

RAZORBACK SUCKER STUDIES ON LAKE MEAD, NEVADA AND ARIZONA

2003-2004 ANNUAL REPORT

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Top left: Wild sub-adult razorback sucker captured at Las Vegas Bay.

Top right: Closed Las Vegas Bay boat ramp.

Left: Adult razorback sucker captured at Echo Bay.

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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.

During the eighth year (July 2003 to June 2004) of the Lake Mead razorback sucker study, emphasis was placed on determining the effects of lowering lake levels on the Blackbird Point spawning location, locating spawning areas of the known populations, locating spawning adults in a potentially new population near the Colorado River inflow, capturing adults to remove fin ray sections for aging, and monitoring sonic-tagged adult fish at Las Vegas Bay and Echo Bay. Trammel netting for adult fish during the spawning period continued and 33 adult and 1 sub-adult (sexually immature and greater than 300 mm in total length) razorback sucker were captured, including five in Las Vegas Bay (the sub-adult fish was captured in Las Vegas Bay) and 29 in Echo Bay. Of the 34 total razorback sucker collected, 24 were recaptures; this recapture rate is higher than the rate found in previous years. The most interesting new capture during the eighth study year was the sub-adult fish at Las Vegas Bay.

Small sections of fin rays were removed from eight razorback sucker for aging during this study year, bringing the total number of fish aged during the study to 72. Aging continued to show that recruitment in Lake Mead has occurred during relatively high and stable lake elevations.

The precipitous drop in lake elevation over the last 4 years has affected razorback sucker spawning sites of Lake Mead. The spawning area used by the Las Vegas Bay population at Blackbird Point appeared to remain unaffected by the declining lake elevation until 2004. As lake levels continued to decline during the 2004 spawning season, the Las Vegas Wash delta moved further out into Las Vegas Bay, resulting in the entire presumptive spawning area along the western shore of Blackbird Point being covered with sediment from the delta. In 2004 only four razorback larvae were captured near this location, suggesting that the same portion of Blackbird Point was used for at least some spawning this year, but that most of the fish in the population did not use this area. No other larvae were found in sampling other Las Vegas Bay locations.

During the last three spawning periods (2002-2004) at Echo Bay, the spawning site used the previous year was dry due to the declining lake; however, each year this population found other suitable spawning sites in portions of Echo Bay that were still inundated. During the 2004 spawning period, larval concentrations and the habitat use of a telemetered fish indicated that the Echo Bay population most likely spawned approximately 250 m to the east of the 2003 site along the north shore of Echo Bay. In 2004 no larval razorback sucker were captured in the Colorado inflow portion of Lake Mead or in the Virgin/Muddy rivers inflow area.

Four adult fish were implanted with 4-year sonic tags and stocked into Las Vegas Bay and Echo Bay in January 2003; two fish were tagged at each location. One Echo Bay fish has not been located since its release, and one Las Vegas Bay fish became stationary sometime in March 2003. The other Echo Bay fish continued to use both the Echo Bay and Rogers Bay areas of Overton Arm. The other Las Vegas Bay fish was captured near Gypsum Wash in a trammel net during a sampling trip in November 2003. Prior to its capture, the fish had been found along the south shore of Las Vegas Bay; however, several extensive searches of Boulder Basin since November failed to relocate this fish.

Average growth, as determined from 17 fish that were recaptured during 2003-2004, was 6.5 mm for this study year. Mean annual growth of Las Vegas Bay fish was 5.6 mm and 6.8 mm for Echo Bay fish. These growth rates continue to be substantially higher than those recorded from other razorback sucker populations.

Site fidelity and home range were examined for adult razorback sucker using movement data obtained from sonic telemetry for the period of 1997-2000. All four Echo Bay fish and six of the eight Las Vegas Bay fish exhibited site fidelity. Home range size for Las Vegas Bay fish ranged from 7.2 to 116.5 ha. Echo Bay home ranges were consistently lower, ranging from only 7.8 to 22.6 ha. The average home range size for Las Vegas Bay (59.6 ha) was approximately 3 times greater than Echo Bay (16.7 ha).

The general research objectives for the upcoming study year include: continue to monitor adults and larvae at the two known populations of razorback sucker at Echo Bay and Las Vegas Bay; continue to age individual razorback sucker from Lake Mead; implant additional captive reared razorback suckers with sonic transmitters and release them into Echo and Las Vegas Bays in hopes they will lead researchers to wild spawning sites; and identify spawning areas and examine habitat use at Echo Bay and Las Vegas Bay during low and declining lake levels. A major emphasis will be determining if the Las Vegas Bay population starts to use another spawning area.

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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 non-native fishes that are successfully established in the Colorado River and its reservoirs have also contributed to their decline (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 1,000 by 2004 (P. Marsh, Arizona State University, personal communication). 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. Predation by bass (*Micropterus* spp.), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), sunfish (*Lepomis* spp.), and other non-native species appears to be the primary reason for the lack of razorback sucker recruitment (Minckley et al. 1991).

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 collected razorback sucker from Lake Mead (Sjoberg 1995). This may be due in part to changes in their 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 dying off 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 the Lake Mead population: 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 about the Lake Mead razorback sucker population. 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, 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 the 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.

An additional objective for the 2003-2004 study year was to determine if adequate sized spawning gravel occurred at the Muddy/Virgin River interface areas, and if any spawning was occurring in that area. Studies in 2002-2003 has suggested that this inflow area may also provide vegetation and

turbidity characteristics similar to Las Vegas Bay, Echo Bay, and the Colorado River inflow that would make it suitable for razorback sucker spawning (Welker and Holden 2003).

This Annual Report presents the results of the eighth study year extending from July 2003 through June 2004. Information and data from previous years (October 1996 to June 2003) are included where applicable.

SUMMARY OF EARLIER STUDY RESULTS, 1996-2003

Since the Lake Mead Razorback Sucker Study began in 1996, more than 1,000 trammel net nights have resulted in nearly 300 razorback sucker captures that were represented by 169 individuals that were implanted with PIT tags. The PIT tags proved valuable in assessing growth and movement patterns for this population of razorback sucker. In 1997 four sub-adult razorback sucker were captured in Echo Bay indicating that recent, natural recruitment had occurred for the Lake Mead population. An additional 13 wild sub-adult razorback sucker were captured in the Blackbird Point area of Las Vegas Bay through 2003. Beginning in 1999 small sections of fin rays were removed from wild razorback sucker for aging, and through 2003, 64 (54 adults and 10 sub-adults) razorback sucker had been aged. The ages of the 54 adult fish ranged from 8 to approximately 35 years and the 10 sub-adult fish were aged between 4 and 6 years. We believe that lake-level fluctuations that promote the growth and then inundation of shoreline vegetation are largely responsible for the pattern of recruitment observed for the Lake Mead population of razorback sucker. The inundated vegetation is thought to serve as protective cover, along with turbidity, allowing young razorback sucker to avoid predation by non-native fishes.

The declining lake elevation during the last 4 years has affected razorback sucker spawning sites at Echo Bay and the Colorado River inflow area of Lake Mead. The spawning site at Las Vegas Bay was not affected through 2003. At Echo Bay from 1997-2001, aggregations of sonic-tagged adults, redd location, 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 has continued to decline during the last three years, the Echo Bay population has found new spawning sites in Echo Bay in response to the stranding of the previous year's site, moving down the wash with the lake. At Las Vegas Bay, during the first 7 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 depths have changed as the lake has dropped. In the late 1990 at a high lake elevation, the spawning location was thought to be near a depth of 80 feet. By 2003 the spawning depth was closer to 20 feet in depth. In 2000 and 2001, larval razorback sucker were captured in the Colorado River inflow region of Lake Mead. Over the last two spawning periods no larval razorback sucker were captured in this region of the lake. Spawning for this population either did not occur or took place outside of our sampling area. Alteration of spawning sites from lake elevation changes is may be responsible for the apparent absence of spawning in the Colorado River inflow region.

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 battery life of 12 months (implanted in 1997 and 1998), and the other half had a life of 48 months. Sonic telemetry showed

a seasonal pattern in use of 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 west shore of Overton Arm. The four hatchery fish implanted with sonic tags and stocked into the Colorado River inflow area during the sixth study year were active in the Grand Wash Area for several months after their early 2002 stocking. Two of the fish are stationary and the remaining two fish were last contacted in the inflow area in April 2002. Despite numerous searches of the lake, the missing fish have not been 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 and one of the Echo Bay fish was not contacted after its release. This report includes movement information for the two remaining fish—one at each location—during the eighth study year. The sonic telemetry data collected during the first 7 years of this study has provided valuable information on razorback sucker spawning, movement patterns, and habitat use.

STUDY AREAS

The majority of 2003-2004 study year activities occurred at the same locations used in the 1996-2003 portion 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). The two most frequented areas were Echo Bay and Las Vegas Bay (Figure 1). Razorback sucker activity was also studied at Las Vegas Wash and the Colorado River inflow area of Lake Mead (that portion of Lake Mead between Pearce Ferry Bay and Iceberg Canyon) (Figure 1). During the 2003-2004 field season, sampling at the Colorado River inflow region of the lake extended from Iceberg Canyon to Hualapai Bay at the southern end of Gregg Basin. Sonic telemetry was conducted in other parts of the lake, including the Overton Arm, Boulder Basin, and Virgin Basin. Larval sampling was performed in Echo Bay, Las Vegas Bay, the Colorado River inflow area, and the Muddy/Virgin River inflow area of the lake. Trammel netting was conducted at Las Vegas Bay and Echo Bay as during previous years (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). These definitions are still accurate for various portions of the wash and are as follows:

- 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 relatively short (200 to 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.

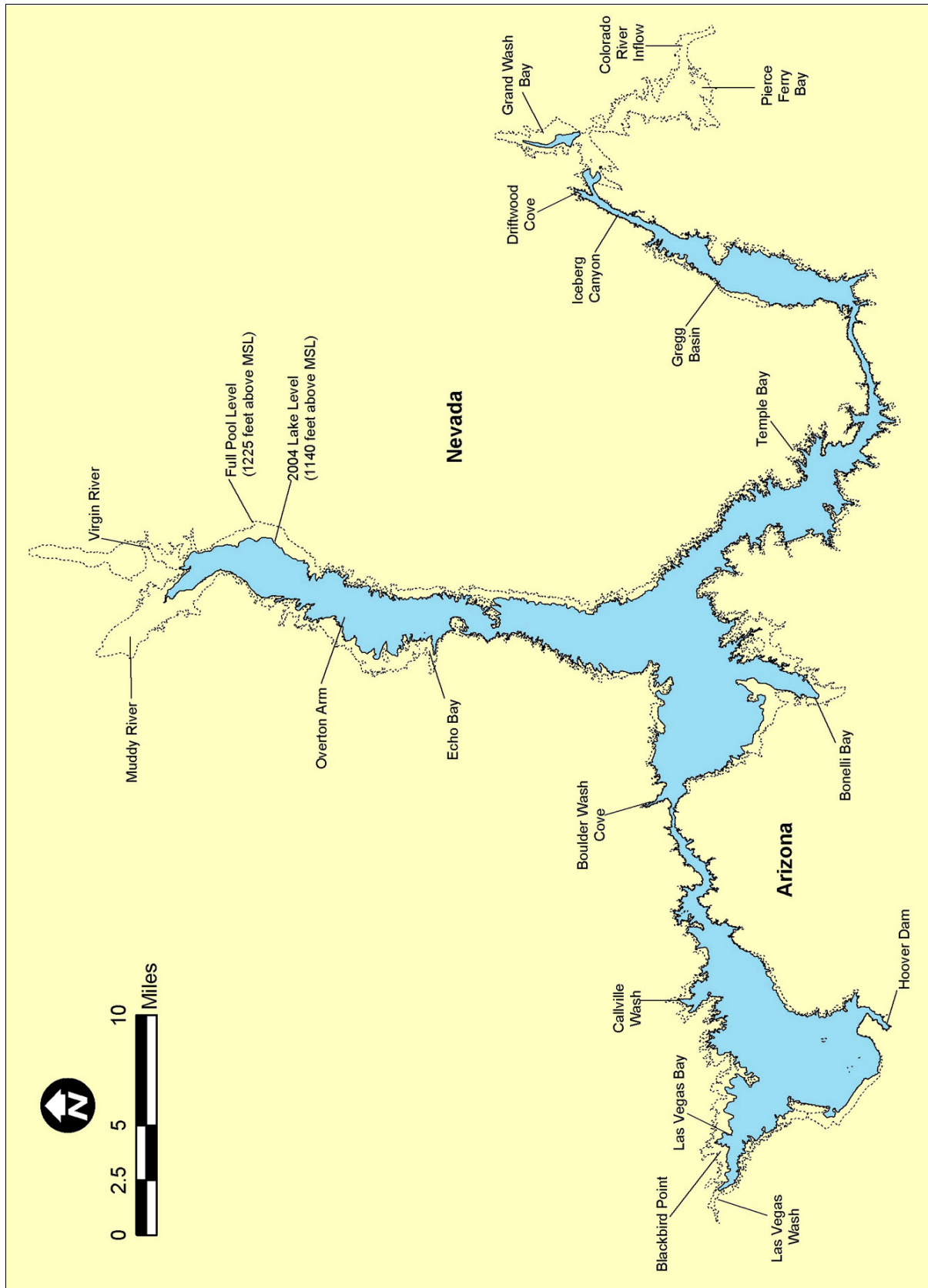


Figure 1. Map of Lake Mead showing general study area locations.

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

- Flowing portion (the area closest to Las Vegas Wash)
- Non-flowing portion (usually has turbid water but very little current)
- Las Vegas Bay (the majority of the bay that is not heavily influenced by Las Vegas Wash)

METHODS

Lake Elevation

Month-end lake elevations for the 2003-2004 field season (July 1-June 30) were measured in feet above mean sea level (amsl) and obtained from Reclamation's Lower Colorado Regional Office website (Reclamation 2004). The effect of decreasing lake levels on razorback sucker habitat was documented in writing and/or photographs during sampling trips to each of the study areas.

Adult Studies

Trammel nets were the primary adult sampling gear (300' long by 6' deep with an internal panel of 1", 1.5", or 2" mesh and external panels of 12" mesh). Nets were generally set with one end near shore in 25-30 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 monthly within each study area from September through May, with variable effort between months. Netting locations for the two primary study sites were selected based on the locations used by sonic-tagged fish and suspected spawning areas.

Fish were taken from the nets, and live fish (with the exception of common carp) were held in large, water-filled containers. Razorback sucker were isolated from other fish species in separate containers. Common carp were enumerated and returned to the lake; other species were measured for total length (TL) and fork length (FL), weighed, and released at the location of capture. Razorback suckers were scanned for PIT tags, tagged with PIT tags if they were not recaptures, measured (including standard length [SL]), weighed, and released at the point of capture.

Larval Sampling

Larval sampling methods followed those developed by Burke (1995) and other researchers on Lake Mohave. The procedure utilizes 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 to 10 inches of water. Two "netters" were stationed observing the area around the lights while equipped with long-handled aquarium dip nets. 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 generally run for 15 minutes at each location, customarily sampling 4 to 8 sites on each night attempted. Larvae were enumerated as they were placed in the holding buckets and then released at the point of capture when sampling at a site was completed.

As a result of decreasing lake levels, larval sampling during spring 2004 could not be conducted at the same twelve 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 2002-2004 only some of the original sites were used, and others were assigned based on initial sampling. At Echo Bay the four western-most sites were above the spring 2004 lake level. Additional larval sites were selected at random to help locate spawning locations. The location of a sonic-tagged, telemetered fish was also used to select larval sites. At Las Vegas Bay larval sampling sites changed from the standard six sites sampled during previous years due to the encroachment of Las Vegas Wash. Sites along Blackbird Point and along the north shore of Las Vegas Bay from Blackbird Point to Government Wash were sampled.

