

RAZORBACK SUCKER STUDIES ON LAKE MEAD, NEVADA AND ARIZONA

2002-2003 ANNUAL REPORT

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Top left: Substrate composition at the Echo Bay Cliff spawning site.

Top right: Distribution of Tamarix spp. at the Virgin River inflow area of Lake Mead.

Left: Sub-adult razorback sucker captured at Las Vegas 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 Division 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 Division 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 seventh year (July 2002 to June 2003) of the Lake Mead razorback sucker study, emphasis was placed on locating spawning adults in a potentially new population near the Colorado River inflow, capturing adults to remove fin ray sections for aging, sonic-tagging adult fish at Las Vegas Bay and Echo Bay, locating spawning areas of the known populations, and assessing vegetative cover in coves and inflow areas around the lake. Trammel netting for adult fish during the spawning period continued during the 2002-2003 field season. During the seventh year 31 adult and 11 sub-adult (sexually immature and greater than 300 mm in total length) razorback sucker were captured, including 21 in Las Vegas Bay (all 11 sub-adult fish were captured in Las Vegas Bay) and 21 in Echo Bay. Of the 42 total razorback sucker collected 23 were recaptures; this recapture rate is similar to the rate found in previous years. The most interesting new captures during the seventh study year were the 11 sub-adult fish at Las Vegas Bay.

Small sections of fin rays were removed from 24 razorback sucker for aging during this study year, bringing to 64 the total number of fish aged during the study. A comparison of the years the fish were spawned with Lake Mead elevation suggests that a major change in lake management that occurred following the filling of Lake Powell may be responsible for the successful recruitment in Lake Mead. Our hypothesis is that reduced annual lake elevation fluctuations allowed for more-extensive cover around the shoreline of the lake, providing habitat for young razorback sucker. Another drawdown period followed by rising lake levels during the 1980s and 1990s may be responsible for successful recruitment of razorback sucker spawned in the late 1990s.

The precipitous drop in lake elevation over the last 3 years has affected razorback sucker spawning sites at Echo Bay and the Colorado River inflow area of Lake Mead, but not the spawning site at Las Vegas Bay. At Echo Bay, during the spawning seasons of 1997-2001, razorback sucker spawned at or near the cliff spawning site at the back of the bay. This site was dry in 2002 and spawning occurred in a different area along the south shore of Echo Bay. During the 2003 spawning season, the 2002 spawning site was dry; however, razorback sucker apparently spawned along the same shore just east of the 2002 spawning site on a gravelly point submerged in 2-5 feet of water. To date, declining lake levels at Las Vegas Bay have not appeared to affect the razorback sucker spawning location. 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. Larval captures during 2003 continue to indicate that the spawning site is along this portion of Blackbird Point. In 2000 at the Colorado River inflow, the spawning area was most likely located in the lower Colorado River

and the larvae drifted to Lake Mead or in upper Lake Mead near Pearce Ferry Bay. In 2001, with lower lake levels, spawning may have either occurred further down lake near Driftwood Island Bay or in the Colorado River and larvae drifted to the lake. In 2002 and 2003 no larval razorback sucker were captured. Spawning for this population either did not occur or took place outside our sampling area. The substrate composition at Echo Bay spawning sites was a mixture of gravel and cobble with nearly 80% of the measured particles at each site classified as gravel. The average substrate size (length of intermediated axis) for each of the two sites was 26.5 mm (gravel classification). Four sites on the western shore and tip of Blackbird Point exhibited substrate composition similar to the Echo Bay sites; however, the Blackbird Point sites contained more cobble. The average substrate size at the Blackbird Point sites ranged from 23 mm to 46 mm (gravel classification). This result indicates that suitable spawning substrate occurs near the supposed spawning areas at Blackbird Point.

Four adult fish were implanted with 4-year sonic tags and stocked into Las Vegas Bay and Echo Bay; two fish were tagged at each location. One Echo Bay fish has not been located since its release in January, and one Las Vegas Bay fish became stationary sometime in March. The remaining two fish (one at Echo Bay and one at Las Vegas Bay) are still active. Lake level may have affected sonic telemetry success at the Colorado River inflow area. The four fish implanted with sonic tags and stocked into the Colorado River inflow area during the sixth study year are not being monitored at this time. Two fish are now stationary and the location of the remaining two fish is unknown. In spite of numerous searches of the lake, the missing fish have not been located.

Average growth, as determined from 22 fish that were recaptured during 2002-2003, was 19.9 mm for this study year. Mean annual growth of Las Vegas Bay fish was 29.7 mm and 10.0 mm for Echo Bay fish. These growth rates continue to be substantially higher than those recorded from other razorback sucker populations. The high annual growth rate obtained during the seventh study year resulted from a young stocked fish that grew from 244 mm to 415 mm in seven months. This value inflated the combined growth rate and the growth rate for Las Vegas Bay.

The amount of aerial cover and the types of plants in terrestrial vegetative communities were examined at six coves (Boulder Wash Cove, Trail Rapids Bay, Teal Cove, Alkali Springs Cove, Callville Wash Cove, and Echo Bay), one wash inflow area (Las Vegas Wash), and three river inflow areas (Muddy River, Virgin River, and Colorado River). Substantial amounts of woody terrestrial vegetation that could serve as protective cover for young razorback sucker when inundated by the lake were found at Las Vegas Wash and Echo Bay—two areas of the lake where recent recruitment of razorback sucker has been documented. The Colorado River inflow, Virgin River inflow, and Muddy River inflow areas of Lake Mead, however, contained substantially higher amounts of dense terrestrial vegetation than either Echo Bay or Las Vegas Wash. All five areas exhibited similar low water clarity. The terrestrial vegetative cover at Callville Wash was similar to that measured at Echo Bay. The amount of aerial cover measured at the other four areas of the lake was generally much lower than the Echo Bay, Las Vegas Wash, and three river inflow areas.

The general research objectives for the upcoming 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, further studying razorback sucker use of Las Vegas Wash, and attempting to locate and determine the source of larval razorback sucker found in the

Colorado River inflow area. The goals for the 2003-2004 field season are as follows: identify spawning areas at Echo Bay, Las Vegas Bay, and the Colorado River inflow area of Lake Mead; sample the Muddy River and Virgin River inflow areas of Lake Mead for larval razorback sucker; identify potential spawning areas for Lake Mead razorback sucker at the Muddy and Virgin River inflow areas; and examine home range and site fidelity characteristics of the Echo Bay and Las Vegas Bay razorback sucker populations.

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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 large-river fishes (Colorado pikeminnow [*Ptychocheilus lucius*], bonytail [*Gila elegans*], humpback chub [*Gila cypha*]) endemic to the basin that is 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 have 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 would disappear 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 about 9,000 by 1999 (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 very 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 major reason for the lack of razorback sucker recruitment (Minckley et al. 1991).

Lake Mead appeared to follow the trend of other lower Colorado River Basin reservoirs, with recruitment to these populations occurring only near the time of reservoir creation. Lake Mead was formed in 1935 when Hoover Dam was closed, and razorback sucker were relatively common lake-wide throughout the 1950s and 1960s. 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 Division of Wildlife (NDOW) nor the Arizona Game and Fish Department collected razorback sucker from Lake Mead (Sjoberg 1995). This may be in part because of changes in their lake sampling programs, but it was a considerable difference from the 30-plus 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 40 years or so 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 they 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 it? Are the Las Vegas Bay and Echo Bay groups separate populations? Does 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 cooperative 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 cooperators included: the U.S. Bureau of Reclamation (BOR), which provided funding, storage facilities, and technical support; the 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 the BOR agreed to contribute additional financial support to the project to facilitate fulfillment of Provision #10 of the Reasonable and Prudent Alternative (RPA) 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). A cooperative agreement between the BOR and the SNWA was completed in July 1998 that specified the areas to be studied and extended the study period into 2000. Additional study objectives added to fulfill the BOR's needs included:

- 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 the BOR and SNWA completed another cooperative agreement to extend BOR funding into 2004.

This *Annual Report* presents the results of the seventh study year extending from July 2002 through June 2003, with information and data from previous years (October 1996-June 2002) included where applicable.

SUMMARY OF PREVIOUS YEAR'S RESULTS

During the sixth year (July 2001 to June 2002) of the Lake Mead razorback sucker study, emphasis was placed on locating spawning adults in a potentially new population near the Colorado River inflow, capturing adults to remove fin ray sections for aging, and locating spawning areas of the known populations. Trammel netting for adult fish during pre-spawning continued; however, unlike the previous three study years, netting was conducted during the 2002 spawning period. Netting during the spawning period appears to have little effect on survival of razorback sucker in the two known populations. Return rates for razorback sucker sampled by USFWS in 2000 and 2001 were similar to return rates for fish captured outside of the spawning period. Additionally, many of the fish captured by USFWS were new captures, indicating that BIO-WEST was not sampling a portion of the populations at both Las Vegas Bay and Echo Bay that moved into these areas late to spawn. During the sixth year 31 adult and 1 sub-adult (sexually immature and greater than 300 mm in total length) razorback sucker were captured, including 18 in Las Vegas Bay and 14 in Echo Bay. Of the 32 total razorback sucker collected 14 were recaptures; this recapture rate is similar to the rate occurring in previous years. The most interesting recapture during the sixth study year was a 617 mm female that was first captured by NDOW on March 2, 1993, at Las Vegas Bay and recaptured by BIO-WEST on March 2, 2002, at Echo Bay. This is the first razorback sucker that has been captured at both Las Vegas Bay and Echo Bay.

Small sections of fin rays were removed for aging 19 razorback sucker during this study year, bringing to 40 the total number of fish aged during the study. A comparison of the years the fish were spawned with Lake Mead elevation suggests that a major change in lake management that occurred following the filling of Lake Powell may be responsible for the successful recruitment in Lake Mead.

The precipitous drop in lake elevation during the fifth and sixth study years has affected razorback sucker spawning sites at Echo Bay and the Colorado River inflow area of Lake Mead, but not the spawning site at Las Vegas Bay. At Echo Bay, during the spawning seasons of 1997-2001, razorback sucker spawned at or near the cliff spawning site at the back of the bay (Abate et al. 2002). This site was dry in 2002 and spawning occurred in a different area along the south shore of Echo Bay. As the lake elevation has dropped and spawning sites have dried, razorback sucker at Echo Bay have apparently found alternative spawning sites closer to the mouth of the bay. Declining lake levels at Las Vegas Bay did not appear to affect the razorback sucker spawning location. Although the exact location of the spawning site at Las Vegas Bay was not identified, it is believed to be somewhere off the west shore or tip of Blackbird Point. In 2000 at the Colorado River inflow, the spawning area was most likely located in the lower Colorado River and the larvae drifted to Lake Mead or in upper Lake Mead near Pearce Ferry Bay. In 2001, with lower lake levels, spawning may have either occurred further down lake near Driftwood Island Bay or in the Colorado River and larvae drifted to the lake.

Four adult fish were implanted with 4-year sonic tags and stocked into the Colorado River inflow area of Lake Mead with the hope that they could be tracked to wild spawning fish in the area. Lake level may have affected sonic telemetry success with these fish. Aside from the one sonic-tagged razorback sucker that became stationary, the remaining tagged fish (3) were active in the area for 1.5 to 2 months. However, after the lake decreased in elevation 8-10 feet these fish could no longer

be located. Despite larvae being captured in this area during the two previous sampling seasons, no larvae were captured at the Colorado River inflow during the sixth study year. These occurrences may indicate that adult razorback sucker abandoned this area as lake levels decreased.

Average growth, as determined from 17 fish that were recaptured during 2001-2002, was 10.9 mm for this study year. Mean annual growth of Las Vegas Bay fish was 11.3 mm and 10.5 mm for Echo Bay fish. These growth rates continue to be substantially higher than those recorded from other razorback sucker populations. Negative growth has consistently been found for fish recaptured during the same spawning period during this study, and this may reflect netting and/or spawning stress.

STUDY AREAS

The majority of 2002-2003 study activities occurred at the same locations used in the 1996-2002 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). 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). However, in the 2002-2003 field season this area extended from Driftwood Cove to the southern entrance of Iceberg Canyon. Sonic telemetry was conducted in other parts of the lake, including the Overton Arm and Boulder Basin (Figure 1). Larval sampling was performed in Echo Bay, Las Vegas Bay, and the Colorado River inflow area. Trammel netting was conducted at Las Vegas Bay and Echo Bay as during previous years (Figure 1). Potential cover in the form of terrestrial vegetation was assessed at 10 sites around the lake: Las Vegas Wash, Echo Bay, Boulder Wash Cove, Trail Rapids Bay, Teal Cove, Callville Wash, Alkali Springs Cove, Muddy River inflow, Virgin River inflow, and Colorado River inflow (Figure 2).

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.

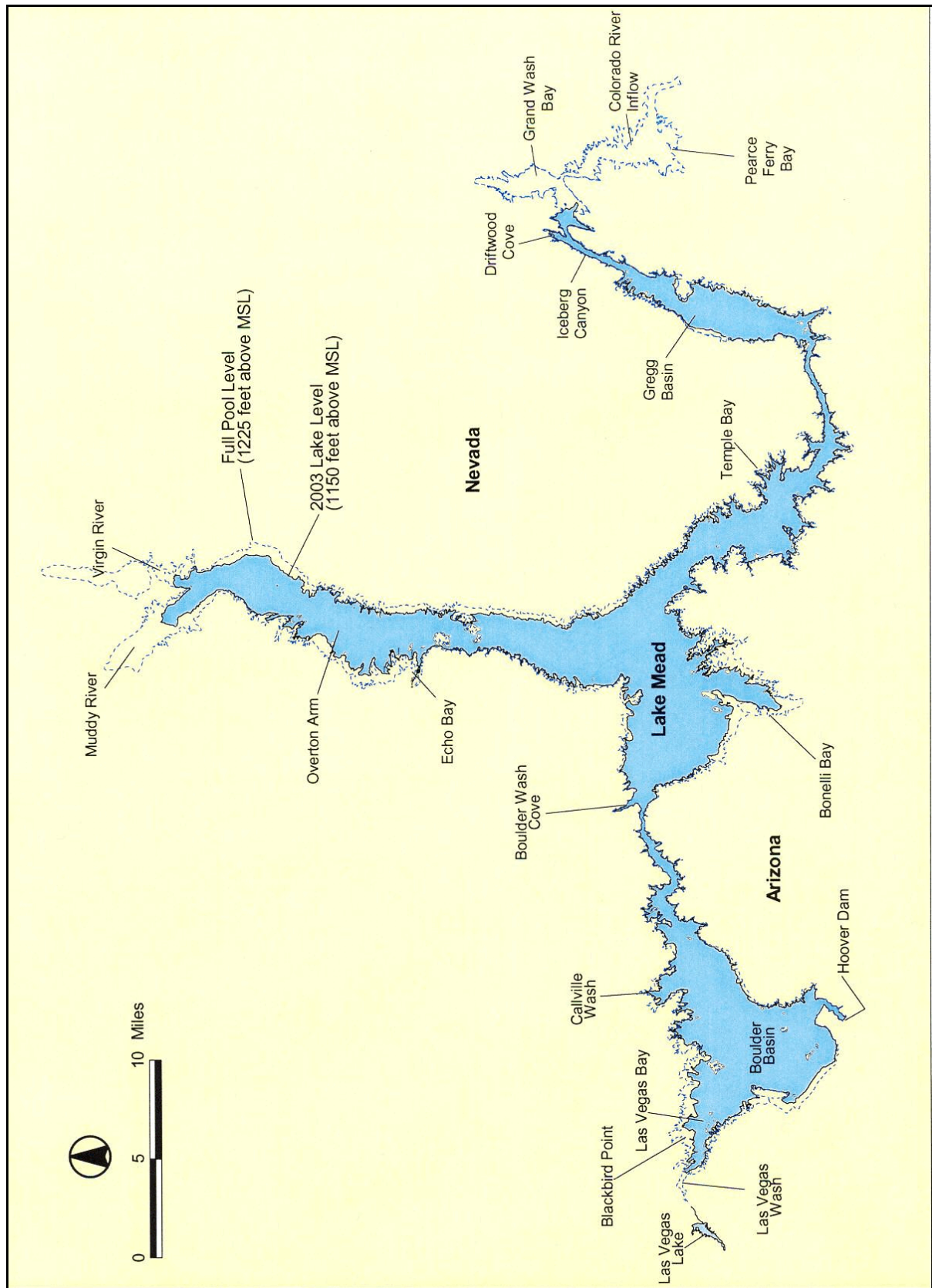


Figure 1. Map of Lake Mead showing general study area locations.

