the 2006–2007 Lake Mead field season (Figure 7). As observed during the previous year (Albrecht et al. 2006a), all locations were within the Las Vegas Bay vicinity. The sonic locations of fish 445 and other telemetered fish in Las Vegas Bay, in conjunction with netting and larval efforts, documented a shift in spawning location in this area of Lake Mead. The average depth at which fish 445 was located at was 29 ft, with depths ranging from eight to 67 ft. The majority of contacts with fish 445 were in Las Vegas Bay near the identified 2006–2007 spawning site; however, the most recent location (12 June 2007) was NE of Sand Island near the mouth of Las Vegas Bay (Table 4). The data point for the most recent location is not plotted on the sonic distribution map due to problems with scale and presentation. Fish 445 is currently classified as active, and we anticipate that tracking this fish will continue to provide valuable data.

Fish 446

Contact was established with fish 446 on 16 different occasions within Las Vegas Bay during the 2006–2007 Lake Mead field season (Figure 7). The average depth that fish 446 used was 31 ft, with depths ranging from 7 to 80 ft. Fish 446 was predominantly located in close proximity to the 2006–2007 identified spawning site throughout the year. The most recent telemetry contact with fish 446 was on 12 June 2007 and near the mouth of Las Vegas Bay. This fish is classified as active, and it is anticipated to provide valuable data about spawning locations and habitat use in the future (Table 4).

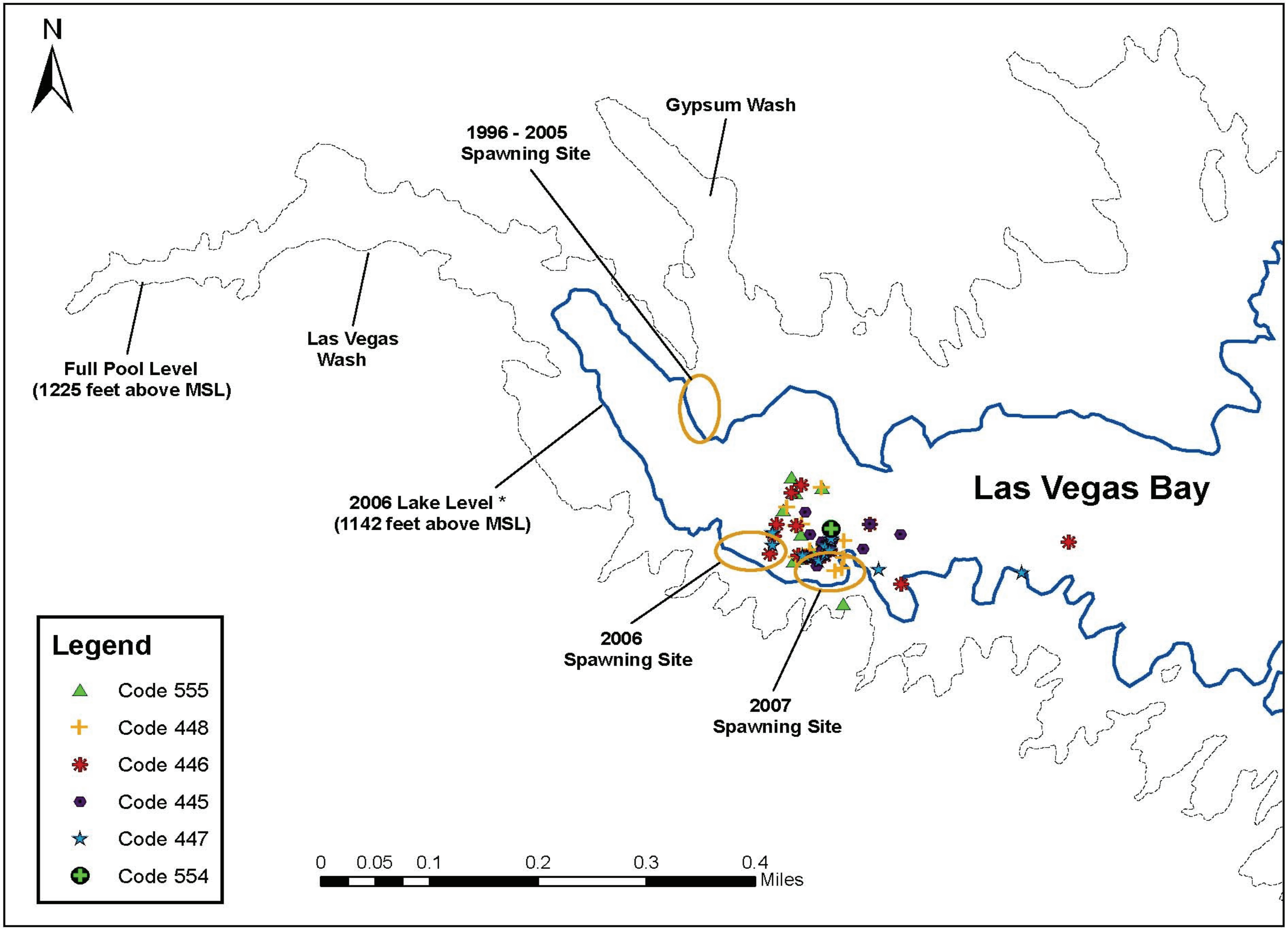

Figure 7. **Distribution of sonic-tagged fish numbers 554, 447, 445, 446, 448, and 555 in Las Vegas Bay during the 2006–2007 Lake Mead study season.**

Fish 448

Fish 448 was located via sonic telemetry on 13 separate occasions (July 2006–June 2007; Figure 7) primarily in the vicinity of the 2006–2007 identified Las Vegas Bay spawning site. The average depth at which fish 448 was located was 27 ft, with minimum and maximum depths ranging from 1434 ft. The most recent telemetry location of the fish occurred on 12 June 2007 near the mouth of Las Vegas Bay (Table 4). Fish 448 is classified as active, and we foresee that it will continue providing habitat and movement data during the 2007–2008 field season.

Fish 555

Throughout the 2006–2007 field season on Lake Mead, fish 555 was located 14 times (July 2006-June 2007; Figure 7). All contacts were in Las Vegas Bay in the vicinity of the 2006–2007 spawning site. Average depth at contact was 25 ft, with depths ranging from 11–37 ft. The most recent sonic location obtained from fish 555 was on 12 June 2007 at the mouth of Las Vegas Bay. Fish 555 is classified as active and continues to provide habitat use and movement data.

Echo Bay Area

Fish 447

Contact was established with fish 447 on 14 separate occasions during the 2006–2007 Lake Mead sampling season (Figures 7, 8, 9, 10). Fish 447 was located in all three of the primary study areas: Las Vegas Bay, Echo Bay, and the northern portions of the Overton Arm. In previous years (Albrecht et al. 2006a) fish 447 was documented using Echo Bay and its immediate vicinity. The last sonic contact during the 2005–2006 field season occurred on 14 June 2006 in Echo Bay. However, the first sonic location garnered during the 2006–2007 field season (7 July 2006; 23 days after previous location) was at the mouth of Las Vegas Bay. Approximately 5.5 weeks later (15 August 2006), fish 447 was again located in the Echo Bay vicinity of Lake Mead (near Stewarts Point which is half way between the Virgin River and Muddy River inflow areas and Echo Bay). Contact with the fish was then lost until 11 November 2006 (95 days later) when it was again located at the mouth of Las Vegas Bay.

The average depth utilized by fish 447 was 30 ft, and depths ranged from 8 to 68 ft. The most recent sonic location was acquired at Las Vegas Bay on 12 June 2007 (Table 4). Fish 447 is currently listed as active.

Fish 222

Fish 222 the only sonic-tagged fish from the 2004–2005 tagging event that continues to provide habitat and movement data. As documented in past reports (Albrecht et al. 2006a), fish 222 has been mobile, moving frequently between Echo Bay and the Muddy River/Virgin River inflow area. During the 2006–2007 field season, fish 222 was located 12 times (Figures 8, 9). Throughout the 2006–2007 field season, the fish continued to move, traveling between Echo Bay and the Muddy River/Virgin River inflow area four times. Similar to seasons past, Rogers and Calico bays seem to be preferred locations during summer and early fall. Echo Bay and the Muddy River/Virgin River inflows were more frequently used throughout winter and during the spawning season. In fact, fish 222 was located adjacent to/within identified spawning locations

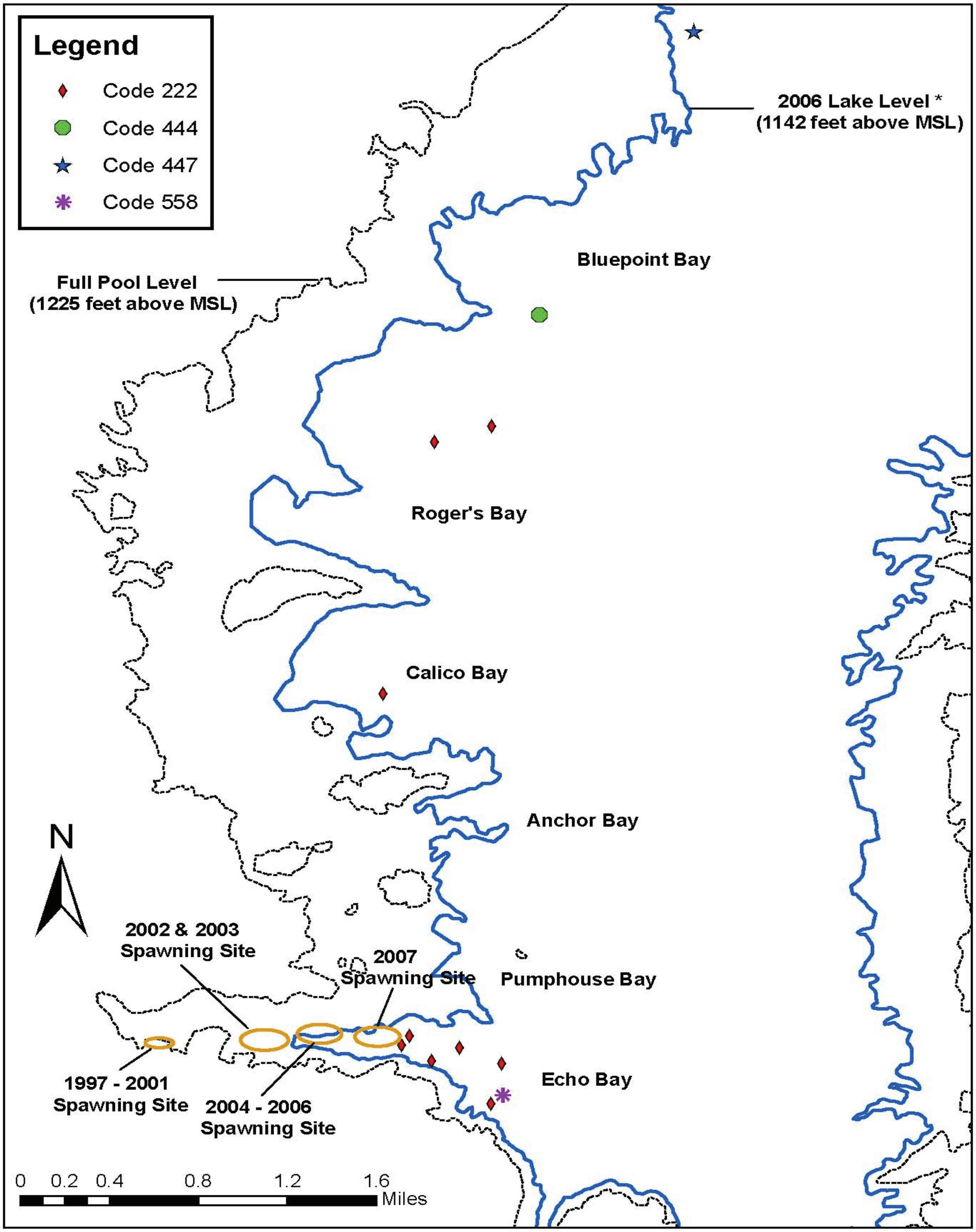

Figure 8. **Distribution of sonic-tagged fish numbers 222, 444, 447, and 558 in Echo Bay during the 2006–2007 Lake Mead study season.**

