

Razorback Sucker Studies on Lake Mead, Nevada

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*One of two juvenile
razorback sucker
captured in 2001 from
Las Vegas Bay, Lake
Mead.*

Submitted to:

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EXECUTIVE SUMMARY

In 1996 the Southern Nevada Water Authority (SNWA) and the Colorado River Commission of Nevada, in cooperation with the Nevada Division of Wildlife (NDOW), initiated a cooperative study to develop information about the Lake Mead razorback sucker population. BIO-WEST, Inc., under contract with the SNWA, developed the study design and had primary responsibility for conducting the study. The NDOW provided equipment, technical support, and field support for the project. Other agencies that joined as cooperators at the beginning of the study included: the Bureau of Reclamation (BOR), 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 (USFWS), which assisted with permitting issues.

During the fifth year (July 2000 to June 2001) of the Lake Mead razorback sucker study, emphasis was placed on locating spawning adults in a potentially new population near the Colorado River inflow, and capturing adults from known populations to remove fin ray sections for aging. Trammel netting for adult fish during pre-spawning continued, and during the fifth year 19 adult and 1 juvenile razorback sucker were captured, including 7 in Las Vegas Bay and 13 in Echo Bay. Of the 20 total razorback sucker collected 14 were recaptures; this recapture rate is similar to the rate found in previous years. During the first 5 years of the study, 120 individual razorback sucker were captured, not counting larvae. The USFWS trammel net collections in March and April, 2001, resulted in the capture of 32 adult and 1 juvenile razorback sucker. Of these, eighteen were captured at Las Vegas Bay, 15 were captured at Echo Bay, and the juvenile was captured at Las Vegas Bay. Only 17 of the 33 fish captured were recaptures. The USFWS sampling occurred during March and April, during the spawning period, whereas the BIO-WEST sampling occurred in December-February, during the pre-spawning period. The difference in the rate of recaptures between the BIO-WEST and USFWS sampling suggests that sampling prior to the spawn results in capturing more of the same fish each year because the larger portion of the populations and more of the fish that have not been captured previously are missed.

Average growth, as determined from 20 fish that were recaptured during 2000-2001, was 12.8 mm for this study year. Mean annual growth of Las Vegas Bay fish was 9.1 mm and for Echo Bay fish was 16.5 mm. Growth by size class was evaluated for all recaptures during the entire study. Smaller fish grew the fastest. One 351 mm juvenile captured in 1998 and recaptured at 570 mm in 2001 had an annual growth rate of 75.2 mm. Negative growth has consistently been found for fish re-captured during the same spawning period, and this may reflect netting and/or spawning stress.

Sonic-tagged adult razorback sucker continued to show the same movement patterns noted in previous years. Numbers of larvae collected in 2001 were higher than during the past few years at Echo Bay, with 987 collected. About the same number of larvae (40) as captured in previous years was found at Las Vegas Bay. Increased numbers at Echo Bay may be related to a lower lake elevation that concentrated larvae. A total of 22 larvae were captured in the Grand Wash Bay area, but trammel netting for adults was unsuccessful.

Small sections of fin rays were removed for aging eight razorback sucker during this study year, bringing to 20 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.

Population estimates suggest that both populations in Lake Mead include about 100 fish or less, but these estimates may be low as a result of sampling time. BIO-WEST has typically sampled before and after spawning. The USFWS sampling in 2001 during the spawning period suggested that the BIO-WEST sampling may be missing a significant portion of the populations.

The 2001-2002 study efforts will include continuing to monitor adult and young razorback sucker at Las Vegas Bay and Echo Bay. Additional fish will be sonic tagged at these locations to replace tags with dead batteries. Trammel netting to gather fin ray sections for aging will occur through the 2002 spawning period, and samples of adults and larvae will be gathered for genetic analysis. Attempts to locate a spawning aggregation in the inflow area will include use of sonic-tagged, stocked, adult razorback sucker that will hopefully aggregate with the wild fish. Also, additional studies, including trammel netting, sonic tagging, drift netting, and larval sampling will be targeted at Las Vegas Wash and the flowing portion of Las Vegas Bay, to determine more clearly how razorback sucker use this area.

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INTRODUCTION

The razorback sucker (*Xyrauchen texanus* [Abbott]) is an endemic fish species of the Colorado River Basin. It was historically widespread and common throughout the larger rivers of the Colorado River Basin (Minckley et al. 1991). The distribution and abundance of the razorback sucker are greatly reduced from historic levels, and it is one of four large-river fishes 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. 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, carp, catfish, sunfish, 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 sportsmen 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 tags (PIT), 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 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 of the project were to:

1. Determine the population size of razorback sucker in Lake Mead,
2. Determine the habitat use and life history characteristics of the Lake Mead population, and
3. 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:

4. Search for new razorback sucker population concentrations via larval light-trapping outside the two established study areas, and
5. 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.

This *Annual Report* presents the results of the fifth study year extending from July 2000 through June 2001, with information and data from previous years (October 1996-June 2000) included where applicable.

SUMMARY OF PREVIOUS YEARS' RESULTS

Lake level during the first four study years started at 1,192 feet above mean sea level (amsl) in October 1996 and rose to a high of 1,218 feet amsl by October 1998 and 1,214 feet amsl by January 2000. Lake level then declined and was at 1,200 feet amsl by June 2000. During these study years, trammel netting and sonic telemetry were used at Echo Bay and Las Vegas Bay to capture razorback sucker for calculating population estimates, determining suspected spawning sites, and monitoring the general condition of individual razorback sucker for growth, spawning condition, general health, and recruitment levels. BIO-WEST netting data were used to make population estimates for Las Vegas Bay and Echo Bay, which were around 200 and 80, respectively.

Sonic telemetry and netting data determined that there was no overlap in distribution between Echo Bay and Las Vegas Bay populations, and that razorback sucker were generally found near their respective spawning locations from November-December through April-May. Post spawning, water temperatures increased, and Echo Bay razorback sucker were increasingly found along the western shore of the Overton Arm while Las Vegas Bay razorback sucker were found along the entire northern shore of Las Vegas Bay. Las Vegas Bay razorback sucker also used the Lake Mead portion of Las Vegas Wash, including the area where the flowing wash enters Lake Mead.

Several razorback sucker stocked by NDOW in 1994 and 1995 were collected during sampling, indicating that stocked fish would aggregate with the wild population. One initial discovery was that the growth rate of recaptured Lake Mead razorback sucker was very high, averaging 10 to 20 mm per year, far higher than growth reported for other razorback populations. As the study progressed, growth information continued to show high growth rates for the fish recaptured. In late 1997 and early 1998, four juvenile razorback sucker between 318 and 383 mm total length (TL) were collected. Aging of a juvenile mortality, as well as an adult mortality, suggested that the populations in Lake Mead were comprised of relatively young fish. Standard aging for razorback sucker used the otolith, requiring sacrificing the fish to be aged. In 1999 and 2000 a non-lethal aging technique using pectoral fin ray sections was developed so larger numbers of captured fish could be aged. Aging of the first 10 to 15 razorback sucker showed ages between 5 and 20 years, whereas most other wild razorback sucker populations average 40 or more years of age.

Larval razorback sucker were collected near Blackbird Point in Las Vegas Bay and in Echo Bay all years of the study, confirming that razorback sucker were reproducing in Lake Mead and using these areas as spawning areas. A few larvae were collected up to 2 miles away from the suspected spawning sites, but they were most likely transported to these areas via wind currents. In 1999 and 2000 video of spawning fish at Echo Bay was recorded, along with documentation of channel catfish predation on eggs.