Spring 2004 larval sampling was also conducted in the Colorado River and the Muddy/Virgin River inflow areas of Lake Mead. From mid-April through May, larval sampling was conducted in the Colorado River inflow area one to three times per week, with five to ten stations sampled per night using methods described in Holden et al. (2000b, 2001) and Abate et al. (2002). In this region of Lake Mead, the east and west shores of Gregg Basin were sampled from Iceberg Canyon to Hualapai Bay. Six to twelve randomly selected sites were sampled on three occasions in the Muddy/Virgin River inflow area of Lake Mead during March. These sites were located on both the north and south shores of Overton Arm.

Age Determination

Selected razorback sucker captured in trammel nets were anesthetized, and an approximately 0.25-inch-long segment of the second left pectoral fin ray was surgically removed. Fish that exhibited signs of stress from netting were excluded from the procedure. In the laboratory, fin ray segments were embedded in thermoplastic epoxy resin and heat cured. This allowed the embedded fin rays to be perpendicularly sectioned using a Buhler isomet low-speed saw. Fin ray sections were subsequently mounted on microscope slides and then sanded, polished, and examined under a stereo-zoom microscope. Each sectioned fin ray was aged by at least two readers. Sections were read a second time (by the readers) in instances where the assigned age was not in agreement. If discrepancies remained between the two ages after the second reading, the readers viewed the structure together and assigned an age.

Population Estimates

Capture data collected by BIO-WEST from 2002-2004 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 hypothesized that an adult stocked fish that had survived 1 year in the wild was able to reproduce and contribute progeny to the population. Estimates for both populations were conducted for the most recent 2-year (2003-2004) and 3-year periods (2002-2004) of this study.

Two abundance estimators were used, Chao's M_h (Chao 1989) and Model M_0 (Otis et al. 1978). The Model M_0 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_0 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, for each period examined, close agreement between the two models indicated a reliable estimate.

Sonic Tracking

Sonic telemetry was utilized to assess adult habitat use and movement. Two razorback sucker sonic-tagged during 2003 were located and monitored monthly or more frequently, depending on the field schedule. Searches for fish were generally made along shorelines with listening points every 0.5 mile or less, depending on shoreline configuration and other factors that could affect the ability to hear a signal (sonic equipment is line-of-sight, so any obstruction could 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 location of the fish, which was then noted using a GPS unit.

Muddy River/Virgin River Inflow Spawning Substrate Composition

The Wolman pebble count method (Wolman 1954) was used to identify the occurrence of suitable spawning substrate at the Muddy River/Virgin River area of Lake Mead. Substrate particle size was examined at five sites between the Overton Marina and the Muddy River mouth along the south shore of the lake. At each site, one transect was established and 100 particles were classified along each transect. All areas pebble counts were performed on shore. At each 1-foot interval the intermediate axis (i.e., the B-axis) of the first substrate material touched (without looking) by an extended finger was measured to the nearest millimeter. Spawning bed substrate composition was quantified by dividing the total number collected from each size class (clay/silt, <0.062 mm; sand, 0.062-2 mm; gravel, 2-64 mm; cobble, 64-256 mm [Cummins 1962]) by the total number of samples collected and multiplied by 100 to obtain percentages. An average substrate composition was obtained from the transects at each site.

Trammel Net Mesh Size Analysis

The length (TL in mm) and catch per unit of effort (CPUE) of razorback sucker sampled using trammel nets with 1", 1.5", or 2" internal panel mesh sizes (external panels of 12" mesh) were evaluated for the 1998-2004 period. The arithmetic average, range of length, and CPUE were computed for each mesh size and examined using box-and-whisker plots. Analysis of variance (ANOVA) was used to test the null hypotheses that no difference existed in razorback sucker length or CPUE among the three sizes of mesh. Mesh sizes served as treatments and years served as blocks. The additivity of the ANOVA models was examined with Tukey's test for nonadditivity (Sokal and Rohlf 1995). The sphericity assumption was examined using Mauchly's criterion (Crowder and Hand 1990). Residual plots were used to examine the tenability of the normality (normal distribution of residuals) and homogeneity of variance assumptions. All tests were considered significant at the 0.05 level.

Home Range Analysis

The Animal Analysis Extension (AMAE) for ArcView© (Hooge and Eichenlaub 1997) was used to examine site fidelity and home range size for razorback sucker in Lake Mead. Movement data were obtained from adult sonic-tagged fish for the period of 1997-2000; this period was chosen due to the lake remaining at a relatively constant elevation during these years. Large fluctuations in lake elevation could cause the home range size to increase or decrease, thereby making the results less comparable between the two study areas. A lake elevation of 1,220 ft amsl was used for all analyses. Site fidelity was examined for eight fish from Las Vegas Bay and four fish from Echo Bay. Site fidelity was tested for each sonic-tagged fish using an extension of the Monte Carlo random walk test (1,000 replicates were generated for each fish) developed by Spencer et al. (1990). A bounding graphic was used to restrict the analysis below the 1,220 ft amsl contour. All tests were considered significant at the 0.05 level. If site fidelity existed, home range size was calculated using kernel home range (Worton 1989), a probabilistic technique. Ninety-five percent probability contours were used to represent the area that each fish used. An unfortunate problem with AMAE is that there is no method to restrict the kernel to a particular elevation (or depth) contour. Therefore, the kernel polygons were clipped to remove unusable portions that included dry land. Little home range area was lost using this method; however, the resulting polygons were less than 95%.

RESULTS

Lake Elevation

The steady decline in lake elevation that has occurred for the last five years continued in the eighth study year. The July 2003 month-end lake elevation was approximately 1,142 ft amsl, and the lake level decreased to 1,129 ft amsl by June 2004, the lowest level of the study (Figure 2).

Adult Sampling

Trammel Netting

Table 1 shows the trammel netting effort, expressed in net nights, that occurred from July 2003 to June 2004, and Figures 3 and 4 show the locations of trammel net sets in the two primary study areas for the same period. One net night is comprised of a single net set overnight. Trammel netting was conducted on 245 net nights during the eighth study year, with 107 net nights spent in the Las Vegas Bay/Boulder Basin area and 138 net nights spent in the Echo Bay/Overton Arm area. Trammel netting effort was concentrated in the Blackbird Point area in Las Vegas Bay (Figure 3), including the flowing and non-flowing portions of Las Vegas Bay, and in the back of Echo Bay (Figure 4). Most of the netting effort was expended from December through May (Holden et al. 1997, 1999).

No netting effort was expended at the Colorado River inflow area during the eighth study year. In past study years netting effort in this portion of the lake was concentrated in areas where razorback sucker larvae were captured, which were possible spawning sites. No razorback sucker larvae were captured during the eighth study year in this area of Lake Mead.

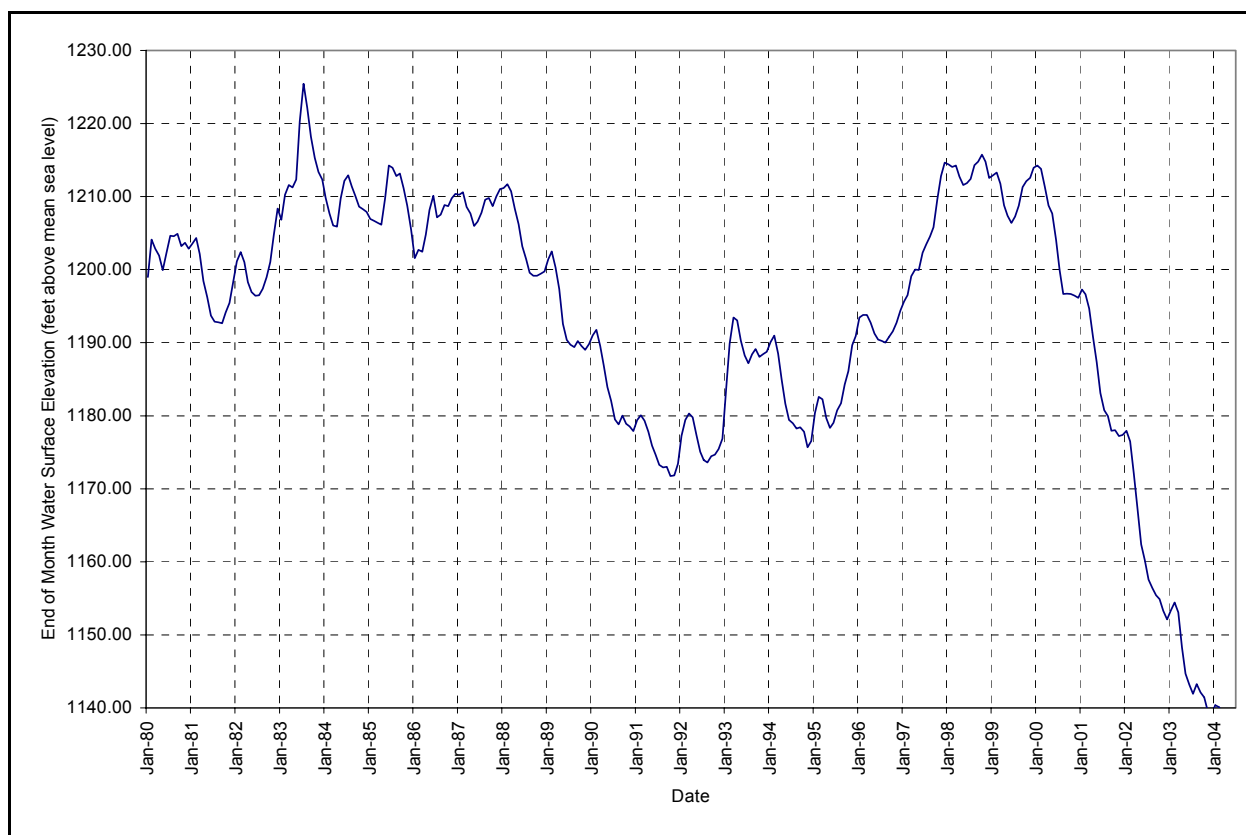


Figure 2. Lake Mead month-end elevations, January 1980 to June 2004.

Table 1. Trammel netting effort (net nights) on Lake Mead by month from July 2003 to June 2004.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY/ OVERTON ARM	TOTAL NET NIGHTS
<u>2003</u>			
July	-	-	0
August	-	-	0
September	-	-	0
October	9	10	19
November	8	5	13
December	10	12	22
<u>2004</u>			
January	18	20	38
February	21	30	51
March	22	23	45
April	19	28	47
May	-	10	10
June	-	-	0
TOTALS	107	138	245

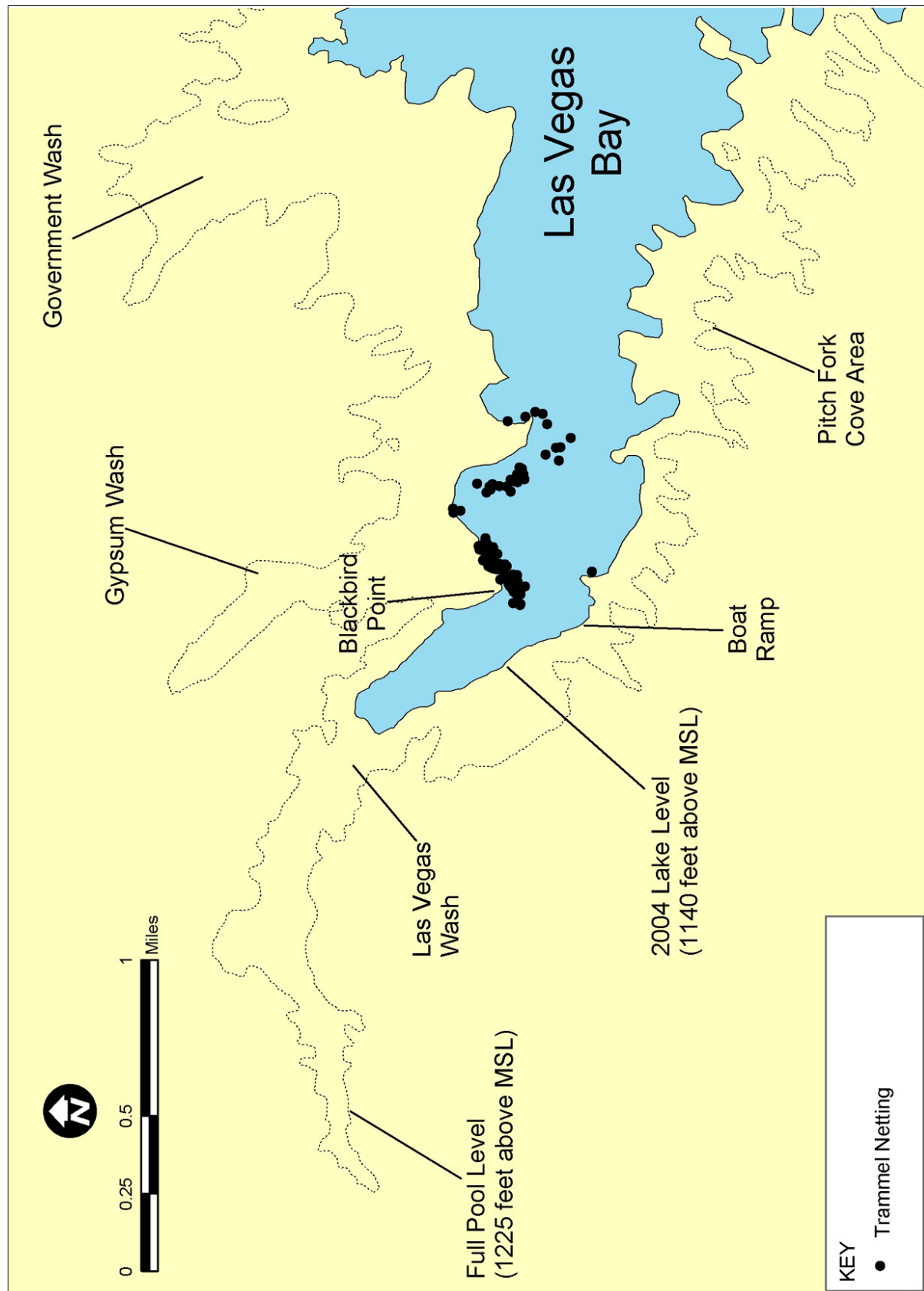


Figure 3. Las Vegas Bay study area showing locations of trammel netting, July 2003 - June 2004.

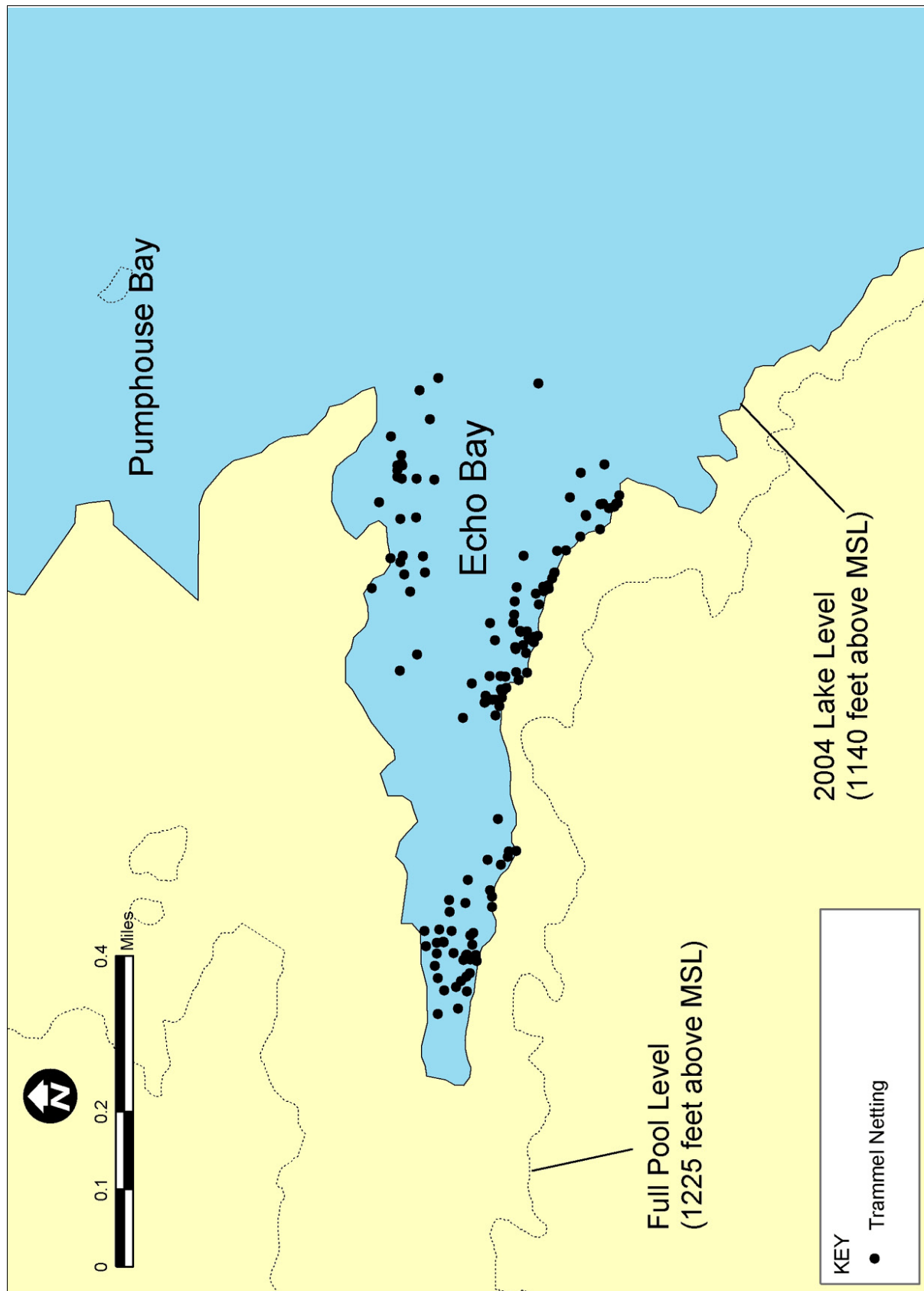


Figure 4. Echo Bay study area showing locations of trammel netting, July 2003 - June 2004.