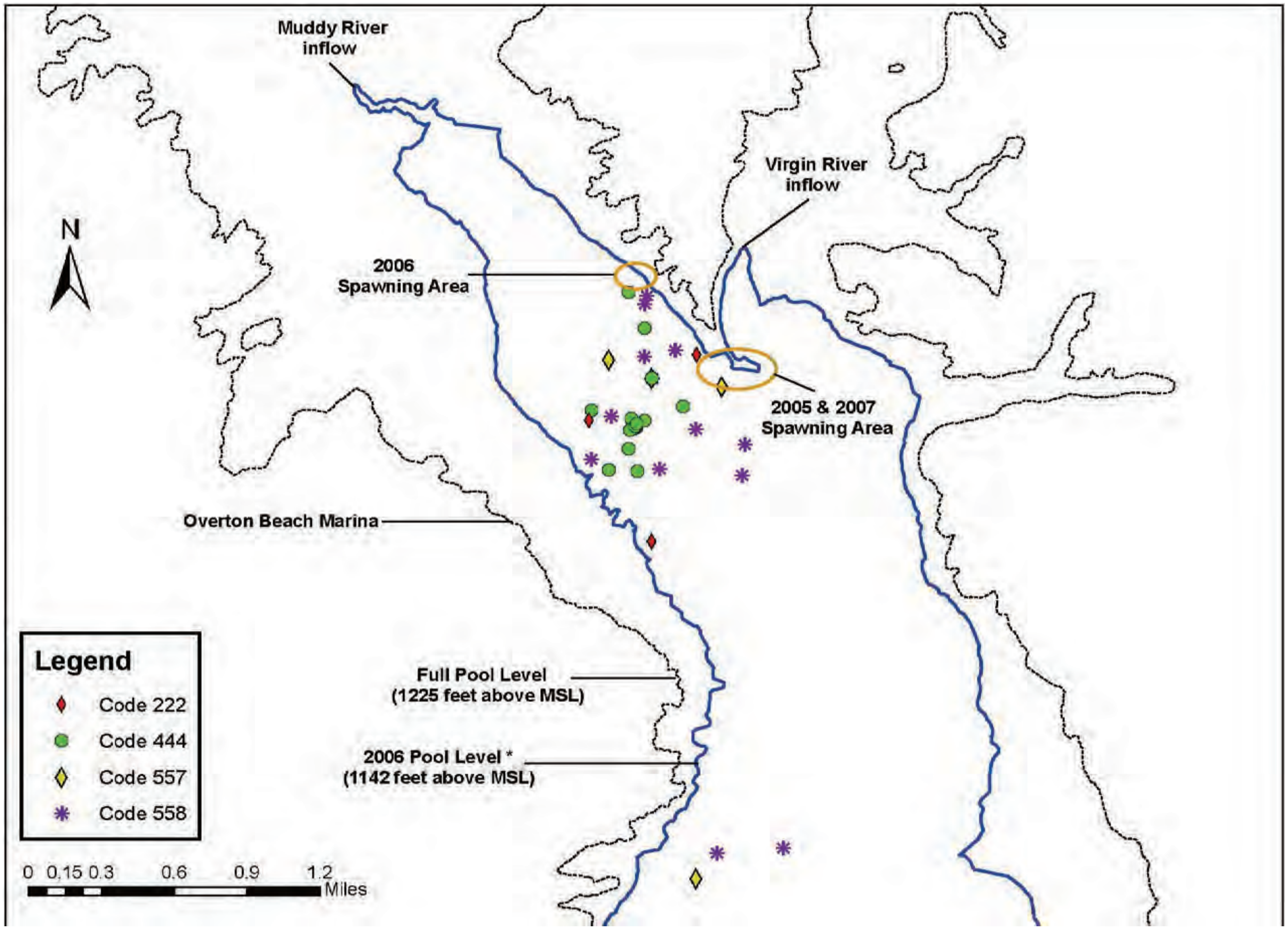

Figure 9. **Distribution of sonic-tagged fish numbers 222, 444, 557, and 558 in the Muddy River/Virgin River inflow area during the 2006–2007 Lake Mead study season.**

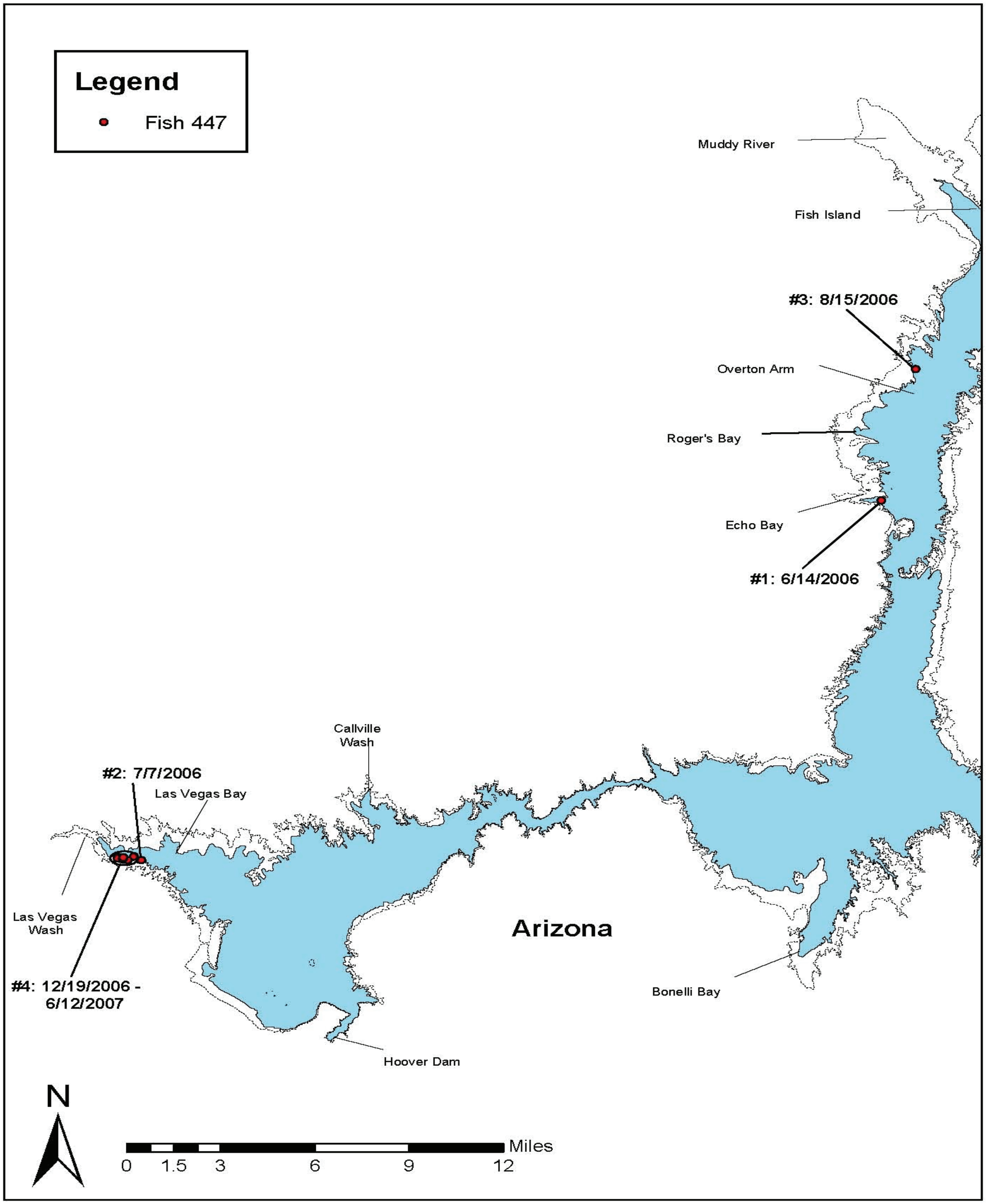

Figure 10. Distribution of sonic-tagged fish number 447 throughout Lake Mead. Number represents chronological order in which the fish was located, along with the corresponding date of each location.

at both Echo Bay and the Muddy/River inflow area of Lake Mead. The average depth that fish 222 was located at was 35 ft, with depths ranging from 14 to 73 ft. Fish 222 was last located on 7 March 2007 in Echo Bay (Table 4). The current status of the fish is unknown. However, due to its highly variable movement patterns, we are hopeful it will be located again.

Muddy River/Virgin River Inflow Area

Fish 444

Contact was established with fish 444 on 21 different occasions during the 2006–2007 field season (Figures 8, 9). The majority of locations were within the Muddy River/Virgin River portion of Lake Mead; however, during the summer the fish was located around Bluepoint Bay in the Echo Bay vicinity of Lake Mead. Fish 444 returned to the Muddy River/Virgin River inflow area on 26 September 2006 where it remained for the duration of the study year. An additional 18 sonic locations of fish 444 were obtained in the inflow area, but, the locations have not changed since the fish was contacted on 7 March 2007. Since then 10 additional contacts (most recently 13 June 2007) have confirmed dormancy, leading to the conclusion that fish 444 has either become a mortality or shed its tag (Table 4).