In spring 1998 sampling of larvae throughout the lake was initiated in a search for other populations. This sampling covered the entire lake in 1999 and 2000. Several larvae were found near the Colorado River inflow area in 2000, but trammel netting in the area did not find any adults.

STUDY AREAS

The majority of 2000-2001 study activities occurred at the same locations used in the 1996 to 2000 portion of the study (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b). The two most-frequented areas were Echo Bay and Las Vegas Bay. Sonic telemetry was conducted in other parts of the lake, including the Overton and Muddy Arms, and Boulder Basin (Figure 1). Although lake-wide larval sampling was not conducted as in the previous year, larval sampling was performed in Echo Bay, Las Vegas Bay, and the Colorado River inflow area/Grand Wash Basin. Trammel netting was conducted at both Las Vegas Bay and Echo Bay as during previous years, and trammel netting was intensified at the Colorado River inflow area and at the southern end of Grand Wash Bay.

As with previous study years, elevation of the lake affected all study areas with the lake elevation steadily decreasing throughout the year. The July 2000 average monthly lake elevation was about 1,200 feet amsl, and the lake level decreased steadily to about 1,183 feet amsl by June 2001, the lowest level of the study (Figure 2).

Decreasing lake levels during the fifth study year influenced habitat conditions in all areas where razorback sucker sampling activities have taken place over the past 5 years. Decreases in lake elevation at the Echo Bay study site reduced the amount of water covering the location where razorback sucker were seen spawning during March 1999 and March 2000 video surveillance. Water level during the March 1999 and March 2000 video surveillance was about 1,211 feet amsl, and this level provided about 17 feet of water over the Echo Bay spawning area. Water level at the end of March 2001 had decreased approximately 16 feet, thus leaving the shallowest portion of the spawning area with only about 1 foot of water covering it and the deepest portion with about 3-4 feet. Water level continued to drop towards the end of the fifth spawning year, and by the end of June 2001 water levels were down to about 1,183 feet, an 11.5 foot decrease. This decrease brought the water level down to 8 feet below the level at which the study first began.

At the Las Vegas Bay study area, decreases in water level elevation had the greatest effect on 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* sp.) and inundated tamarisk (*Tamarix chinensis*) at the point of inflow. Farther upstream of the inflow area, there was a channelized area of the wash that was ascendable 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.

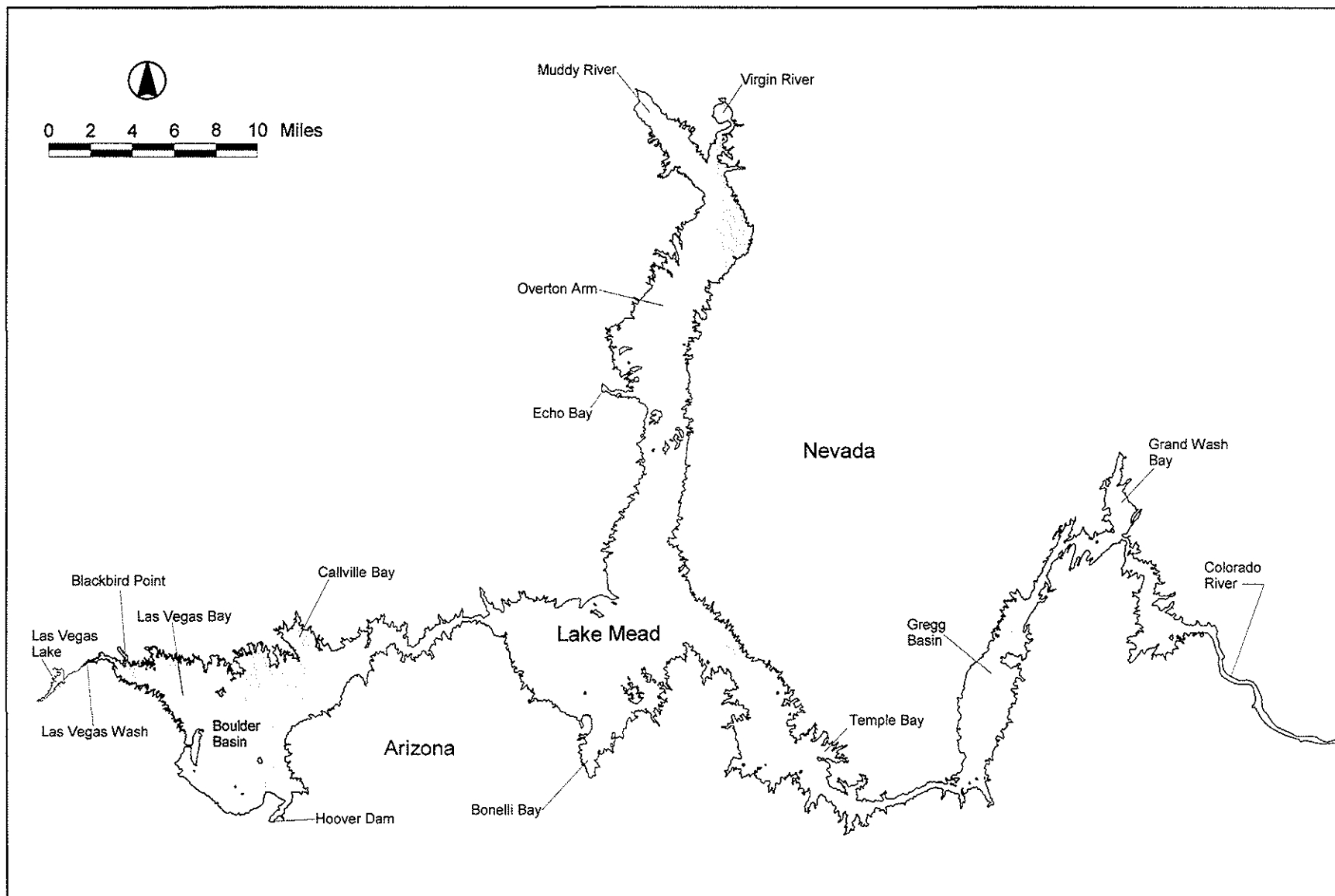


Figure 1. Map of Lake Mead showing general study area locations.