As with the previous five study years (Holden et al. 2000a, 2000b, 2001; Abate et al. 2002; Welker et al. 2003), the timing of trammel netting for the eighth 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 the warmer air and water temperatures encountered during the summer netting efforts appeared to stress razorback sucker that were brought to the surface. For this reason, trammel netting during the eighth study year was not conducted during the warm months from July to September. 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 (March-May). This practice was again employed during the eighth 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. 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.

Four adult and one sub-adult (TL 370 mm) razorback sucker were captured at Blackbird Point (Table 2) during the 107 net nights in the eighth study year. This is the same general area where most of the razorback sucker in Las Vegas Bay were captured during previous years (Holden et al. 1997, 1999, 2000a, 2000b, 2001; Abate et al. 2002; Welker et al. 2003). Most were captured in shallow water (20-30 ft deep) off the tip of Blackbird Point, with nets set from the tip of the point toward the south shore of Las Vegas Bay. The razorback sucker catch rate for trammel netting at the Las Vegas Bay area was 0.04/net night for the eighth study year. This rate was much lower than the previous year's rate (0.19/net night).

At Echo Bay nets were set throughout the entire bay, with more emphasis placed on the back portion of the bay in areas where concentrations of larval razorback sucker were highest. Twenty-nine adult razorback sucker were captured during 138 net nights (Table 2). The razorback sucker catch rate for trammel netting at Echo Bay was 0.20/net night, which is similar to the rate obtained during the previous study year (0.22/net night).

The first male razorback sucker expressing milt was captured on October 8, 2003, and the first female razorback sucker expressing eggs was captured on February 24, 2004; both fish were captured at Echo Bay. Recapture rates varied between study locations in the eighth study year. At Las Vegas Bay, four of the five razorback sucker caught were recaptures (80%); one of these was stocked by NDOW in 1998 and two were stocked in 2001 (three of five captures in 2004 were stocked fish). At Echo Bay, 20 of the 29 razorback sucker caught were recaptures (69.0%). Of the nine new captures at Echo Bay, one had been stocked by NDOW in 2003 and the other eight were wild fish. Four of the 29 Echo Bay captures in 2004 were fish stocked by NDOW in the past (Table 2), indicating that stocked fish are able to find/incorporate themselves with wild populations.

At Echo Bay 86 individual razorback sucker have been handled during the eight study years, 66 have been captured and PIT-tagged by us and 20 others had been previously PIT tagged by NDOW. At Las Vegas Bay, 83 unique razorback sucker have been handled including 73 individuals PIT tagged by us and 10 previously PIT tagged by NDOW. Lakewide, 169 individual razorback sucker have been handled during this study.

Table 2. Location, tagging, and size information for razorback sucker collected in Lake Mead from July 2003-June 2004.

DATE	LOCATION	PIT TAG NO.	DATE STOCKED	RECAPTURE	TL ^a (mm ^e)	FL ^b (mm)	SL ^c (mm)	WT ^d (g ^f)	SEX
10/28/2003	EB ^g	53245F7418		No	631	590	527	2895	M ^h
11/12/2003	LVB ⁱ	1F484B0648	1/17/2001	Yes	650	606	542	3810	F ^j
12/17/2003	EB	1F7818430E		Yes	599	559	498	2185	M
12/17/2003	EB	201D576408		Yes	584	525	475	2267	M
12/18/2003	EB	1F7D5D6225	12/2/2003	No	522	473	420	1781	M
12/18/2003	EB	1F476B7936	7/25/1995	Yes	651	603	545	3316	F
1/12/2004	LVB	20370C7F1E		Yes	586	555	510	2540	M
1/13/2004	EB	53257A0259		No	683	635	570	3580	F
1/13/2004	EB	1F4A457C56	7/25/1995	Yes	545	505	450	2273	M
1/19/2004	EB	7F7D2B2D5F		Yes	609	560	503	2560	M
2/2/2004	EB	53257A0259		Yes	680	636	570	3610	F
2/16/2004	EB	1F777A3B35		Yes	672	624	573	3367	F
2/17/2004	EB	53255B4E7F		No	613	568	515	2670	F
2/19/2004	LVB	1F4A1E2356	1/17/2001	Yes	678	636	589	4998	F
2/24/2004	EB	7F7D4C302B		Yes	596	548	491	2217	M
2/24/2004	EB	7F7D482104		Yes	682	646	568	3704	F
2/24/2004	EB	53263D264D		Yes	602	549	498	2533	M
2/25/2004	LVB	1F7E530010	11/25/1998	Yes	581	538	483	2584	M
3/8/2004	EB	1F777A3B35		Yes	684	633		3250	F
3/8/2004	EB	53261E2310		No	619	582		2940	F
3/8/2004	EB	1F4A16047D	½2/2002	Yes	600	560		3050	F
3/16/2004	LVB	5326133B67		No	370	344	308	529	I ^k
3/17/2004	EB	201D653628		Yes	645	601	540	2813	F
3/17/2004	EB	5324580E11		No	666	610	553	2629	F
3/17/2004	EB	53261E2310		Yes	618	576	523	2891	F
3/17/2004	EB	53255E6C50		No	616	579	510	2906	M
3/18/2004	EB	53257C0232		Yes	579	536	480	2506	M
3/29/2004	EB	201D653628		Yes					F
4/5/2004	EB	5325615E4A		No	756	686		4724	F
4/5/2004	EB	53245E1F27		No	578	572		2329	F
4/5/2004	EB	1F7B477827		Yes	635	581		2360	M
4/14/2004	EB	5325615E4A		Yes	756				F
4/27/2004	EB	53257A0259		Yes	680	640		1350	F
4/27/2004	EB	53245E1F27		Yes	595	543	486	2128	F

^a TL = Total length.

^b FL = Fork length.

^c SL = Standard length.

^d WT = Weight.

^e mm = Millimeters.

^f g = Grams.

^g EB = Echo Bay.

^h M = Male.

ⁱ LVB = Las Vegas Bay.

^j F = Female.

^k I = Immature.

Video Surveillance

Several attempts were made to observe razorback sucker spawning activity at Echo Bay during spring 2004 using underwater video surveillance. However, increased water turbidity prevented these observations. High turbidity resulted from shallow water and wave action at the back of the bay. Low larval fish numbers at Las Vegas Bay made it difficult to pinpoint spawning sites. Numerous attempts were made to locate razorback spawning grounds, but turbid water conditions limited visibility. Razorback spawning at Las Vegas Bay was not observed, and no spawning redds were located. The poor visibility resulted from a high silt load from Las Vegas Wash.

Growth

Seventeen individual fish were recaptured during the eighth study year, 13 at Echo Bay and 4 at Las Vegas Bay. The difference in TL between capture periods was used to determine mean annual growth (Table 3). The combined (Echo and Las Vegas Bays) mean annual growth of razorback sucker recaptured from Lake Mead during this sampling year was 6.5 mm. The combined mean annual growth of recaptured fish the previous year was 7.8 mm (Welker and Holden [2003] miscalculated growth in their Table 3). Mean annual growth of fish recaptured at Echo Bay was 6.8 mm (4.2 mm for stocked fish and 7.7 mm for wild fish) and ranged from 0.0 mm to 14.6 mm. Razorback sucker recaptured at Las Vegas Bay had a mean annual growth of 5.6 mm (5.9 mm for stocked fish and 4.5 mm for wild fish) and ranged from 0.0 mm to 9.4 mm. These growth rates continue to be substantially higher than those of other razorback sucker populations (Modde et al. 1996, Pacey and Marsh 1998).

Table 3. Lake Mead recaptured razorback sucker growth histories for fish captured from July 2003 through June 2004.

PIT TAG NUMBER	CAPTURE DATE	SIZE TOTAL LENGTH (mm)^a	RECAPTURE DATE	SIZE TOTAL LENGTH (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (mm/ 365 Days)
LAS VEGAS BAY							
<u>Stocked Fish</u>							
1F484B0648	1/7/03	650	11/12/03	650	0	305	0.0
1F4A1E2356	3/19/01	651	2/19/04	678	27	1050	9.4
1F7E530010	11/25/98	538	2/25/04	581	43	1890	8.3
Mean annual growth calculated from first and last capture of each stocked fish							5.9
<u>Wild Fish</u>							
20370C7F1E	3/25/02	578	1/12/04	586	8	647	4.5
Mean annual growth calculated from first and last capture of each wild fish							4.5
Mean annual growth calculated from first and last capture of stocked and wild fish							5.6
ECHO BAY							
<u>Stocked Fish</u>							
1F476B7936	2/9/01	641	12/18/03	651	10	1029	3.5
1F4A16047D	4/17/02	583	3/8/04	600	17	681	9.1
1F4A457C56	1/21/03	546	1/13/04	546	0	352	0.0
Mean annual growth calculated from first and last capture of each stocked fish							4.2

^a Total length in millimeters.

^b The date a fish was stocked into Lake Mead.

Table 3 (cont.).

PIT TAG NUMBER	CAPTURE DATE	SIZE TOTAL LENGTH (mm) ^a	RECAPTURE DATE	SIZE TOTAL LENGTH (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (mm/ 365 DAYS)
ECHO BAY (CONT.)							
Wild Fish							
1F777A3B35	4/2/03	677	3/8/04	684	7	336	7.6
1F7818430E	1/21/03	591	12/17/03	599	8	326	9.0
201D653628	3/26/02	623	3/17/2004	645	22	711	11.3
1F7B477827	4/2/03	580	3/18/04	580	0	346	0.0
53263D264D	1/21/03	596	2/24/04	602	6	393	5.6
7F7D4C302B	4/23/03	584	2/24/04	596	12	301	14.6
201D576408	4/2/02	562	12/17/03	584	22	615	13.1
7F7D2B2D5F	1/26/01	600	1/19/2004	605	14	1020	5.0
7F7D482104	2/9/99	668	2/24/04	682	14	1815	2.8
Mean annual growth calculated from first and last capture of wild fish							7.7
Mean annual growth calculated from first and last capture of stocked and wild fish							6.8

^a Total length in millimeters.^b The date a fish was stocked into Lake Mead.

Sonic Telemetry

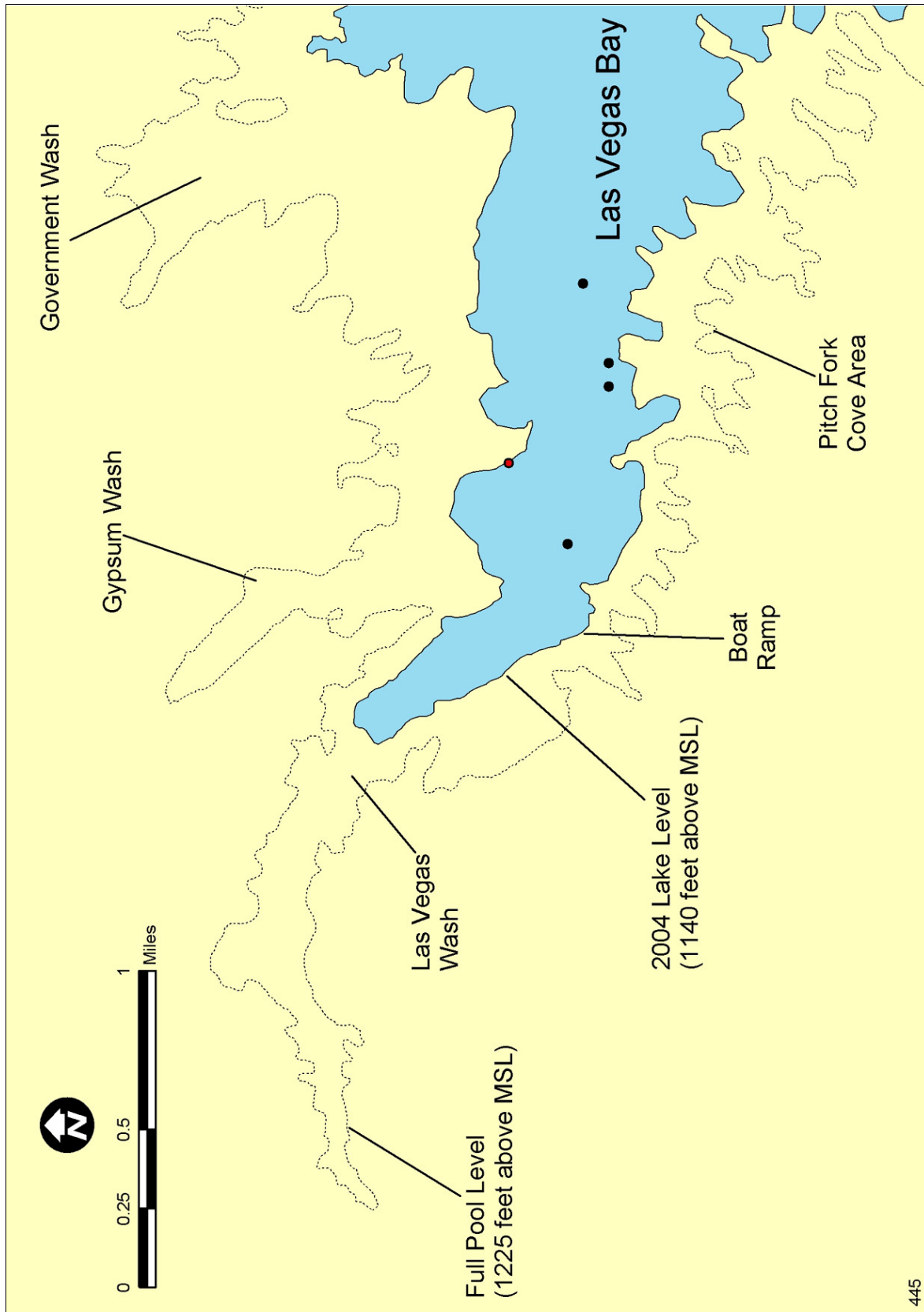
During the first 5 years of the study, 42 (38 wild and 4 hatchery-reared) fish were equipped with internal or external sonic tags. Approximately half of these tags had a battery life of 12 months (implanted in 1997 and 1998). The other half a life of 48 months. At the beginning of the seventh study year, none of the 48-month tags implanted during the first 5 years of the study were operational, and the four hatchery fish that were implanted with 48-month tags in 2002 and released into the Colorado River inflow region of Lake Mead were either stationary or their whereabouts were unknown.