Fish 557

Throughout the 2006–2007 Lake Mead field season, fish 557 was contacted four times via sonic telemetry (Figure 9). All locations were relegated to the Muddy River/Virgin River inflow area of Lake Mead and obtained between 15 August 2006–28 February 2007. During the 2007 spring spawning season, fish 557 was located both near and within the identified 2007 Fish Island spawning area (Figure 9). The average depth used by fish 557 was 22 ft, with depths ranging from 11 to 48 ft. This fish was last contacted on 28 February 2007; thus its current status is unknown (Table 4). We remain optimistic that fish 557 will be located during broader searches of Lake Mead.

Fish 558

Contact was established with fish 558 on 14 separate occasions during the 2006–2007 field season (Figures 8, 9). The majority of sonic locations were obtained from the Muddy River/Virgin River inflow area of Lake Mead, which included positions in and around the 2006–2007 identified spawning location. The average depth at which fish 558 was located was 22 ft, with depths ranging from 9 to 77 ft. Between the dates of 14–20 March 2007, fish 558 migrated from the Muddy River inflow area of Lake Mead to the mouth of Echo Bay. It was at this point that contact was last established (Table 4). The current status of the fish is unknown, but efforts to determine its location and movements will continue.

Telemetry Summary

During the 11th study year the habitat use and movements of nine sonic-tagged fish were monitored and provided a total of 127 separate location points. One of the fish was a residual tagged fish (code 222) from the 2004–2005 tagging event, while the remaining eight fish were the result of the 2005–2006 tagging event. By using the data gathered from sonic-tagged fish, in conjunction with trammel netting and larval sampling data, shifts in spawning locations were once again documented in all three study areas (Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area) of Lake Mead (Figures 7, 8, and 9). Along with spawning locations, sonic-tagged fish provided valuable data on movement patterns within and amongst Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area. As described in detail above, tagged fish were documented moving between the Muddy River/Virgin River inflow area and Echo Bay, and between the Muddy River/Virgin River inflow area, Echo Bay, and Las Vegas Bay. In fact, one sonic-tagged individual (fish 447) was the first fish observed to move between the northern portions of the Overton Arm and Las Vegas Bay during this study (doing so twice) (Figure 10).

The average depth at which tagged fish were located throughout all portions of Lake Mead was 28 ft, with minimum and maximum depths of 7 and 80 ft. A comparison of depths used by tagged fish amongst Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area showed significant differences (Figure 11). As shown in previous reports (Albrecht et al. 2006a), Echo Bay fish inhabited deeper water compared with fish in Las Vegas Bay and the Muddy River/Virgin River inflow area (ANOVA, $p<0.01$; Tukey post hoc test, $p<0.05$). This may be explained by the diel migration behavior typically observed between the profundal areas surrounding Echo Bay and the bay itself (Albrecht et al. 2006a; Figures 11 and 12).

Larval Sampling

Sampling for razorback sucker larvae was initiated in late January 2007. Larvae were first collected on February 5, 2007, at Las Vegas Bay over a gravel/cobble shoreline located on the western shoreline and within 25 m of several of the sonic-tagged fish. At Echo Bay, the first razorback sucker larvae were captured on March 8, 2007, towards the back of the bay. In contrast, at the Muddy River/Virgin River inflow areas, the first and only razorback sucker larvae found this season (two specimens) were captured on April 10, 2007, at the base of Fish Island near the Virgin River inflow. Both larval fish were captured in a small cove that at higher lake elevations would be the first area to cause Fish Island to become an actual island. Typically, 8 to 12 monitoring sites at Echo Bay, Las Vegas Bay, and the Muddy River/Virgin River inflow area were sampled weekly (with few exceptions) during February, March, and April 2007. The number of razorback sucker larvae collected at Las Vegas Bay was much higher in 2007 (Table 5) than in 2006, 2005, 2004, and 2003 (1,431; 257; 76; 4; and 73, respectively); the majority of larvae were collected along the western shoreline of Las Vegas Bay, which confirms continued use of that relatively new spawning location. Overall, the catch per minute (CPM), or the number of fish captured per minute of sampling of razorback sucker larvae at Las Vegas Bay, was higher in 2007 than in 2006 (0.39 vs. 0.12, respectively). Larval capture and sample locations in Las Vegas Bay are shown in Figure 13.

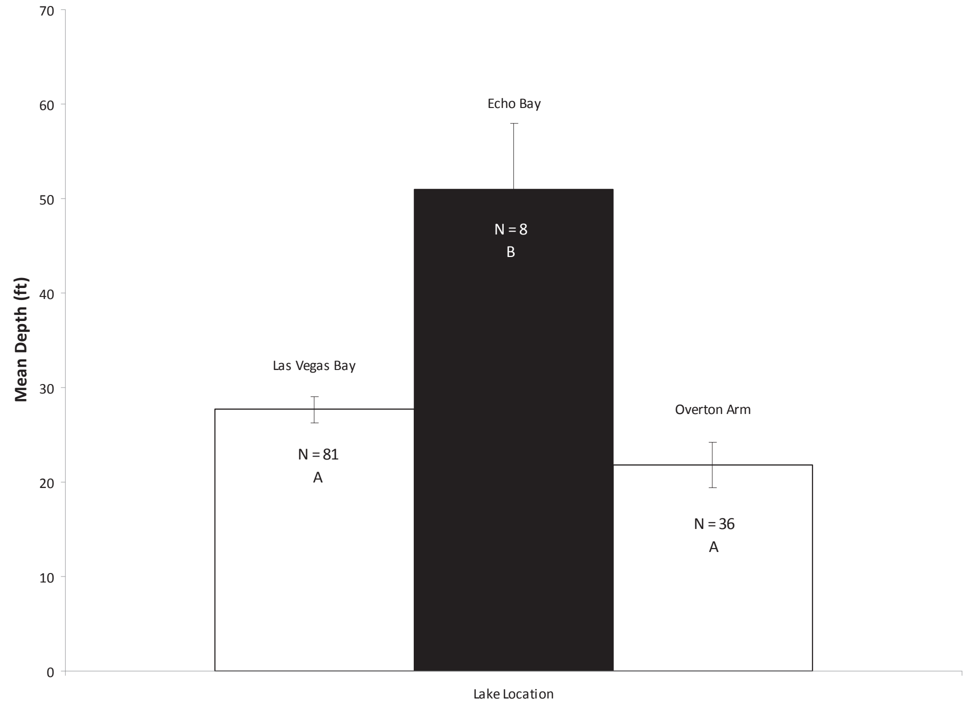

Figure 11. **Average depths at which sonic-tagged fish were located during the 2006-2007 Lake Mead study season. The black bar denotes significance, N is the number of sonic contacts within each portion of Lake Mead, and A and B refer to Tukey post hoc significance grouping.**

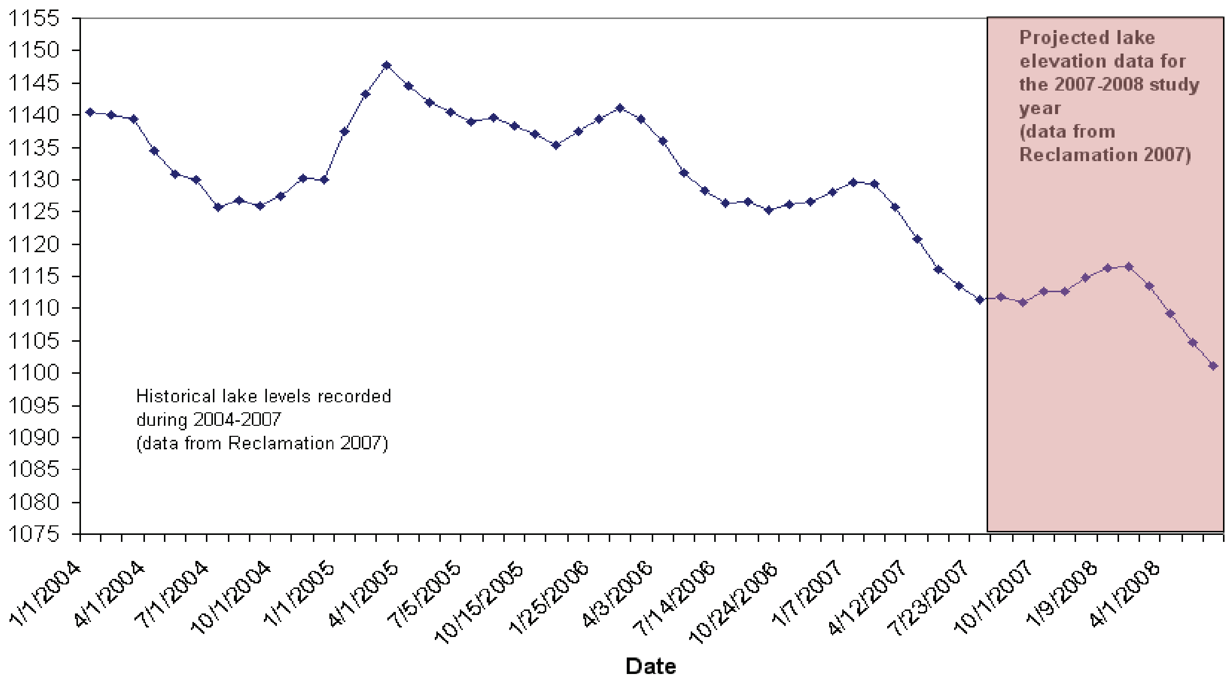

Figure 12. **Lake Mead elevations using a combination of actual, recorded, and historical lake elevation data, as well as projected lake elevation for the 2007–2008 study period.**

Table 5. Number of razorback sucker larvae collected at the Las Vegas Bay, Echo Bay, and Muddy River/Virgin River inflow areas of Lake Mead during 2007.

DATE	LAS VEGAS BAY SAMPLING SITES			ECHO BAY SAMPLING SITES			MUDDY RIVER/ VIRGIN RIVER INFLOW SAMPLING SITES		
	Minutes Sampled	Larvae Collected	CPM [a]	Minutes Sampled	Larvae Collected	CPM	Minutes Sampled	Larvae Collected	CPM
1/30/07	180	0	0.000						
1/31/07				120	0	0.000			
2/05/07	180	35	0.194						
2/06/07							120	0	0.000
2/07/07				120	0	0.000			
2/12/07	60	13	0.217						
2/15/07	180	121	0.672						
2/20/07	714	669	0.937						
2/21/07							180	0	0.000
2/26/07	150	180	1.200						
2/28/07				120	0	0.000	45	0	0.000
3/04/07							30	0	0.000
3/05/07	480	180	0.375	60	8	0.133			
3/06/07							180	0	0.000
3/08/07				180	51	0.283			
3/12/07	150	45	0.300						
3/13/07	360	92	0.256						
3/14/07							180	0	0.000
3/15/07				420	92	0.219			
3/19/07				228	212	0.930			
3/28/07				180	192	1.067			
4/02/07	360	60	0.167						
4/03/07							180	0	0.000
4/04/07							60	0	0.000
4/05/07				150	107	0.713			
4/09/07	150	21	0.140						
4/10/07							180	2	0.011
4/11/07				90	81	0.900			
4/16/07							90	0	0.000
4/30/07	90	15	0.167						
Totals	**3,054**	**1,431**	**0.385**	**1,668**	**743**	**0.425**	**1,245**	**2**	**0.001**

[a] CPM = Catch per minute.