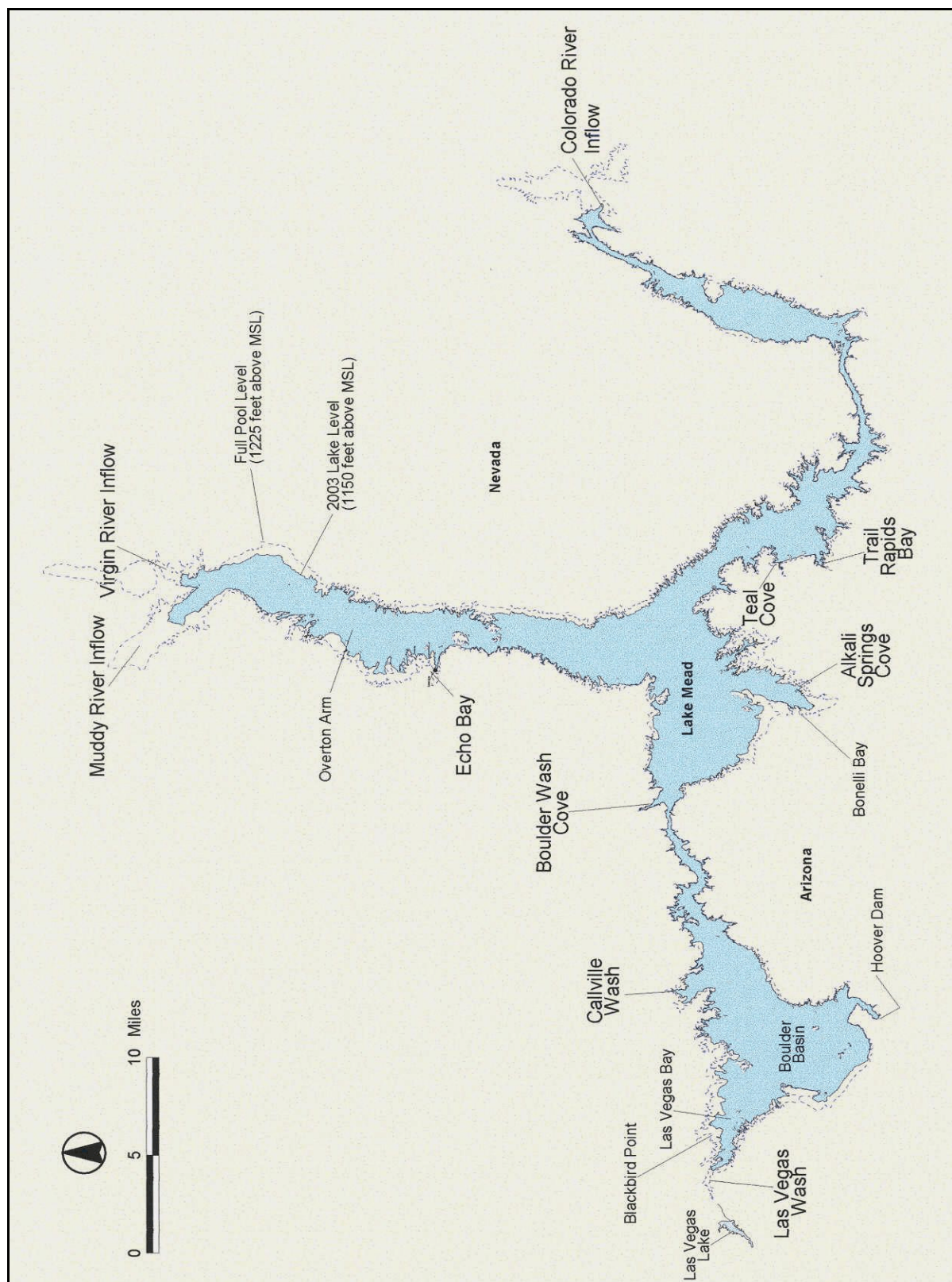


Figure 2. Map of Lake Mead showing the 10 sites at which potential vegetative cover was assessed.

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), and
- Las Vegas Bay (the majority of the bay that is less-heavily influenced by Las Vegas Wash).

METHODS

Lake Elevation

Month-end lake elevations for the 2002-2003 field season (July 1-June 30) were measured in feet above mean sea level (amsl) and obtained from the BOR's Lower Colorado Regional Office website (BOR 2003). The effect of decreasing lake levels on razorback sucker habitat was documented in writing 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 feet of water, with the net stretched out into deeper areas. All trammel nets were set in the late afternoon just before sundown and pulled in the 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 were held in large, water-filled containers. Razorback sucker were isolated from other fish species in separate containers. Common carp (*Cyprinus carpio*) were enumerated; and other species were measured for total length (TL) and fork length (FL), weighed, and released at the location of capture. Razorback suckers were checked for PIT tags, tagged with PIT tags if they were not recaptures, measured (including standard length [SL]), weighed, and returned to 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 suckers to capture them. After sundown two 12-volt "crappie" lights were connected to a battery, placed over each side of the boat, and submerged 4 to 10 inches into the water. Two "netters" were stationed looking down on the area around the lights with long-handled aquarium dip nets. Larval razorback suckers which 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. Usually, 4 to 8 sites were sampled on each night that larval sampling was attempted. Larvae were enumerated as they were

placed in the holding buckets and were released at the point of capture when sampling at a site was completed. As a result of decreasing lake levels, larval sampling during spring 2003 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). In 2003, as in 2002, 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 2003 lake level. Because at least one of these larval sampling sites was a known spawning location, new larval sites were selected at random to help discern if razorback sucker at Echo Bay could utilize new 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 and followed the method used in 2002 where a majority of the sites sampled occurred along Blackbird Point and in the non-flowing portion of Las Vegas Wash.

Spring 2003 larval sampling focused on the Colorado River inflow and Iceberg Canyon areas. Sampling was conducted in these areas one to three times per week with five to eight stations sampled per night using methods described in Holden et al. (2000b, 2001) and Abate et al. (2002).

Juvenile Sampling

Limited juvenile (sexually immature razorback sucker between 20 mm and 300 mm in TL) sampling was conducted with minnow traps at Las Vegas Bay and Echo Bay during the seventh study year. Minnow traps were generally set overnight and remained in place for 2 consecutive nights. Sampling took place in areas with emergent vegetation and in open water areas near the back of Echo Bay and near Blackbird Point at Las Vegas Bay.

Age Determination

Selected razorback sucker caught in trammel nets were anesthetized, and then 0.25-inch segments of the second left pectoral fin rays were surgically removed. Fish that exhibited signs of stress from netting were excluded from the procedure. In the laboratory fin ray segments were set into molds and the molds filled with a thermoplastic epoxy and then heat cured. The molds enabled the embedded sections to be set into a mounting bracket that held the ray segment perpendicular to a Buhler isomet low-speed saw. After the segments were thin sectioned with the saw, they were sanded and polished, and examined under a stereo-zoom microscope.

During the seventh study year aging was conducted by Kirk Dahle and Tim Welker. Mr. Dahle was responsible for the fin ray sectioning of specimens collected in 2001, 2002, and 2003 and, having aged 1,500 specimens of various species, has extensive experience. Dr. Welker oversaw aging activities during the fifth and sixth study years and has previous experience aging shovelnose sturgeon (*Scaphirhynchus platyrhynchus*).

Sonic Tagging and Tracking Additional Razorback Sucker at Las Vegas and Echo Bays

Implant Procedures

Sonotronics Model CTT-83-3 (48-month tag) tags were implanted in four adult razorback sucker (two at Las Vegas Bay and two at Echo Bay) in January 2003 and used to monitor razorback sucker movement and habitat use through June 2003. The 48-month tags had an air weight of 24 g (8 g water weight) and measured 65 mm long by 18 mm in diameter. The tags utilized frequencies of 75, 76, and 77 kHz. Each tag had its own unique code so that individual fish could be distinguished. The following surgical protocol was established from procedures developed by Valdez and Nilson (1982), Kaeding et al. (1990) and Valdez and Trinca (1995) for humpback chub; Tyus (1982) for Colorado squawfish (pikeminnow); 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) was used to assure that the tags were not too large for the fish being tagged. Surgical implants were performed on shore. Three people were involved in the surgery – a surgeon, an assistant, and an anesthetist who also monitored respiration of the fish. The surgeon and anesthetist were members of the BIO-WEST staff and were responsible for ensuring that all aspects of the surgical procedure were followed and monitored.

Prior to surgery each fish was placed in a live well with fresh water. All surgical instruments were cold-sterilized with 90% isopropyl alcohol and allowed to air dry on a disposable sterile cloth. Two 5-gallon buckets were placed above the level of the surgical table, one with anesthetic solution and one with fresh lake water. Each bucket had a 5-foot length of tygon tubing attached to the bottom allowing the anesthetist to alternately irrigate the gills of the fish with anesthetic or fresh water, according to the reaction of the fish. Just prior to surgery each fish was anesthetized with Finquel, a brand of tricaine methanesulfonate (MS-222), at a concentration of 100 mg/l for 2-4 minutes or until the fish lost equilibrium in the holding tank but continued moderate opercular movement. During surgery the gills were bathed with anesthetic at 50 mg/l, as needed, and then with fresh water about half way through the surgery to expedite post-surgical recovery.

Each fish was removed from the anesthetic bath by the anesthetist and placed on a surgical cradle. A 3-4 cm incision was made just lateral to the midline by the surgeon. The incision was generally on the left side anterior to the pelvic girdle and about 1-2 cm lateral to the midline of the fish. The sonic transmitter was inserted through the incision and pushed back to rest on the pelvic girdle. The incision was closed with 4-6 stitches using 3-0 Maxon absorbable polygluconate monofilament suture with an attached PH 26 curved needle. Each fish was allowed to recover in the live well, then released at the point of capture, usually within an hour of surgery.

Tracking Procedure

Sonic telemetry was utilized to assess adult habitat use and movement. Sonic-tagged razorback sucker 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 effect the ability to hear a signal; sonic equipment is line-of-site, 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 the GPS unit.

Spawning Substrate Composition

The Wolman pebble count method (Wolman 1954) was used to assess substrate composition of known razorback sucker spawning sites at Echo Bay and identify the occurrence of suitable spawning substrate at Blackbird Point. Substrate particle size was examined at two Echo Bay spawning sites—the cliff spawning bar at the back of Echo Bay and the 2003 spawning site along the south shore of Echo Bay. Four sites were examined near the tip of Blackbird Point in Las Vegas Bay. At each site, one to four transects were established and 100 particles were classified along each transect. At the Echo Bay cliff spawning site, substrate composition was quantified on the portion of the spawning bar where razorback sucker were observed spawning in 1999, 2000, and 2001. Substrate size was measured along two transects at the 2003 Echo Bay spawning site and along one transect at each of the four Blackbird Point sites. All areas where pebble counts were performed were on shore. At each 1-foot interval the intermediate axis (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 Echo Bay spawning site.

Lake Mead Vegetation Assessment

It has been hypothesized that young razorback sucker use inundated terrestrial vegetation as protective cover from predatory fish (Golden and Holden 2003). Recruitment of razorback sucker in Lake Mead appears to occur during high lake levels that follow an extended drawdown period. It is during the drawdown period that terrestrial vegetation grows between the full pool elevation and the lake shoreline. Current lake levels are at their lowest point in 25 years.

The composition and the amount of aerial cover (the area of ground covered by the vertical projection of the aerial portions of plants) provided by terrestrial vegetation at several Lake Mead coves and wash/river inflow areas was assessed between the 1,140 and 1,220 ft AMSL contours to identify areas of the lake where recruitment of juvenile razorback sucker might be enhanced by the occurrence of dense stands of protective cover. On June 16, 2003, areas of Lake Mead that might possess vegetational characteristics similar to those at Las Vegas Wash and Echo Bay—two areas where recent natural recruitment of razorback sucker has been documented—were identified from a small fixed-wing aircraft. In late August the composition, distribution, and aerial cover of vegetation were assessed “on the ground” at the following areas of Lake Mead: Echo Bay, Las Vegas Wash, Muddy River inflow, Virgin River inflow, Colorado River inflow, Callville Wash, Boulder Wash Cove, Trail Rapids Bay, Teal Cove, and Alkali Springs Cove (Figure 2). Polygons that depicted vegetation distribution and composition were drawn onto hard copy maps created from a digital elevation model using ArcView® geographic information systems (GIS) software. Vegetation polygons in large areas, such as the Muddy River inflow, were drawn onto maps from elevated vantage points (e.g., Mormon Mesa). The characteristics of these polygons were later verified during a site visit. The amount of aerial cover for each vegetation polygon was classified as <25% aerial cover, 25-50% aerial cover, 50-75% aerial cover, and >75% aerial cover. The dominant plant species and average plant height were also identified for each polygon. ArcView®

was used to determine the area (ha) of each polygon and to construct maps depicting their distribution at each site. Water turbidity at each study site was assessed using a secchi disc.

RESULTS

Lake Elevation

Similar to the sixth study year, lake elevation steadily decreased throughout the seventh study year. The July 2002 month-end lake elevation was approximately 1,157 feet amsl, and the lake level decreased to about 1,143 feet amsl by June 2003, the lowest level of the study (Figure 3).

Decreasing lake levels during the last 3 study years influenced habitat conditions in all areas where razorback sucker sampling activities have taken place over the past 7 years. In 2001 decreases in lake elevation at the Echo Bay study site entirely exposed the substrate where razorback sucker were seen spawning during March 1999 and March 2000 video surveillance. In 2002 razorback sucker apparently spawned on a gravelly point on the south shore of Echo Bay approximately 0.25 mile from the dry cliff spawning site. By the beginning of the 2003 spawning season, the lake level had decreased about 8 feet from the previous year. This decrease in lake level further exposed the western half of Echo Bay, creating a distance of approximately 0.5 mile between the water's edge and the cliff spawning site and also exposing the suspected 2002 spawning site. At this point the water level was 48 feet below the level of the lake when the study was initiated in 1996 and 70 feet below the study-high water level that occurred during October 1998.

Similar to the previous study year, decreases in water level elevation continued to effect study activities associated with the Las Vegas Wash area. As with past study years, considerable study activity was conducted at or near the confluence of Las Vegas Wash and Las Vegas Bay. This area has continued to undergo substantial changes in both geomorphic configuration and location relative to the effects of lake elevation, sedimentation, and wash flows. When the study began in 1996, the lake elevation was about 1,192 feet amsl, allowing for a substantial wetland-type area with bulrushes (*Scirpus* spp.), cattails (*Typha* spp.), and inundated tamarisk (*Tamarix* spp.) at the point of inflow. Farther upstream of the inflow area, there was a channelized area of the wash that was accessible by boat because of a lake-induced back-flow effect. Lake elevation rose approximately 20 feet during 1996 and 1997, thereby inundating this area and causing a delta to form farther upstream at a relatively new inflow area.

As the lake elevation began to decrease in late 1999 and early 2000, increasing amounts of sediment continued to move downstream, filling in a major portion of the bulrush and tamarisk area that was exposed at the beginning of the study in 1996. Additionally, a new delta was formed, thus further limiting boat travel into the flowing, channelized portion of the wash.

Changes in the geomorphic configuration and location of the Las Vegas Bay/Las Vegas Wash interface continued during the seventh study year. The aforementioned decreasing lake levels affected this area by further extending the wash delta out into Las Vegas Bay. As lake levels decreased and the wash continued to transport large amounts of sediment toward the lake, the

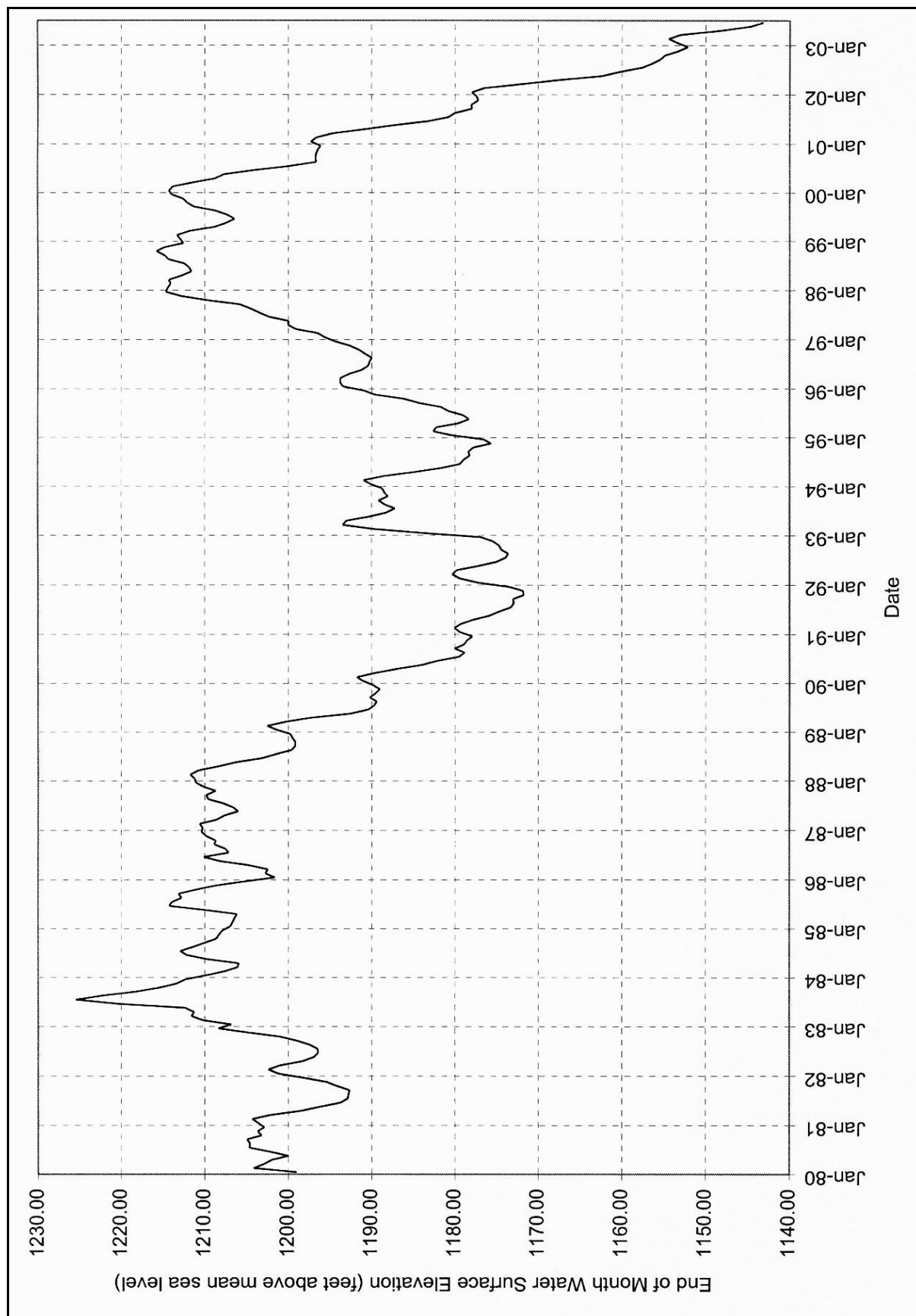


Figure 3. Lake Mead month-end elevations, January 1980 to June 2003.

riverine section of the wash that was present during the previous study year increased in size and continued to extend to the south. The encroachment of the wash delta further into Las Vegas Bay even forced Las Vegas Bay Marina to relocate to Horsepower Cove in the northeastern corner of Boulder Basin. The interface of the lake and the wash is similar in function to that reported in Holden et al. (2001). During the seventh study year, most study activities in this area of Lake Mead occurred within the lentic portion of Las Vegas Bay.