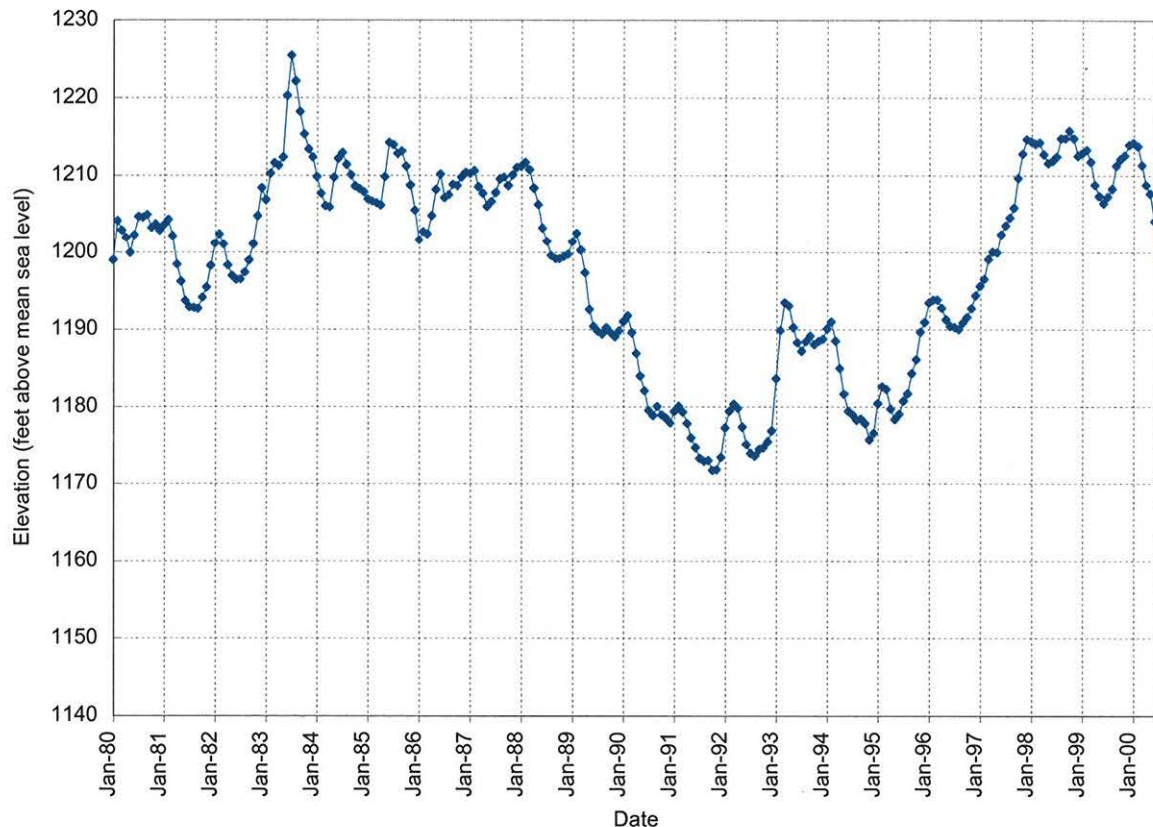


Figure 2. Lake Mead month-end elevations, January 1980 to June 2001.

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 fifth study year. The aforementioned decreasing lake levels affected this area by further extending the wash delta out into Las Vegas Bay and thereby completely covering any vegetation that was present during the previous low-water period that occurred prior to 1998. The formation of this delta coincident with the lowering of lake water levels served to eliminate the portion of the wash that formerly was identified as the flowing portion of Las Vegas Bay. Instead, the wash channel was comprised of a silt-sand mixture in which flows cut sinuous paths down to the lake edge.

At the point where the wash and lake waters mixed, a slight drop could be found. This edge was comprised of sand and silt that was being aggraded by the wash flows.

Most study activities for the fifth study year occurred within the full pool elevation of Lake Mead, (1,229 feet amsl). The only activity that occurred above the full pool elevation of the lake was a minimal amount of larval light sampling that occurred in Las Vegas Wash upstream and downstream of the North Shore Road Bridge that crosses the wash below Lake Las Vegas. Also, larval light sampling was performed in portions of Colorado River upstream of the Lake Mead/Grand Canyon boundary.

Specific definitions for the various portions of the wash in which the study was conducted were given in Holden et al. (2000). These definitions still properly define 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 the wash proper and the bay. Since lake elevation affects what is called the wash or bay, the above definitions are used to differentiate the various habitats at the time of sampling. Throughout the text of this report, three portions of Las Vegas Bay are referred to using the 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

Adult Studies

The general study techniques used during the first 4 years of research were also used during the fifth year of research (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b). Trammel nets were the primary sampling gear for collecting adults, and sonic telemetry was utilized to assess adult habitat use and movement. Spawning adults were searched for using larval sampling techniques employed during the previous 3 study years, and changes to past methods are detailed in the next section. Netting locations for the two primary study sites were selected based on the locations used by sonic-tagged fish and areas suspected of containing spawning razorback sucker. In the Grand Wash and Colorado River inflow areas, netting locations were selected based on capture locations of larval razorback sucker that were collected during night larval sampling.

In March and April 2001, the USFWS sampled the two study areas for adult razorback sucker using trammel nets for toxic loading studies of the fish. Their collection data are included in this report.

Larval Sampling

Spring 2001 larval sampling was conducted with the same methods used during the third and fourth study years. Larval sampling was conducted at the same 12 standard larval sites in Echo and Las Vegas Bays that were sampled in spring 1999 (Holden et al. 2000a). Larvae were sampled, as during previous years, for a standardized 15 minutes (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b). In addition to the standard sites, sampling was

conducted in the areas surrounding Echo and Las Vegas Bay in order to discern potentially different spawning areas, amount of larval drift, direction of drift, and larval habitat use.

Spring 2001 lake-wide larval sampling focused on the Colorado River inflow/Grand Wash Basin areas. Sampling was conducted in these areas nightly on a biweekly basis with 10-12 stations sampled per night. At the beginning of the sampling season, each sample location was sampled for 15 minutes; however, after consultation with BOR personnel who had experience collecting larvae in locations where lower levels were present, sampling times at individual sites were adjusted to allow more time for larvae to swim to the light. Minimum sampling times were increased to 20 minutes and, if razorback sucker larvae were captured at a site, then sampling time was extended 10 minutes. If larvae were captured during the extended period the sampling time was again extended, and so forth until no razorback sucker larvae were captured at that site. Sites for larval sampling in these areas were selected early in the spawning season so that those areas where larvae were caught the previous year would be covered at least once, and usually twice, per weekly sampling trip. Other sites were selected based on whether they had the potential to concentrate drifting larva, such as in the backs of coves and lee side of points.

In addition to standard larval sampling at Echo Bay and Las Vegas Bay, and sampling at the upper end of the lake, limited larval light trapping was conducted at the Las Vegas Wash inflow, and downstream of the North Shore Road bridge that crosses Las Vegas Wash. Larval light trapping in the wash was conducted with methods outlined in Holden et al. (2000b).

Juvenile Sampling

Limited juvenile sampling was conducted at Echo Bay during the fifth study year. Sampling for juvenile razorback sucker was conducted using fyke nets (3' x 4' x 3/8"), experimental gill nets, and minnow traps at various locations within the lake. Specific methods for these types of sampling can be found in previous annual reports (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a). In 2001, no sampling was conducted at Las Vegas Bay until after July.

Age Determination

During 1997-1998, aging of two razorback sucker was conducted using otoliths and fin rays (Holden et al. 1999), and during 1998-1999 the potential to use fin rays as a non-lethal and non-destructive technique to age razorback sucker in Lake Mead was further investigated (Holden et al. 2000a). During 1999-2000, information gained from published aging literature was incorporated into a non-lethal aging technique. This technique was then used to age 11 adult razorback sucker collected from Echo and Las Vegas Bays during the fourth study year (Holden et al. 2000b).

The method developed for aging during the fourth year provided mixed results. Obtaining razorback sucker for aging, removing the fin ray section, and the actual aging of the section went as planned. However, problems included the speed and recovery of the sampled fish, and the excessive amount of time needed to perform the specimen preparation and aging (Holden et al. 2000). Because of the complications with fin ray extraction, new methods were devised that would potentially reduce irritation for the fish and thereby speed healing. A new cutter was designed to

allow for a more- precise cut and a smaller section to be taken for aging. This cutter cut from the top and bottom rather than coming into the cut either solely on the top or bottom.