Las Vegas Bay

Fish 445

On January 7, 2003, sonic tag 445 (48-month battery life expectancy) was implanted into a 650-mm TL female captured at Blackbird Point during standard adult trammel netting. Throughout the seventh study year, fish 445 was located most often (28 contacts) along the south shore of Las Vegas Bay between Pitchfork Cove and the Las Vegas Bay boat ramp. A smaller number of the contacts (seven) were made in the non-flowing portion of Las Vegas Wash. During the spawning period (March through May) fish 445 was not found near Blackbird Point.

During the eighth study year, fish 445 was contacted five times from July until November 2003. This fish continued to use the south side of Las Vegas Bay near the Pitch Fork Cove area (Figure 5). On November 11, 2003, this fish was captured in a trammel net along the east shore of Gypsum



445

Figure 5. Distribution of fish number 445 in Las Vegas Bay (the red dot represents the November 2003 trammel net capture location).

Wash. The fish was in very good condition, and the incision made in January 2003 for implanting the sonic transmitter had healed well. The length of this fish was identical to its tagging length (650 mm TL), but its weight had decreased by 148 g. No contact has been made with this fish since its November capture in the trammel net despite exhaustive searches of Las Vegas Bay and Boulder Basin. At the end of the 2003-2004 study year its location remained unknown.

Echo Bay

Fish 355

On January 7, 2003, sonic tag 355 (48-month battery life expectancy) was implanted into a 596-mm TL male that was captured in Echo Bay during standard adult trammel netting. During the seventh study year, this fish was found at the back of Rogers Bay until March 13, when it was located at the back of Echo Bay along the south shore in very shallow water. This fish remained at this location in 5-10 ft of water and approximately 5-10 ft from shore until mid May. It was found at the back of Rogers Bay during the remainder of the study year.

During the eighth study year, fish 355 was contacted 19 times. From July 2003 until mid-February 2004, this fish was found in Rogers Bay (Figure 6). The areas used in Rogers Bay ranged in depth from 20 to 40 ft. On February 24, 2004, fish 355 was located in Echo Bay near a gravelly point on the north shore of the bay in 8 ft of water. It was captured in a trammel net in this area the following morning; the fish was expressing milt and had grown 6 mm in TL from the time it was tagged in January 2003. It remained in the vicinity of the gravelly point in 8 to 12 ft of water until April 21, 2004. The shoreline habitat used by fish 355 in Echo Bay during spring 2004 was the presumptive spawning site for the Echo Bay population during the eighth study year (Figure 7). On May 3, 2004, this fish moved back to Rogers Bay where it remained for the rest of the study year.

Telemetry Summary

During the eighth study year, habitat use and movement of two fish were monitored. At Echo Bay fish 355 exhibited behavior similar to the previous study year. This fish used the Rogers Bay area outside the spawning period and was found in Echo Bay from February through April. Fish 355 appeared to move between the two areas over a period of a few days. Fish 445 was found in the Blackbird Point and Pitch Fork Cove areas of Las Vegas Bay, similar to the pattern exhibited during the seventh study year. Unfortunately, contact with this fish was lost after its capture in a trammel net during a November sampling trip. No other sonic tags were located during the eighth study year.

Larval Sampling

Echo Bay and Las Vegas Bay

Sampling for razorback sucker larvae was initiated in late February 2004. Larvae were first collected on February 24 at Echo Bay on a gravelly point on the north shore of the bay. At Las Vegas Bay, the first razorback sucker larvae were captured on March 23, 2004, in a small cove at the tip of Blackbird Point. The last larval razorback sucker was collected on May 10 at Echo Bay (Table 4). Five to eight monitoring sites at Echo Bay were sampled bi-weekly (with few exceptions) during March, April, and May 2004. At Las Vegas Bay, four sites at Blackbird Point were sampled bi-weekly during the spring spawning period in addition to four to six randomly selected sites between Las Vegas Wash and Government Wash on either the north or south shores of Las Vegas Bay. This sampling method was used to monitor larval production in the known spawning area at

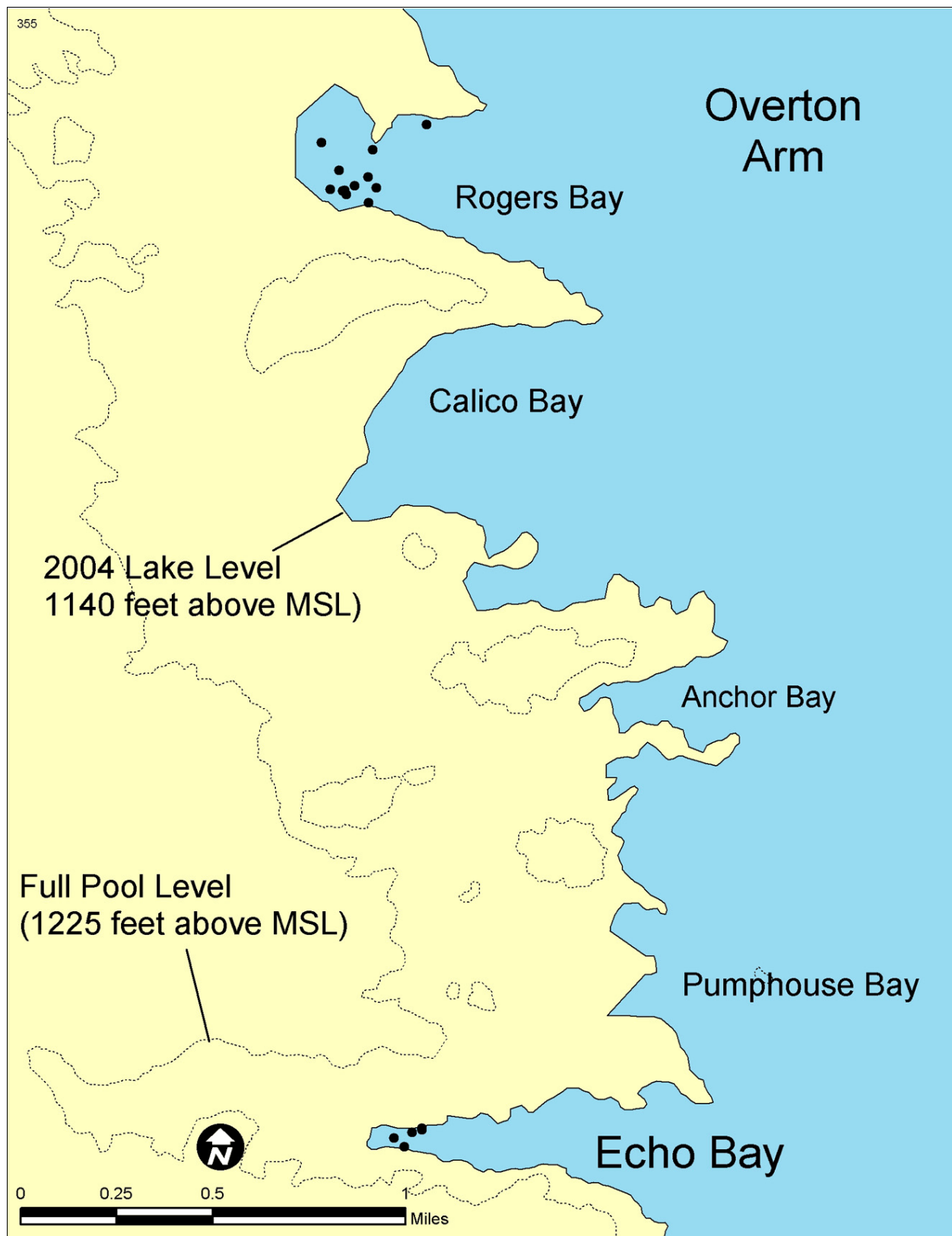


Figure 6. Distribution of fish number 355 in Overton Arm.

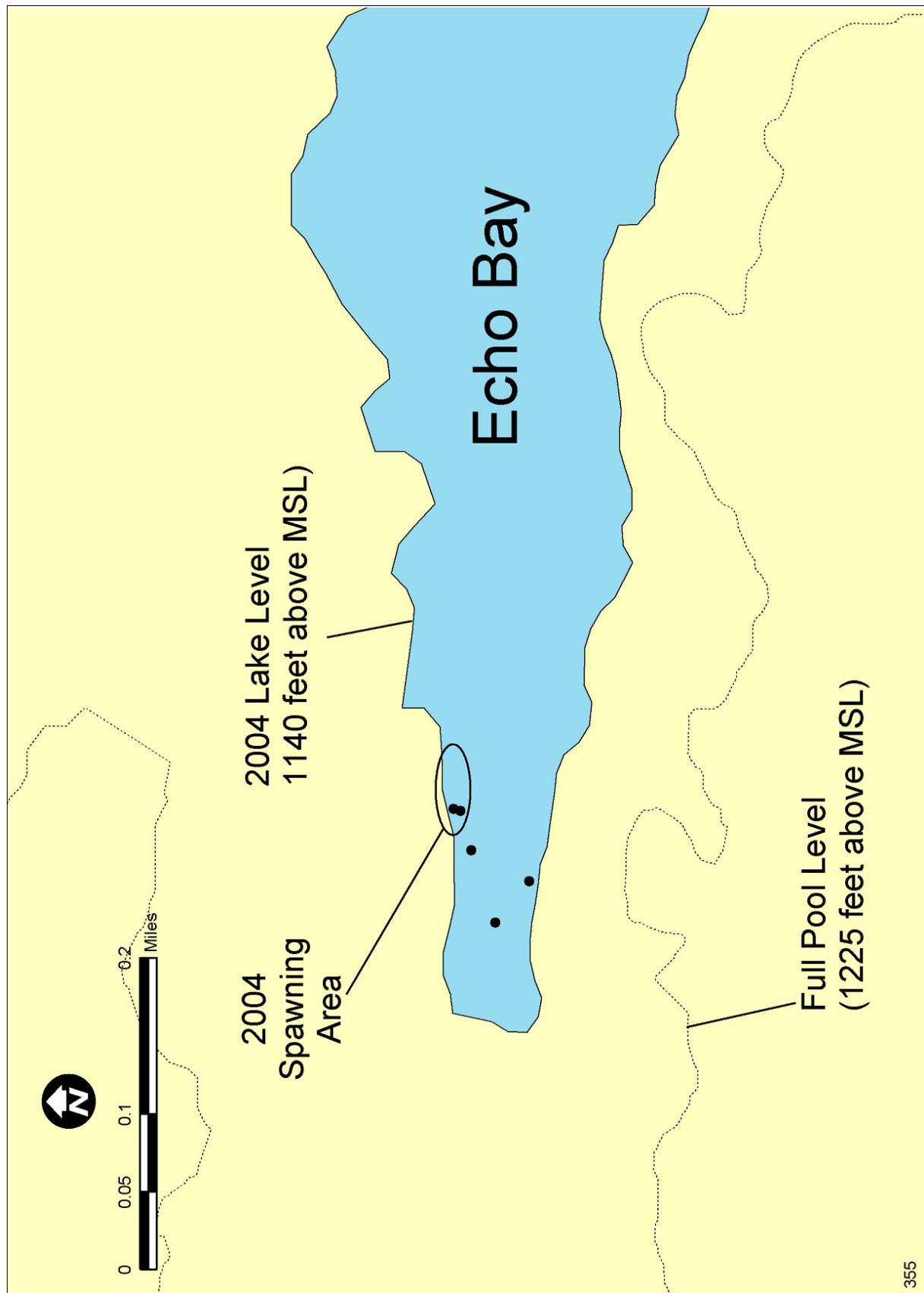


Figure 7. Distribution of fish number 355 in Echo Bay.

Table 4. Number of razorback sucker larvae collected at the Las Vegas Bay, Echo Bay, Muddy/Virgin River inflow, and Colorado River inflow areas of Lake Mead during 2004.

DATE	LAS VEGAS BAY SAMPLING SITES			ECHO BAY SAMPLING SITES			MUDDY/VIRGIN RIVER INFLOW SAMPLING SITES			COLORADO RIVER INFLOW SAMPLING SITES		
	MINUTES SAMPLED	LARVAE COLLECTED	CPM ^a	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM
2/24/04				75	1	0.01						
3/01/04	90	0	0.00									
3/02/04	120	0	0.00									
3/03/04				90	3	0.03						
3/04/04				120	7	0.06						
3/08/04				120	13	0.11						
3/09/04				120	20	0.17						
3/15/04	135	0	0.00									
3/16/04				120	20	0.17						
3/17/04							105	0	0.00			
3/18/04	130	0	0.00									
3/22/04	135	0	0.00									
3/23/04	120	2	0.02									
3/24/04				90	26	0.29						
3/29/04				120	32	0.27						
3/30/04							110	0	0.00			
3/31/04	100	0	0.00									
4/01/04	90	2	0.02									
4/05/04				90	51	0.57						
4/06/04							135	0	0.00			
4/07/04	120	0	0.00									
4/12/04	110	0	0.00									
4/13/04				90	13	0.14						
4/15/04										120	0	0.00
4/19/04	105	0	0.00									
4/20/04				90	1	0.01						
4/21/04										95	0	0.00
4/22/04										125	0	0.00
4/26/04	105	0	0.00									
4/27/04				105	19	0.18						
4/29/04										115	0	0.00
5/03/04				90	0	0.00						
5/04/04										120	0	0.00
5/05/04	95	0	0.00									
5/10/04				95	1	0.01						
5/11/04	60	0	0.00									
5/12/04										105	0	0.00
5/13/04										80	0	0.00
5/18/04										180	0	0.00
Totals	1515	4	0.003	1415	207	0.150	350	0	0.000	940	0	0.000

^a CPM = Catch per minute.

Blackbird Point and to identify other spawning sites for the Las Vegas Bay population. The number of razorback sucker larvae collected within Las Vegas Bay was lower in 2004 (Table 4) than in 2003 and 2002 (4, 73, and 176, respectively). The catch per minute (CPM), the number of fish captured per minute of sampling, of razorback sucker larvae was also lower in 2004 than in 2003 (0.003 and 0.06, respectively). The highest CPM at Las Vegas Bay during 2004 was 0.02. Larval capture and sample locations are shown for Las Vegas Bay in Figure 8.

The number of larvae collected at Echo Bay in 2004 was lower than the number collected in 2003 and 2002. Two hundred-seven larvae were collected during 2004, compared with 552 razorback sucker larvae collected during 2003 and 1,020 collected during 2002. The 2004 CPM at Echo Bay was lower than in 2003 and 2002 as well (0.15, 0.43, and 1.67, respectively). Larvae in Echo Bay were collected throughout the sampling period, but there appeared to be a distinct peak in numbers from late March through early April (Table 4). The highest CPM at any Echo Bay site during 2004 was 0.57 on April 5. The larval razorback sucker sample and capture sites for Echo Bay are shown in Figure 9.

In spring 2004 the spawning site used by the Echo Bay population during the 2003 spawning period was dry because of declining lake levels. As in 2002 and 2003, razorback sucker spawning occurred at a new location in 2004. High turbidity prevented identification of the exact location of the spawning site(s) in Echo Bay. High concentrations of larval razorback sucker and the presence of sonic-tagged fish 355 for nearly 1.5 months on a gravelly area along the north shore indicated that this was the spawning site used during the eighth study year (Figure 9). This site was located 250 m to the east of the 2003 spawning area.

River Inflow Areas

Larval sampling outside of the Echo Bay and Las Vegas Bay areas during spring 2004 was conducted at the Muddy/Virgin River and Colorado River inflow areas. The Muddy/Virgin River inflow area of Lake Mead was identified as an area that could harbor undiscovered spawning populations of razorback sucker (Welker and Holden 2003). Larval sampling in the Muddy/Virgin River inflow area was conducted on three occasions in March 2004 along the north and south shores of Overton Arm (Figure 10). Total effort in this area of Lake Mead included 27 sites and 350 minutes of sampling with two crappie lights and two netters (Table 4). No larval razorback sucker were captured.