Decreasing lake levels have had a substantial effect on vegetative cover at the two main study areas (Las Vegas Bay/Wash and Echo Bay). At the beginning of this project in 1996, lake levels increased and thereby inundated upland shoreline and wetland vegetation including tamarisk, cattail, and cottonwood (*Populus* spp.). Holden et al. (2001) hypothesized that inundated vegetation is an important factor for successful recruitment of razorback sucker in Lake Mead. Although lake level has declined from October 1998 to the present, inundated vegetation was present to some degree throughout the decline until the middle of the sixth study year. The amount of inundated vegetation during the seventh study year declined to the point where very little of this habitat was inundated and only limited submergent aquatic vegetation, such as spiny naiad (*Najas marina*), provided vegetated aquatic habitat.

The geomorphic layout of the Colorado River inflow area has changed drastically since razorback sucker work began in spring 2000 (Holden et al. 2000b) and has limited access to some areas of the lake. During spring 2000 relatively high lake levels allowed access to Pearce Ferry as well as the lower Grand Canyon portion of the Colorado River. As lake levels dropped, Pearce Ferry Bay was cut off from the main flow of the Colorado River by a sand berm that prevented boating from Pearce Ferry Bay to sample areas near Grand Wash Bay and Driftwood Island. Access to Grand Wash Bay was also eliminated as dropping lake levels altered river morphology. At the beginning of the seventh study year, decreasing lake levels restricted larger boat access to the Colorado River upstream of Iceberg Canyon and Driftwood Cove, and by the end of the study year only boats with shallow drafts could ascend the lower portions of the river.

Adult Sampling

Trammel Netting

Table 1 shows the trammel netting effort that occurred from July 2002 to June 2003, and Figures 4 and 5 show the location of trammel net sets in the two primary study areas for the same time period. Trammel netting was conducted on 225 net nights (one net night is comprised of a single net set overnight) during the seventh study year, with 113 net nights spent in the Las Vegas Bay/Boulder Basin area, 94 net nights spent in the Echo Bay/Overton Arm area, and 18 net nights spent in the Pearce Ferry Bay pond.

Trammel netting effort during the seventh study year was partially concentrated in the Blackbird Point area in Las Vegas Bay (Figure 4), including the flowing and non-flowing portions of Las Vegas Bay and the back of Echo Bay (Figure 5) (Holden et al. 1997, 1999). No netting effort was expended at the Driftwood Island Bay/Colorado River inflow area during the seventh study year.

Table 1. Trammel netting effort (net nights) on Lake Mead by month from July 2002 to June 2003.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY/ OVERTON ARM	PEARCE FERRY BAY	TOTAL
2002				
July				0
August				0
September				0
October			18	18
November	9	10		19
December	20	20		40
2003				
January	15	5		20
February	14	5		19
March	15	14		29
April	20	20		40
May	20	20		40
June				0
Totals	113	94	18	225

In past study years in this portion of the lake netting effort was concentrated in areas where razorback sucker larvae were captured, which were possible spawning sites. No razorback sucker larvae were captured during the seventh study year in this area of Lake Mead. Therefore, netting was not conducted at the Driftwood Island Bay/Colorado River inflow area, and effort increased at Las Vegas and Echo Bays in an attempt to acquire more fin ray samples for aging from those two populations. However, netting was conducted at Pearce Ferry Bay in an attempt to capture adult razorback sucker that may have been trapped when it became isolated from Lake Mead.

As with the previous four study years (Holden et al. 2000a, 2000b, 2001; Abate et al. 2002), the timing of trammel netting for the seventh 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 occurring during the summer netting efforts appeared to stress razorback sucker that were brought to the surface. For this reason, trammel netting during the seventh study year was not conducted from July to September (warm months). 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 seventh 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 a portion of the populations in both Las Vegas Bay and Echo Bay that moved into these areas late to spawn.

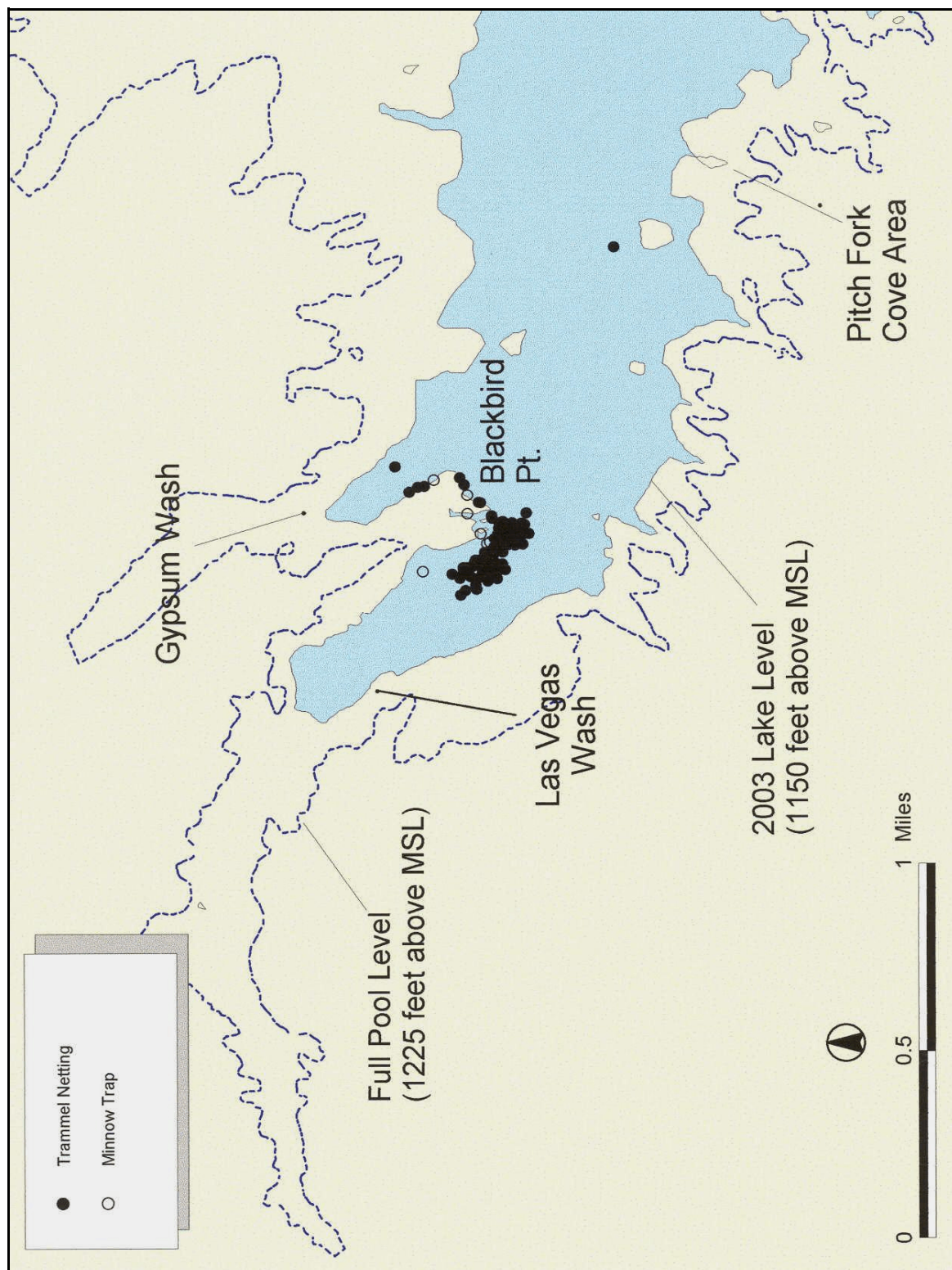


Figure 4. Las Vegas Bay study area showing locations of trammel netting and minnow trapping, July 2002 - June 2003.

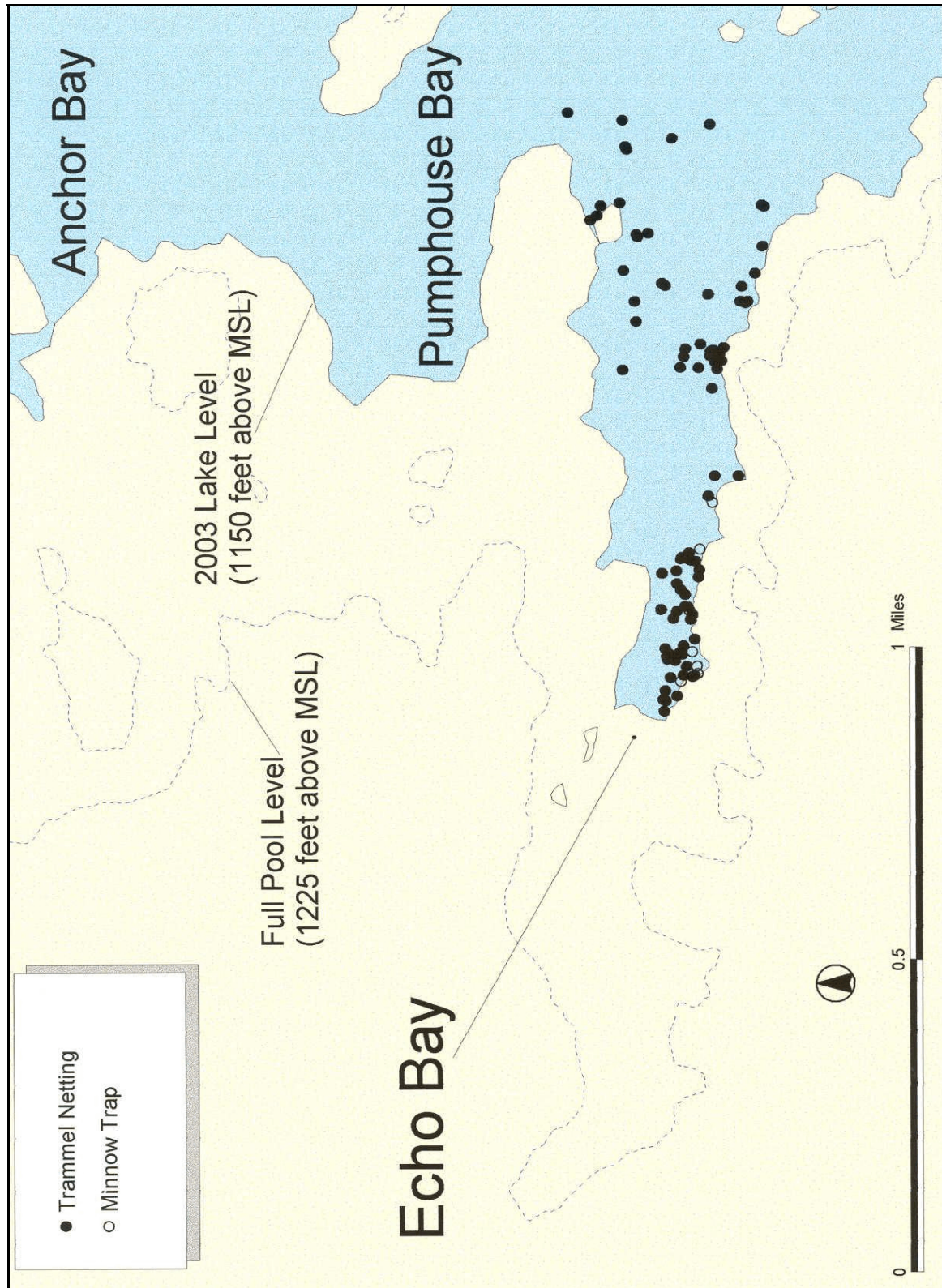


Figure 5. Echo Bay/Overton Arm study area showing locations of trammel netting and minnow trapping, July 2002-June 2003.

Netting effort was concentrated at the two primary study areas from December 2002 through May 2003, when BIO-WEST was attempting to capture adult and sub-adult razorback sucker for aging. Netting in Pearce Ferry Bay was conducted over a 3-day period in October 2002.

At Blackbird Point in Las Vegas Bay, 10 adult and 11 sub-adult (TL for sub-adult fish ranged from 354-471 mm; one fish was a NDOW stocked fish) razorback sucker were captured by BIO-WEST (Table 2) during 113 net nights in the seventh study year. This is the same general area where most of the Las Vegas Bay razorback sucker were captured during previous years (Holden et al. 1997, 1999, 2000a, 2000b, 2001; Abate et al. 2002). Most were captured in a deep water section of Blackbird Point, with nets set from the western side of the point toward the Las Vegas Bay boat ramp. Razorback sucker catch rates for trammel netting at the Las Vegas Bay area were 0.19/net night for the seventh sample year. This rate was similar to the previous year (0.24/net night).

At Echo Bay nets were set throughout the entire bay, with more emphasis placed on the back portion of the bay where most of the larval razorback sucker were captured during this study year. During 94 net nights 21 razorback sucker were captured (Table 2). The razorback sucker catch rate for trammel netting at Echo Bay was 0.22/net night, which is the same rate that occurred during the previous study year.

Eighteen net nights of sampling were conducted at Pearce Ferry Bay during October 15-17. It was believed that adult razorback sucker could be trapped in the bay. A local fisherman indicated that several razorbacks were near the boat launch area of Pearce Ferry Bay in November 2001. Shoals of up to 20 adult fish were seen in the same area in the mid 1970s. No razorback sucker sub-adults or adults were captured during this netting effort in the seventh study year.

The first male expressing milt was captured on January 21, 2003, at Echo Bay, and the first female razorback sucker expressing eggs was captured on April 2, 2003, at Echo Bay. Recapture rates varied between study locations during the seventh study year. At Las Vegas Bay 8 of the 21 (38.1%) razorback sucker caught were recaptures. One of the recaptured fish was stocked by NDOW in 1995, four were stocked in 2001, and one was stocked in 2002 (six of twenty-one captures in 2003 were stocked fish). At Echo Bay fifteen of the twenty-one (71.4%) razorback sucker caught were recaptures. Of the six new captures at Echo Bay, none had been stocked by NDOW (three of twenty-one captures in 2003 were stocked fish).

At Echo Bay 58 individual razorback sucker have been captured and PIT tagged during the seven study years. In addition, 19 other razorback sucker previously PIT tagged by NDOW were recaptured. Hence, 77 individual PIT-tagged razorback sucker were handled at Echo Bay during the first 7 years of the study.

At Las Vegas Bay 72 individual razorback sucker have been captured and PIT tagged. In addition, nine razorback sucker previously PIT tagged by NDOW were recaptured during this study. Consequently, 81 unique PIT-tagged razorback sucker have been handled at Las Vegas Bay during the 7 years of this study. Lakewide, 158 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 2002-June 2003.