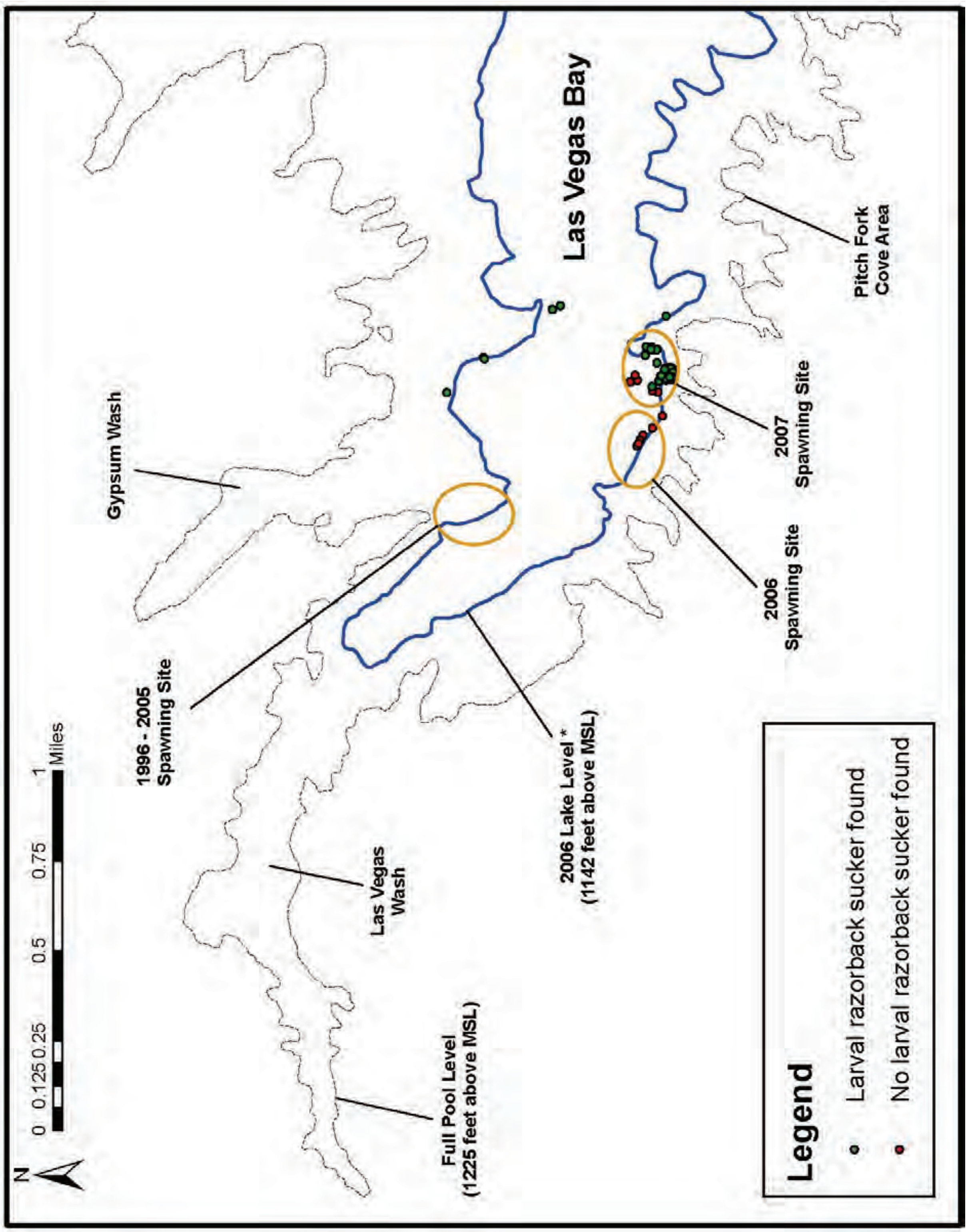

Figure 13. Las Vegas Bay study area showing larval razorback sucker sample and capture locations, 2007.

The number of larvae collected at Echo Bay in 2007 was also higher than the number collected in 2006, lower than 2005, but higher than 2004 or 2003. In 2007 we captured a total of 743 larval fish at Echo Bay. During 2006, 250 larvae were collected at Echo Bay, compared with 1,330 larval fish collected in 2005. In comparison, 207 razorback sucker larvae were collected during 2004, and 552 were collected during 2003. This results in a relatively high 2007 CPM of 0.43 larvae per minute, which is higher than most of the catch rates observed during the 2006–2003 spawning periods except for 2005(1.36 larval fish per minute) and 2003 (0.43). The 2007, 2006, 2005, 2004, and 2003 CPM at Echo Bay has been 0.43, 0.29, 1.36, 0.15, and 0.43, respectively. The larval razorback sucker sample and capture sites for Echo Bay are shown in Figure 14.

In 2007 razorback sucker larvae were collected for the third consecutive year along the Fish Island shoreline, which was a highlight of the 2006–2007 study year. Capture of larval razorback sucker at the Muddy River/Virgin River inflow area is highly significant and demonstrates that successful spawning can and does occur in areas other than Echo and Las Vegas bays, provided that the area has the proper physical conditions. As expressed in past reports (e.g., Albrecht et al. 2006a), it has long been hypothesized that cover in the form of turbidity and vegetation allows for razorback recruitment in Lake Mead, despite predatory pressures and competitive interactions between razorback sucker and nonnative fishes. The capture of larval razorback sucker for the third strait year indicates that the Muddy River/Virgin River inflow area of the lake is yet another important location for Lake Mead razorback sucker.

This year, shortly after the capture of several razorback sucker suspected to be spawning near the Muddy River vicinity, BIO-WEST personnel began capturing razorback sucker larvae. Larval sampling was initiated in order to confirm that spawning was actually occurring in this relatively understudied area in order to ensure that adult fish were not simply using these habitats as feeding or resting locations. In 2007 all larvae were collected along the northern end of the Fish Island shoreline, near the confluence of the Virgin River. Larval catches were limited to a gravel/cobble stretch of shoreline in an area of high turbidity and near cover associated with the Virgin River inflow/delta. Larval captures followed regular use of this area by sonic-tagged fish, as well as multiple wild subadult and adult razorback sucker captures while trammel netting in the vicinity. Only two larval razorback sucker were captured near Fish Island during April 2007 despite regular sampling efforts to find larval fish. We hypothesize that turbid conditions surrounding the capture of the larvae, coupled with lake-level fluctuations, hindered additional capture efforts. Larval captures occurred April 10, 2007. The 2007 larval CPM at the Muddy River/Virgin River inflow area was 0.001, compared with catch rates of 0.003 in 2006, and 0.05 during the 2005 spawning period (Table 5 and Figure 15).

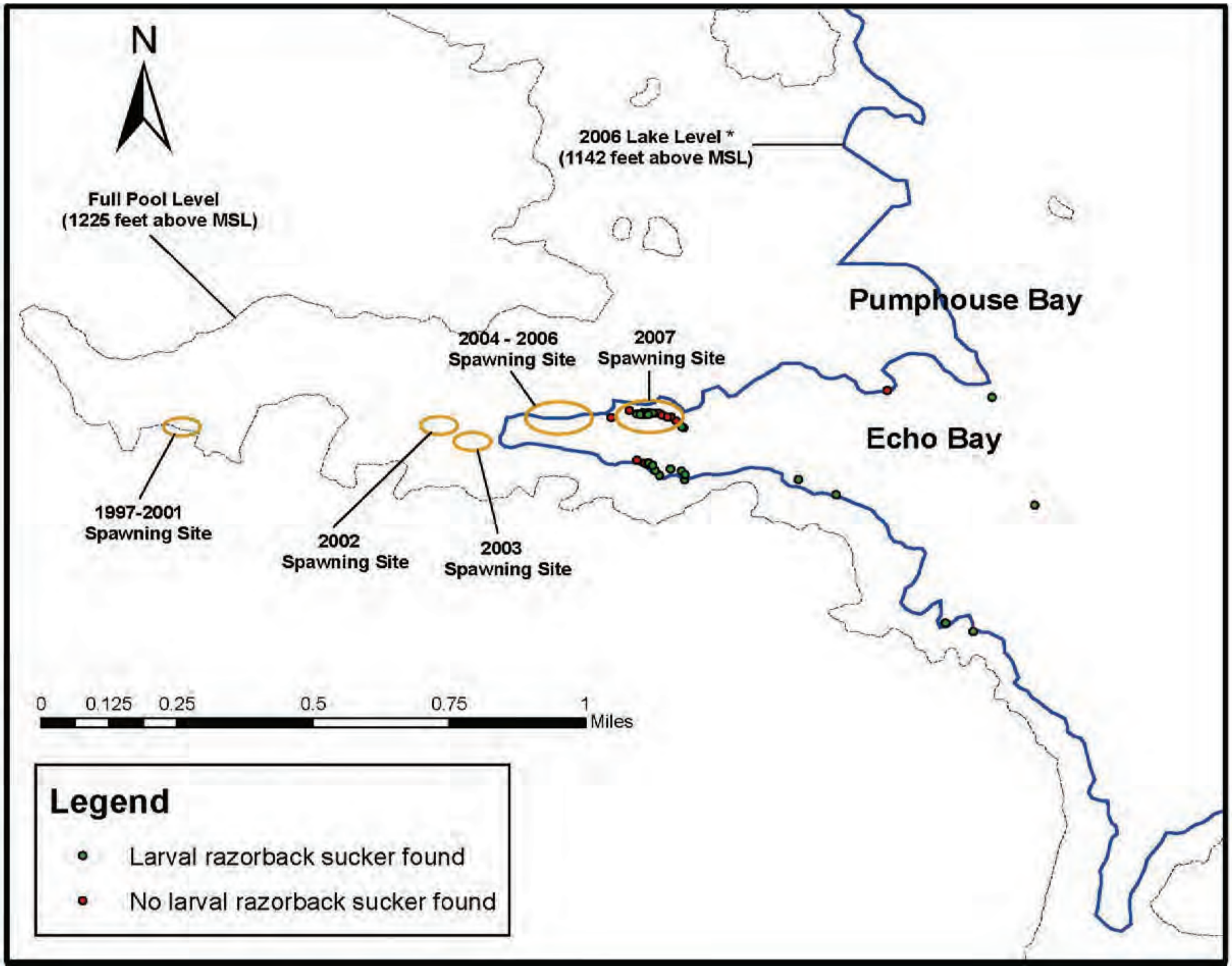

Figure 14. **Echo Bay study area showing larval razorback sucker sample and capture locations, 2007.**