The other advance that was made in the aging process during the fifth study year was the use of a motorized, thin-bladed saw for sectioning the fin ray. The previous method used to prepare fin rays for aging involved embedding them in epoxy, sectioning the segment manually with a fine-tooth jeweler saw, and then sanding and polishing. Although this system worked well and created readable fin ray sections that produced ages for all fish sampled, it was time consuming. The new method devised for aging involved using an updated method for embedding the fin ray segments in epoxy and sectioning the embedded segments. The embedding process used for the fifth study year involved setting the segments into molds and filling them with a thermoplastic epoxy that was then heat cured. These 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. The saw produced a very even and thin cut that required little polishing and was much easier to read.

During this study year, the person responsible for aging razorback sucker was changed from Jack Ruppert to Tim Welker. To assure a smooth transition and to assure that aging was being conducted similarly, all previously aged fin ray and otolith sections and those collected during this study year were analyzed at the same time by Ruppert, Welker, and Paul Abate. An age was prescribed only after all three individuals were in agreement.

RESULTS

Adult Sampling

Trammel Netting

Table 1 shows the trammel netting effort that occurred from July 2000 to June 2001, and Figures 3, 4, and 5 show the location of trammel net sets in the two primary study areas and the Grand Wash/Colorado River inflow areas for the same time period. A total of 186 trammel net nights (one net night is comprised of a single net set overnight) were conducted during the fifth study year, with 49 net nights spent in the Las Vegas Bay/Boulder Basin area, 39 net nights spent in the Echo Bay/Overton Arm area, and 98 net nights spent in the Grand Wash/Colorado River inflow areas.

Trammel netting effort during the fifth study year was partially concentrated in the Blackbird Point area in Las Vegas Bay (Figure 3), including the flowing and non-flowing portions of Las Vegas Bay, and in the back of Echo Bay (Figure 4) (Holden et al. 1997, Holden et al. 1999). However, the majority of netting occurred at the Grand Wash Bay and Colorado River inflow areas during a search for additional razorback sucker spawning sites.

As with the previous two study years (Holden et al. 2000a, Holden et al. 2000b), the timing of trammel netting for the fifth study year was coordinated with seasonal differences in water and air temperature, and with the spawning season. Netting during the first 2 study years revealed that warmer air and water temperatures associated with netting during the summer months appeared to

Table 1. Trammel netting effort (net nights) on Lake Mead by month from July 2000 to June 2001.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY/ OVERTON ARM	COLORADO RIVER INFLOW AREA	TOTAL
2000				
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	5	4	0	9
November	4	5	0	9
December	5	5	0	10
2001				
January	20	10	0	30
February	15	15	0	30
March	0	0	0	0
April	0	0	0	0
May	0	0	70	70
June	0	0	28	28
Total	49	39	98	186

stress razorback sucker that were brought to the surface under these conditions. Additionally, trammel netting during the spawning season had the potential to disrupt spawning activity. For these reasons, trammel netting during the fifth study year was not conducted from July to September (warm months). With the exception of netting conducted during May and June at the Grand Wash and Colorado Inflow areas, netting was not conducted during March, April, and May (spawning season) either. A limited number of larval razorback sucker were captured in this area in April and May (discussed in more detail in the Larval Sampling section of this report), thereby indicating that spawning was occurring in this area. Netting was then used in an attempt to locate adult razorback sucker in the area.

As with the previous two study years (Holden et al. 2000a, Holden et al. 2000b), the timing of trammel netting for the fifth study year was coordinated with seasonal differences in water and air temperature, and with the spawning season. Netting during the first 2 study years revealed that warmer air and water temperatures associated with netting during the summer months appeared to stress razorback sucker that were brought to the surface under these conditions. Additionally, trammel netting during the spawning season had the potential to disrupt spawning activity. For these reasons, trammel netting during the fifth study year was not conducted from July to September (warm months). With the exception of netting conducted during May and June at the Grand Wash and Colorado Inflow areas, netting was not conducted during March, April, and May (spawning season) either. A limited number of larval razorback sucker were captured in this area

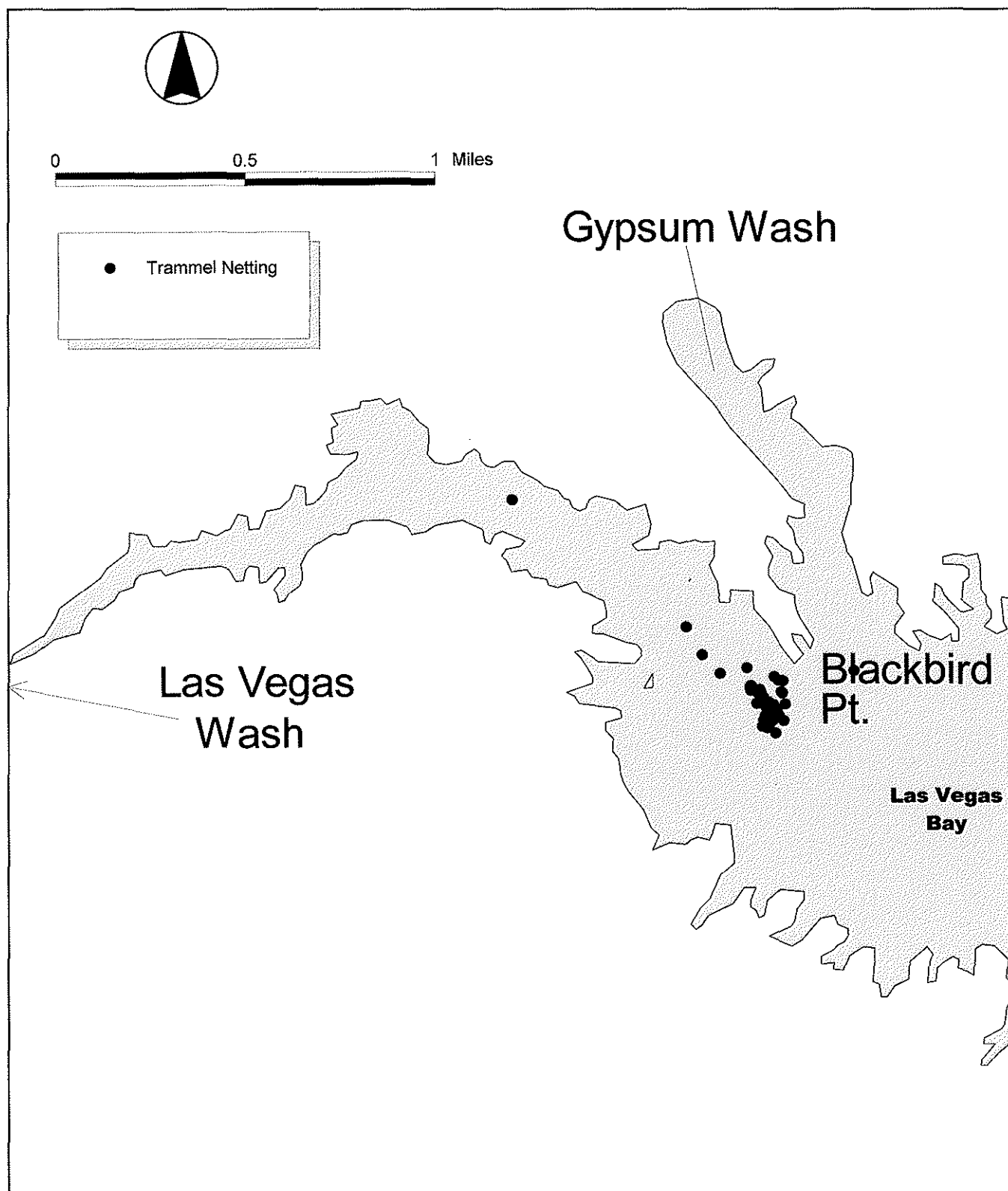


Figure 3. Las Vegas Bay study area showing locations of trammel netting, July 2000-June 2001.