DATE	LOCATION	PIT TAG NUMBER	DATE STOCKED	RECAPTURE	TL ^a (mm ^e)	FL ^b (mm)	SL ^c (mm)	WT ^d (g ^f)	SEX
11/18/02	EB ^g	53256F7978		No	551	510	455	1926	U ^h
12/3/02	LVB ^f	53261F6644		No	354	325	281	541	I ⁱ
12/4/02	EB	1F78417335		Yes	705	653	602	4224	F ^j
12/6/02	LVB	53256B4761		No	376	349	305	625	I
12/6/02	LVB	5324641330		No	400	375	331	812	I
12/6/02	LVB	1F484B0648	1/17/01	Yes	658	605	550	4054	F
12/19/02	LVB	532461545C		No	395	366	316	729	I
1/7/03	LVB	5325637C1A		No	665	619	578	4040	F
1/7/03	LVB	1F484B0648	1/17/01	Yes	650	610	545	3958	F
1/21/03	EB	53263D264D		No	596	561	495	2369	M ^k
1/21/03	EB	531F0A6332		No	612	571	505	2326	M
1/21/03	EB	1F7818430E		Yes	591	548	498	2180	M
1/21/03	EB	1F4A457C56		Yes	546	514	460	2124	M
1/22/03	LVB	5324601726		No	394	367	320	870	I
2/3/03	EB	5325630B13		No	580	540	482	2234	F
2/3/03	EB	1F7B4D0F0A		Yes	655	609	548	3583	F
2/3/03	EB	1F7B083727		Yes	574	530	472	2243	M
2/5/03	LVB	532617266A		No	385	360	306	762	I
2/18/03	LVB	53240D6301		No	443	412	365	1130	I
3/4/03	LVB	5326063458		No	635	593	534	3630	M
3/20/03	LVB	5325527D56		No	420	391	345	817	I
3/26/03	EB	5325630B13		Yes	581	539	480	2077	F
4/2/03	EB	53257C0232		No	580	540		2748	M
4/2/03	EB	2037175B37		Yes	639	589	530	3145	M
4/2/03	EB	1F777A3B35		Yes	677	632	560	2851	F
4/2/03	EB	1F4A017E18	1/22/02	Yes	563	521	464	2318	F
4/8/03	LVB	5326010A32		No	422	392	354	863	I
4/8/03	LVB	1F5007206A	1/17/01	Yes	638	595	541	3402	F
4/9/03	EB	1F4A1A5429	1/22/02	Yes	519	477	425	1819	M
4/17/03	LVB	53256C6224		No	618	576	512	3380	F
4/17/03	LVB	1F7A217F47		Yes	596	540	495	2596	M
4/22/03	LVB	7F7D4C0651		Yes	650	605	542	3372	M
4/23/03	EB	7F7D4C302B		Yes	584	540	485	1920	M
4/23/03	EB	53256F7978		Yes	569	508	463	2097	F
5/4/03	LVB	1F4A401641	9/30/02	No	415	386	338	908	I
5/6/03	EB	5326230509		No	507	571	423	1638	U
5/6/03	EB	53256F7978		Yes	561	504	453	2063	F
5/6/03	EB	1F7B477827		Yes	594	555	503	2360	M
5/15/03	EB	1F4B224430	1/22/02	Yes	540	494	443	1880	F
5/17/03	LVB	1F4A1B7E7E	5/26/95	Yes	629	585	528	3755	F
5/22/03	LVB	532603134E		No	471	430	384	1298	F
5/22/03	LVB	1F5007206A	1/17/01	Yes	640	596	534	3632	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.

^f LVB = Las Vegas Bay.

^h U = Unidentifiable.

ⁱ I = Immature.

^j F = Female.

^k M = Male.

Video Surveillance

Several attempts were made to observe razorback sucker spawning activity at Echo Bay during spring 2003 using underwater video surveillance. However, increased water turbidity prevented these observations. High turbidity resulted from shallow water and wave action in the back of the bay.

Low larval fish numbers at Las Vegas Bay made it difficult to pinpoint spawning sites. However, numerous attempts were made to locate razorback spawning grounds, but turbid water conditions limited underwater camera 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

Twenty-one individual fish were recaptured during the seventh study year, fourteen at Echo Bay and seven at Las Vegas Bay. The difference in TL between capture periods was used to determine mean annual growth (Table 3). Fish recaptured within a 6-month period were excluded from population growth calculations, but they were included in Table 3. The combined (Echo and Las Vegas Bays) mean annual growth of razorback sucker recaptured from Lake Mead during this sampling year was 19.9 mm. The combined mean annual growth of recaptured fish the previous year was 10.9 mm (Abate et al. 2002). The high annual growth rate obtained during the seventh study year resulted from a young stocked fish that grew from 244 mm to 415 mm in 7 months. This value inflated the combined growth rate and the growth rate for Las Vegas Bay. Mean annual growth of fish recaptured at Echo Bay was 10.0 mm (5.5 mm for stocked fish and 14.5 mm for wild fish) and ranged from -39.1 mm to 75.2 mm. Razorback sucker recaptured at Las Vegas Bay had a mean annual growth of 29.7 mm and ranged from -4.0 mm to 291.7 mm. These growth rates continue to be substantially higher than those of other razorback sucker populations (Modde et al. 1996, Pacey and Marsh 1998).

Sonic Tagging and 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 1 year (implanted in 1997 and 1998) and 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. In January 2003 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. This report includes movement information for these four fish from the time of their release in January through June, 2003, and an update on the four fish that were released into the Colorado River inflow area in 2002.

Table 3. Lake Mead recaptured razorback sucker growth histories for fish captured from July 2002 through June 2003.

PIT TAG NUMBER	CAPTURE DATE	SIZE TL (mm) ^a	RECAPTURE DATE	SIZE TL (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENT	GROWTH PER YEAR
<u>LAS VEGAS BAY STOCKED FISH</u>							
1F484B0648	1/17/01 ^b	620	2/21/01	631	11	34	118.1
	2/21/01	631	12/1/01	637	6	280	7.8
	12/1/01	637	12/6/02	658	21	365	21.0
	12/6/02	658	1/7/03	650	-8	31	-94.2
1F4A1B7E7E	5/26/95 ^b	527	5/17/03	629	102	2,871	13.0
1F4A401641	9/30/02 ^b	244	5/4/03	415	171	214	291.7
1F5007206A	1/17/01 ^b	623	3/19/01	626	3	62	17.7
	3/19/01	626	6/7/02	642	16	438	13.3
	6/7/02	642	4/8/03	638	-4	301	-4.0
	4/8/03	638	5/22/03	640	2	44	2.0
1F7A217F47	12/13/99 ^b	539	12/6/00	561	22	353	22.7
	12/6/00	561	5/7/02	578	17	511	12.1
	5/7/02	578	4/17/03	596	18	340	19.3
Mean annual growth calculated from first and last capture of each stocked fish							44.1
<u>LAS VEGAS BAY WILD FISH</u>							
1F7A217F47	12/13/99	539	12/6/00	561	22	353	22.7
	12/6/00	561	5/7/02	578	17	511	12.1
	5/7/02	578	4/17/03	596	18	340	19.3
7F7D4C0651	4/21/97	605	4/22/03	650	45	2,161	7.6
Mean annual growth calculated from first and last capture of each wild fish							15.3
Mean annual growth calculated from first and last capture of stocked and wild fish							29.7
<u>ECHO BAY STOCKED FISH</u>							
1F4A017E18	1/22/02 ^b	560	2/27/02	566	6	35	62.6
	2/27/02	566	4/2/03	563	-3	395	-2.8
1F4A1A5429	1/22/02 ^b	512	4/9/03	519	7	437	5.8
1F4A457C56	7/25/95 ^b	488	9/14/98	505	17	1,129	5.5
	9/14/98	505	1/26/99	514	9	132	24.9
	1/26/99	514	1/8/00	527	13	342	13.9
	1/8/00	527	1/25/01	530	3	377	2.9
	1/25/01	530	3/19/01	528	-2	54	-13.5
	3/19/01	528	1/21/03	546	18	662	9.9
1F4B224430	1/22/02 ^b	536	5/15/03	540	4	473	3.1
Mean annual growth calculated from first and last capture of each stocked fish							5.5
<u>ECHO BAY WILD FISH</u>							
1F777A3B35	12/18/01	672	4/2/03	677	5	464	3.9
1F7818430E	2/24/01	577	1/21/03	591	14	687	7.4
1F78417335	2/25/00	704	12/4/02	705	1	999	0.4
1F7B083727	2/25/01	521	3/19/01	546	25	384	23.8
	3/19/01	546	2/27/02	610	64	338	69.1
	2/27/02	610	2/3/03	574	-36	336	-39.1
1F7B477827	4/20/97	573	5/6/03	594	21	2,176	3.5
1F7B4D0F0A	2/27/02	650	2/3/03	655	5	336	5.4
2037175B37	2/9/99	625	4/2/03	639	14	1,493	3.4
5325630B13	2/3/03	580	3/26/03	581	1	53	6.9
53256F7978	11/18/02	551	4/23/03	569	18	155	42.4
7F7D4C302B	2/10/98	347	3/11/98	351	4	31	47.1
	3/11/98	351	2/24/01	570	219	1,063	75.2
	2/24/01	570	4/23/03	584	14	779	6.6
Mean annual growth calculated from first and last capture of each wild fish							14.5
Mean annual growth calculated from first and last capture of stocked and wild fish							10.0

^a mm = Millimeters.

^b Date the fish was stocked into Lake Mead.

Las Vegas Bay

Tag 445

Tag 445 (48-month life expectancy) was implanted on January 7, 2003, into a 650-mm TL female captured at Blackbird Point. Throughout the seventh study year, fish 445 was located a total of 35 times. A majority of the contacts (28) were along the south shore of Las Vegas Bay between Pitchfork Cove and the Las Vegas Bay boat ramp (Figure 6). A smaller number of the contacts (seven) were made in the non-flowing portion of Las Vegas Wash. From February through April this fish was found using depths that ranged from 75 to 140 feet. In January, May, and June, this fish used depths less than 50 feet. During the spawning period (March through May) fish 445 was not found near Blackbird Point.

Tag 256

This 665-mm TL female razorback sucker was implanted with tag 256 (48-month life expectancy) on January 7, 2003. Eighteen contacts were made with this fish from the time of its release until the end of May. Six of the contacts were near Blackbird Point during the first month after release and nine were made in a small cove along the northwest shore of Black Island (Figure 7). This fish apparently died sometime between January 20 and mid February. It was found stationary near Black Island on February 21 and remained at this location until the tag was recovered in shallow water in mid June.

Echo Bay

Tag 355

Tag 355 (48-month life expectancy) was implanted on January 7, 2003, into a 650-mm TL female that was captured in Echo Bay during standard adult trammel netting. Twenty-two contacts with this fish were made at Rogers Bay and Echo Bay during the seventh study year (Figures 8 and 9). The first contact with fish 355 was near the back of Rogers Bay in shallow water. This fish remained in the back of Rogers Bay until March 13 when it was located in the back of Echo Bay along the south shore in very shallow water. Fish 355 remained in this location in 5-10 feet of water and approximately 5-10 feet from shore until mid May. It was found in the back of Rogers Bay during the remainder of the study year.

Tag 456

This 691-mm TL male razorback sucker was implanted with tag 456 (48-month life expectancy) on January 21, 2003. This fish was not contacted after its release. Several exhaustive searches of Overton Arm in February and of the lake between Overton Arm and both the Temple and Virgin Basins failed to locate this fish. It is suspected that the tag malfunctioned.

Colorado River Inflow Area

Tag 253

Tag 253 (48-month life expectancy) was implanted on November 29, 2002, into a 615-mm TL female that was released back into Floyd Lamb State Park pond. This fish was harvested out of the pond and released into Bradley Bay on January 22, 2002. From January 23 through March 28, 2002, six contacts were made with fish 253. Contact with this fish was lost until it was relocated in

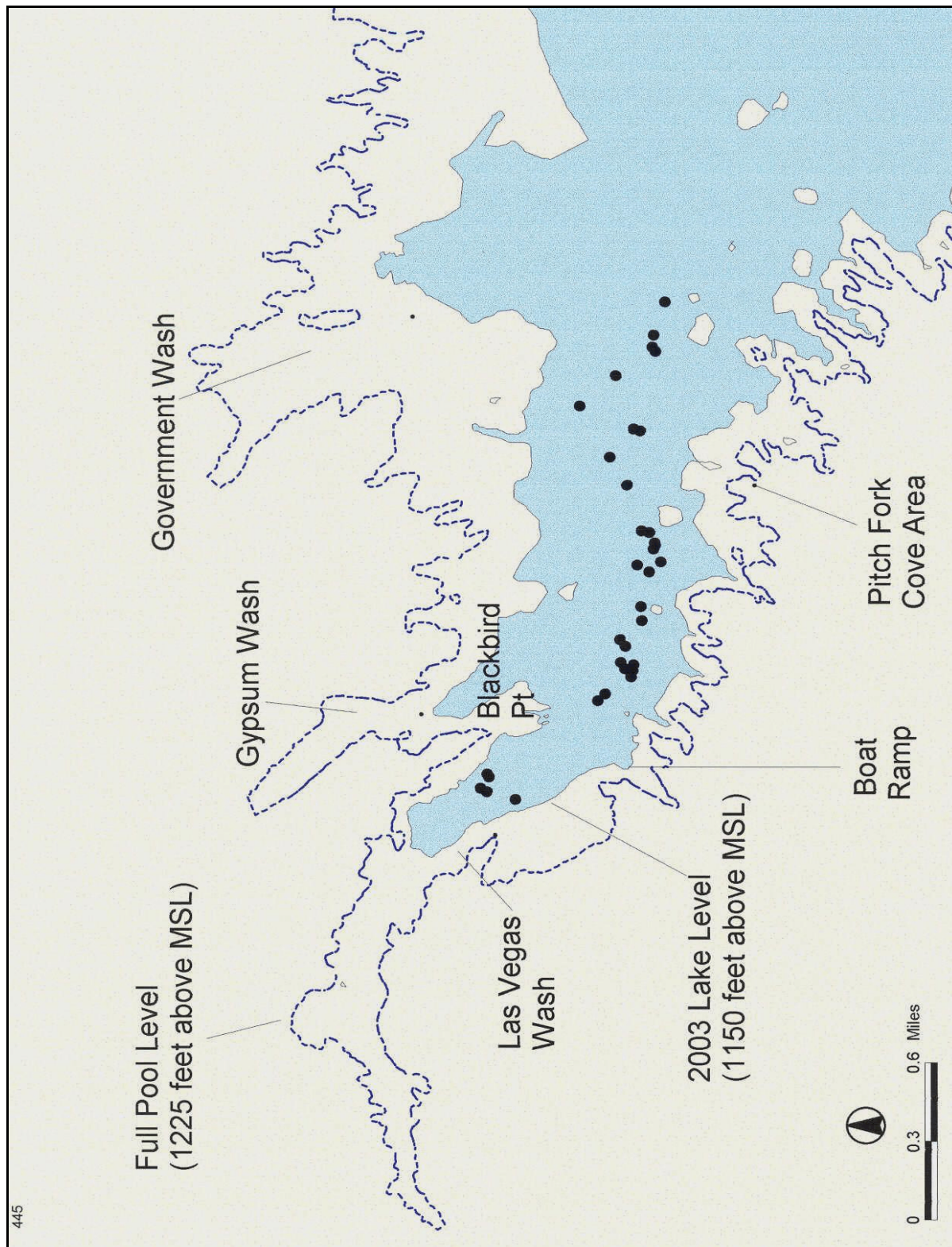


Figure 6. Distribution of fish number 445.

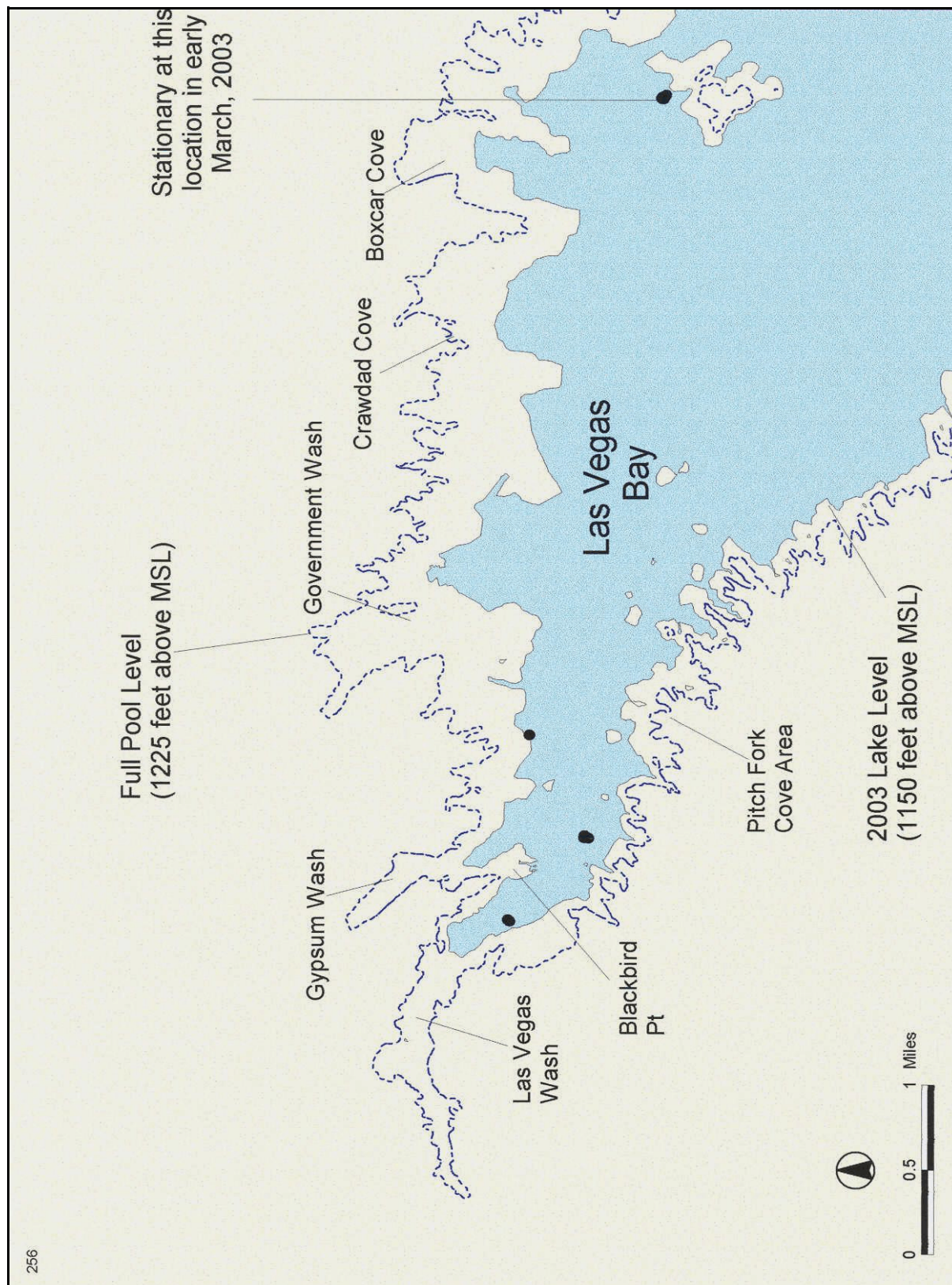


Figure 7. Distribution of fish number 256.