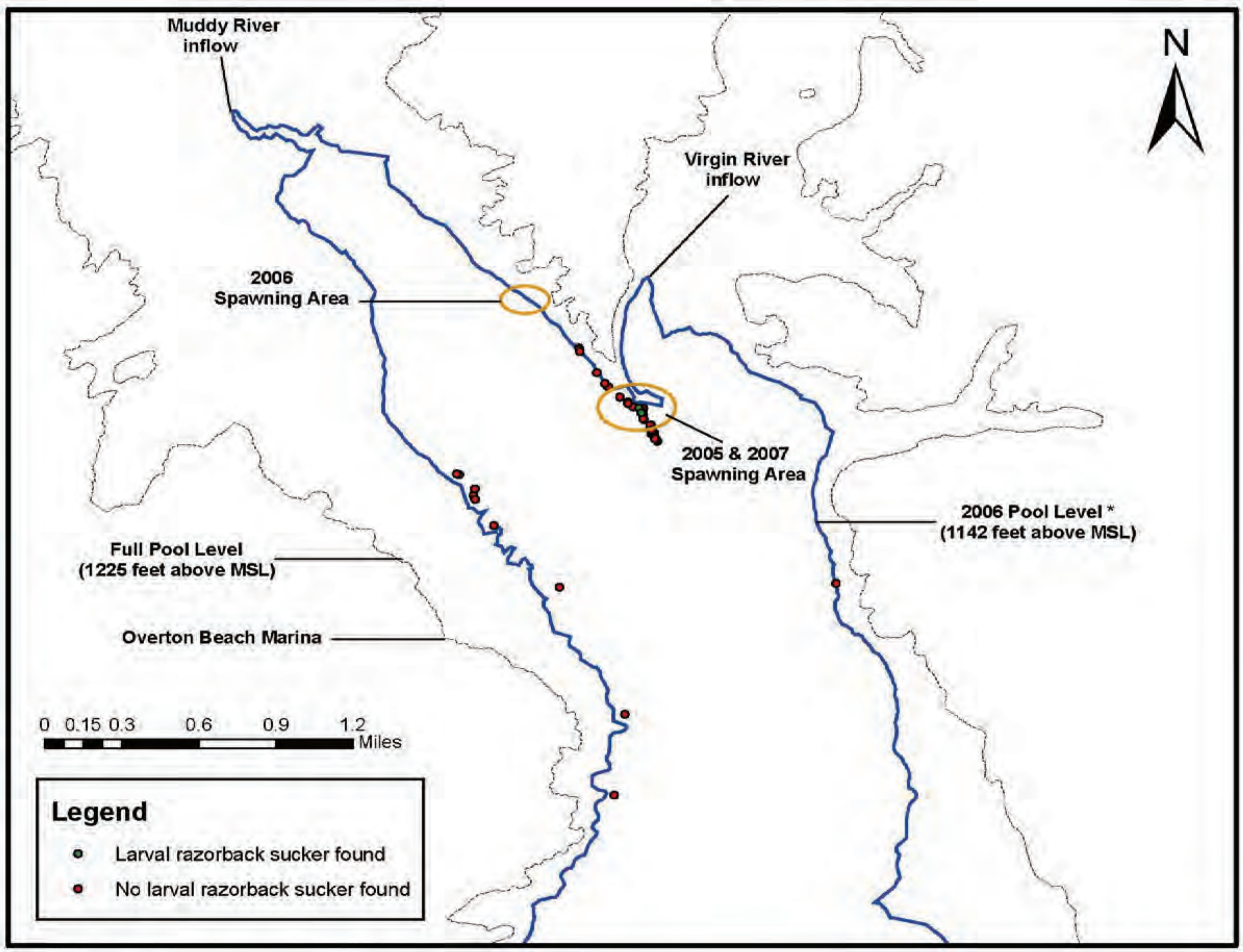

Figure 15. **Muddy River/Virgin River inflow (Fish Island) area showing larval razorback sucker sample and capture locations, 2007.**

Annual Spawning Site Identification and Observations

Decreasing lake levels during the last 7 years influenced habitat conditions in all areas where razorback sucker sampling activities have occurred during this 11-year study. As of June 1, 2007, the lake elevation was at 1,113 ft amsl, compared with 1,128 ft amsl 1 year earlier. As a result of decreasing lake levels, the fish shifted spawning site locations to accommodate varying conditions.

During the 2005–2006 study year, fish used a new spawning location in Las Vegas Bay for the first time during our studies (Albrecht et al. 2006a). This was the result of receding lake levels and the dessication of the historical spawning site (Blackbird Point [Albrecht et al. 2006a]). This report documents another and/or continued shift in the primary spawning location of razorback sucker in the Las Vegas Bay/Las Vegas Wash portion of Lake Mead. The primary spawning location during the 2005–2006 field season was located 500 m south of the wash inflow area, along the western shoreline of the bay (Albrecht et al. 2006a). This year's primary spawning site was in the same general vicinity, approximately 150 m further southeast of last year's spawning location (Figure 13). Figure 13 shows that larval razorback sucker were captured in surrounding locations; however, the vast majority of larval captures (92%) occurred within the identified primary spawning location.

As described in past annual reports (Welker et al. 2003, 2004; Albrecht et al. 2005; Albrecht et al. 2006a), receding lake levels have resulted in the frequent shifting of the primary Echo Bay spawning site in an eastward (down the bay) direction. Data from this spawning season suggest that the trend continued during 2007 (Figure 14). The most recently used spawning location shifted eastward approximately 85 m to a northern gravel shoreline < 200 m from the Echo Bay launch ramp. The distribution of larval fish captures included a broad area of Echo Bay; however, the highest densities and majority of larval razorback sucker were captured within the identified 2007 primary spawning location.

Relatively little is known regarding the spawning location in the Muddy River/Virgin River inflow area of Lake Mead. Similar to the 2005–2006 field season, the collection of ripe adult razorback sucker signified that spawning occurred in this portion of Lake Mead; however, confirmation of the degree of successful spawning was difficult due to the lack of larval collections (only two razorback sucker larvae were collected). The spawning location in the inflow region of the Muddy and Virgin rivers was in the same vicinity identified during the 2005 study year (Figure 15). This location was ascertained via a combination of sonic locations, adult/subadult razorback sucker captures, and the collection of two larvae. Future efforts in this area of Lake Mead are crucial to determine parameters such as changes in the size of the spawning aggregate, changes in spawning locations, and the degree to which successful spawning is indeed occurring in the Muddy River/Virgin River inflow area.

Razorback Sucker Aging

Forty-one of the razorback sucker collected by trammel netting on Lake Mead during the 2006–2007 sampling period had fin ray sections surgically removed for age determination. A definitive age was obtained for all 41 fish (Table 6 and Figure 16). Twenty-one of the 41 specimens were aged at 7 years or less, with the remainder aging between 8–25 years. Interestingly, the oldest and youngest fish aged this year came from Las Vegas Bay. The oldest was a male razorback sucker that was determined to be 25 years of age, while the youngest was a 3-year-old fish that was too small for gender identification. Also of interest were 12 relatively young fish collected from the Muddy River/Virgin River inflow area. All of these fish were aged and had been spawned between 2000–2003, according to back-calculation techniques.

Table 6. Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead.

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
	LAS VEGAS BAY		
05/10/1998	588	10[b]	1987
12/14/1999	539	13	1986
12/14/1999	606	17+	1979–1982
12/14/1999	705	19+	1977–1980
01/08/2000	650	18+	1978–1981
02/27/2000	628	17+	1979–1982
01/09/2001	378	6	1994
02/07/2001	543	11	1989
02/22/2001	585	13	1987
12/01/2001	576	8–10	1991–1993
12/01/2001	694	22	1979
12/01/2001	553	10	1991
02/02/2002	639	16	1985
03/25/2002	650	22	1979
03/25/2002	578	10–11	1990–1991
03/25/2002	583	22–24	1977–1979
03/25/2002	545	20[b]	1982
03/25/2002	576	20	1982
05/07/2002	641	15	1986
06/07/2002	407	6	1995
06/07/2002	619	20[b]	1982
06/07/2002	642	20[b]	1982
12/03/2002	354	4	1998
12/06/2002	400	4	1998

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
12/06/2002	376	4	1998
12/19/2002	395	4	1998
01/07/2003	665	16	1986
01/22/2003	494	4	1998
02/05/2003	385	4	1998
02/18/2003	443	5	1997
03/04/2003	635	19	1983
03/20/2003	420	4	1998
04/08/2003	638	21[b]	1982
04/17/2003	618	10	1992
04/22/2003	650	20–22	1980–1982
05/04/2003	415	3+[c]	1999
03/03/2004	370	5	1998
02/22/2005	529	6	1998
02/22/2005	546	6	1998
03/29/2005	656	16	1989
01/26/2006	740	15	1991
02/21/2006	621	23	1983
03/23/2006	461	5	2001
03/23/2006	718	16	1990
03/31/2006	635	7	1999
03/31/2006	605	6	2000
04/04/2006	629	6	2000
04/25/2006	452	4	2002
04/25/2006	463	4	2002
01/30/2007	514	5	2002
02/06/2007	519	5	2002
02/06/2007	574	8	1999
02/13/2007	526	5	2002
02/16/2007	530	5	2002
02/20/2007	534	6	2001
02/21/2007	358	3	2004
02/21/2007	511	5	2002
02/27/2007	645	13	1994
02/27/2007	586	15	1992
02/27/2007	603	13	1994
02/27/2007	650	17	1990
03/06/2007	515	4	2003
03/06/2007	611	13	1994