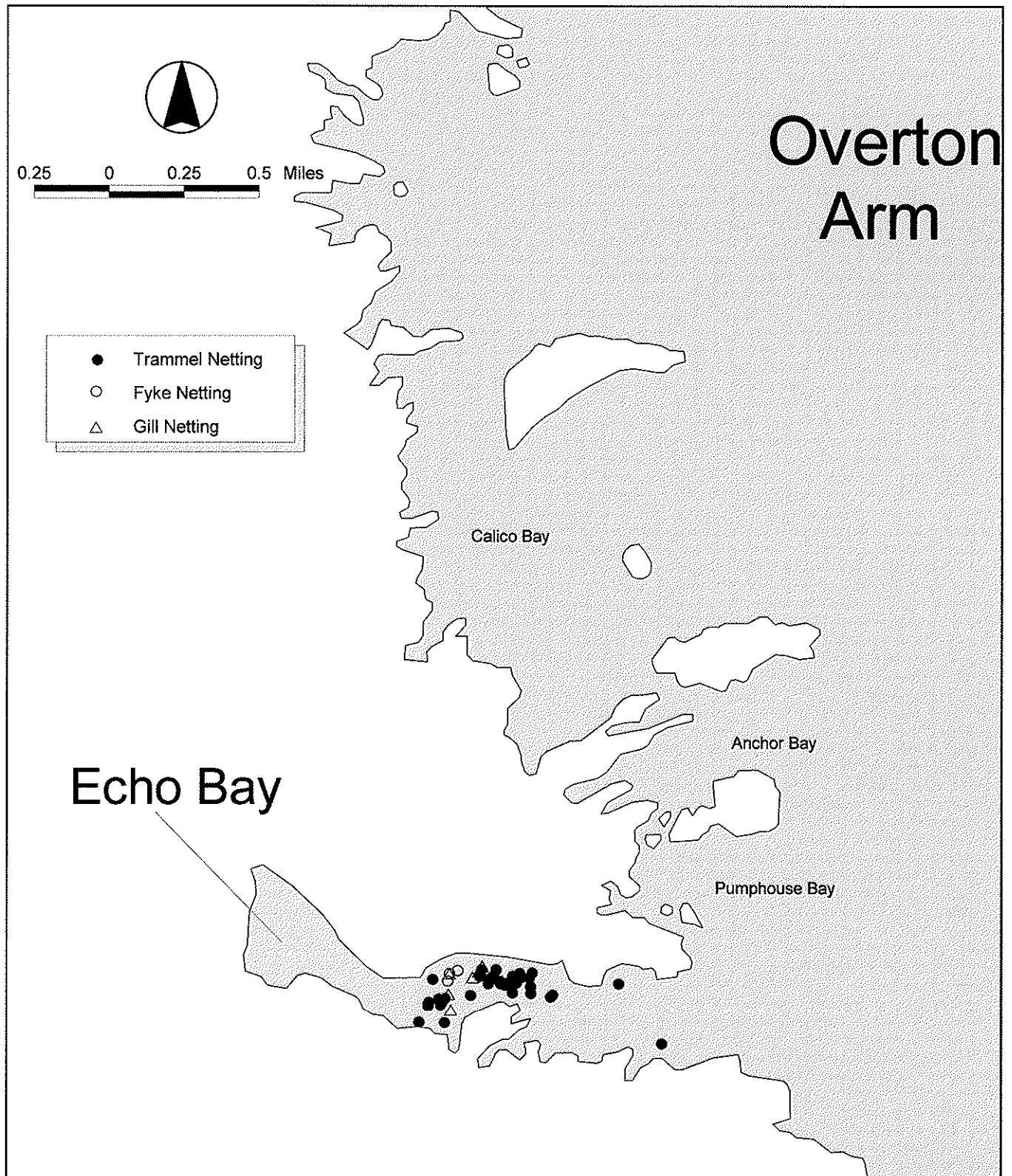


Figure 4. Echo Bay/Overton Arm study area showing location of fyke netting, gill netting, and trammel netting for July 2000-June 2001.