In 2000 and 2001 larval razorback sucker were found in the Colorado River inflow area near Driftwood Island and Grand Wash Bay; however, sampling in this region of the lake in 2002 and 2003 did not produce additional larval fish. As in the previous two years, no razorback sucker were captured in the Colorado River inflow area in 2004. A total of 940 minutes of sampling were expended at 75 sites between the Colorado River delta at the center of Iceberg Canyon to Hualapai Bay at the south end of Gregg Basin (Table 4, Figure 11). Red shiner (*Cyprinella lutrensis*), juvenile largemouth bass (*Micropterus salmoides*), and striped bass (*Morone saxatilis*) were collected.

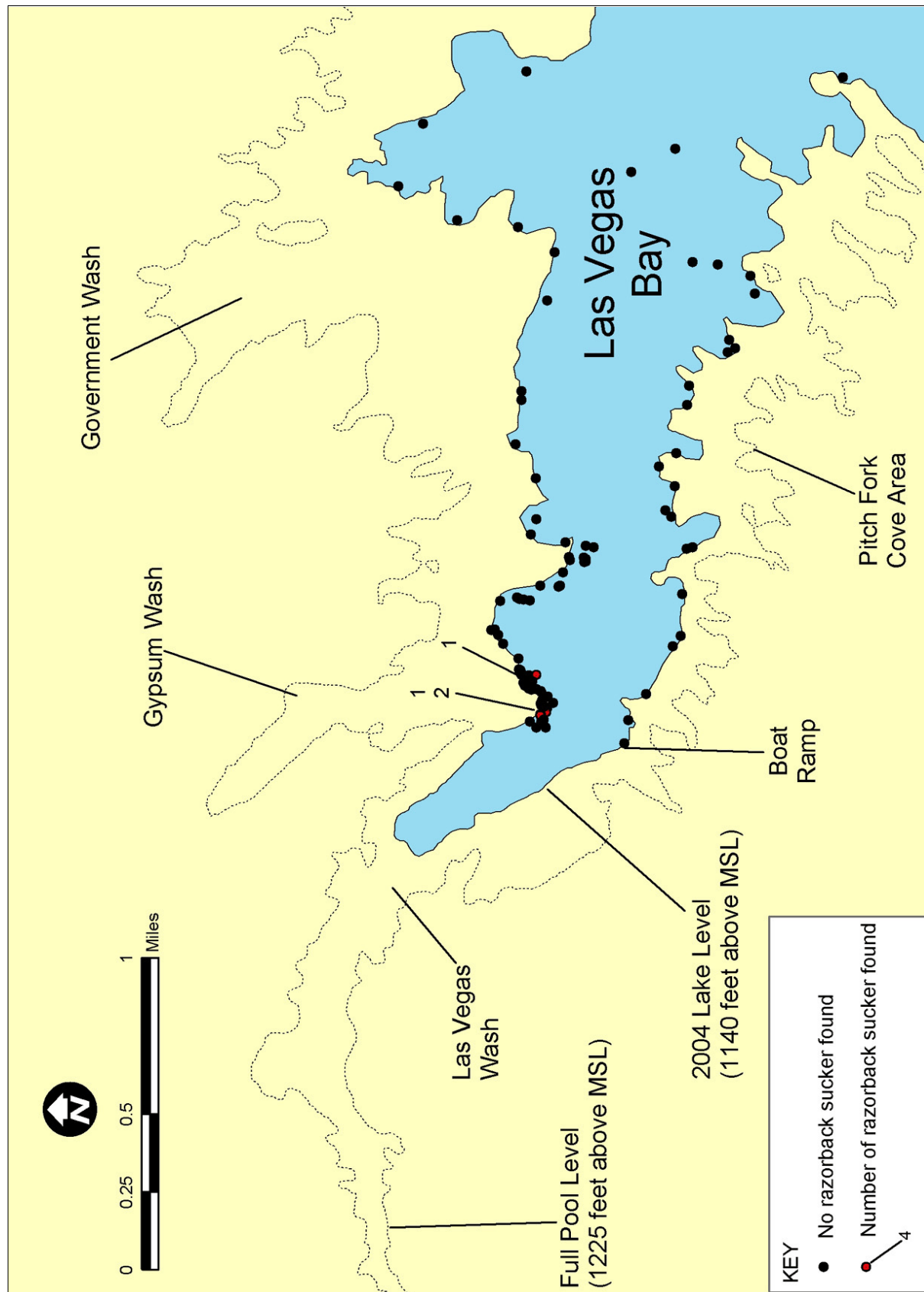
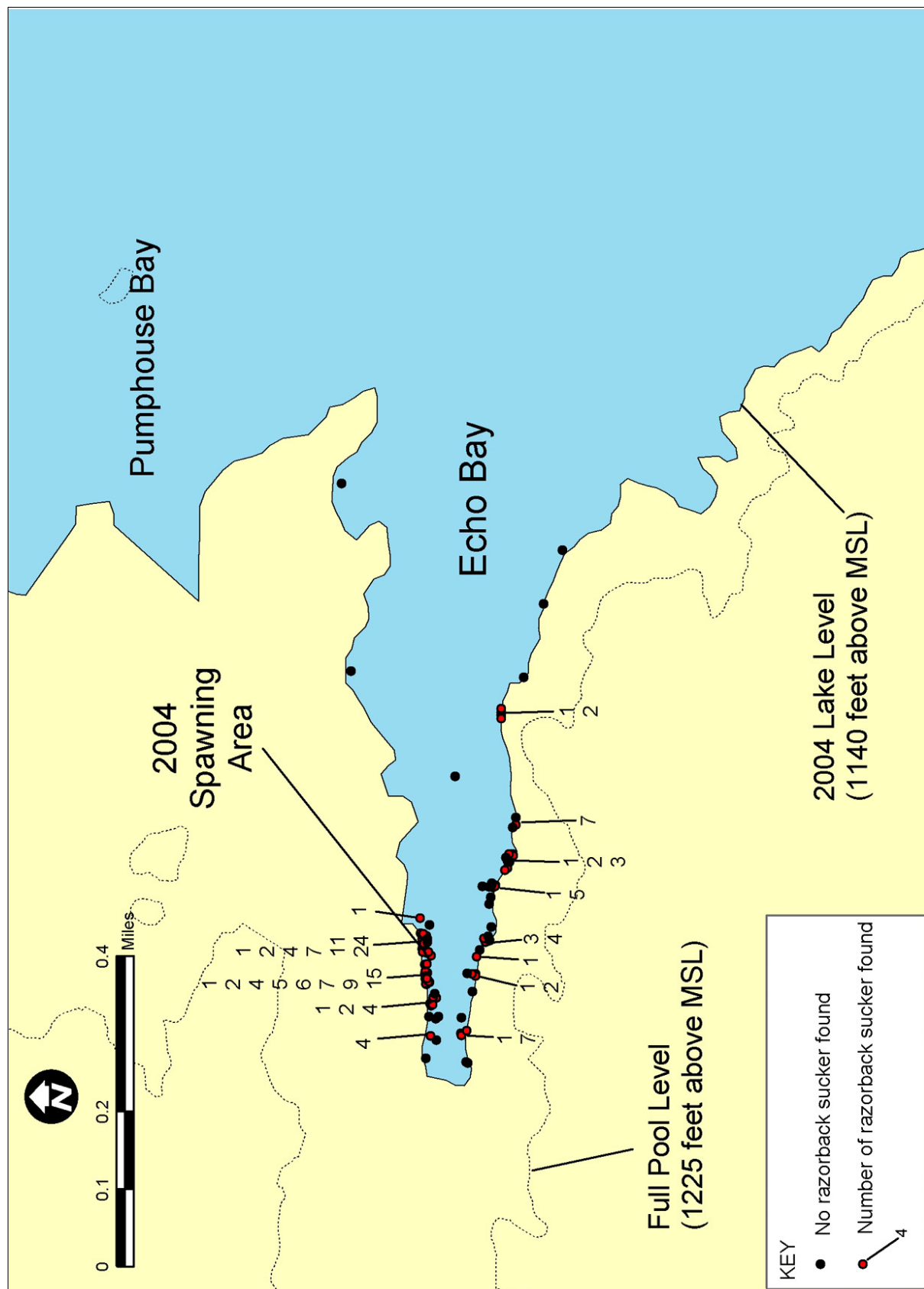


Figure 8. Las Vegas Bay study area showing larval razorback sucker sample and capture locations.



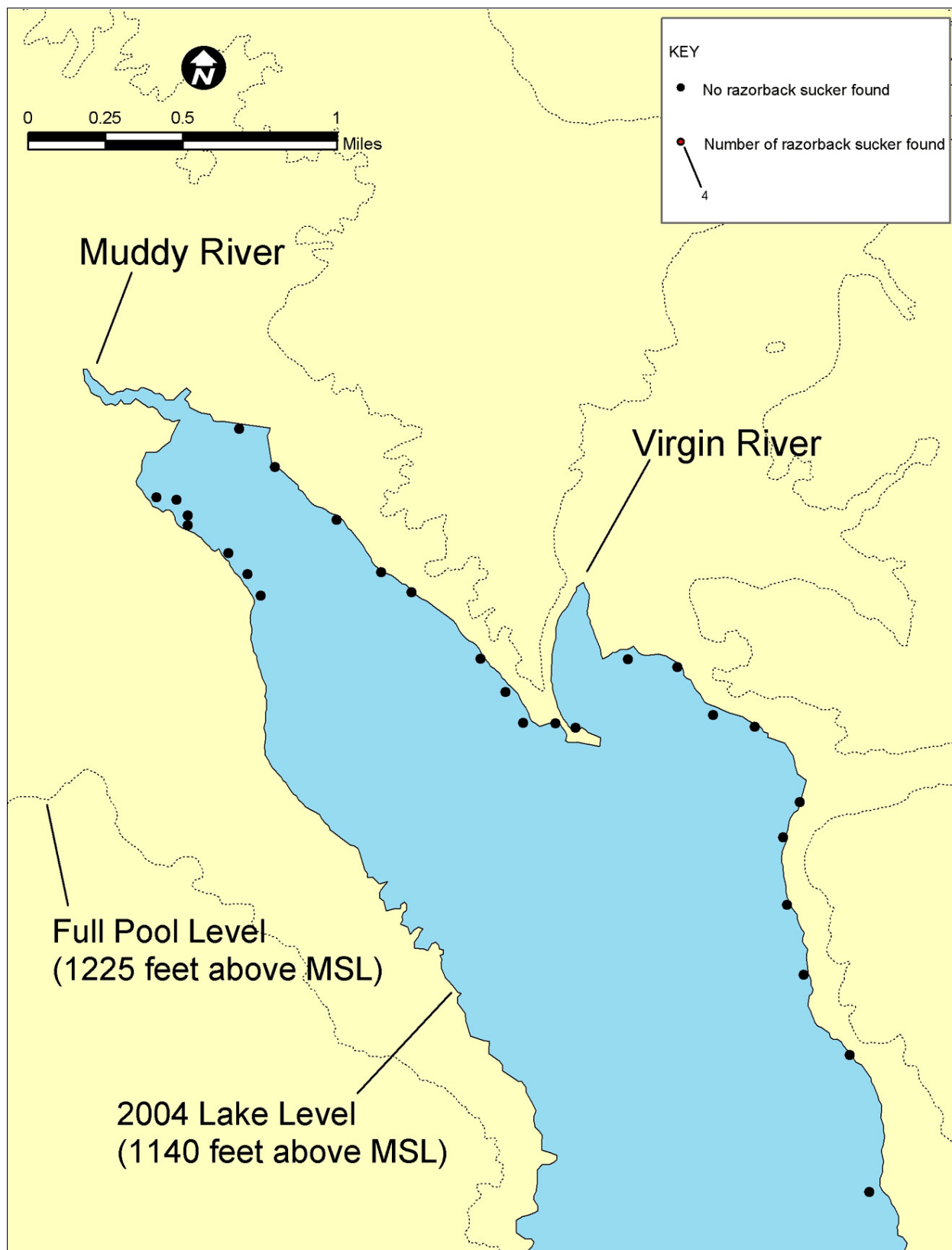


Figure 10. Muddy/Virgin River inflow area showing larval razorback sucker sample locations.

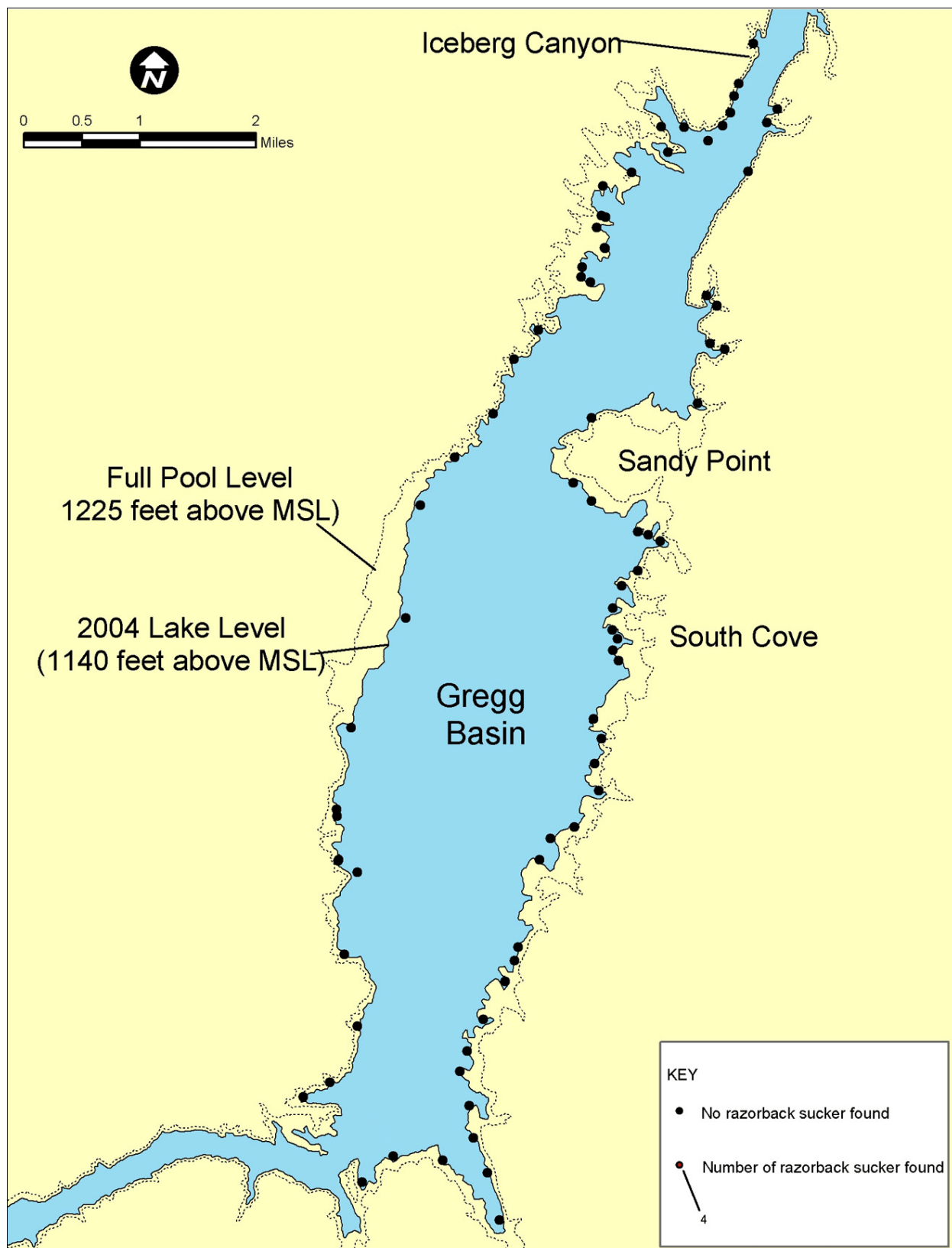


Figure 11. Colorado River inflow study area showing larval razorback sucker sample locations.