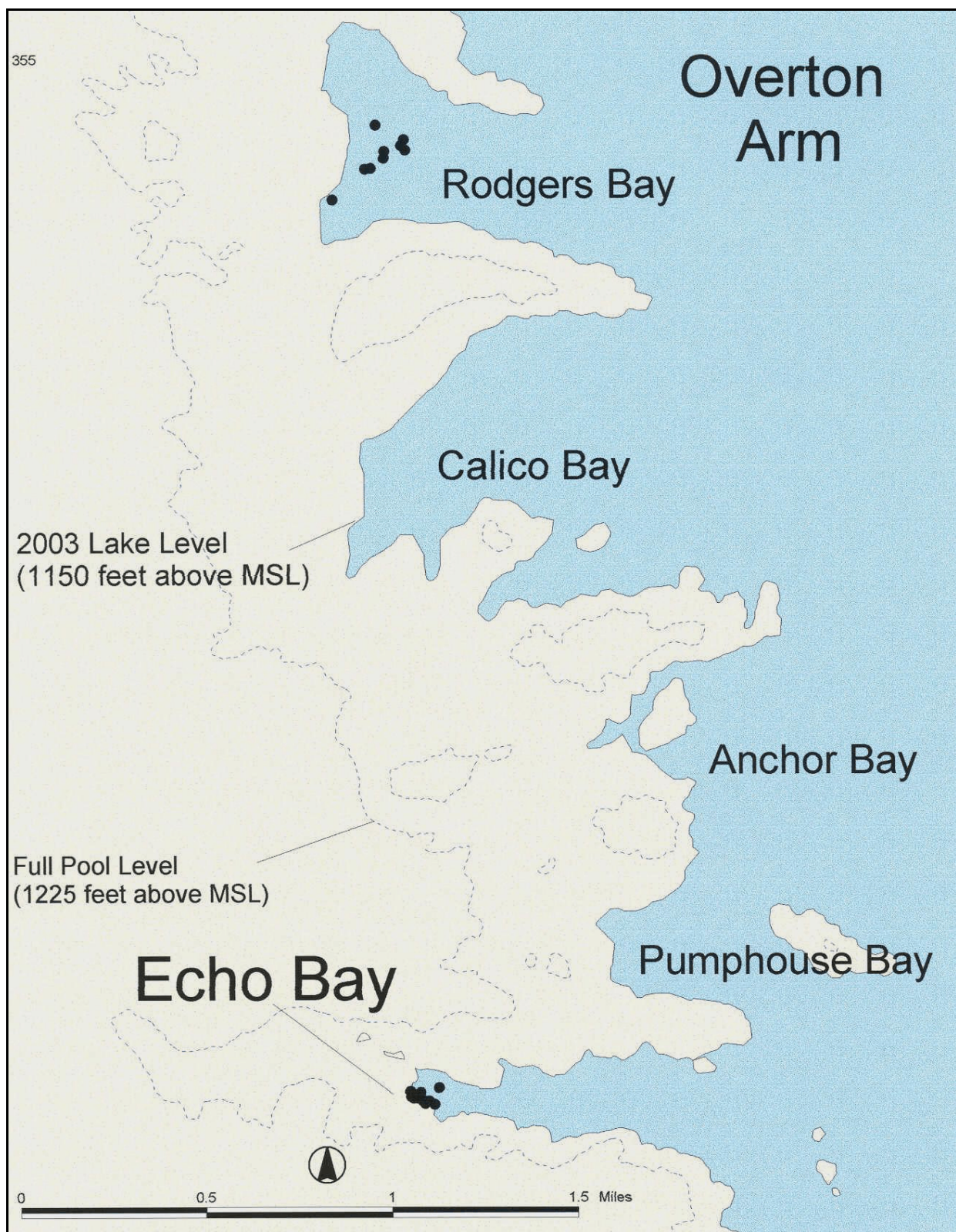


Figure 8. Distribution of fish number 355 in Overton Arm.

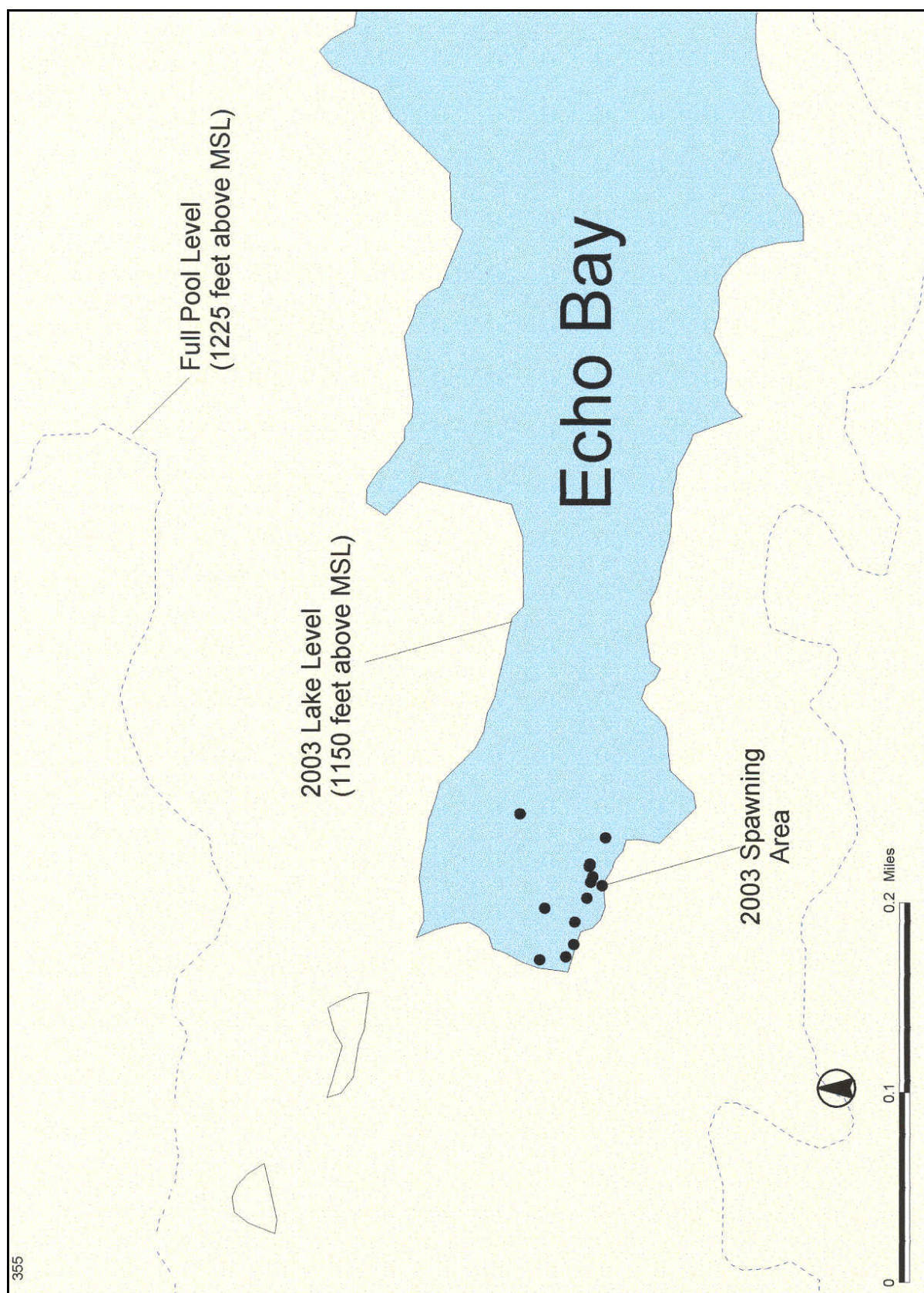


Figure 9. Distribution of fish number 355 in Echo Bay.

Overton Arm near Sand Island on January 24, 2003. It was contacted nine times at the same location from January until mid April. This fish had apparently died sometime before January 24, 2003, then became stationary near Sand Island.

Three additional sonic-tagged razorback sucker (Tags 2345, 242, and 349) from Floyd Lamb State Park were stocked with fish 253 into Bradley Bay. Tag 2345 became stationary near the mouth of Chuckwalla Cove near the end of March 2002. Searches up the Colorado River from Driftwood Island to Separation Rapid failed to locate the remaining two fish, tags 242 and 349, in the river. Extensive searches in the Gregg, Temple, Virgin, and Boulder Basins of Lake Mead, as well as Overton Arm, during the seventh study year failed to locate these fish.

Telemetry Summary

Echo Bay and Las Vegas Bay sonic telemetry results for the seventh study year provided some interesting data on habitat use for razorback sucker. Fish 355 was found in relatively shallow water in Rogers Bay during the non-spawning season. During the March-April spawning season, this fish was frequently found on the same gravelly point in shallow water near the back of Echo Bay. This indicated that the fish was probably spawning at this location. In Las Vegas Bay fish 445 was contacted most often in deep water near Pitchfork Cove. This fish didn't appear to move to Blackbird Point to spawn and did not utilize habitat near the wash inflow in the same manner as some previously tagged fish. Plotting telemetry data on elevation corrected maps did not identify any unusual habitat use patterns for fish 445 that could be attributed to decreasing lake levels. Unfortunately, fish 256 became stationary near Black Island in Las Vegas Bay and fish 456 was not contacted after its release at Echo Bay. Of the four fish released into Lake Mead near the Colorado River inflow (tags 253, 2345, 242, and 349), two became stationary and two were not contacted after May 2002. Fish 253 was last contacted in early March, 2002, near Sandy Point in Gregg Basin. This tag was stationary when it was located near Sand Island in Overton Arm some 10 months later. This fish had moved nearly 42 miles down the lake.

Larval Sampling

Echo Bay and Las Vegas Bay

Sampling for razorback sucker larvae was initiated in late February 2003. Larvae were first collected on March 4 at Las Vegas Bay, along the west shore in a small cove near the Las Vegas Wash-Lake Mead interface. At Echo Bay the first razorback sucker larvae were collected on March 5, 2003. The last larval razorback sucker was collected on May 21 at Echo Bay (Table 4). Five to eight monitoring sites at each known spawning area were sampled bi-weekly (with few exceptions) during March, April, and May 2003. Additional sampling effort was expended on Pearce Ferry Bay during 2003 to determine if razorback sucker were spawning in this area of Lake Mead. The number of razorback sucker larvae collected within Las Vegas Bay was lower in 2003 than in 2002 (73 and 176, respectively), as was the catch per minute (number of fish captured per minute of sampling [CPM]) (0.06 and 0.18, respectively [Table 4]). The highest CPM at Las Vegas Bay during 2003 was 0.30. The number of larval razorback sucker sampled and their capture locations are shown for Las Vegas Bay in Figure 10.

Table 4. Number of razorback sucker larvae collected at the Las Vegas Bay, Echo Bay, and Colorado River Inflow areas of Lake Mead during 2003.

DATE	LAS VEGAS BAY SAMPLING SITES			ECHO BAY SAMPLING SITES			COLORADO RIVER INFLOW SAMPLING SITES		
	MINUTES SAMPLED	LARVAE COLLECTED	CPM ^a	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM
2/20/03				30	0	0.00			
2/21/03	45	0	0.00						
3/04/03	90	3	0.03						
3/05/03				90	34	0.38			
3/11/03	90	0	0.00						
3/12/03				90	41	0.46			
3/13/03	30	0	0.00						
3/18/03				93	54	0.58			
3/19/03	90	0	0.00						
3/24/03				90	94	1.04			
3/31/03	105	10	0.10						
4/01/03				90	22	0.24			
4/07/03	90	21	0.23						
4/08/03				90	72	0.80			
4/10/03	75	1	0.01						
4/13/03				90	62	0.69			
4/15/03							195	0	0.00
4/16/03	120	2	0.02						
4/21/03	30	4	0.13						
4/22/03				90	37	0.41			
4/23/03							105	0	0.00
4/24/03							60	0	0.00
4/30/03							150	0	0.00
5/01/03							150	0	0.00
5/02/03				105	72	0.69			
5/03/03	90	27	0.30						
5/05/03	75	0	0.00						
5/06/03				90	52	0.58			
5/07/03							105	0	0.00
5/13/03							165	0	0.00
5/14/03							150	0	0.00
5/15/03				90	9	0.10			
5/16/03	90	0	0.00						
5/19/03							150	0	0.00
5/20/03				90	3	0.03			
5/21/03	90	5	0.06						
5/26/03				90	0	0.00			
5/27/03	90	0	0.00						
5/28/03							150	0	0.00
Totals	1,200	73	0.06	1,218	552	0.43	1,380	0	0.00

^a CPM = catch per minute.

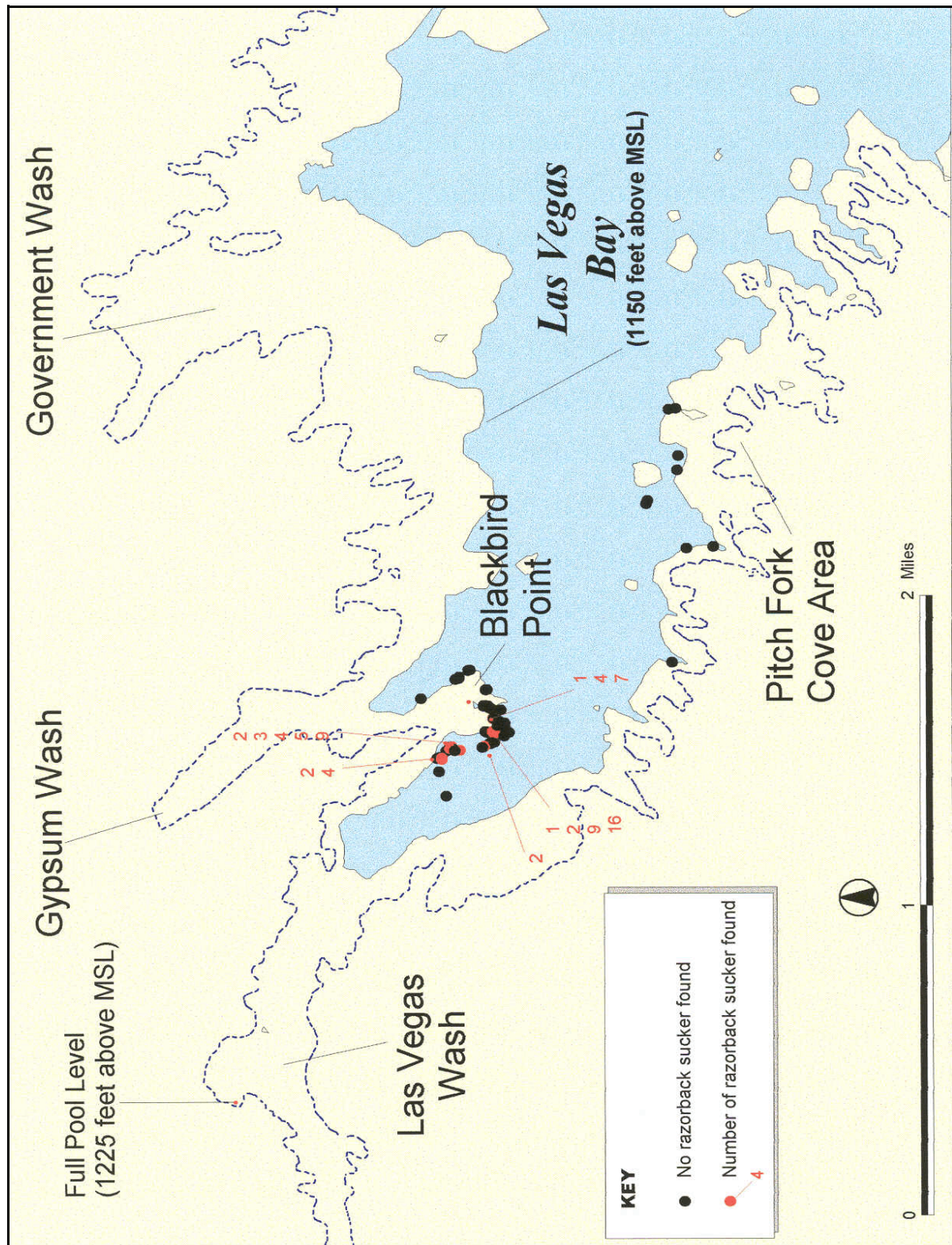


Figure 10. Las Vegas Bay study area showing larval razorback sucker sample and capture locations.