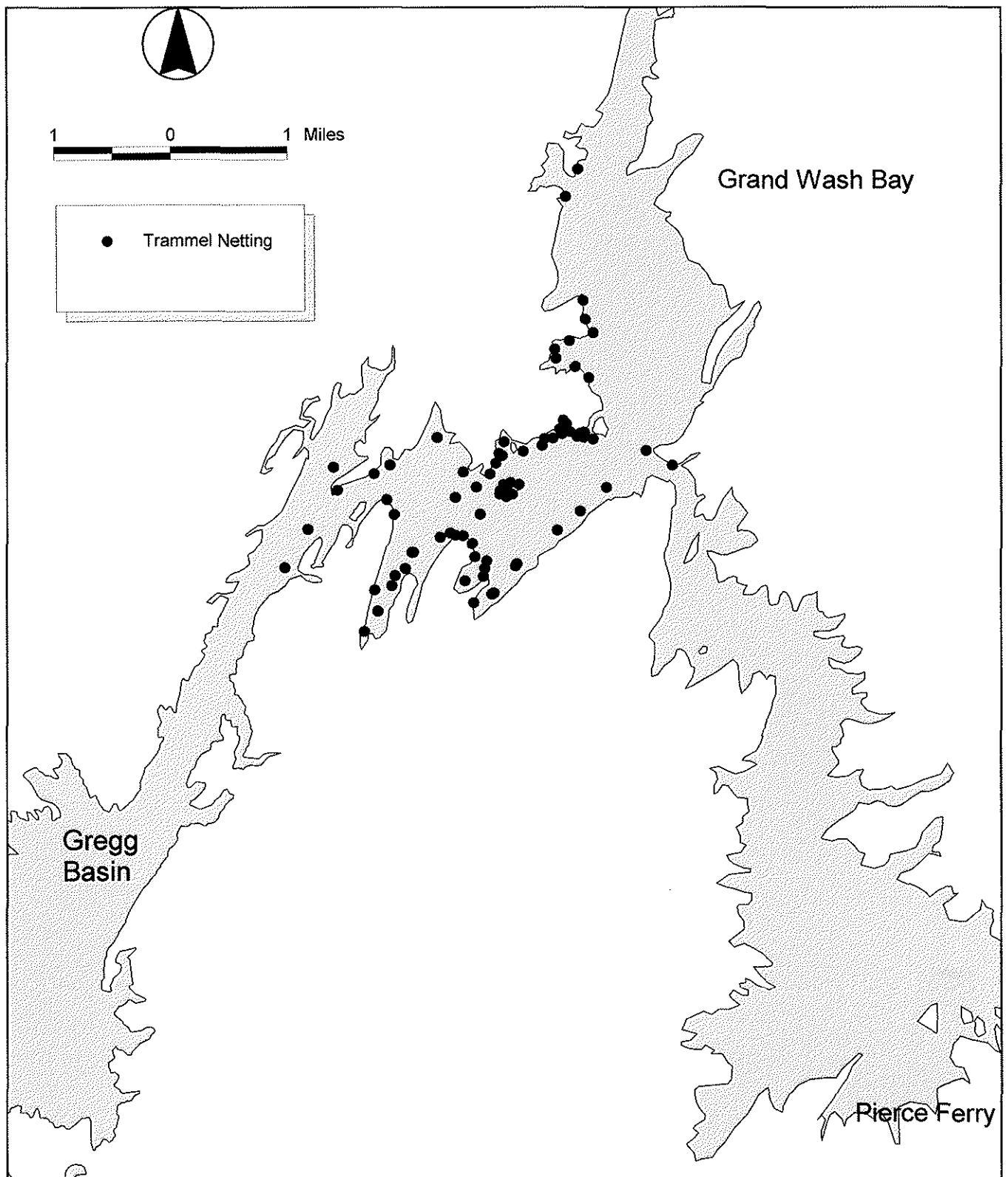


Figure 5. Grand Wash/Colorado River inflow areas showing location of trammel netting.

in April and May (discussed in more detail in the Larval Sampling section of this report), thereby indicating that spawning was occurring in this area. Netting was then used in an attempt to locate adult razorback sucker in the area.

Netting effort was concentrated at the two primary study areas from October 2000 through February 2001, when BIO-WEST was attempting to capture adult and juvenile razorback sucker for fin ray sampling. Other trammel netting that occurred during the fifth study year was performed by the USFWS, and they provided BIO-WEST with the razorback sucker capture information that was used for recapture and growth analyses in this report.

At Blackbird Point in Las Vegas Bay, six adult and one juvenile (378 mm) razorback sucker were captured by BIO-WEST during 49 net nights in the fifth 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, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b). 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 Marina. One razorback sucker was captured approximately 600 feet to the north of this location. Razorback sucker catch rates for trammel netting at the Las Vegas Bay area were 0.14/net night for the fifth sample year.

At Echo Bay, nets were set throughout the entire bay, with more emphasis placed on the portion of the bay where razorback sucker were most-often captured in past study years and where sonic-tagged razorback sucker were previously located. This area started in the middle of the bay and extended to the back of the bay. During 39 net nights, 13 razorback sucker were captured. The razorback sucker catch rate for trammel netting at Echo Bay was 0.33/net night.

Extensive trammel netting was conducted near the inflow area of the Colorado River and in Grand Wash Basin in May and June 2001, after 22 razorback sucker larvae were found in this area. Ninety-eight net nights were conducted from May 4 to June 20 in the Grand Wash Bay area. Netting took place in all coves in the southern portion of the basin including in Bradley Bay, in Twin Coves, in Chuckwalla Cove, around in Driftwood Island, on either side of Lava Point, near South American Point, near Paiute Point, in Cormorant Cove, and in Grand Wash Bay proper. No razorback sucker juveniles or adults were captured during this netting effort.

Similar to the previous two study years, limited trammel netting was conducted during the spawning season. The first male expressing milt was captured on January 25, 2001, at Echo Bay, and the first female razorback sucker expressing eggs was first captured on February 9, 2001, at Echo Bay (Table 2).

Recapture rates varied between study locations during the fifth study year. At Las Vegas Bay, 4 of the 7 (57.1%) razorback sucker caught were recaptures and 1 new capture was a fish stocked by NDOW in 2001. At Echo Bay, 10 of the 13 (76.9%) razorback sucker caught were recaptures. Of the 10 recaptures at Echo Bay, 4 had been stocked by NDOW. The recapture rate for both populations was 70.0%.

Table 2. Location, tagging, and size information for razorback sucker collected in Lake Mead from July 2000 to June 2001.

Date	Agency	Location	PIT Tag No.	Recaptured	TL (mm)	FL (mm)	SL (mm)	Weight (g)	Sex	Disposition *	Physical Condition
6/14/2000	BIO-WEST	BBP	2037205732	No	687	634	583	3742	F	RI	good
12/6/2000	BIO-WEST	BBP	1F7A217F47	Yes	561	511	462	2163	F	RA	good
1/9/2001	BIO-WEST	BBP-deep set	201D5E1055	No	378	351	311	799	I	RC	good
1/25/2001	BIO-WEST	EB- RZ cove	1F4A457C56	Yes	530	500	446	2055	M	RA	good
1/26/2001	BIO-WEST	EB-285 set	7F7D2B2D5F	Yes	600	555	500	2615	M	RA	good
2/7/2001	BIO-WEST	BBP-deep set	1F780E2239	Yes	666	611	535	3730	M	RA	good
2/7/2001	BIO-WEST	BBP-deep set	201D562647	No	543	504	455	1990	M	RC	good
2/7/2001	BIO-WEST	BBP-deep set	7F7D78472F	Yes	625	582	533	3055	M	RA	good
2/7/2001	BIO-WEST	BBP-deep set	201D697169	Yes	707	657	595	4620	F	RA	poor
2/9/2001	BIO-WEST	EB-285 set	1F476B7936	Yes	641	589	536	3031	F	RC	good
2/21/2001	BIO-WEST	BBP-LVW side	1F484B0648	Yes	631	585	520	3350	F	RC	good
2/24/2001	BIO-WEST	285	203718652C	Yes	713	660	583	3941	F	RA	good
2/24/2001	BIO-WEST	285	2037194749	Yes	616	561	500	2525	F	RA	good
2/24/2001	BIO-WEST	285	1F7A252D15	Yes	583	539	475	2047	M	RA	good
2/24/2001	BIO-WEST	285	20371A3B54	Yes	568	527	465	1940	M	RA	good
2/24/2001	BIO-WEST	EB-RZ cove	1F4A592D11	Yes	703	667	595	3936	F	RA	good
2/24/2001	BIO-WEST	EB-RZ cove	1F7809065A	No	576	531	474	2222	M	RC	good
2/24/2001	BIO-WEST	EB-RZ cove	1F7B106D69	No	553	509	447	1687	M	RC	good
2/24/2001	BIO-WEST	EB@cliff	7F7D4C302B	Yes	570	526	469	1984	M	RC	good
2/24/2001	BIO-WEST	EB@cliff	1F7818430E	No	577	535	465	1977	M	RC	good
2/24/2001	BIO-WEST	EB@cliff	201D576408	Yes	566	513	470	2119	M	RA	good
3/19/2001	USFWS	LVB			641			3640	M		
3/19/2001	USFWS	LVB			388			800	F?		
3/19/2001	USFWS	LVB			691			4960	F		
3/19/2001	USFWS	LVB	1F4A1E2356		651			4460	F		
3/19/2001	USFWS	LVB			694			3820	F		
3/19/2001	USFWS	LVB	1F48400D4C		571			2240	M		
3/19/2001	USFWS	LVB			712			4620	F		
3/19/2001	USFWS	LVB	1F5007206A245		626			3540	F		
3/19/2001	USFWS	LVB	1F4A40391E		576			2280	M		
3/19/2001	USFWS	LVB	40381B734C		636			3520	M		
3/19/2001	USFWS	EB	1F7B083727		546			1820	M		
3/19/2001	USFWS	EB	7F7D2B2D5F		595			2440	M		
3/19/2001	USFWS	EB			484			2220	F		
3/19/2001	USFWS	EB			570			1800	M		
3/19/2001	USFWS	EB	1F4A457C56		528			1760	M		
3/19/2001	USFWS	EB	201D576408		559			1900	M		
3/19/2001	USFWS	EB			648			3020	F		
3/19/2001	USFWS	EB			609			2980	M		
3/19/2001	USFWS	EB			569			3020	M		
3/19/2001	USFWS	EB	1F4A217303		645			2740	F		
3/19/2001	USFWS	EB	20371A3B54		567			1660	M		
3/19/2001	USFWS	EB	7F7D15463D		668			2720	F		
3/19/2001	USFWS	EB			672			3480	F		
3/19/2001	USFWS	EB			574			2620	M		
3/19/2001	USFWS	EB	1F7A721C59		608			2780	M		
4/9/2001	USFWS	LVB			636			2620	M		
4/9/2001	USFWS	LVB	7F7D7B2741		588			1640	M		
4/9/2001	USFWS	LVB	7F7D78472F		616			2180	M		
4/9/2001	USFWS	LVB	201D562647		537			1420	M		
4/9/2001	USFWS	LVB			621			2680	M		
4/9/2001	USFWS	LVB	40381B734C		634			2840	M		
4/9/2001	USFWS	LVB			628			3040	M		