Spawning Area Substrate Assessment

The average substrate size at the five Muddy/Virgin River inflow area sites ranged from 27.4 to 31.9 mm (intermediate axis length) (Table 5) and classified as coarse gravel. The majority of substrate particles measured at each site was gravel sized (82-86%) with cobble and sand comprising less than 18% of the total particles measured. The average particle size and the particle composition were similar to results obtained at the Echo Bay cliff spawning site in 2003 (Welker and Holden 2003).

Table 5. Substrate composition at shoreline sites at the Muddy/Virgin River inflow area.

SUBSTRATE SIZE CLASS	PERCENT COMPOSITION AT EACH SITE				
	SITE #1	SITE #2	SITE #3	SITE #4	SITE #5
% Silt/Clay ($<0.062\text{mm}$ ^a)	0.0%	0.0%	0.0%	0.0%	0.0%
% Sand (0.062-2 mm)	6.0%	6.0%	5.0%	5.0%	6.0%
% Gravel (2-64mm)	83.0%	82.0%	83.0%	86.0%	86.0%
% Fine Gravel (2-8 mm)	11.0%	20.0%	16.0%	20.0%	18.0%
% Medium Gravel (8-16 mm)	34.0%	25.0%	16.0%	22.0%	19.0%
% Coarse Gravel (16-64 mm)	38.0%	37.0%	51.0%	44.0%	49.0%
% Cobble (64-256 mm)	11.0%	12.0%	12.0%	9.0%	8.0%
% Small Cobble (64- 128 mm)	11.0%	12.0%	11.0%	9.0%	8.0%
% Large Cobble (128-256 mm)	0.0%	0.0%	1.0%	0.0%	0.0%
Average substrate size (mm)	31.9	31.4	28.3	27.4	28.6
Coefficient of Variation	0.94	0.97	0.94	1.00	1.00

^a mm = Millimeters.

Razorback Sucker Aging

Determination of Lake Mead razorback sucker age distribution was added to the project in 1998 when a sub-adult fish (381 mm TL) was collected and subsequently died (Holden et al. 1999). This initiated development of a non-lethal aging technique using fin ray sections beginning in 1999 (Holden et al. 2000a). A major emphasis of the effort in 2003-2004 involved collecting fin ray sections from razorback sucker for aging.

Eight of the razorback sucker collected during trammel netting on Lake Mead during the 2003-2004 sampling period had fin ray sections surgically removed. A definitive age was obtained for all eight fish (Table 6). Three specimens were aged at 10 years or less, one ranged from 10 to 15 years of age, and four fish ranged from 16-20 years of age. One specimen, a sub-adult fish, was aged at 5 years.

One of the eight wild fish was likely spawned around 1982, one in 1983, two in 1985, one in 1989, one in 1993, one in 1994, and one in 1998 (Table 6). Table 6 shows the results of aging efforts for the 64 fish previously aged and the 8 fish aged in 2004. Figure 12 shows the number of razorback recruits per year plotted against Lake Mead elevations from January 1935 to June 2004. All of the fish aged were spawned between 1974 and 1998, with the exception of one fish that was spawned around 1966. The majority of these fish were spawned during high lake elevations from 1978-1989 and 1997-1998.

Population Estimate

Table 7 shows the results of the population modeling using the two models from the program CAPTURE (Rexstad and Burnham 1992), as well as estimates from the model selection procedure. Echo Bay razorback sucker estimates ranged from a low of 23 fish to a high of 52 fish for the two time periods. Las Vegas Bay estimates were higher than those of Echo Bay, ranging from a low of 11 fish to a high of 310 (the estimate of 310 has an extremely large confidence interval). Population abundance remains highly variable at both study areas and any patterns are difficult to distinguish because of the high variability.

Trammel Net Mesh Size Analysis

Mean lengths of razorback sucker were similar for all mesh sizes (1"=590 mm, 1.5"=609 mm, 2"=591 mm) (Figure 13). The range of lengths captured with the 2" and 1" mesh sizes were similar (1"=359, 2"=409 (Figure 13). Only the 2" mesh captured fish less than 350 mm and greater than 750 mm. The lowest length range was found for the 1.5" mesh (range=192) (Figure 13). The highest average CPUE was found for the 2" mesh (0.34) (Figure 14) and the lowest for the 1" mesh (0.15; 1.5"=0.21; Figure 14). No significant difference, however, was found among the three mesh sizes for mean length (ANOVA; $F=0.28$, $p=0.76$) or CPUE (ANOVA; $F=3.03$, $p=0.09$).

Home Range Analysis

Site fidelity was exhibited by the four Echo Bay fish and by six of the eight Las Vegas Bay fish (Monte Carlo random walk test, $p<0.05$) (Table 8). The two Las Vegas Bay fish that lacked site fidelity were frequently found using both the Boxcar/Roadrunner Cove and Blackbird Point regions of the lake—these two areas are nearly 6 miles apart. Most home ranges for Las Vegas Bay fish included these two areas (an example is depicted in Figure 15); however, site fidelity for the six Las Vegas Bay fish most likely resulted from high use of the Blackbird Point area. Home ranges for all Echo Bay fish included Echo Bay, with the Rogers Bay area of Overton Arm also included in the home ranges of two of these fish (Figure 16).

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
<u>LAS VEGAS BAY</u>			
05/10/98	588	10 ^b	1987
12/14/99	539	13	1986
12/14/99	606	17+	1979-1982
12/14/99	705	19+	1977-1980
01/08/00	650	18+	1978-1981
02/27/00	628	17+	1979-1982
01/09/01	378	6	1994
02/07/01	543	11	1989
02/22/01	585	13	1987
12/01/01	576	8-10	1991-1993
12/01/01	694	22	1979
12/01/01	553	10	1991
2/02/02	639	16	1985
3/25/02	650	22	1979
3/25/02	578	10-11	1990-1991
3/25/02	583	22-24	1977-1979
3/25/02	545	20 ^c	1982
3/25/02	576	20	1982
5/07/02	641	15	1986
6/07/02	407	6	1995
6/07/02	619	20 ^c	1982
6/07/02	642	20 ^c	1982
12/3/02	354	4	1998
12/6/02	400	4	1998
12/6/02	376	4	1998
12/19/02	395	4	1998
1/7/03	665	16	1986
1/22/03	494	4	1998
2/5/03	385	4	1998
2/18/03	443	5	1997
3/4/03	635	19	1983
3/20/03	420	4	1998
4/8/03	638	21 ^c	1982
4/17/03	618	10	1992
4/22/03	650	20-22	1980-1982
5/4/03	415	3+ ^b	1999
3/3/04 ^d	370	5	1998

Table 6 (cont.).

DATE COLLECTED	TOTAL LENGTH (mm ^a)	AGE	PRESUMPTIVE YEAR SPAWNED
<u>ECHO BAY</u>			
01/22/98	381	5	1993
01/09/00	527	13	1987
01/09/00	550	13	1987
01/09/00	553	13	1987
01/09/00	599	12-14	1986-1988
01/27/00	557	13	1986
01/27/00	710	19+	1979-1981
02/09/01	641	13	1988
02/24/01	577	18+	1980-1982
02/24/01	570	8	1992
02/24/01	576	15	1986
02/24/01	553	18	1983
12/18/01	672	13	1988
2/27/02	610	18-20	1982-1984
3/26/02	623	16	1986
4/02/02	617	35+	1966-1968
4/17/02	583	20 ^c	1982
11/18/02	551	13	1989
5/02/02	568	18-19	1983-1984
12/04/02	705	26	1976
1/21/03	591	16	1986
2/3/03	655	27-29	1974
2/3/03	580	13	1989
4/2/03	639	19-20	1982
4/2/03	580	23-25	1978
4/23/03	584	10	1992
5/6/03	507	9+	1993
5/6/03	594	20	1982
12/18/03 ^d	522	20	1982
1/14/04 ^d	683	14	1989
2/18/04 ^d	613	10	1993
3/17/04 ^d	616	19	1983
3/17/04 ^d	666	17	1985
3/17/04 ^d	618	9	1994
4/6/04 ^d	755	17	1985

^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 Obtained from fin rays collected during the 2002-2003 study year.

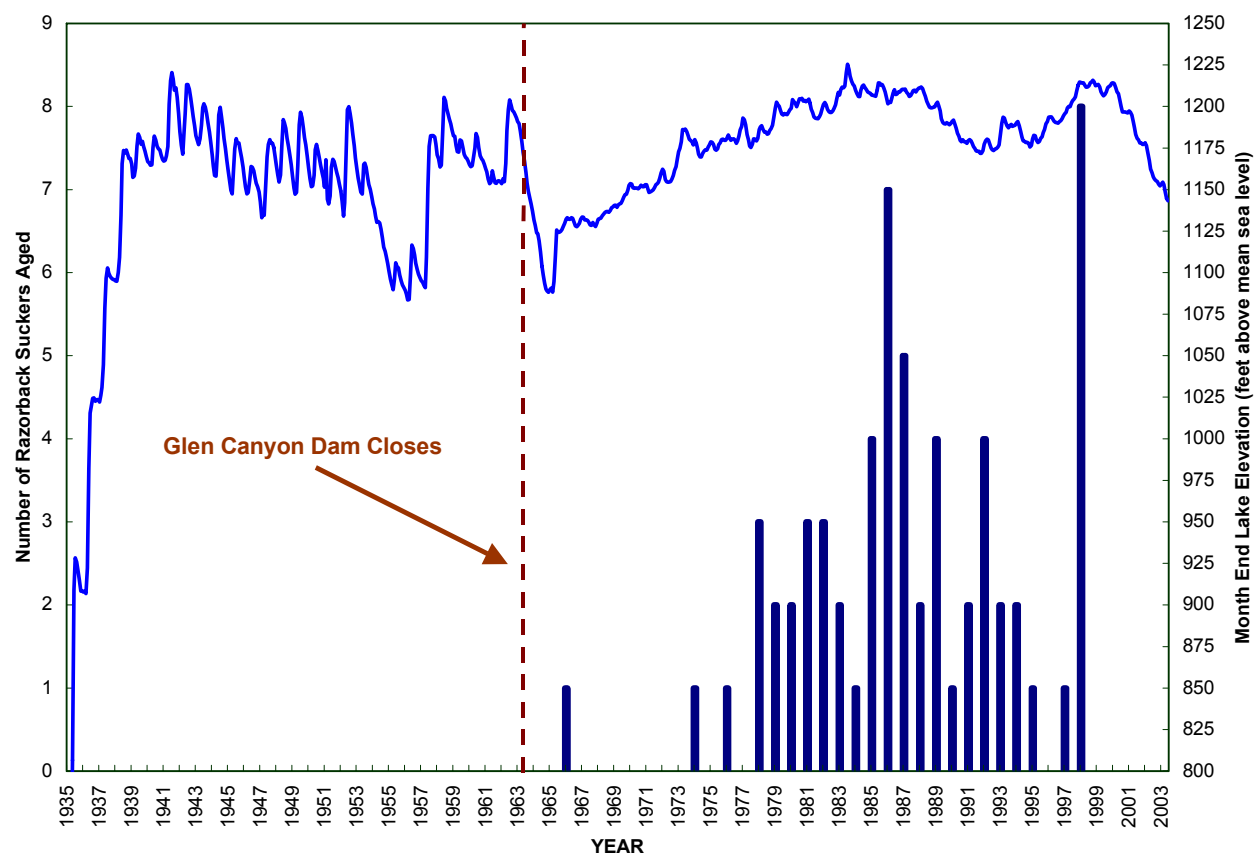


Figure 12. Lake Mead hydrograph from January 1935 to June 2004 with the number of aged razorback sucker that were spawned each year.

Table 7. Population estimates using data from 2002-2004.

ESTIMATOR	2002-2004	95% CONFIDENCE INTERVAL	2003-2004	95% CONFIDENCE INTERVAL
ECHO BAY				
Model M_o	50	38-72	31	19-73
Chao M_h	52	39-92	27	17-67
Model Selection Procedure				
Jackknife	51	40-81	23	17-44
LAS VEGAS BAY				
Model M_o	112	70-211	11	8-29
Chao M_h	310	108-1104	20	9-100
Model Selection Procedure				
Jackknife	202	141-298		
Model M_o			11	8-29

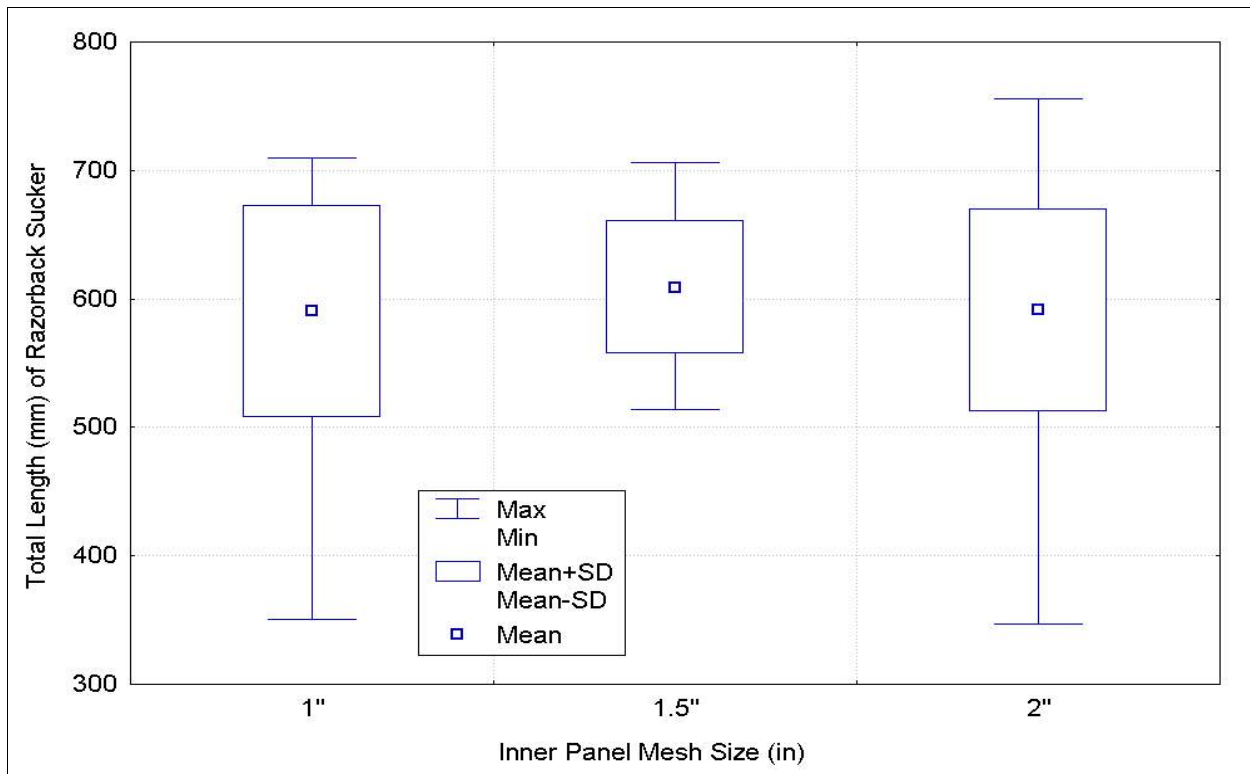


Figure 13. Mean, standard deviation (SD), and range (Min=minimum, Max=maximum) of razorback sucker lengths (TL in mm) captured in trammel nets with 1", 1.5", and 2" inner panel mesh.