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
03/06/2007	565	6	2001
03/13/2007	586	7	2000
03/13/2007	636	25	1982
03/13/2007	524	5	2002
04/02/2007	704	9	1998
04/09/2007	644	11	1996
	ECHO BAY		
01/22/1998	381	5	1993
01/09/2000	527	13	1987
01/09/2000	550	13	1987
01/09/2000	553	13	1987
01/09/2000	599	12–14	1986–1988
01/27/2000	557	13	1986
01/27/2000	710	19+	1979–1981
02/09/2001	641	13	1988
02/24/2001	577	18+	1980–1982
02/24/2001	570	8	1992
02/24/2001	576	15	1986
02/24/2001	553	18	1983
12/18/2001	672	13	1988
02/27/2002	610	18–20	1982–1984
03/26/2002	623	16	1986
04/02/2002	617	35+	1966–1968
04/17/2002	583	20[b]	1982
05/02/2002	568	18–19	1983–1984
11/18/2002	551	13	1989
12/04/2002	705	26	1976
01/21/2003	591	16	1986
02/03/2003	655	27–29	1974
02/03/2003	580	13	1989
04/02/2003	639	19–20	1982
04/02/2003	580	23–25	1978
04/23/2003	584	10	1992
05/06/2003	507	9+	1993
05/06/2003	594	20	1982
12/18/2003	522	20	1982
01/14/2004	683	14	1989
02/18/2004	613	10	1993
03/17/2004	616	19	1983
03/17/2004	666	17	1985
03/17/2004	618	9	1994

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
04/06/2004	755	17	1985
03/02/2005	608	15	1990
03/02/2005	624	8	1996
01/10/2006	630	12	1994
02/01/2006	705	16	1990
02/16/2006	601	22	1984
01/11/2007	535	5	2002
01/11/2007	493	5	2002
02/01/2007	637	7	2000
02/08/2007	609	12	1995
02/14/2007	501	4	2003
03/02/2007	590	11	1996
03/09/2007	660	12	1995
03/16/2007	691	21	1986
03/28/2007	564	13	1994
	FISH ISLAND		
02/23/2005	608	6	1998
02/22/2006	687	33[d]	1973
02/22/2007	452	4	2003
02/22/2007	542	5	2002
02/22/2007	476	5	2002
02/22/2007	459	4	2003
02/22/2007	494	5	2002
03/01/2007	477	5	2002
03/01/2007	512	4	2003
03/08/2007	463	5	2002
03/08/2007	455	4	2003
03/15/2007	516	4	2003
04/03/2007	508	4	2003
04/11/2007	498	7	2000

[a] mm = Millimeters.
[b] Fish stocked from Echo Bay larval fish captured in 1999 and raised at Nevada Department of Wildlife Lake Mead Fish Hatchery.
[c] Fish stocked from Floyd Lamb State Park ponds (1982 Dexter National Fish Hatchery cohort placed in Floyd Lamb State Park ponds in 1984).
[d] Fish was aged at 33 years of age, +/- 2 years.

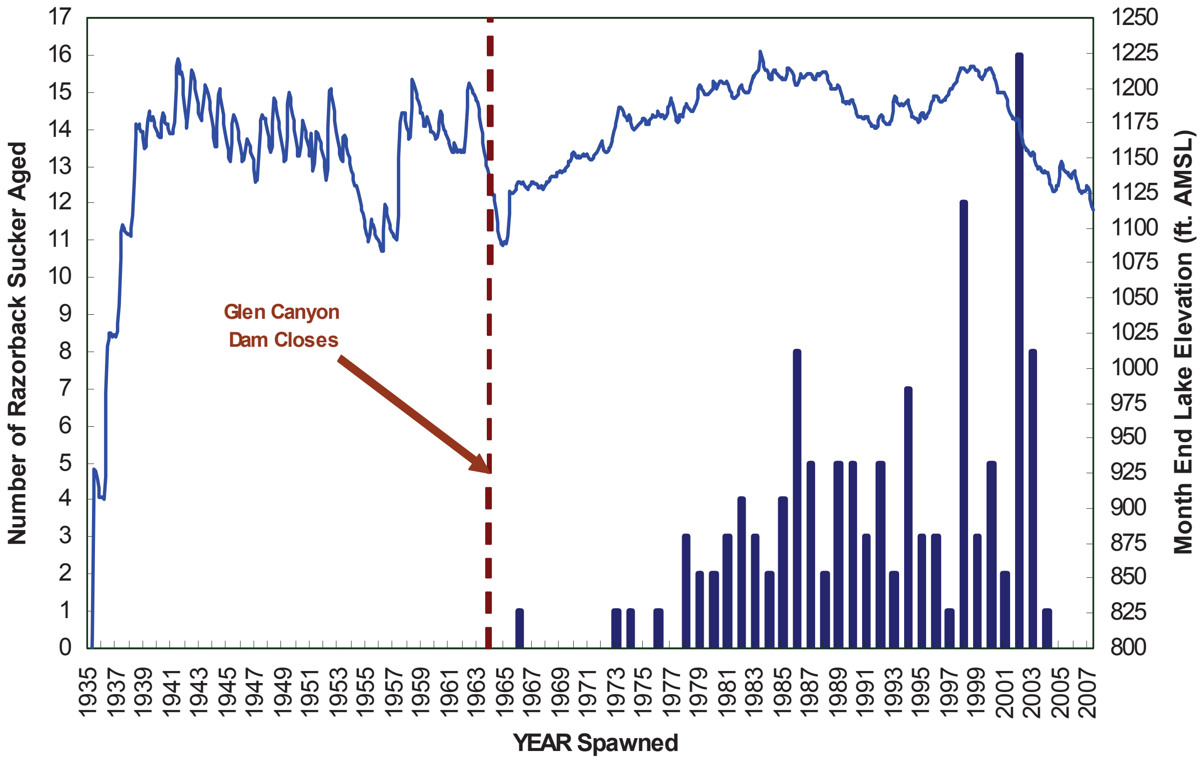

Figure 16. **Lake Mead hydrograph from January 1935 to June 2007 with the number of aged razorback sucker that were spawned each year.**

Only in the last two study years have we aged fish that were spawned after 1999, which suggests a continued pattern of recruitment in Lake Mead, even during relatively low lake elevations (Albrecht et al. 2006a). This year (2007) marks the first time that we have captured and aged a razorback sucker from Lake Mead that was back-calculated to have been spawned as recently as 2004.

Table 6 shows the ages of 91 fish previously aged and the additional 41 fish aged in 2007. Figure 16 shows the number of razorback sucker recruits per year plotted against Lake Mead elevations from January 1935 to June 2007. All of the fish aged were spawned between 1973–2004, with the exception of one fish that was spawned around 1966. Until the last few seasons the majority of fish aged were spawned during high-lake elevations between the 1978–1989 and 1997–1999 periods. However, our most recent data show recruitment occurring beyond 1999, which coincides with the steady decline in lake levels during recent years. Based on data obtained this season, 2002 was one of the better years for recruitment, despite dropping lake levels. In all, it appears that some level of recruitment is possible in Lake Mead regardless of lake level.

Population Estimate

As indicated in Albrecht et al. (2006a) we initially planned to forego reporting population estimates for Lake Mead razorback sucker this year due to the nature of the data collected and the violation of many of the assumptions that accompany closed model population estimation techniques. However, we have included population estimation information this season simply from an informative and purely demonstrative standpoint. We strongly caution basing any management decisions solely on the population estimation information provided below due to the violations of many of the assumptions involved with closed model population estimation techniques, which are more fully described by Albrecht et al. (2006a).

In regard to the 2007 population estimates of Lake Mead razorback sucker, please note that we can no longer categorize Echo Bay as a closed population, or as one separate from the Muddy River/Virgin River spawning aggregate, due to the numerous occasions in which fish from Echo Bay have moved into the northernmost portions of Lake Mead and vice versa. Hence we provide a population estimate that includes data obtained from Echo Bay and the Muddy River/Virgin River inflow area as a combined estimate. Of additional interest, and as described previously in the trammel netting section of this report, CPUE was vastly elevated this year. This increase in CPUE was evident lake wide but particularly at Las Vegas Bay and the Muddy River/Virgin River inflow area. This increase in CPUE is mentioned here again because it also reflects the overall increase in razorback sucker abundance, similar to the increase observed in the population estimates generated this year.

Table 7 shows the results of 2007 population modeling using two models from the program CAPTURE (Rexstad and Burnham 1992), as well as estimates from the model selection procedure. Due to the information obtained since the finding of the Virgin River/Muddy River spawning aggregate, particularly the routine exchange of fish between Echo Bay and the northernmost portions of Lake Mead, we chose to lump data from these two locations for this report. The Echo Bay and Muddy River/Virgin River inflow combined razorback sucker estimates ranged from a low of 84 fish to a high of 242 fish during 2005–2007. The Las Vegas Bay population estimates were higher than those of the northern end of Lake Mead, ranging from a low of 69 to a high of 793 fish (the estimate of 793 has an extremely large confidence interval). In both locations there is an apparent increase in the estimates provided (compared with past reports) due to the relatively large number of young and unmarked fish captured during the 2007 spawning season.

Overall, population abundance remains highly variable at both study areas, and any patterns are therefore difficult to distinguish. However, as suggested previously and given the wide variability of the population estimates provided over the years, perhaps an additional indication of relative population trends on Lake Mead can be gleaned from the annual trammel netting CPUE, which has been expressed as the number of fish collected per net night in our annual reports. Catch per unit effort information is also provided in this report (Figure 6). As is evident, CPUE was dramatically higher this season compared with past study years. Coupled

Table 7. Population estimates using data from 2005–2007.

ESTIMATOR	2005–2007	95% CONFIDENCE INTERVAL
Echo Bay and Muddy River/virgin River Inflow Areas		
Model M_o	107	84–145
Chao M_h	142	97–242
Model Selection Procedure		
Jackknife	148	110–217
Las Vegas Bay		
Model M_o	97	69–158
Chao M_h	271	113–793
Model Selection Procedure		
Jackknife	169	119–250

with the rather large number of new and young fish captured this season, it appears as though Lake Mead razorback sucker are undergoing or have undergone a possible pulse in recruitment (thereby increasing the number of razorback sucker in Lake Mead and in turn boosting our capture numbers). Likewise (and equally plausible), it is also possible that recent lower lake elevations may have concentrated fish; hence we were able to more effectively sample and capture fish during the 2007 spawning season.

Unfortunately, it is too soon to tell what has caused the increase in captured razorback sucker this year. Regardless of whether a recruitment pulse has occurred or our previous efforts to catch razorback sucker in Lake Mead were rather ineffective (i.e., inability to catch the majority of individuals comprising a given population) during higher lake levels, these results are a positive indication of the unique ability of Lake Mead razorback sucker to maintain what appears to be a sustainable population despite pressures imposed by nonnative fishes and ever-changing lake conditions. Future monitoring and research efforts on Lake Mead should help us understand the increase in numbers of new and young fish captured in 2007.

Lake Mead Long-term Monitoring Recommendations: An Update

Given that lake levels are expected to continue to decline during the 2007–2008 field season, perhaps achieving the lowest levels observed during the course of this study, the general research objectives for the 12th study year include continuing to monitor the two populations of razorback sucker at Echo Bay and the Muddy River/Virgin River inflow area, as well as at Las Vegas Bay. Aging efforts will also continue. In addition to the continuation of general long-term data collections and monitoring efforts, emphasis will also be placed on a re-evaluation of our overarching hypothesis (if desired by collaborators) by directing some of our efforts towards investigating, gathering, and summarizing any potential limnological data gathered from Lake

Mead in an effort to better understand some of the physical conditions that may explain continued recruitment under low lake conditions. The following proposed work plan was developed to define specific objectives for the 12th study year.