At Echo Bay, 40 individual razorback sucker have been captured and PIT-tagged during the 5 study years. In addition, 27 other razorback sucker previously PIT-tagged by NDOW were captured. Hence, 67 individual PIT-tagged razorback sucker were handled at Echo Bay during the first 5 years of the study.

At Las Vegas Bay, 46 individual razorback sucker have been captured and PIT-tagged. In addition, seven razorback sucker previously PIT-tagged by NDOW were captured during this study. Consequently, 53 unique PIT-tagged razorback sucker have been handled at Las Vegas Bay during the 5 years of this study. Lakewide, 120 individual razorback sucker were handled during the 5 years of the study.

Thirty-three individual fish were captured by the USFWS in March and April at Las Vegas and Echo Bays in 2001 (Table 2). One fish captured at Las Vegas Bay was a 388 mm TL juvenile. Of the 33 fish captured (18 at Las Vegas Bay and 15 at Echo Bay), 16 were new captures (10 at Las Vegas Bay and 6 at Echo Bay) giving a 48.5 % capture rate for newly captured fish (51.5% recapture rate). Five fish, four at Las Vegas Bay and one at Echo Bay, were stocked by NDOW. The Echo Bay fish was stocked in 1998 and the four Las Vegas Bay fish were stocked in January 2001. Fish sampled by USFWS during 2000 were recaptured in 2001 at a rate of approximately 52.0%, which is similar to recapture rates experienced by BIO-WEST in past study years.

Video Surveillance

Several attempts were made to observe razorback sucker spawning activity at Echo Bay during spring 2001 using underwater video surveillance. However, water turbidity conditions and the shallowness of the spawning site prevented observations of spawning fish. Water depth at the spawning area during spring 2001 ranged from approximately 3 feet in March to 0.5 feet in early May, as water levels in the bay dropped over this time period. High turbidity resulted from wave action and carp spawning in the back of the bay. Despite the turbid conditions, a large spawning redd was found at the previously identified spawning area (Holden et al. 1999, 2000a). The redd substrate was relatively clean, whereas substrate adjacent to the redd had a thick covering of silt. On April 11, during night larval sampling, an adult razorback sucker was observed swimming off the redd as our boat approached the spawning site.

Low larval fish numbers at Las Vegas Bay made it difficult to pinpoint spawning sites. Numerous attempts, however, were made to locate razorback spawning grounds, but turbid water conditions limited camera underwater 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 and from numerous green algae blooms (*Carteris* sp.) that occurred over the larval sampling period.

Growth

Twenty individual fish were recaptured during the fifth study year (including both BIO-WEST and USFWS captures), fourteen at Echo Bay and six at Las Vegas Bay. The difference in TL between capture periods was used to determine mean annual growth (Table 3). The combined (Echo and Las Vegas bays) mean annual growth of razorback sucker recaptured from Lake Mead during this sampling year was 12.8 mm. The combined mean annual growth of recaptured fish the previous

Table 3. Lake Mead recaptured razorback sucker growth histories for fish captured from July 2000 through June 2001.

PIT TAG NO.	CAPTURE DATE	SIZE TL (mm)	RECAPTURE DATE	SIZE TL (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (mm/365 days)
Echo Bay							
1F476B7936	7/16/97	574	1/26/99	616	42	550	27.9
	1/26/99	616	2/9/01	641	25	733	12.4
1F4A457C56	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
1F4A592D11	2/28/97	681	2/24/01	703	22	1434	5.6
1F7A252D15	1/27/00	557	2/24/01	583	30	387	28.3
1F7A721C59	4/20/97	582	3/19/01	608	26	1409	6.7
1F7B083727	2/25/00	521	3/19/01	546	25	384	23.8
201D576408	1/28/99	519	1/8/00	550	31	340	33.3
	1/8/00	550	2/24/01	566	16	406	14.4
203718652C	2/9/99	703	1/27/00	710	7	348	7.3
	1/27/00	710	2/24/01	713	7	387	6.6
2037194749	2/25/00	575	2/24/01	616	41	359	41.7
20371A3B54	1/27/00	544	2/24/01	568	24	387	22.6
7F7D15463D	2/9/99	660	2/9/00	673	13	360	13.2
	2/9/00	673	3/19/01	668	-5	400	-4.6
7F7D2B2D5F	1/27/97	590	3/12/98	594	4	405	3.6
	3/12/98	594	1/26/99	595	1	314	1.2
	1/26/99	595	1/8/00	599	4	342	4.3
	1/8/00	599	1/26/01	600	1	378	1.0
7F7D4C302B	3/11/98	351	2/24/01	570	219	1063	75.2
1F4A217303	11/24/98	614	3/19/01	645	31	835	13.6
Mean annual growth calculated from first and last capture of each fish							20.1

Table 3. Continued.

PIT TAG NO.	CAPTURE DATE	SIZE TL (mm)	RECAPTURE DATE	SIZE TL (mm)	TOTAL GROWTH (mm)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (mm/365 days)
Las Vegas Bay							
1F4A40391E	5/7/98	532	3/19/01	576	44	1032	15.6
1F780E2239	1/7/00	650	2/7/01	666	16	390	15.0
201D697169	12/13/99	705	2/7/01	707	2	414	1.8
7F7D78472F	2/7/00	628	2/7/01	625	-3	360	-3.0
7F7D7B2741	2/23/00	591	4/9/01	598	7	406	6.3
1F4A40391E	5/1/97	504	3/19/01	576	72	1398	18.8
Mean annual growth calculated from first and last capture of each fish							9.1

year was 9.1 mm (Holden et al. 2000b). Mean annual growth of recaptured fish at Echo Bay was 16.5 mm and ranged from -4.6 mm to 75.2 mm. Razorback sucker recaptured at Las Vegas Bay had a mean annual growth of 9.1 mm and ranged from -3.0 mm to 18.8 mm. These growth rates continue to be substantially higher than those of other razorback sucker populations.