The number of larvae collected at Echo Bay in 2003 was lower than the number collected in 2002. Five hundred fifty-two razorback sucker larvae were collected during 2003, compared with 1,022 razorback sucker larvae collected during 2002, 987 in 2001, 73 in 2000, 95 in 1999, and 197 during 1998. The 2003 CPM at Echo Bay was lower than in 2002 (0.43 and 1.67, respectively). The CPM was higher in 2003 than the second, third, and fourth study years (1997-1998, 1998-1999, 1999-2000), but lower than the first, fifth, and sixth study years (1996-1997, 2000-2001, 2001-2002). 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 May (Table 4). The highest CPM at any Echo Bay site during 2002 was 1.04 on March 24. The larval razorback sucker sample and capture sites are shown for Echo Bay in Figure 11.

The previously documented razorback sucker spawning site at Echo Bay (cliff spawning site, Figure 11) was dry July 2001 through June 2002. In 2002 razorback sucker spawning occurred elsewhere in Echo Bay. High turbidity prevented identification of the exact location of the spawning site(s) in Echo Bay. High concentrations of larval razorback sucker in two coves along the south shore of the bay indicate that spawning most likely occurred on a point separating the two coves (Figure 11). In 2003 the presumptive spawning site used in 2002 was dry. High concentrations of larvae and the presence of a sonic-tagged fish for nearly 2 months on a gravelly point indicated that this was the spawning site used during the seventh study year. This site was located 30 meters to the east of the 2002 spawning area on the south shore of Echo Bay (Figure 11). This information indicates that razorback sucker in Lake Mead can change spawning areas as the lake changes elevation.

Colorado River Inflow Area

Larval sampling outside of the Echo Bay and Las Vegas Bay areas during spring 2003 was conducted entirely at the Colorado River inflow area. In 2000 and 2001 larvae were found near Driftwood Island in Twin Coves and Bradley Bay. However, these sites were inaccessible in 2002 and 2003 because of dropping lake levels. Therefore, the sampling effort was concentrated between the north end of Iceberg Canyon and Sandy Point area (Figure 12). This area was sampled in a random fashion from April 15 to May 19.

Larval sampling in Pearce Ferry Bay was conducted on April 24, 2003. A second attempt was made to sample this area on May 8; however, high turbidity caused poor sampling conditions. On both dates numerous sites were sampled from shore in water approximately 0.5 m deep. No larval razorback sucker were captured during 60 minutes of sampling; however, juveniles and adults of a non-native species, red shiner (*Cyprinella lutrensis*), were collected.

No razorback sucker larvae were captured in the Colorado River Inflow Area in 2003. Total effort in this area of Lake Mead included 98 sampling sites and 1,380 minutes of sampling with two crappie lights and two netters (Table 4). During the previous year only one larval sucker was captured in this area of the lake; this occurred on April 22 in Chuckwalla Cove. This specimen was identified as a flannelmouth sucker (*Catostomus latipinnis*) in the lab by BIO-WEST and later verified (D. Snyder, curator, Colorado State University Larval Fish Lab, personal communication). During spring 2001, 22 larval razorback sucker (voucher specimens identified by D. Snyder, Colorado State University Larval Fish Lab) were found at 13 of the 257 sites sampled in the Colorado River inflow area.

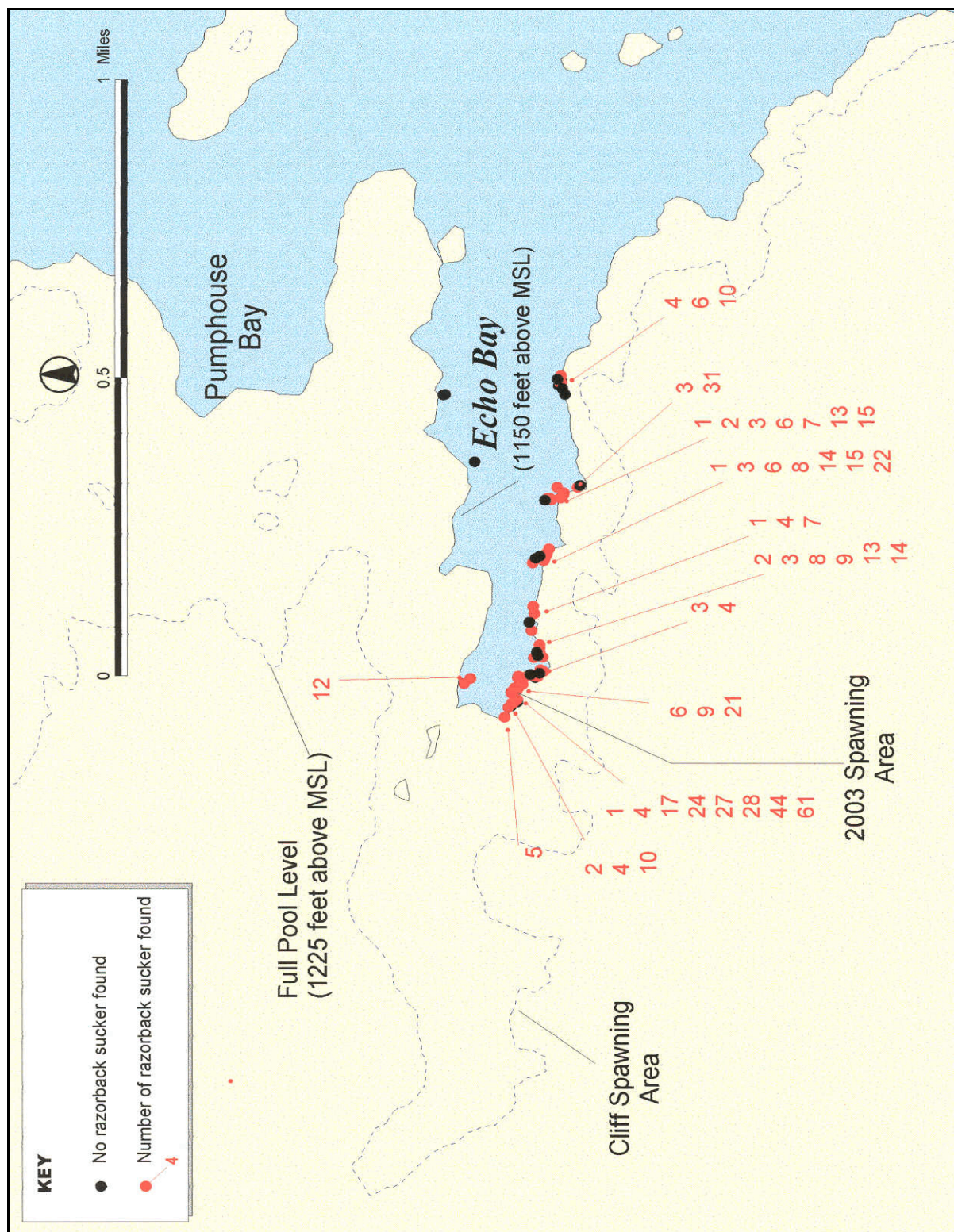




Figure 12. Colorado River inflow study area showing larval razorback sucker sample locations.

Influence of Fluctuating Lake Elevation on Razorback Sucker Spawning Locations

Lake Mead elevation during the spawning period (month-end elevation for March in each year) ranged from a high of 1,214.3 feet amsl in 1998 to a low of 1,144.5 feet amsl in 2003 (1997 = 1,199.1 feet amsl, 1999 = 1,211.8 feet amsl, 2000 = 1,211.3 feet amsl, 2001 = 1,194.7 feet amsl, 2002 = 1,167.5); a difference of nearly 70 feet. Most of the decline in lake elevation (67 feet) has occurred since the 2000 spawning season. The data suggest that the drop in lake elevation over the last three spawning seasons has influenced spawning location at Echo Bay and spawning success and/or location at the Colorado River inflow area of Lake Mead.

At Echo Bay in 1997 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 in two small coves and at the base of a 50-foot-high cliff (Figure 11). In 1998 spawning again occurred in these same areas of Echo Bay. Aggregations of spawning adult fish at the base of the cliff were videotaped with an underwater camera in 1999, verifying that spawning was occurring in this portion of Echo Bay. Fish were again observed using the cliff area for spawning in 2000 and 2001. Water depth at the cliff spawning site during the 2001 spawning season was between 1-2 ft. At the end of the spawning season in May 2001, this site was dry. The data suggest that fish can use the cliff site for spawning until the lake elevation dips below 1,189 feet amsl. During the 2002 spawning season, the cliff spawning site was dry and lake elevations were between 1,171 and 1,162 ft amsl. High concentrations of larval razorback sucker were captured in 2002, despite the absence of the cliff spawning site. Larval concentrations indicate that razorback sucker most likely spawned to the east of the cliff site along the south shore of Echo Bay on a point that separates two small coves (Figure 11). At the beginning of the 2003 spawning season this point was dry. High larval concentrations found near the 2002 spawning site indicated that spawning most likely occurred on a gravelly point approximately 30 m to the east of the 2002 spawning area along the south shore.

Larval concentrations like those found at Echo Bay were not found at Las Vegas Bay during any study year. The highest concentrations of larval razorback sucker were found in 1998 and 2002; most of these larvae were captured along the west shore and tip of Blackbird Point. During this study sonic-tagged and trammel net-captured adults were also found in the highest concentration along the western shore and tip of Blackbird Point during the spawning period, suggesting that spawning was occurring near the tip of Blackbird Point. From 1997-2000 the spawning area was thought to be at a depth of about 60-80 feet (Holden et al. 2000a). In 2002 ripe razorback sucker were caught at a depth of only 15-20 feet but in the same area of previous years' captures. All razorback sucker larvae in 2003 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 of this study, but the depths have changed as the lake has dropped. Lake elevation during the 2003 spawning season was about 1,150 feet amsl, or about 60 feet lower than during the spawning periods in 1999 and 2000. As lake levels continue to decline and the Las Vegas Wash Delta moves out into Las Vegas Bay, the spawning area near the tip of Black Bird Point may become either dry or covered with the encroaching sediment from the wash delta.

In 2000 larvae were found in the Colorado River inflow area of Lake Mead near God's Pocket and Pearce Ferry Bay. In 2001 larvae were found further down lake at Bradley Bay, Driftwood Island, and Twin Coves. High concentrations of larvae were not found in any particular area during either year, thereby making it difficult to locate spawning sites. Extensive netting efforts in areas where larvae were captured failed to produce adult fish. In 2002 and 2003 declining lake levels prevented access to some areas where larvae were found during the previous two study years; therefore, most larval sampling in the inflow area in 2002 was concentrated further down lake near Bradley Bay and Twin Coves. In 2003 most larval sampling was conducted near Iceberg Canyon. In 2002 and 2003 no razorback sucker larvae were found in this area of Lake Mead.

Spawning Area Substrate Assessment

The average substrate size at the two Echo Bay spawning sites was identical (26.5 mm [intermediate axis length]) (Table 5) and classified as coarse gravel (Figures 13 and 14). The majority of substrate particles measured at each site was gravel sized (cliff spawning site=87%, 2003 spawning site=79%) with cobble and sand comprising 9% and 4% of the total particles measured at both sites, respectively. The average particle size measured at the four Blackbird Point sites ranged from 23 mm to greater than 46 mm (Table 5). The substrate composition at these four sites was similar to that at Echo Bay, with between 72% and 90% classified as gravel. However, the Blackbird Point sites tended to have higher percent composition of cobble-sized particles.

Juvenile Sampling

Sampling for juvenile razorback sucker during previous study years has produced none. Therefore, juvenile sampling was de-emphasized during the seventh study year with only minnow traps used to sample for these fish. No juvenile razorback sucker and only 18 fish representing four species (green sunfish [*Lepomis cyanellus*], 14; bluegill [*Lepomis macrochirus*], 1; red shiner, 1; largemouth bass [*Micropterus salmoides*], 1) were captured during the seventh study year (July 2002 through June 2003) using this gear. Locations of minnow traps sets for Las Vegas Bay (Blackbird point) are shown on Figure 4 and on Figure 5 for Echo Bay.

Razorback Sucker Aging

Determining ages of Lake Mead razorback sucker was added to the project in 1998 when a sub-adult fish (381 mm) was collected and subsequently died (Holden et al. 1999). This initiated development of a non-lethal aging technique using fin ray sections during 1999 (Holden et al. 2000a). A major emphasis of the effort in 2002-2003 involved collecting fin ray sections from razorback sucker for aging.

Twenty-four of the razorback sucker collected during trammel netting on Lake Mead during the 2002-2003 sampling period had approximately 0.25-inch sections of the second left pectoral fin ray surgically removed. The fin ray sectioning went well for all fish. There was minimal bleeding at the surgical sites, and all fish quickly regained equilibrium and swam off normally when released.

Table 5. Substrate composition of spawning areas at Echo Bay and Blackbird Point.

SUBSTRATE SIZE CLASS	PERCENT COMPOSITION					
	ECHO BAY CLIFF SPAWNING SITE	ECHO BAY 2003 SPAWNING SITE	BLACKBIRD POINT SITE #1	BLACKBIRD POINT SITE #2	BLACKBIRD POINT SITE #3	BLACKBIRD POINT SITE #4
Silt/Clay (<0.062 mm ^a)	0.0%	4.9%	0.0%	1.0%	0.0%	1.0%
Sand (0.062-2 mm)	4.0%	3.6%	2.0%	1.0%	1.0%	3.0%
Gravel (2-64 mm)	87.0%	78.8%	72.0%	86.0%	83.0%	90.0%
Fine Gravel (2-8 mm)	20.8%	9.1%	7.0%	8.0%	7.0%	12.0%
Medium Gravel (8-16 mm)	22.8%	24.9%	17.0%	21.0%	21.0%	31.0%
Coarse Gravel (16-64 mm)	40.5%	44.9%	48.0%	57.0%	55.0%	47.0%
Cobble (64-256 mm)	9.0%	8.5%	26.0%	12.0%	16.0%	6.0%
Small Cobble (64-128 mm)	9.8%	6.7%	19.0%	10.0%	15.0%	5.0%
Large Cobble (128-256 mm)	0.8%	1.8%	7.0%	2.0%	1.0%	1.0%
Average substrate size (mm)	26.5	26.5	46.3	29.6	37.2	23.3
Coefficient of Variation	1.01	1.12	0.94	1.01	0.92	1.01

^a mm = Millimeters.

A definitive age was obtained for 20 of the 24 razorback sucker processed, and an age range determined for the other fish (Table 6). Twelve specimens were aged at 10 years or less, two of them ranged from 10 to 15 years of age, four of them ranged from 16-20 years of age (one of these fish was a known-age fish that was stocked into Lake Mead), and six were greater than 20 years old. Nine of the specimens were sub-adults and were aged from 4 to 5 years (one of these fish was a known-age fish that was stocked into Lake Mead). Table 6 also includes an estimate of the year each fish hatched.

One of the 22 wild fish was likely spawned around 1974, one in 1976, one in 1978, one in 1981, two in 1982, one in 1983, two in 1986, two in 1989, two in 1992, one in 1993, one in 1997, and seven in 1998. Table 6 shows the results of aging efforts for the 40 fish previously aged and the 24 (22 wild fish and 2 stocked fish) fish aged in 2003. Figure 15 shows the number of fish spawned per year plotted against Lake Mead elevations from January 1935 to June 2003. All of the fish aged by BIO-WEST were spawned between 1974 and 1998, except for one fish that was spawned around 1966. Most of these fish were spawned during high lake elevations from 1978-1989 and 1997-1998.



Figure 13. Substrate composition at the Echo Bay cliff spawning site, 1997-2001.



Figure 14. Substrate composition at the Echo Bay 2003 spawning site.

Cove and Inflow Vegetation Assessment

Most of the vegetation at the 10 study sites (Figure 2) was composed of *Tamarix* spp. (woody cover). The only study site with large amounts of non-woody cover was Las Vegas Wash. Most of this vegetation was found near the wash-lake interface at the wash delta. Stands of vegetation that were included in the >75% aerial cover category at any of the study sites were composed primarily of *Tamarix* spp. and averaged over 1 m in height (Table 7). Stands of vegetation that were classified as possessing <25% aerial cover were composed of either woody or herbaceous vegetation and ranged from less than 100 mm to greater than 2,000 mm in height. The vegetation included in the other two cover categories (50-75% and 25-50% aerial cover) were equally as variable in composition and height across the 10 study areas (Table 7). The Muddy River inflow (Figure 16), Virgin River inflow, and Colorado River inflow (Figure 17) had the highest amount of aerial cover of the 10 areas sampled. Greater than 80% of the area sampled at these three study sites was included in the >75% aerial cover category. The vegetation was composed mainly of *Tamarix* spp. and was approximately 1,500 mm in height at each of the sites. Figures 18 and 19 depict the typical *Tamarix* spp. stands found at the three areas. Greater than 90% of the area sampled at the Colorado River inflow was included in the two most-dense cover categories. Las Vegas Wash (Figure 20), Echo Bay, and Callville Wash also contained high amounts of aerial cover with 45.9%, 27.1%, and 26.6% of the area sampled at each study site included in the >75% aerial cover category, respectively (Table 7). The three river inflow areas not only contained the highest percentage of dense aerial cover but also contained the largest amount of land with dense stands of woody vegetation (predominately *Tamarix* spp.). The Muddy River inflow, Virgin River inflow, and Colorado River inflow areas contained between 1,000 and 1,500 ha of land with dense stands of woody vegetation that averaged nearly 1,500 mm in height. The study site with the next highest amount of this vegetative cover was Las Vegas Wash which only had 30.9 ha. The lowest aerial cover was found at Trail Rapids Bay. Nearly 94 % of the area sampled at this study site was included in the <25% aerial cover category (Figures 21 and 22).