In 2006 we were asked to compile a set of monitoring recommendations that would facilitate continued, future data collections on Lake Mead should funding be reduced during future years. Albrecht et al. (2006b) evaluated the Lake Mead database with the intent of streamlining efforts on Lake Mead, while striving to maintain the rigor and soundness of future data collections. The database was evaluated to determine optimal times for catching larval, juvenile/subadult, and adult razorback sucker. Albrecht et al. (2006b) made recommendations regarding how future efforts could be maximized in terms of efficiency of data collected by life stage, location, and time frame for sampling razorback sucker on Lake Mead. The study conducted this year (2006–2007) tested those recommendations (although inadvertently due to unforseen logistical circumstances).

Overall, the recommendations provided for a very successful year: Large numbers of adult and juvenile/subadult fish were collected. Larval catch rates fell within typical or higher ranges than those found during past field seasons. It was possible to effectively trammel net, larval sample, and monitor the habitat use of sonic-tagged fish during February–April. However, we did deviate from the monitoring recommendations because larval sampling was initiated in February, rather than March, as described by Albrecht et al. (2006b). This deviation resulted from the observation of relatively warm water temperatures early in the season, particularly at Las Vegas Bay, and the subsequent desire to study the resultant behavior of sonic-tagged fish at Las Vegas Bay, which extensively used shoreline habitats during February. This type of behavior has been indicative of spawning in the past.

Based on results from this season, we suggest modifying the monitoring recommendations found in Albrecht et al. (2006b) to initiate larval sampling in February rather than March. Albrecht et al. (2006) recommended that larval sampling be postponed until the first part of March to reduce time and costs but, as shown earlier in this report, larval fish were consistently captured in early February during the 2007 spawning period at Las Vegas Bay (Table 4). In fact, some of the highest larval capture rates of 2007 were observed during February at Las Vegas Bay. Since field crews conduct trammel netting in February, larval sampling could easily be incorporated simultaneously with trammel netting and the associated sonic telemetry efforts.

Although lake levels were relatively low during the 2007 spawning period, which may have contributed to an early production of larval fish at Las Vegas Bay, we believe that the possibility of documenting early larval fish production in future years, regardless of lake level, is pertinent to maintaining the long-term database and could contribute to our overall understanding of Lake Mead razorback sucker. In summary, based on what was learned during the 2006–2007 study year, we recommend that larval sampling, trammel netting, and sonic telemetry be conducted from the first part of February through the latter part of April, during the same time frame recommended for adult, juvenile, and subadult sampling.

DISCUSSION AND CONCLUSIONS

Information collected during the 2006-2007 field season (11th study year) on Lake Mead has expanded our knowledge of spawning behavior, habitat use, recruitment patterns, growth, and age of razorback sucker populations in Lake Mead. Additionally, information has been gained regarding age at sexual maturity, the nature of stocked and wild fish interactions, population abundance, and razorback sucker response to decreasing lake elevations, particularly at Las Vegas Bay.

Sonic telemetry, trammel netting, and larval collection continued to reaffirm the importance of Echo and Las Vegas bays to spawning razorback sucker. This combination of methodologies also helped us gather valuable data regarding the spawning aggregate in the relatively newly identified Muddy River/Virgin River inflow area of Lake Mead. Additional data on annual razorback sucker growth confirmed rates documented in previous years, and aging data from 41 adult razorback sucker were added to the data from 91 fish aged from 1998–2006, bringing the total number of aged fish to 132 and demonstrating continued recruitment as late as the 2004 spawning period.

Sonic telemetry proved very successful during the 2006–2007 study year. We were able to maintain contact with most of the fish throughout the year, including 8 of the original 10 fish tagged during the 2005–2006 study year and one fish tagged from 2004–2005. When considering the amount of time in which sonic tags have been implanted and the mobility of razorback sucker, the proportions of fish relocated exceeded our original expectations. Along with habitat and movement data, sonic-tagged fish provided crucial information regarding the general location of the razorback sucker population, thus greatly enhancing our ability to catch adults, subadults, and larvae. Additionally, sonic telemetry allowed us to document movements among the three spawning areas of Lake Mead (Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow). As documented in previous reports (Albrecht et al. 2006a), razorback sucker appear to move frequently between Echo Bay and the Muddy River/Virgin River inflow region of Lake Mead. We were also able to document the first and second known movement of a sonic-tagged fish between the Overton Arm and Las Vegas Bay. This is the first documentation of such behavior; however, Mueller et al. (2000) documented similar long-range movements.

Sonic-tagged fish provided invaluable data about the movement patterns and habitat use of razorback sucker in Lake Mead. The data led to the determination of new spawning locations, new and interesting movement patterns, and valuable information regarding habitat use. In addition to habitat and movement data, sonic-tagged fish played an essential role in helping determine the placement of trammel nets for the successful capture of razorback sucker. As the lake recedes (Figure 12), sonic-tagged fish will continue to provide invaluable data in relation to changes in movement patterns, habitat use, and selected spawning sites.

Larval razorback sucker were captured at each of the previously documented spawning locations of Lake Mead (Las Vegas Bay, Echo Bay, and the Muddy River/Virgin River inflow area) during the 2006–2007 study year. In terms of both numbers of larvae captured and CPUE, this most recent study year was comparable with or exceeded past study seasons. In Las Vegas Bay, both the numbers of larvae (1,431) and the CPUE (0.39 fish/min) exceeded those documented in past years (Albrecht et al. 2006a). Similarly, sampling efforts in Echo Bay resulted in the second-highest amount of larval fish collected (743) and the second-highest CPUE (0.43 fish/min). A greater number of captures and higher capture rates occurred only in 2005 (1,330 larvae and 1.36 fish/min, respectively). In regards to the Muddy River/Virgin River inflow area, similar to past study years very few larvae were collected. Hence trends and comparisons are difficult to make in that location.

Compared with Las Vegas Bay, larval captures in Echo Bay were delayed approximately 1 month. This may be attributed to localized, cooler water temperatures coupled with the dynamics of lake-level fluctuation differences between the two study areas. This trend was also noted in Albrecht et al. (2006a). Larval catches at Echo Bay appeared to peak during the end of March and beginning of April, while catch rates at Las Vegas Bay appeared to peak toward the latter part of February and first part of March (Table 5). As in 2005 and 2006, BIO-WEST teamed with biologists from NDOW and Reclamation to collect additional larval razorback sucker for future repatriation efforts. Larval catches provided for this report only include catches made by BIO-WEST during standard/historical sampling efforts and do not reflect the total number of larval fish collected for hatchery rearing in collaboration with NDOW and Reclamation. Larval fish are currently being held and reared by NDOW, and BIO-WEST continues to work with NDOW to design experimental stocking procedures and monitoring strategies. Larval fish were also collected from Las Vegas Bay during collaborative efforts.

Perhaps the most interesting conclusion is that successful spawning is still occurring despite a continued decline in lake levels. At Echo Bay the spawning movement pattern of razorback sucker relative to lake levels was similar to that documented during the previous 3 years. This phenomenon indicates that Echo Bay razorback sucker exhibit spawning site fidelity but possess enough plasticity in their spawning behavior to use alternate locations when the preferred site is inaccessible. This behavior has also been observed in the Green River, Utah (Tyus 1987, Bowen et al. 2001), where different spawning sites were used at different river elevations. During all years of the study, the spawning site selection at Echo Bay has varied from less than 10 ft to more than 20 ft depending on lake level. Since 2004 the spawning site has been at essentially the same location along the northern shoreline of Echo Bay.

In 2006 and in 2007, as a result of the dessication and sedimentation of Blackbird Point (Albrecht et al. 2006a) and our increased ability to locate adult razorback sucker habitat by following sonic-tagged fish, we have documented a successful (i.e., larval fish were produced) shift in spawning site selection of the Las Vegas Bay razorback sucker population using multiple methodologies. During 2006 and again in 2007, the Las Vegas Bay razorback sucker population spawned along the southwestern shoreline. Although differential selection of spawning habitats was the norm at Echo Bay, this is only the second time during the course of our research that a similar shift occurred at Las Vegas Bay (2006 and 2007 spawning periods). While we had speculated internally that the Las Vegas Bay population would make the shift when/if required, it has now been documented twice. Evaluating the ramifications of this shift, particularly in terms of recruitment, and identifying how spawning at this new location will add individuals to the spawning population will be important in future study years. Furthermore, as the lake level is projected to decline through 2008, it will also be a monitoring priority to follow the Las Vegas Bay population's spawning habitat selection to identify any additional shifts in spawning site habitat use.

It is important to note that since the conclusion of the 2006–2007 Lake Mead field season, the most recently identified spawning sites in Las Vegas Bay and Echo Bay have become desiccated due to receding lake levels. Depths of the previously identified spawning locations in the Muddy River/Virgin River inflow area have been drastically reduced, and these areas will most likely become dry in the near future. Continued monitoring of razorback sucker in all three portions of Lake Mead through sonic telemetry, adult netting, and larval sampling will continue to be invaluable in describing future habitat use and spawning locations as the lake level and habitat available to razorback sucker continues to diminish.

Combined information obtained from efforts in the northernmost portions of Lake Mead near the Muddy River/Virgin River inflow areas provide fairly sound evidence that the Muddy River/Virgin River spawning aggregate is an extension of habitat use by the Echo Bay spawning population. Based on data collected since 2005, it appears that the Echo Bay population is much more diverse and broader in its use of spawning habitats than previously thought. Similarly, the size of the population in the northern end of Lake Mead appears to be larger than previously reported, and the number of new recruits displayed in this area of the lake is highly interesting and worthy of continued investigation. Based on the most recent data, we recommend that the spawning aggregate in Echo Bay and the Muddy River/Virgin River inflow area be considered one and the same. Likewise, we propose that the broad use of spawning habitats throughout the northern portion of Lake Mead be considered highly important in terms of the overall status of razorback sucker in Lake Mead, suggesting that the total numbers of fish inhabiting the lake are likely higher than previously thought. The results provided herein suggest a highly interactive, dynamic nature of razorback sucker habitat use in the northern portions of Lake Mead, this notion is further strengthened by the elevated numbers of fish captured in the northern portions of Lake Mead and at Las Vegas Bay during 2007. Whether the increased capture rates in 2007 were due to the low lake and therefore the possibility of increased sampling and capture efficiency, or if in fact the populations have simply undergone a recent pulse of recruitment, the result is the same: There appear to be greater numbers of razorback sucker in Lake Mead than considered until now.