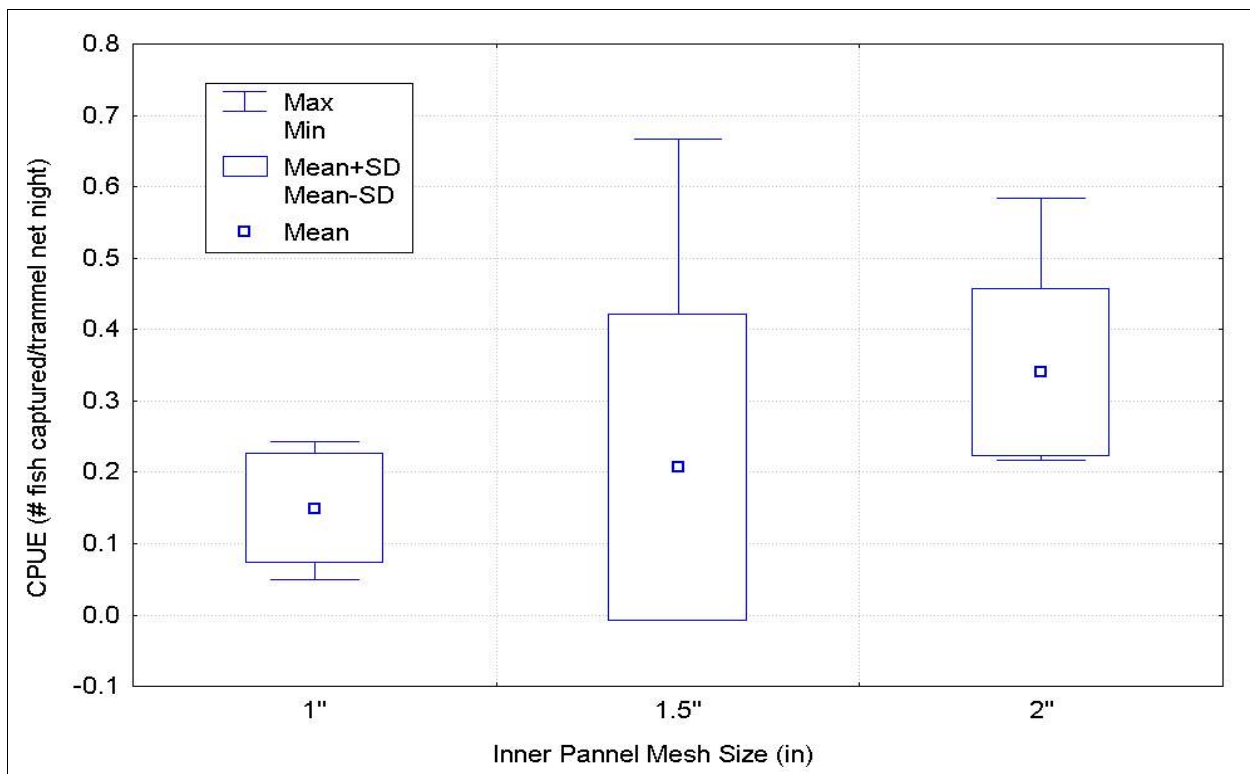


Figure 14. Mean, standard deviation (SD), and range (Min=minimum, Max=maximum) of razorback sucker CPUE in trammel nets with 1", 1.5", and 2" inner panel mesh.

Table 8. Results for Las Vegas Bay and Echo Bay home range analyses.

SONIC TAG	MONTE CARLO P-VALUE	KERNEL HOME RANGE (HA)
<u>Las Vegas Bay</u>		
247	0.001	7.2
276	0.001	91.2
294	0.001	55.2
384	0.02	116.5
464	0.001	69.1
2264	0.07 ^a	--
2444	0.001	51.4
2525	0.41 ^a	--
Mean		86.1
<u>Echo Bay</u>		
79	0.002	22.6
357	0.04	7.8
365	0.001	19.6
3344	0.001	16.7
Mean		16.7

^a Not statistically significant.

Home range size for Las Vegas Bay fish ranged from 7.2 to 116.5 ha (range=109.3 ha) (Table 8). Echo Bay home ranges were consistently lower, ranging from only 7.8 to 22.6 ha (range=14.8 ha). The average home range size for Las Vegas Bay fish (59.6 ha) was approximately three times greater than Echo Bay (16.7 ha; Table 8). Examples of small and large home range sizes for Lake Mead razorback sucker are located in Figures 15, 16, and 17.

DISCUSSION

Information collected during the eighth year of razorback sucker studies on Lake Mead has expanded knowledge on age, growth, habitat use, recruitment, and spawning behavior. Sonic telemetry, trammel netting, and collection of larvae reaffirmed the importance of Echo Bay and Las Vegas Bay to spawning razorback sucker. Additional data on annual razorback sucker growth confirmed rates documented in previous years, and aging data from eight adult razorback sucker were added to the data from 64 fish aged from 1998 to 2003. Despite having only two sonic-tagged razorback sucker at Echo Bay and Las Vegas Bay, habitat-use patterns indicate that Echo Bay and Blackbird Point provide important habitat during both spawning and non-spawning periods. Additionally, both of the sonic-tagged fish using these two areas appear to have utilized the same general types of habitat as previous years but were more often found in deeper water compared with the two previous years. As in 2003 Echo Bay sonic telemetry results for fish 355 indicated that this fish frequented the area where razorback sucker larvae were most concentrated, suggesting that this fish and others were able to utilize a new spawning location and locate other spawning razorback sucker as water levels decreased.

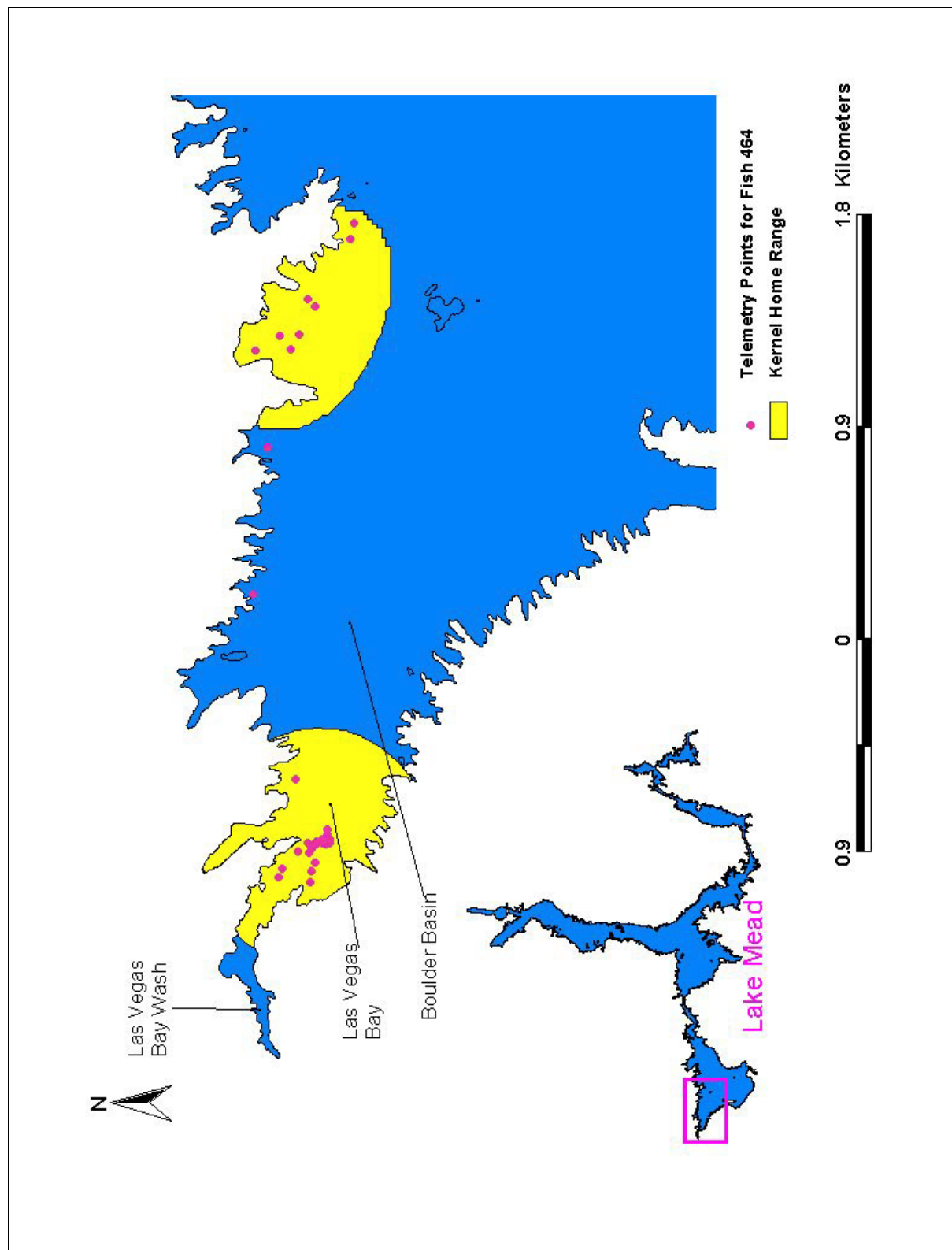


Figure 15. Las Vegas Bay study area showing telemetry locations and the kernel home range for fish 464.

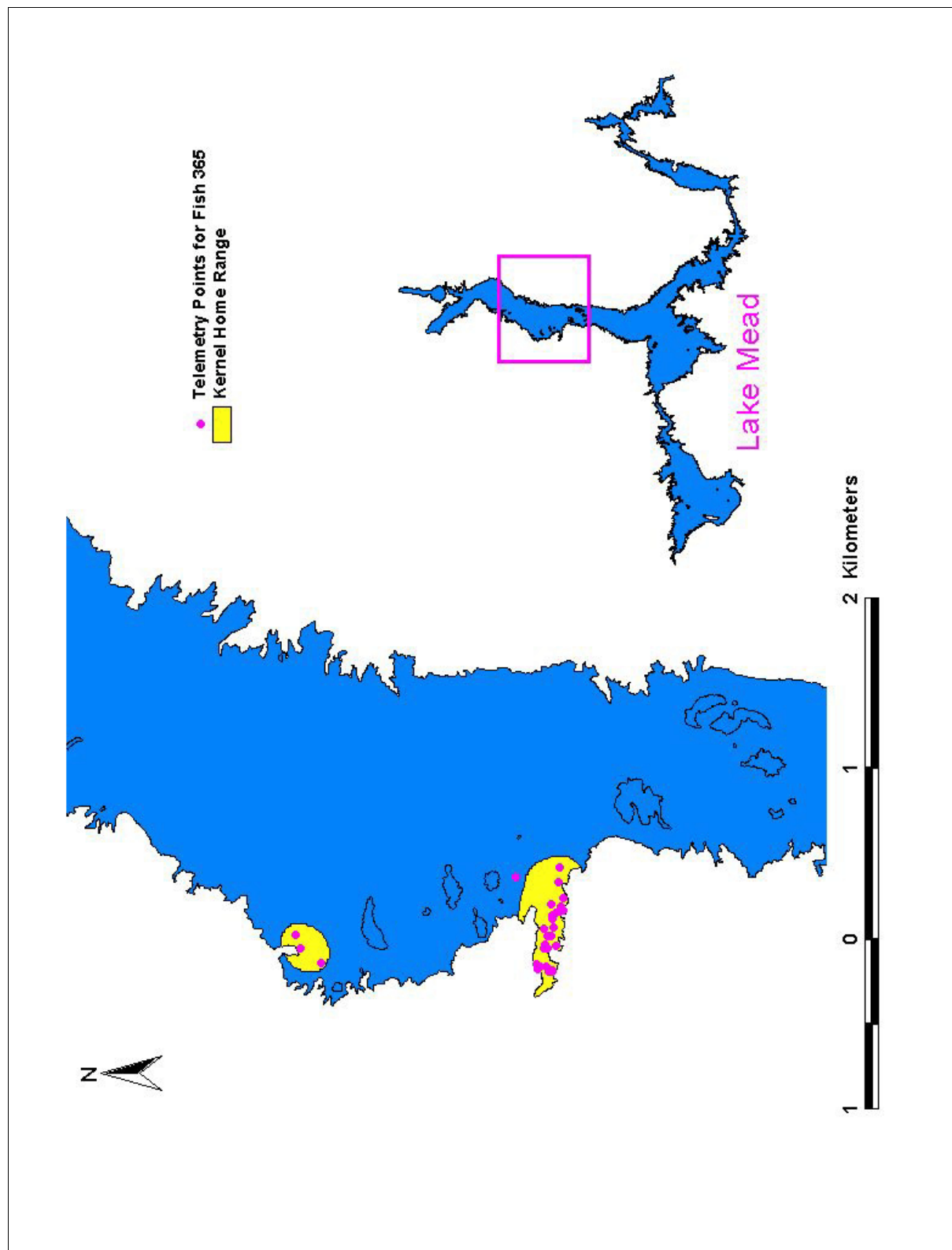


Figure 16. Echo Bay study area showing telemetry locations and the kernel home range for fish 365.

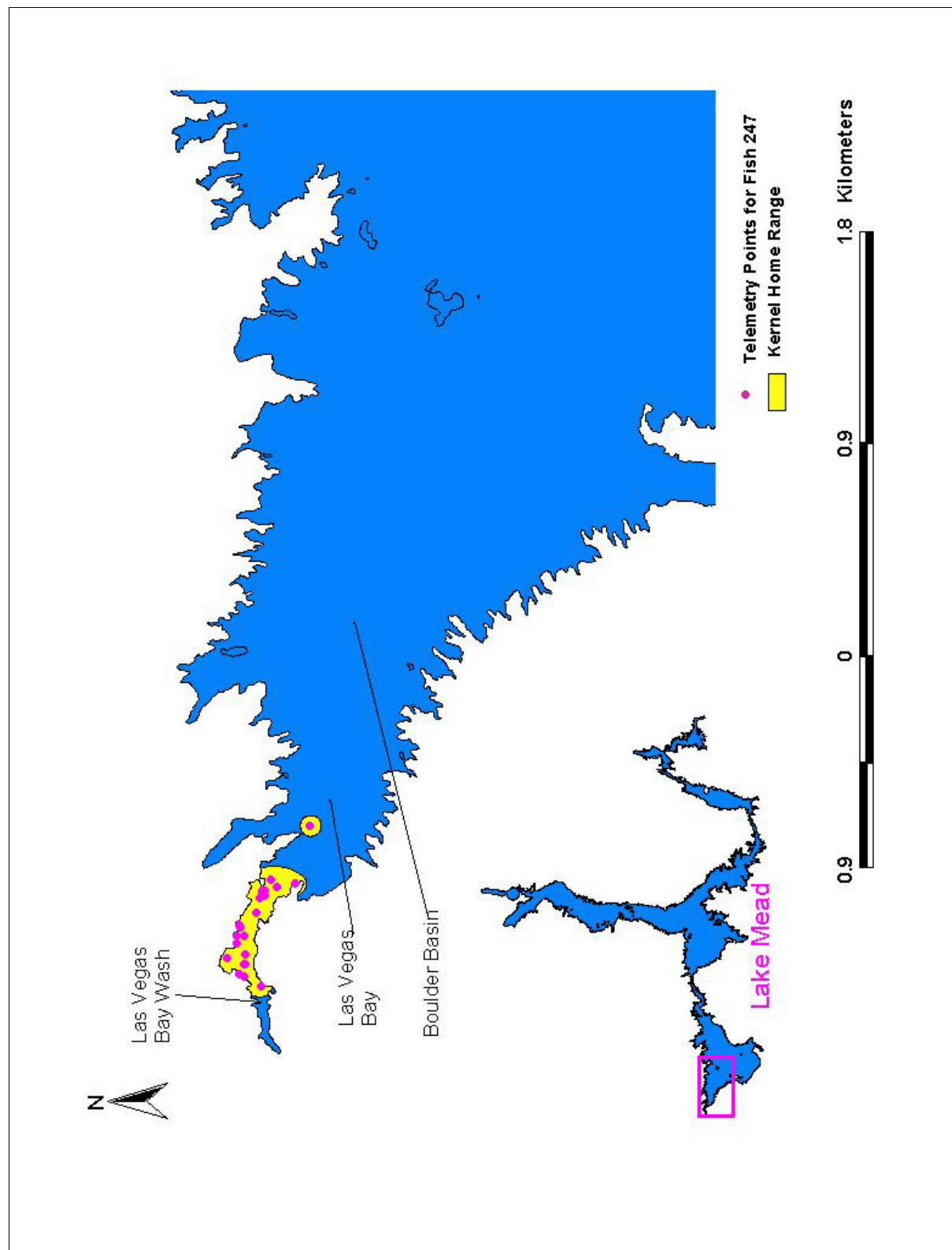


Figure 17. Las Vegas Bay study area showing telemetry locations and the kernel home range for fish 247.