Secchi disc measurements ranged from <0.5 m at the Colorado River inflow to 6.0 m at Trail Rapids Bay (Table 7). Las Vegas Wash and the three river inflow areas had the highest turbidity with secchi depths of 1 m or less.

Population Estimate

Capture data collected by BIO-WEST from 2001-2003 were used to calculate abundance estimates for razorback sucker populations at Echo Bay and Las Vegas Bay. Stocked fish, except those that had survived at least 1 year in Lake Mead, were not used in the population estimates. 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 (2002-2003) and 3-year periods (2001-2003) of this study.

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
02/27/00	628	17+	1979-1982
01/08/00	650	18+	1978-1981
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 ^d	354	4	1998
12/6/02 ^d	400	4	1998
12/6/02 ^d	376	4	1998
12/19/02 ^d	395	4	1998
1/7/03 ^d	665	16	1986
1/22/03 ^d	494	4	1998
2/5/03 ^d	385	4	1998
2/18/03 ^d	443	5	1997
3/4/03 ^d	635	19	1983
3/20/03 ^d	420	4	1998
4/8/03 ^d	638	21 ^c	1982
4/17/03 ^d	618	10	1992
4/22/03 ^d	650	20-22	1980-1982
5/4/03 ^d	415	3+ ^b	1999

Table 6. Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead (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
5/02/02	568	18-19	1983-1984
12/04/02 ^d	705	26	1976
1/18/02 ^d	551	13	1989
1/21/03 ^d	591	16	1986
2/3/03 ^d	655	27-29	1974
2/3/03 ^d	580	13	1989
4/2/03 ^d	639	19-20	1982
4/2/03 ^d	580	23-25	1978
4/23/03 ^d	584	10	1992
5/6/03 ^d	507	9+	1993
5/6/03 ^d	594	20	1982

^a mm = Millimeters.

^b Fish stocked from Echo Bay larval fish captured in 1999 and raised at NDOW 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.

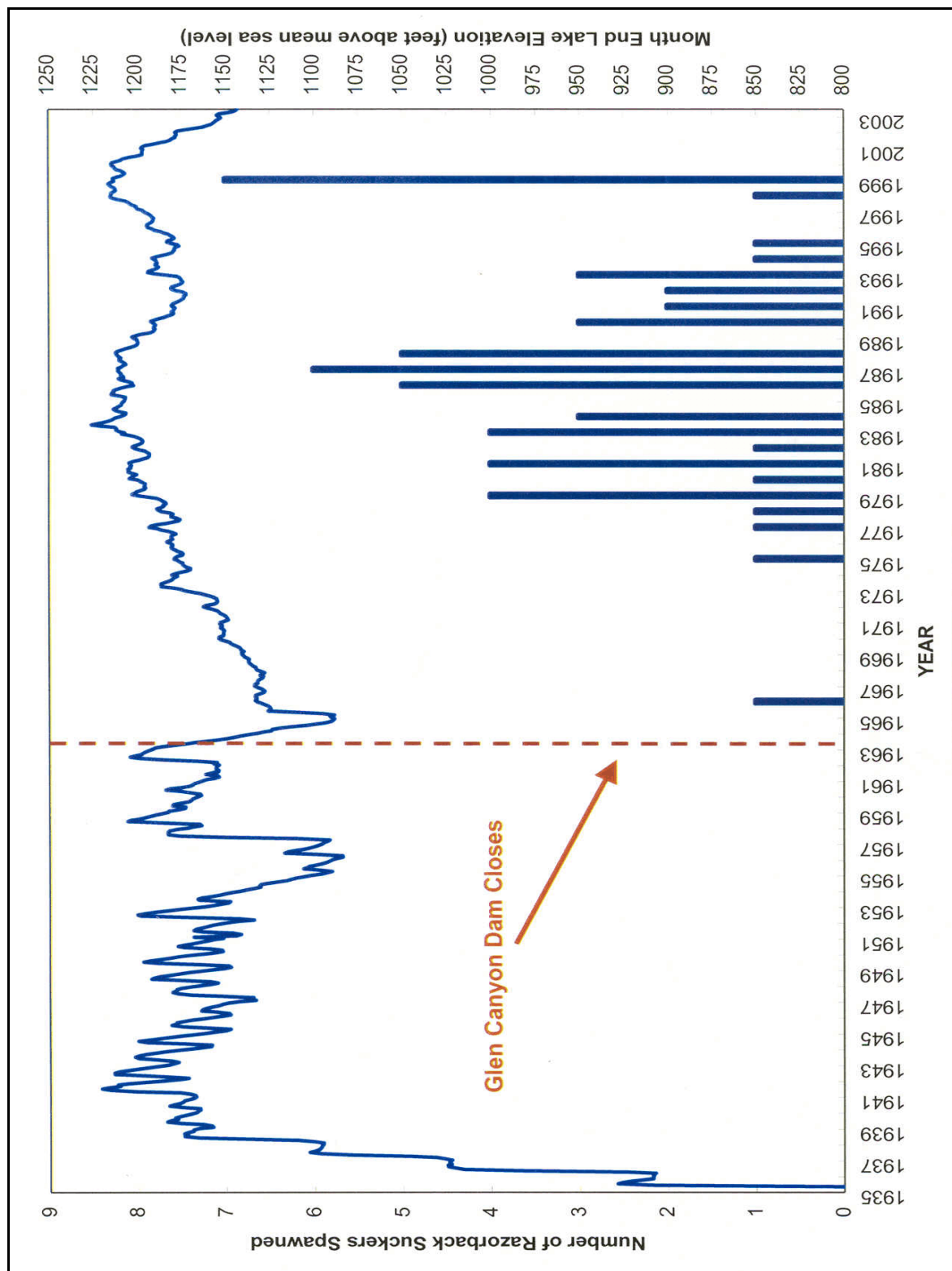


Figure 15. Lake Mead hydrograph from January 1935 to June 2003 with the number of aged razorback sucker that were spawned each year.

Table 7. Attributes of Lake Mead coves and inflow areas assessed for possible introduction of razorback sucker.

VARIABLES (VEGETATION AERIAL CATEGORY)	COVES AND INFLOW AREAS									
	LAS VEGAS WASH	ECHO BAY	BOULDER WASH COVE	TRAIL RAPIDS BAY	TEAL COVE	CALLVILLE WASH	ALKALI SPRINGS COVE	MUDDY RIVER INFLOW	VIRGIN RIVER INFLOW	COLORADO RIVER INFLOW
>75% COVER	45.9%	27.1%	0.0%	0.0%	17.3%	26.6%	9.7%	80.2%	82.9%	82.6%
Hectares	30.9	5.7	0.0	0.0	0.9	2.3	4.4	1,093.5	954.3	1,622.5
Dominant Plant Type/Species	woody /Tamarix spp.	woody /Tamarix spp.	-	-	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.
Average Plant Height ^a (mm ^b)	2,000	876	-	-	1,975	1,483	775	1,663	1,553	1,580
50-75% COVER	6.7%	5.8%	0.0%	0.0%	0.0%	7.5%	0.0%	<1.0%	0.0%	8.8%
Hectares	4.5	1.2	0.0	0.0	0.0	0.6	0.0	3.4	0.0	173.3
Dominant Plant Type/Species	herbaceous /Setaria spp.	woody /Tamarix spp.	-	-	-	woody /Tamarix spp.	-	herbaceous /Typha spp.	-	woody /Tamarix spp.
Average Plant Height (mm)	305	528	-	-	-	1,000	-	2,000	-	1,366
25-50% COVER	2.1%	0.0%	37.2%	6.2%	8.2%	16.9%	92.3%	5.9%	12.3%	1.8%
Hectares	1.4	0.0	0.5	0.3	0.4	1.5	41.2	81.2	141.0	33.8
Dominant Plant Type/Species	herbaceous /Salsola iberica	-	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.
Average Plant Height (mm)	250	-	1,425	181	340	1,600	1,200	1,866	955	1,500
<25% COVER	45.3%	67.1%	62.8%	93.8%	74.5%	49.0%	0.0%	13.7%	4.8%	6.8%
Hectares	30.5	14.1	0.8	3.7	3.9	4.2	0.0	186.7	55.5	134.3
Dominant Plant Type/Species	herbaceous /Xanthium spp.	woody /Tamarix spp.	woody /Tamarix spp.	woody /Tamarix spp.	herbaceous /Setaria spp.	woody /Tamarix spp.	-	woody /Tamarix spp.	woody /Tamarix spp.	bare ground
Average Plant Height (mm)	82	1,591	506	1,923	159	2,313	-	139	1,000	-
Secchi Depth (mm)	0.7	2.0	4.7	6.0	4.7	3.0	2.0	1.0	1.0	<0.5

^a Average plant height for each cover category at a location was weighted by the number of hectares.

^b mm = Millimeters.

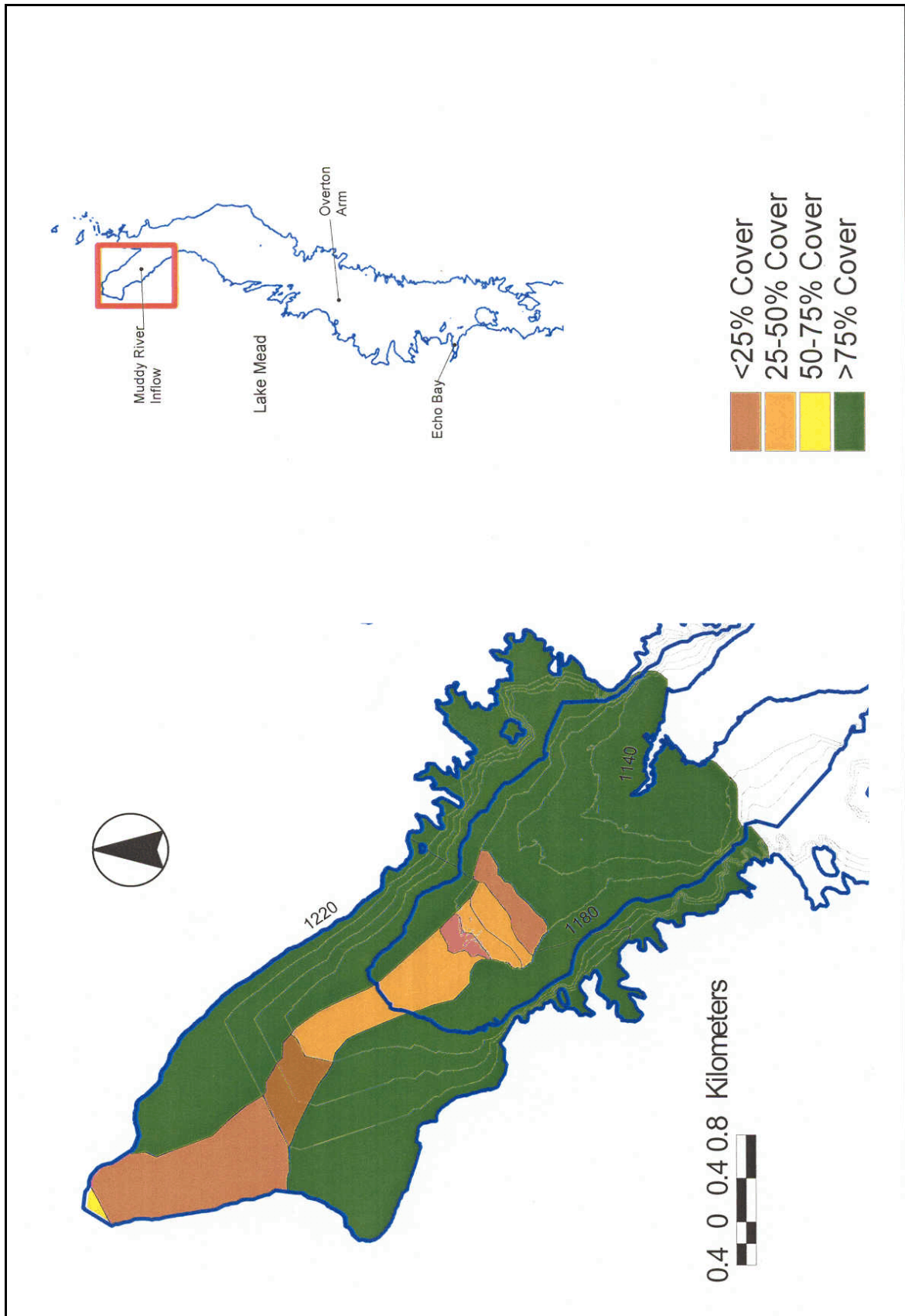


Figure 16. Map depicting the distribution of vegetation cover categories at the Muddy River inflow area.

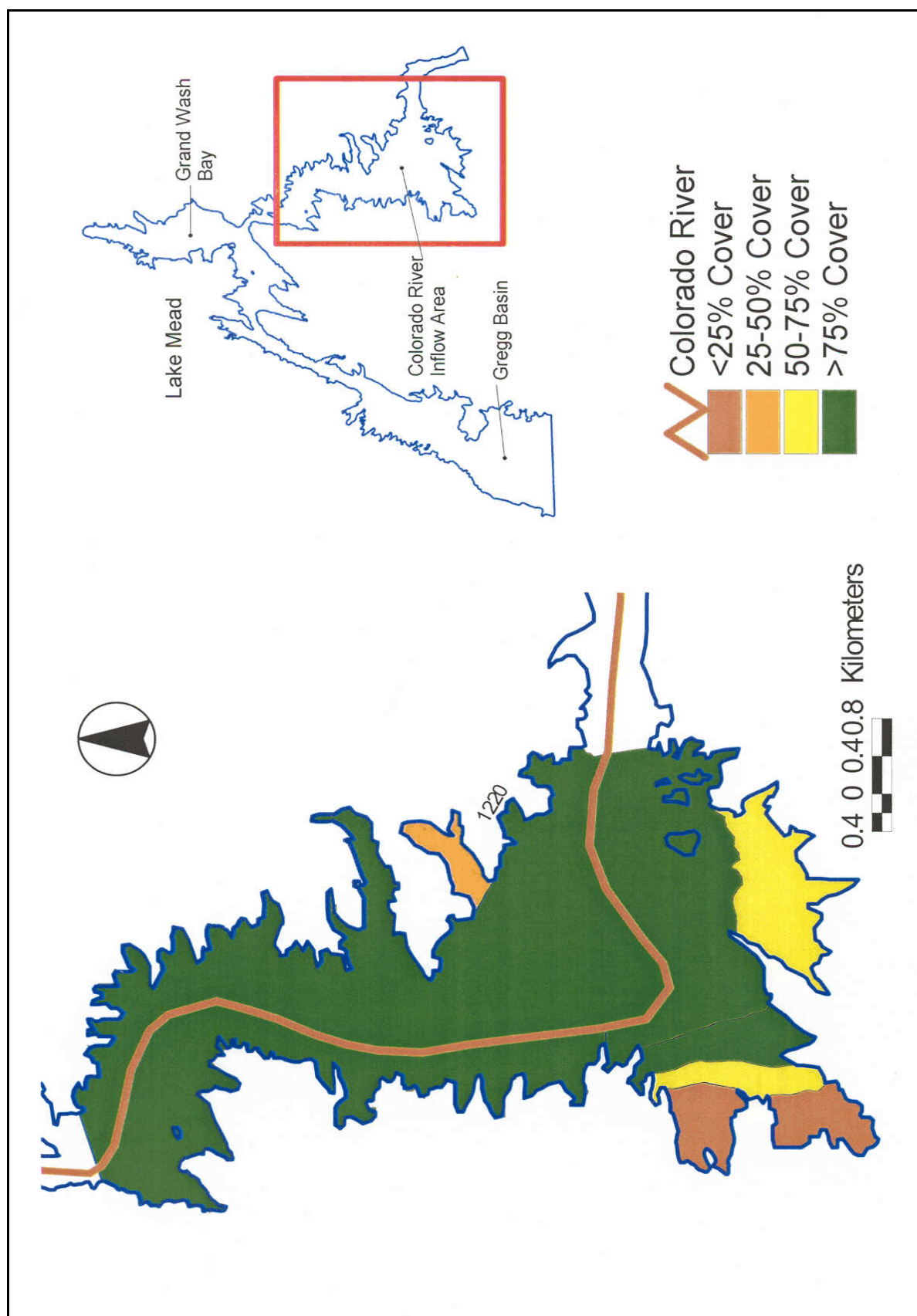


Figure 17. Map depicting the distribution of vegetation cover categories at the Colorado River inflow area.



Figure 18. Dense stands of woody cover (mostly *Tamarix* spp. with some *Salix* spp.) at the Colorado River inflow area.



Figure 19. Dense woody cover composed of *Tamarix* spp. near Pearce Ferry Bay at the Colorado River inflow area.