The observed increase in razorback sucker in all sampling locations—particularly the continued pulses of new, young, individuals—begs evaluation of the historical overarching hypothesis describing why and how Lake Mead continues to support the only known, sustainable population of razorback sucker (Albrecht et al. 2006a). In the past the rare and continued recruitment of Lake Mead razorback sucker has been attributed to a change in the management of Lake Mead which was thought to be responsible for the apparent, sudden recruitment of razorback sucker. From the 1930s to 1963, Lake Mead was either filling (a time when initial recruitment likely occurred and created the original lake population of razorback sucker) or it was operated with a sizable annual fluctuation. The lake was drawn down approximately 100 ft in the mid 1960s as Lake Powell filled: since that time it has been operated with relatively small annual fluctuations but relatively large multiple-year fluctuations. It has been suspected that the drawdown of Lake Mead (for filling of Lake Powell and a subsequent drawdown in the 1990s) allowed terrestrial vegetation to become well established around the lake shoreline. The vegetation was then inundated as the lake rose, but (with small annual fluctuations) the vegetation remained intact for many years and provided cover in coves and other habitat that young razorback sucker may inhabit. Furthermore, vegetation coupled with turbidity (an additional form of cover) near the inflows have resulted in recruitment events. Before 1970, vegetation was unlikely to establish due to relatively large, annual reservoir fluctuations. The presence of individual razorback sucker older than 30 years indicates that limited recruitment may have occurred during the 1966–1978 period, a time when lake elevations slowly rose to their highest levels (1978–1987) and the maximum amount of intact inundated vegetation probably existed in the lake.

To date, much of our hypothesis regarding continued razorback sucker recruitment in Lake Mead has revolved around the presence/absence of vegetative cover. While turbidity was and is recognized as an important form of cover in Lake Mead, slightly less emphasis has been placed on its affect on recruitment. Data collected during the 2007 spawning period suggests that turbidity may be much more important for razorback sucker recruitment in Lake Mead than previously thought, at least under conditions imposed by low lake level conditions. Until this season, turbidity was deemed important and likely allowed for limited, sporadic recruitment of a few individuals during low-water years; however, recently, we have noticed a pulse of recruitment during low water/declining lake conditions. Figure 16 best exemplifies the pulses in recruitment in relation to lake elevation. As shown, 2002 and 2003 have now been identified as strong recruitment years. In fact, the most documented recruitment to date occurred in 2002. Given that 2002 was a relatively low and declining lake year, it appears as though turbidity may be much more important for razorback sucker recruitment than we have typically given it credit. While both turbidity and vegetative cover are likely important, at low water levels, turbidity apparently is and should be considered highly important; at minimum it is noteworthy of future investigation.

Items to evaluate in terms of turbidity and its effects range from fairly simple to complex. For example: Have turbidity levels increased in recent years (e.g., particularly years since 1999 when the lake was at/near full pool)? Has there been a recent increase in the productivity of Lake Mead, especially near the known spawning locations? What impacts have lowered lake conditions had on the recruitment and status of litoral predatory fishes? Is it possible that lowered lake conditions have also impacted nonnative fish populations (such as green sunfish, bluegill, and other littoral fishes), and are these data even available for evaluation? Is it possible that larger deltas near the inflows could in fact increase sediment loading and turbidity levels of the lake at lower reservoir elevations? Are there other water quality parameters that may have changed in Lake Mead recently, parameters that might impact early life stage fishes and particularly affect young razorback sucker survival?

One hypothesis explaining the recent pulse in recruitment in Lake Mead is that both low and high lake conditions are conducive to recruitment events. We have already described how recruitment is likely a possibility at high water levels due to the presence of inundated vegetation. For example, consider Lake Mohave, where natural razorback sucker recruitment has not been documented. Golden and Holden (2003) have shown that cover, in terms of both turbidity and vegetation, is more abundant in Echo Bay and Las Vegas Bay than in other Lake Mead or Lake Mohave coves. Furthermore, it has been accepted for years that turbidity plays a role in the susceptibility of young razorback sucker to predation (Johnson and Hines 1999). This information led to the formulation of the hypothesis that low, annual fluctuations and large, multi-year lake elevation changes that promote the growth of vegetation around the lake, the inundation of that vegetation, and turbid conditions are the major reasons for razorback sucker recruitment in Lake Mead. Until now the majority of data collected using aging techniques demonstrated that most of the recruitment on Lake Mead seemed to coincide with high lake elevations, although a few limited, sporadic recruitment events occurred at low lake elevations. Thus the focus of our attention has been on recruitment events that happened to align with high lake levels. However, in light of the data collected this season, it is apparent that recruitment pulses can and do occur at lowered lake conditions, when vast expanses of vegetative cover may not be readily available. Given this, we hypothesize that turbidity may be an important driving factor allowing for recruitment under low lake level conditions on Lake Mead. It seems logical that the deltas associated with the various inflows in Lake Mead begin to expand during low water years and wave action on the exposed sediment of the deltas could contribute to increased cover in the form of turbidity. In fact, we have observed this during the course of our studies. As the deltas expand due to the dropping lake levels coupled with the hydrological forces of flowing water at the inflows, more and more sediment could foreseeably become subject to the effects of erosion. As stated previously, this may in turn increase the amount of sediment (turbidity) that enters Lake Mead at the inflows and effectively provide a form of cover for early life stage razorback sucker. Hence cover in the form of turbidity increases, ultimately leading to increased recruitment. Since data obtained in 2007 show that pulses in razorback sucker recruitment are possible at both low (e.g., 2002–2003) and high lake elevations (e.g., 1985–1978 or 1998–1999), cover (in the form of turbidity and/or vegetation) similar to that found on Lake Mead is a potential key to understanding and enabling the sustainability of the species basin wide. Therefore, we recommend that the interactions of these types of cover be explored in greater detail.

Growth rates of recaptured Lake Mead razorback sucker continue to surpass those recorded for other wild razorback sucker populations. Mean annual growth for Lake Mead fish recaptured in 2006–2007 was 8.1 mm, compared with very low growth (less than 2.0 mm per year) for razorback sucker in Lake Mohave (Pacey and Marsh 1998) and the Green River (McAda and

Wydoski 1980, Tyus 1987). As indicated in Mueller (2006), these elevated growth rates indicate that Lake Mead razorback sucker populations are relatively young. As an increasing amount of young fish (< 7 years old) are captured and tagged, we remain hopeful that crucial data will be provided that will enable us to acquire much needed knowledge regarding this relatively unknown life stage of razorback sucker in Lake Mead and how this life stage can be promoted in other locations.

Fin-ray extraction and aging efforts continued during the 11th study year, resulting in the definitive age determination of 41 adult/subadult razorback sucker. Calculated ages ranged from 3- to 25-years old. Ages of the 41 fish evaluated during the 2006–2007 study year and the 91 previously aged fish helped identify that recruitment occurred fairly regularly from 1974–2003. The greatest recruitment occurred during 2002–2003, with a total of 24 razorback sucker resulting from those spawning events alone. Fifty-one percent of the fish aged from the most recent study year were less than 7 years old, indicating a strong recruitment trend in recent years (1998–2004). As stated previously, this strong pulse of young fish indicates that successful spawning and recruitment are indeed occurring at diminished lake levels, which necessitates reformation of our original hypothesis concerning factors that may result in successful recruitment of razorback sucker.

The population estimates for razorback sucker populations in Lake Mead generated from data collected during the 2006–2007 study year have increased in comparison with estimates from past study years. However, we are apprehensive about suggesting that a significant increase in the number of razorback sucker inhabiting Lake Mead has truly occurred. Other unknown factors—such as lowered lake levels, higher concentrations of fish in sampling areas, or increased sampling efficiency—may be artificially boosting the population estimates. Whatever the case, we must reiterate that direct management decisions and actions should not be solely based on these population estimates. Future study years will undoubtedly reveal more information regarding the population dynamics and trends of razorback sucker in Lake Mead, specifically in respect to the parameters that are currently driving the recent trends of increased recruitment.

RECOMMENDED WORK PLAN FOR 2007–2008

Specific Objectives for the 12th Study Year

1. Continue historical data collection including the continuation of tracking efforts associated with the active, sonic-tagged Floyd Lamb State Park razorback sucker in hopes of: (1) following spawning populations at the known spawning areas, particularly Las Vegas Bay, in order to evaluate whether any further shifts in spawning site selection occurs; (2) further investigating the new Fish Island spawning site to evaluate habitat use and help further understand habitat use in this area of Lake Mead; and (3) potentially identify other, new spawning areas as dictated by tracking sonic-tagged fish. Larval

sampling, adult trammel netting, and fin-ray collection and aging techniques, with particular emphasis on PIT-tagging adult razorback sucker, will also continue. This will further assist in understanding the size and habitat use of the populations of razorback sucker throughout the northern end of Lake Mead, help document the exchange of fish between the Fish Island site and the Echo Bay spawning area, and elucidate recruitment patterns in those areas. Methods will follow those outlined in Albrecht et al. (2006b) and updated in this report.

2. Provided the results and discussion of this year's efforts on Lake Mead, particularly the observation of continued pulses in razorback sucker recruitment despite lowered lake conditions, an investigation and re-evaluation of our overarching hypothesis may be warranted. We recommend that efforts be made to gather, investigate, and evaluate other pieces of information that may help us to understand the continued pulses in recruitment observed on Lake Mead to date and serve to re-evaluate the overarching hypothesis as to why Lake Mead razorback sucker are able to maintain relatively consistent populations despite changing physical and biological conditions on Lake Mead. Efforts could be directed at finding, evaluating, and incorporating other data collected on Lake Mead by other groups, particularly data that tracks/monitors changes in the physical, limnological, and/or water quality conditions in Lake Mead. Special attention could then be given to evaluating changes (if any) of turbidity levels in Lake Mead, with specific attention given to data collected near known spawning locations. In all, the goal would be to investigate if physical conditions in Lake Mead have changed in recent years, with the overall purpose of tying this information back to years of rather strong recruitment based on our aging results. Depending upon the indications of the literature and data review, this effort may be expanded to include trends in other, nonnative fish species that may have predatory or competitive impacts on razorback sucker recruitment. In general, the goal would be to investigate questions similar to those broached in the discussion section of this annual report.

Note

In addition to this annual report, we are preparing a review report that outlines and summarizes our efforts on Lake Mead during the past decade. The hope is to condense data collected to date into a format that is user friendly and describes the study from its inception to its current status. Furthermore, it is our hope that the review document will be useful for various user groups, audiences, and other parties–those interested in the questions, methodologies, results, and lessons learned while studying this unique species in Lake Mead.

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