Larval sampling CPM for the 2004 spawning season decreased at Las Vegas Bay and at Echo Bay, compared with the previous year. The CPM and total number of larvae at Las Vegas Bay in 2004 were lower than in all other study years. Numbers of larvae at Echo Bay continued to decline at this site. The year 2004 marks the fourth year in a row with lower larval catch numbers than the previous year; the number caught in 2004 was less than half the number caught in 2003. At this time it is unclear why larval numbers decreased at both areas. A potential reason could be that declining lake elevations may have altered spawning sites, thereby forcing some fish to use spawning areas other than those at Blackbird Point or Echo Bay, or not spawn at all. This may be especially true for Blackbird Point, where the Las Vegas Wash delta has covered the suspected spawning area with sediment and undoubtedly affected spawning participation and success in 2004. Another potential reason is that the 2004 spawning locations were more exposed to wind and wave action. This phenomenon would result in lower concentrations of larvae near the spawning areas as larvae were more dispersed by wind-driven currents. We suspect this is the major reason that we have consistently found fewer larvae and had lower CPM at Las Vegas Bay than Echo Bay. The Blackbird Point spawning location has been much more open and accessible to the wind than the rather narrow Echo Bay. But as the lake has declined, the Echo Bay fish have had to spawn nearer the mouth of the bay, in an area that has increasingly become more accessible to the wind. Therefore, we suspect that lower larval catch at Echo Bay is due in part to larvae becoming more scattered. At Blackbird Point the low numbers in 2004 were likely due to loss of the previously used spawning area and apparent lack of a new, nearby spawning area.

At Echo Bay a pattern of razorback sucker moving down the wash to spawn as the lake declines has now occurred for 3 years. This phenomenon indicates that razorback sucker at Echo Bay exhibit spawning site fidelity but possess enough flexibility in their spawning behavior that they can spawn at alternate locations when the preferred site is inaccessible. This behavior was also seen 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 at Echo Bay has been at a depth of 10 to 20 feet.

During the previous four years, declining lake levels at Las Vegas Bay did not appear to affect the razorback sucker spawning location, which was initially very deep but became shallower as the lake declined. Although the exact location of the spawning site at Las Vegas Bay is unknown, it is believed to be somewhere off the west shore or tip of Blackbird Point. As lake levels have continued to decline, Las Vegas Wash has migrated further out into Las Vegas Bay. During the 2004 spring spawning period (February through April), sediment from the wash was affecting the remaining portion of this suspected spawning location. At the end of June 2004, the wash delta covered the entire suspected Blackbird Point spawning area with sediment. Low larval and adult catch rates during 2004 were likely due to the loss of the spawning area and/or the less than suitable conditions created by the sediment. This may indicate that declining lake levels and changes to the habitat in this area have altered spawning habitat, potentially influenced spawning success, or changed the desirability of this area for razorback sucker. Although larval sampling was conducted in other Las Vegas Bay locations no larvae were found, suggesting that the Las Vegas Bay razorback sucker population did not find another nearby location as was seen at Echo Bay.

As in 2003, video surveillance in 2004 was unsuccessful in documenting spawning activity at the suspected Echo Bay spawning site. Larval abundance in this area indicated that spawning was occurring there; however, turbidity and shallow water at the spawning site made use of video

sampling gear unproductive. Similarly at Las Vegas Bay, high turbidity from sediment-laden flows from Las Vegas Wash also limited the usefulness of underwater video equipment.

Even though we broadened our sampling area to include the southern portion of Gregg Basin, no razorback sucker larvae were found during sampling in the Colorado River inflow area in 2004. Failure to capture larvae in this area may be attributed to decreasing lake levels that may have altered spawning habitat, prevented access to spawning sites, or changed fish distribution in the area. As the lake level has dropped during the last three field seasons, the portion of Lake Mead from Pearce Ferry to the southern end of Iceberg Canyon has changed from lacustrine to riverine habitat. The capture of larval razorback sucker in 2000 and 2001 indicated that spawning most likely occurred in this section of the inflow area. Today, these spawning areas are most likely covered by sediment or are stranded above the river as a result of the change in habitat.

In 2004 we quantified the substrate composition of five sites along the Muddy/Virgin River inflow area of Lake Mead—an area that exhibits characteristics conducive to razorback sucker repatriation efforts (Welker and Holden 2003). The potential spawning substrate at these sites was predominately medium and coarse gravel with some small cobble—similar to the substrate composition at the Echo Bay spawning sites (Welker and Holden 2003). This indicates that suitable spawning substrate exists in this area. Descriptions of spawning substrate used by razorback sucker in other areas of the Colorado River basin are general in nature. In both lacustrine and riverine environments, razorback sucker have been found spawning on similar substrates of gravel, cobble, or a mix of the two substrate types (Douglas 1952, Tyus 1987, Tyus and Karp 1990, Minckley et al. 1991). At Echo Bay the two spawning sites are located on gently sloping shorelines similar to spawning site shorelines in other lacustrine habitats throughout the basin (USFWS 1998). The potential spawning sites measured at the Muddy/Virgin River inflow area are also located on this type of shoreline. The high turbidity and high potential vegetative cover densities (Welker and Holden 2003), along with the occurrence of suitable spawning substrate, makes this a likely area for repatriation efforts if lake levels increase.

Growth of recaptured Lake Mead razorback sucker continues to surpass growth rates recorded for other wild razorback sucker populations. Mean annual growth for 2003-2004 recaptured fish in Lake Mead was 6.5 mm, compared with about 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).

In 2001 BIO-WEST sampled during the pre-spawning and early spawning periods when resident fish and early spawners could be sampled; however, many fish, particularly those that are late spawners, were probably absent from both spawning areas. During 2002 BIO-WEST sampled during both the spawning (March-May) and non-spawning periods. Nine of the thirteen fish caught during the spawning period were new captures, giving a 69.2% capture rate for previously uncaptured fish. Outside the sampling period, 8 of the 17 fish were new captures. This produced a 47.0% capture rate for previously uncaptured fish. When the catches of both periods are combined, a capture rate of 56.7% is obtained for previously uncaptured fish, which is nearly 27% higher than in 2001. In 2003 razorback sucker were again sampled during the spawning and non-spawning periods. Eighteen of 42 fish captured during the two periods were new captures, giving a 42.9% capture rate for previously uncaptured fish. In 2004 only 10 of 34 fish were new captures, giving a capture rate of 29.4% which is 14% lower than in 2003 and 27% lower than in 2002. It is unknown why the capture rate for previously uncaptured fish has dropped approximately 14%

during each of the last two field seasons. As more fish are tagged from these two small populations, the capture rate of previously uncaptured fish will likely decrease, especially under conditions of low recruitment.

Since 1998 BIO-WEST has sampled razorback sucker from Lake Mead using trammel nets with inner panel mesh sizes of 1", 1.5", and 2". The average length of razorback sucker and the CPUE were not significantly different among the three mesh sizes; however, the average CPUE and the range of lengths were greatest for the 2" mesh. Fish captured in nets with 2" inner panel mesh during this study tend to suffer greater stress (suggested by the observation of net marks, surface abrasions, torn fins, and the inability to maintain equilibrium in a holding tank) than razorbacks captured with the other mesh sizes. During this study, however, severely stressed fish captured with any of the mesh sizes were rare except during periods when ambient air temperatures exceeded 90 ° F. Based on the results of this analysis and observations made during this study, researchers studying razorback sucker can sample populations with nearly equal effectiveness using any of the three mesh sizes. However, to reduce netting stress, we suggest using only the 1" mesh to sample this species during periods when ambient air temperatures exceed 80 ° F.

During the eighth study year, aging efforts continued and fin clipping proved to be an appropriate method for obtaining a hard structure. Calculated ages ranged from 5 to more than 20 years for the eight razorback sucker collected in 2004. Ages of the eight fish aged in 2004 and the 64 previously aged fish show that recruitment has occurred fairly regularly from 1974 to 1998. The greatest recruitment occurred from 1985 to 1987 and in 1998. Several fish aged at 4-10 years indicate recent (1990s) recruitment to the Lake Mead population. Such evidence of recent, natural recruitment is absent from other razorback sucker populations. Overall, this aging procedure continues to produce viable results. As more fish are aged, the aging procedure may be helpful in determining what conditions are needed for successful recruitment of Lake Mead razorback sucker.

The majority of fish aged by BIO-WEST were spawned from 1974 to 1998. If Lake Mead followed the same pattern of razorback sucker abundance as other reservoirs (Minckley et al. 1991), a population would have developed in the late 1930s, the fish would have lived in the lake for 40-50 years, and then they would have disappeared as a result of a lack of recruitment. As noted in the introduction of this report, a large population did develop in the late 1930s; those fish should have disappeared around 1980 according to the pattern observed in other reservoirs. This suggests that the recruitment that occurred in the late 1970s and perhaps the early 1980s, was a result of spawning from the original population. The more recent recruitment in the late 1980s and 1990s may be the result of the fish that recruited in the late 1970s and early 1980s. The populations seen today in Lake Mead may be comprised of some older fish, many of which may have had parents from the original population and some from the relatively few fish that recruited in the later 1970s and early 1980s.

The comparison of Lake Mead's elevation with the timing of razorback sucker recruitment (Figure 12) suggests that a change in the management of Lake Mead may be responsible for the apparent, sudden recruitment of razorback sucker in the lake. 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. We suspect

that the drawdown 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 habitats that young razorback sucker may inhabit. During the pre-1970 period, vegetation could not become established because of the relatively large annual fluctuations. The presence of individual razorback sucker greater than 30 years indicates that limited recruitment may have occurred during the period of 1966-1978, 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.

Lake Mohave, where natural razorback sucker recruitment has not been documented, also has large annual fluctuations. Golden and Holden (2003) have shown that cover is more abundant in Echo Bay and Las Vegas Bay than in other Lake Mead or Lake Mohave coves. This information leads to the hypothesis that a combination of low, annual fluctuations and large, multi-year lake elevation changes that promote the growth of vegetation around the lake, followed by inundation of that vegetation, are the major reasons for razorback sucker recruitment in Lake Mead. However, not all Lake Mead coves have the proper conditions for cover to develop. The timing of the change in Lake Mead management (pre- and post-Lake Powell) coincided with the final years of the original Lake Mead razorback sucker population, which resulted in some recruitment prior to the extinction of the original population.

This hypothesis is further supported by our netting and aging results from the seventh and eighth study years. Eleven wild sub-adult fish were captured during these two field seasons, 10 of which were aged at 4 or 5 years. These fish would have been spawned in 1997 or 1998. From 1988 through 1991, Lake Mead dropped from approximately 1,210 ft amsl to 1,180 ft amsl (Figure 2). This low lake elevation was sustained until 1995 when lake levels climbed steadily to approximately 1,215 ft amsl in 1997. Lake elevations persisted near this level until 2000. Similar to what we have observed in coves around Lake Mead during the current low lake elevations, terrestrial vegetation undoubtedly grew between the 1,180 ft amsl and 1,215 ft amsl elevations during the 1988-1991 drawdown period. Much of this vegetation was inundated from 1997 through 2000 and available as protective cover for young razorback sucker. We believe this inundated terrestrial vegetation, along with turbidity, allowed a few razorback sucker that were spawned in 1997 and 1998 to avoid predation by non-native fishes. We hypothesize that when the lake rises sometime in the future, this chain of events will occur again and allow for continued recruitment of razorback sucker, but that at present or lower levels recruitment may be very restricted.

Past population estimates for both the Echo Bay and Las Vegas Bay populations indicate that there are 50-100 fish at each location. The lower population estimate for the 2003-2004 period, as compared with previous estimates, indicates a decline in numbers of fish in the population, and/or that lowering lake levels may have decreased the use of this part of the lake, thus preventing effective sampling of the entire population and resulting in lower population estimates. The latter explanation seems more likely, because the 1-year population estimate for the Lake Mead population has declined steadily since 2001 when the lake elevation began declining.

To our knowledge, no other researchers have attempted to quantify site fidelity or home-range size for populations of razorback sucker. Past telemetry studies have concentrated primarily on identifying movement patterns (Tyus et al. 1981, Marsh and Minckley 1991), especially for riverine

populations. In this study, high and relatively stable lake levels from 1997 to 2000 most likely promoted site fidelity by providing the habitats necessary for reproduction and survival within a relatively small geographic area. For example, many Las Vegas Bay fish used the Las Vegas Wash area outside the spawning period (June through December) and then moved to nearby Blackbird Point to spawn. Similarly, many Echo Bay fish were found during both the non-spawning and spawning periods within Echo Bay.

WORK PLAN FOR 2004-2005

The general research objectives for the 2004-2005 study year include continuing to monitor the two known 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 Las Vegas Wash. In addition to the general research objectives, specific objectives for 2004-2005 were identified that would provide answers to specific research questions. The following proposed work plan was developed to define specific objectives for the ninth study year and outline the strategies and actions necessary to accomplish these goals.

Specific Objectives for the Ninth Study Year

1. Implant additional captive-reared (Floyd Lamb) razorback sucker with sonic transmitters and release them into Echo Bay and Las Vegas Bay.
2. Identify spawning areas and examine habitat use at Echo Bay and Las Vegas Bay during low and declining lake levels.

Strategies and Actions

Objective 1. Implant additional razorback sucker with sonic transmitters and release into Echo and Las Vegas Bays.

Six razorback sucker will be implanted with sonic tags in fall 2004 (between October and December) and released into Echo Bay (2 fish) and Las Vegas Bay (four fish). These newly tagged fish will be used to monitor razorback sucker movement and habitat use through June 2005, with an emphasis on locating spawning locations at Las Vegas Bay. The fish will be obtained from a pond at Floyd Lamb State Park (located near Las Vegas, Nevada). The Floyd Lamb State Park fish are Lake Mohave stock that were placed into the pond in 1984. These fish are 24-year-old adult fish. If suspected spawning concentrations are found, trammel netting and/or underwater video will be used to confirm the spawning location.

Each fish will be implanted with a 48-month tag (Sonotronics Model CTT-83-3) that possesses an air weight of 24 g (8 g water weight) and measures 65 mm in length by 18 mm in diameter. The tags utilize frequencies of 75, 76, and 77 kHz. Each tag has its own unique code so that individual fish can be distinguished. Sonic transmitters will be surgically implanted using a protocol developed by Valdez and Nilson (1982), Kaeding et al. (1990), and Valdez and Trinca (1995) for humpback chub; and Tyus (1982) and Valdez and Masslich (1989) for Colorado squawfish (pikeminnow) and razorback sucker. A transmitter air weight to fish weight of 2% (Bidgood 1980, Marty and

Summerfelt 1990) will be utilized to assure that the tags are not too large for the fish being tagged. After tagging the fish will be stocked into either Echo Bay or Las Vegas Bay.

Objective 2. Identify spawning areas and examine habitat use at Echo Bay and Las Vegas Bay during low and declining lake levels.

Two methods will be used to identify spawning areas for razorback sucker in Lake Mead. The first method is to monitor larval production in a broader area around the two study areas. Larval light trapping will begin in late February and continue into mid May in the Overton Arm to the Muddy River/Virgin River inflow areas and in the broader Las Vegas Bay. As in past study years, concentrations of larvae were very useful in identifying razorback sucker spawning areas. If larvae are located, trammel netting in the vicinity will be conducted to attempt to locate adult fish. A second method, tracking sonic-tagged razorback sucker, will also be used. In 1997, 2003, and 2004, sonic-tagged fish were tracked to spawning redds at Echo Bay, and it is believed that fish tagged during the ninth study year will exhibit similar behavior. Currently, there is one active sonic-tagged fish at each study location; however, the Las Vegas Bay fish has not been contacted since November 2003. Additional fish from Floyd Lamb State Park will be tagged and released into each of these areas to increase the number of sonic-tagged fish. These fish will be tracked weekly during the spawning period (late February through mid May) and bi-weekly outside the spawning period.

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