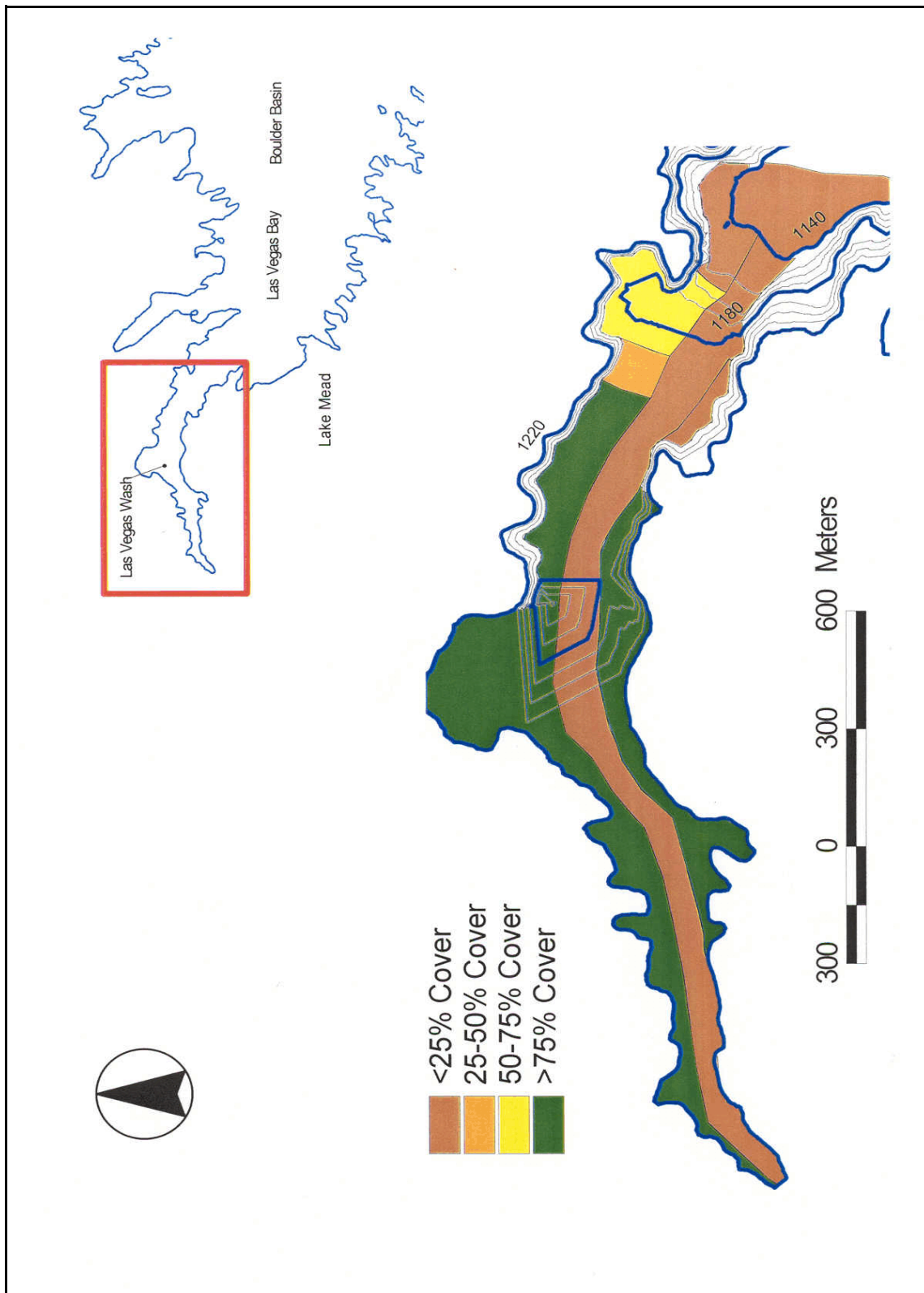


Figure 20. Map depicting the distribution of vegetation cover categories at Las Vegas Wash.



Figure 21. This photo typifies the sparse cover found at Trail Rapids Bay.



Figure 22. Sparse cover at Trail Rapids Bay typical of the <25% cover category.

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. For each period examined, close agreement between the two models indicated a reliable estimate. If the estimators gave very different numbers, then a reliable estimate was believed to lie somewhere between the two numbers.

Table 8 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 48 fish to a high of 70 fish for the two time periods. Las Vegas Bay estimates were higher than those of Echo Bay, ranging from a low of 76 fish to a high of 423 (the estimate of 423 had an extremely large confidence interval). Population abundance remains highly variable at both study areas and any patterns are difficult to distinguish due to the high variability.

Table 8. Population estimates using data from 2001-2003.

ESTIMATOR	ECHO BAY			
	2001-2003	95% CI^a	2002-2003	95% CI
Model M_o	57	48-83	49	34-92
Chao M_h	73	49-144	48	32-102
MODEL SELECTION PROCEDURE				
Jackknife	73	52-121	46	34-76
ESTIMATOR	LAS VEGAS BAY			
	2001-2003	95% CI	2002-2003	95% CI
Model M_o	76	54-126	110	61-247
Chao M_h	97	58-209	423	102-2203
MODEL SELECTION PROCEDURE				
Jackknife	99	66-170	173	121-256

^a CI = Confidence Interval.

DISCUSSION

Information collected during the seventh 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 continued to confirm 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 24 adult razorback sucker were added to the data from 40 fish aged in 1998, 1999, 2000, and 2001. 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 than during the two previous years. At 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, as well as others, was able to utilize a new spawning location and locate other spawning razorback sucker as water levels decreased.

Similar to 2002, video surveillance in 2003 was unsuccessful in documenting spawning activity at the suspected Echo Bay spawning site. High larval abundance in this area indicated that spawning was occurring there. However, turbidity and shallow water at the spawning site made extensive use of this sampling gear unproductive. Similarly at Las Vegas Bay, high turbidity resulting mostly from sediment-laden flows from Las Vegas Wash also limited the usefulness of underwater video equipment.

Larval sampling CPE for the 2002 spawning season decreased at Las Vegas Bay and at Echo Bay, compared with the previous year. The CPE and total number of larvae at Las Vegas Bay in 2003, however, were higher than in all other study years except 1998 and 2002. The high numbers of larvae at Echo Bay continued a trend of high larval abundance at this site. The 2003 larval catch numbers for Echo Bay were higher than in all study years except 1997, 2001, and 2002; the number caught in 2003 was nearly half the number caught in 2002. 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 fish to use spawning areas other than those at Blackbird Point or Echo Bay.

No razorback sucker larvae were found during sampling in the Colorado River inflow area. Failure to capture larvae in this area may be attributed to lowering lake levels that may have altered spawning habitat, prevented access to spawning sites, or changed fish distribution in the area. Sonic-tagged fish that were released into this area of Lake Mead in 2002 remained in close proximity to the release area for several months; this is the same general area where larvae were captured in 2001. However, as lake levels dropped, several of the fish began to move down lake. Contact with all fish was lost by May 2002. In January 2003 one of the sonic-tagged fish released into this area was found stationary in Overton Arm over 40 miles from its last contact in the inflow area. This is evidence that the other sonic-tagged fish, and perhaps wild fish, moved to other areas of Lake Mead as water levels dropped and the habitat changed in the inflow area.

The precipitous drop in lake elevation over the last 3 years has influenced razorback sucker spawning sites at Echo Bay and the Colorado River inflow area of Lake Mead but not the spawning site at Las Vegas Bay. At Echo Bay, during the spawning seasons of 1997-2001, razorback sucker spawned at or near the cliff spawning site at the back of the bay. In 2003 the 2002 site was dry and spawning occurred on an adjacent point to the east along the south shore. This indicates that razorback sucker in Lake Mead 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. To date, declining lake levels at Las Vegas Bay have not appeared to affect the razorback sucker spawning location. 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. If the lake continues to drop, the Las Vegas Bay spawning site

may eventually be negatively impacted by low water levels. Additionally, as lake levels have declined, Las Vegas Wash has migrated out into Las Vegas Bay. The wash is depositing large quantities of silt and sand into Las Vegas Bay, approximately 65 tons per day (T. Porta, Nevada Division of Environmental Protection, personal communication). At the end of June 2003, the wash delta had migrated to within 0.25 mile of the suspected spawning area at Blackbird Point. This spawning site may become covered with wash sediment.

The substrate composition of spawning bars used by razorback sucker in Echo Bay was predominately medium and coarse gravel with some small cobble. 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, Minckley et al. 1991, Tyus 1987, Tyus and Karp 1990). At Echo Bay the two spawning sites are located on gently sloping shorelines, which is similar to spawning sites in other lacustrine habitats throughout the basin (USFWS 1998). The location of the spawning site(s) at Blackbird Point has not been found. Its general location is thought to be along the tip or west shore. The substrate composition measured at four sites near the suspected spawning area at Blackbird Point was very similar to the substrate composition of the two Echo Bay spawning sites, indicating that suitable spawning substrate exists in this area. To our knowledge this is the first quantitative study of razorback sucker spawning substrate.

Growth of recaptured Lake Mead razorback sucker continues to surpass growth rates recorded for other wild razorback sucker populations. Mean annual growth for recaptured fish at Echo Bay was 10.0 mm, compared with 10.5 mm the previous sampling year and 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). At Las Vegas Bay mean annual growth was 29.7 mm, which is much higher than previous years. This value was inflated by a stocked fish that grew 171 mm in 7 months. If the mean annual growth for the Las Vegas Bay population were recalculated without this value, the growth is 13.9 mm, which is similar to other study years.

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 captured 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. Only 6 of 22 fish captured during the spawning period were new captures, giving a 27.7% capture rate for previously uncaptured fish. For the non-spawning period, 12 of 20 fish were new captures. This gave a 60.0% capture rate for previously uncaptured fish. The combined capture rate for the two periods was 42.9%, which is approximately 14% lower than the rate for 2002, but it is still 13% higher than 2001. It is unknown why the rate of capture for previously uncaptured fish dropped in 2003. 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.

During the seventh study year, aging efforts continued and fin clipping was the appropriate method for obtaining a hard structure. Calculated ages ranged from 4 to more than 25 years for the 24 razorback sucker collected in 2003. Ages of the 22 wild fish aged in 2003 and the 40 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 process continues to produce viable results, and as more fish are aged it 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 and the fish would have lived in the lake for 40-50 years and then 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, and 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 of the fish 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 that had, potentially, many 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 15) 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 and has been operated with relatively small annual fluctuations, but relatively large multiple-year fluctuations, since that time. We suspect that the draw down 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. Individuals greater than 30 years indicate that limited recruitment may have occurred during the period of 1966-1978 when lake elevations slowly rose to their highest levels (1978-1987), a time when the maximum amount of intact inundated vegetation probably existed in the lake.

Lake Mohave, where razorback sucker natural 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. But 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 2002-2003 netting and aging results. Ten wild sub-adult fish were captured this past field season, seven 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 amsl to 1,180 amsl (Figure 3). This low lake elevation was sustained until 1995 when lake levels climbed steadily to approximately 1,215 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 amsl and 1,215 amsl elevations during the 1988-1991 drawdown period. Much of this vegetation was inundated from 1997 through 2000 and was available as protective cover for young razorback sucker. This inundated terrestrial vegetation, we believe, allowed razorback sucker that were spawned in 1997 and 1998 to avoid predation by non-native fishes.

As suspected, Las Vegas Wash and Echo Bay both contained substantial amounts of woody terrestrial vegetation that could be used as protective cover by young razorback sucker if lake levels were to rise. Both areas also exhibited high turbidity, which could also serve as protective cover for young razorbacks. However, these two areas contained much less terrestrial vegetation than the Muddy River, Virgin River, and Colorado River inflow areas. These three areas also exhibited high turbidity. Larval razorback sucker have been captured by BIO-WEST in the Colorado River inflow area and an adult fish was captured there by Arizona Game and Fish Department in the late 1990s. Shoaling adult fish also were observed in the shallow water of the Pearce Ferry boat ramp in the 1970s. A single adult razorback sucker was captured near the Virgin and Muddy River inflow area of Lake Mead in 1999 during standard gill netting surveys conducted by NDOW. Substrate on the east shore of the Muddy River inflow and the west shore of the Virgin River inflow is similar to that found at the two Echo Bay spawning sites (personal observation). An apparent adult population of razorback sucker exists somewhere in the Colorado River inflow area. It is likely – based on the capture of an adult fish (although this could be a fish from the nearby Echo Bay population) in the Virgin and Muddy River inflow areas and the occurrence of large amounts of potential cover, high turbidity, and nearby suitable spawning substrate – that a population of razorback sucker also could exist in this region of Lake Mead.

If a future management goal is to establish additional populations of razorback sucker in Lake Mead through juvenile fish introduction, a knowledge of the amount and types of vegetation that may be inundated at specific areas as lake levels increase would be desirable. Cover in the form of inundated terrestrial vegetation and turbidity has been suggested as necessary for recruitment of razorback sucker in lacustrine habitats of the lower Colorado River (Golden and Holden 2003). The cover that has grown between the current lake shoreline and the full pool elevation of 1,225 ft amsl during the declining lake levels of the last 3 years gives an indication of the type and amount of cover potentially available to young razorback sucker if lake levels were to rise. If cover in the form of inundated terrestrial vegetation and turbidity are necessary for recruitment, then the Colorado River inflow, Virgin River inflow, and Muddy River inflow areas of Lake Mead represent the best

potential habitat for establishing additional razorback sucker populations in the lake through the supplemental introduction of juvenile fish.

Population estimates for both the Echo Bay and Las Vegas Bay populations indicate there are 50-100 fish at each location. The lower population estimate for the 2002-2003 period, as compared with the 2001-2003 time period in Echo Bay, either indicates a decline in numbers of fish in the population 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 abundance estimates. The Las Vegas Bay estimates are higher for the 2002-2003 time period than for the 2001-2003 time period, which indicates an increase in population size. This may very well be the case as numerous previously uncaptured fish were found in 2003 including ten sub-adult fish. The sub-adult fish represent new and recent recruitment to the Las Vegas Bay population.

WORK PLAN FOR 2003-2004

The general research objectives for 2003-2004 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, further studying razorback sucker use of Las Vegas Wash, and attempting to determine the source of larval razorback sucker found in the Colorado River inflow area. In addition to the general research objectives, goals were identified that would provide answers to specific research questions. The following proposed work plan was developed to define the goals for the eighth study year and outline the strategies and actions necessary to accomplish these goals.

Goals for the Eighth Study Year

1. Identify potential spawning areas for Lake Mead razorback sucker at the Muddy and Virgin River inflow areas.
2. Identify spawning areas at Echo Bay, Las Vegas Bay, and the Colorado River inflow area of Lake Mead.
3. Sample the Muddy River and Virgin River inflow areas of Lake Mead for larval razorback sucker.
4. Examine home range and site fidelity characteristics of the Echo Bay and Las Vegas Bay razorback sucker populations.

Strategies and Actions

1. Identify potential spawning areas for Lake Mead razorback sucker at the Muddy and Virgin River inflow areas.
 - The Wolman Pebble Count Method (Wolman 1954, Kondolf and Li 1992) will be used to identify potential spawning areas for razorback sucker. A series of transects will be established across the suitable substrate along the west shore of the Muddy River inflow area and the east shore of the Virgin River inflow area. At each step on a transect, an observer will reach down and touch a substrate particle without looking. The size of each particle will be measured in millimeters across its intermediate axis. The percent composition of each substrate particle size (modified Wentworth classification for substrate particle size [Cummins 1962]) will be quantified from these data. The substrate size and composition measured at these two areas will be compared with the substrate measured at the two spawning sites at Echo Bay.
2. Identify spawning areas at Echo Bay, Las Vegas Bay, and the Colorado River inflow area of Lake Mead.
 - Two methods will be used to identify spawning areas for razorback sucker in Lake Mead. The first method will be to monitor larval production at the three study areas. Larval light trapping will begin in late February, continue into mid May at Echo and Las Vegas Bays, and begin in mid to late March at the inflow. As in past study years, concentrations of larvae were very useful in identifying razorback sucker spawning areas. A second method, tracking sonic-tagged razorback sucker, will be used at Las Vegas and Echo Bays. In 1997 sonic-tagged fish were tracked to spawning redds at Echo Bay, and it is believed that fish tagged during the seventh study year will exhibit similar behavior. Currently there is one active tagged fish at each study location. Tracking these fish will occur weekly during the spawning period (late February through mid May) and bi-weekly outside the spawning period. Additional fish from Floyd Lamb State Park may be tagged and released into each of these areas to increase the number of sonic-tagged fish.
3. Sample the Muddy River and Virgin River inflow areas of Lake Mead for larval razorback sucker.
 - In March, April, and May 2004, crappie lights will be used to sample for larval razorback sucker at shoreline sites at the Muddy River and Virgin River inflow areas. Sampling will occur once per week during the March-May time period. If larval razorback sucker are captured at either of the two areas, trammel netting will be initiated near the site of larval capture in an attempt to net adult razorback sucker.

4. Examine home range and site fidelity characteristics of the Echo Bay and Las Vegas Bay razorback sucker populations.
 - Site fidelity and home range size are important components of an animal species behavioral ecology. Knowledge of each can provide information on seasonal habitat use, animal association, and the amount of habitat needed to complete all components of an animal's life history. ArcView® GIS software (Environmental Systems Research Institute, Inc., Redlands, California) and the Animal Movement Analysis ArcView® Extension (Hooge and Eichenlaub 1997) will be used to quantify home range size, site fidelity, and movement patterns of razorback sucker at Echo Bay and Las Vegas Bay. Sonic telemetry movement data collected from both populations since 1996 will be analyzed. Site fidelity, home range size, and movement patterns will be examined for both spawning (February-May) and non-spawning time periods (June-January).

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