Several razorback sucker, captured by BIO-WEST and USFWS from Las Vegas and Echo Bays in 2001 were recaptured within 60 days of previous capture. These fish lost between 2 mm and 13 mm in TL. It is possible that this decrease in size is a result of measurement error. However, it fits a pattern of negative growth observed in razorback sucker collected in trammel nets more than once within a short period of time (Holden et al. 2000). Table 4 shows those razorback sucker collected more than one time during 2000-2001 sampling year. The days between capture ranged from 20 to 60, and in all cases, negative growth was exhibited. This decrease in size of razorback sucker collected multiple times within 1 or 2 months could be an indicator of stress experienced during trammel netting.

Growth for various length classes of razorback sucker that were captured from 1996-2001 by BIO-WEST and in 2001 by USFWS was examined to determine if growth was faster for fish that were shorter in length, and presumably younger, at time of first capture. The highest growth rates were found for the two shortest length classes (fish < 400 mm and fish 500-550 mm TL) (Table 5). The <400 mm length class only contained one fish which was 351 mm at time of first capture and grew to 570 mm in 2.9 years for an average growth rate of 75.2 mm per year. The 11 fish in the 500-550 mm length class exhibited an average growth rate of 25.1 mm per year. Very slow growth was found for the two longest length classes (651-700 mm and >700 mm) (Table 5). Eleven fish in the 651-700 mm length class grew an average of 5.5 mm per year. The two fish in the >700 mm length class grew even more slowly, averaging only 3.8 mm per year. Figure 6 graphically displays this trend of decreasing growth per year with increasing length at time of first capture. Although

Table 4. Growth of recaptured Lake Mead razorback sucker collected twice within 60 days of previous capture.

DATE	LOCATION	PIT TAG NUMBER	RECAPTURE	TOTAL LENGTH (mm)
1/25/01	Echo Bay	1F4A457C56	Yes	530
3/19/01	Echo Bay	1F4A457C56	Yes	528
Total Growth				-2
2/24/01	Echo Bay	201D576408	Yes	566
3/19/01	Echo Bay	201D576408	Yes	559
Total Growth				-7
2/24/01	Echo Bay	20371A3B54	Yes	568
3/19/01	Echo Bay	20371A3B54	Yes	567
Total Growth				-1
1/26/01	Echo Bay	7F7D2B2D5F	Yes	600
3/19/01	Echo Bay	7F7D2B2D5F	Yes	595
Total Growth				-5
3/19/01	Las Vegas Bay	1F48400D4C	No	571
4/9/01	Las Vegas Bay	1F48400D4C	Yes	558
Total Growth				-13
2/7/01	Las Vegas Bay	201D562647	No	543
4/9/01	Las Vegas Bay	201D562647	Yes	537
Total Growth				-6
3/19/01	Las Vegas Bay	40381B734C	No	636
4/9/01	Las Vegas Bay	40381B734C	Yes	634
Total Growth				-2

growth of Lake Mead razorback sucker slows with increasing length and age, rapid growth can be exhibited by fish that are already quite long. One fish (pit tag=2037194749) in the 551-600 mm length class grew 41.7 mm in a single year (Table 5).

Body length of male and female razorback sucker was examined to determine growth potential and to determine if differences in length exists between males and females in Lake Mead and the individual populations at Echo Bay and Las Vegas Bay. Length frequency distributions were also used to examine differences in male and female length. Data collected from 1996-2001 were used to compute average lengths and maximum lengths for sexes within each population and to construct

Table 5. Growth for various length classes of recaptured razorback sucker from Lake Mead.

PIT TAG NO.	CAPTURE DATE	SIZE TL (mm)	RECAPTURE DATE	SIZE TL (mm)	TOTAL GROWTH (mm)	Number of Years Between Measurements	GROWTH PER YEAR (mm/365 days)
Less Than 400 mm in Length at Time of First Capture							
7F7D4C302B	3/11/98	351	2/24/01	570	219	2.9	75.2
500-550 mm in Length at Time of First Capture							
1F4A457C56	9/14/98	505	3/19/01	528	23	2.5	9.3
1F7B083727	2/25/00	521	3/19/01	546	25	1.1	23.8
201D576408	1/28/99	519	2/24/01	566	47	2.0	23.0
20371A3B54	1/27/00	544	2/24/01	568	24	1.1	22.6
7F7D222A48	1/27/97	545	3/11/98	565	20	1.1	18.1
1F4A40391E	5/7/98	532	3/19/01	576	44	2.8	15.6
1F7A217F47	12/13/99	539	12/6/00	561	22	1.0	22.7
7F7D483714	4/21/97	515	5/7/98	562	47	1.0	45.6
7F7D4A7E47	1/28/97	512	2/12/98	555	43	1.0	42.0
7F7D4D6275	2/25/97	502	2/22/00	584	82	3.0	27.8
						Average	25.1
551-600 mm in Length at Time of First Capture							
1F476B7936	5/19/97	581	2/9/01	641	60	3.7	16.3
1F4A157B07	3/8/97	571	2/10/98	585	14	0.9	15.4
1F7A252D15	1/27/00	557	2/24/01	583	26	1.1	24.5
1F7A39743A	3/12/97	590	2/9/00	585	-5	2.9	-1.7
1F7A721C59	4/20/97	582	3/19/01	608	26	3.9	6.7
2037096F31	9/14/98	600	2/9/00	633	33	1.4	23.9
2037194749	2/25/00	575	2/24/01	616	41	1.0	41.7
7F7B012325	11/20/96	591	3/12/98	606	15	1.3	11.6
7F7D2B2D5F	1/27/97	590	1/8/00	599	9	2.9	3.1
7F7D2F320A	12/10/97	595	9/14/98	600	5	0.8	6.7

Table 5. Continued.

PIT TAG NO.	CAPTURE DATE	SIZE TL (mm)	RECAPTURE DATE	SIZE TL (mm)	TOTAL GROWTH (mm)	Number of Years Between Measurements	GROWTH PER YEAR (mm/365 days)
551-600 mm in Length at Time of First Capture							
1F7D66324C	1/29/99	563	2/22/00	574	11	1.0	10.5
7F7D4A0478	3/10/97	600	12/13/99	606	6	2.7	2.2
7F7D51650E	3/10/97	565	2/10/00	619	54	2.9	18.8
7F7D7B2741	2/23/00	591	4/9/01	598	7	1.1	6.3
						Average	13.3
601-700 mm in Length at Time of First Capture							
1F4A217303	11/24/98	614	3/19/01	645	31	2.3	13.6
1F4A592D11	2/28/97	681	2/24/01	703	22	3.9	5.6
201D5F2A3A	3/12/97	645	2/9/00	649	4	2.9	1.4
7F7D15463D	2/9/99	660	2/9/00	673	13	1.0	13.2
7F7D164F08	1/28/99	601	2/9/00	601	0	1.0	0.0
7F7D3B3240	5/19/97	667	2/9/00	694	27	2.7	10.1
7F7D482104	2/10/98	675	2/9/99	668	-7	1.0	-7.1
1F780E2239	1/7/00	650	2/7/01	666	16	1.1	15.0
1F7815490B	11/19/98	642	2/22/00	641	-1	1.2	-0.8
7F7D4B7A54	2/10/97	617	3/9/98	630	13	1.1	12.2
7F7D78472F	2/7/00	628	2/7/01	625	-3	1.0	-3.0
						Average	5.5
Greater Than 700 mm in Length at Time of First Capture							
201D697169	12/13/99	705	2/7/01	707	2	1.1	1.8
7F7D3B6539	12/18/96	713	11/30/99	730	17	2.9	5.8
						Average	3.8

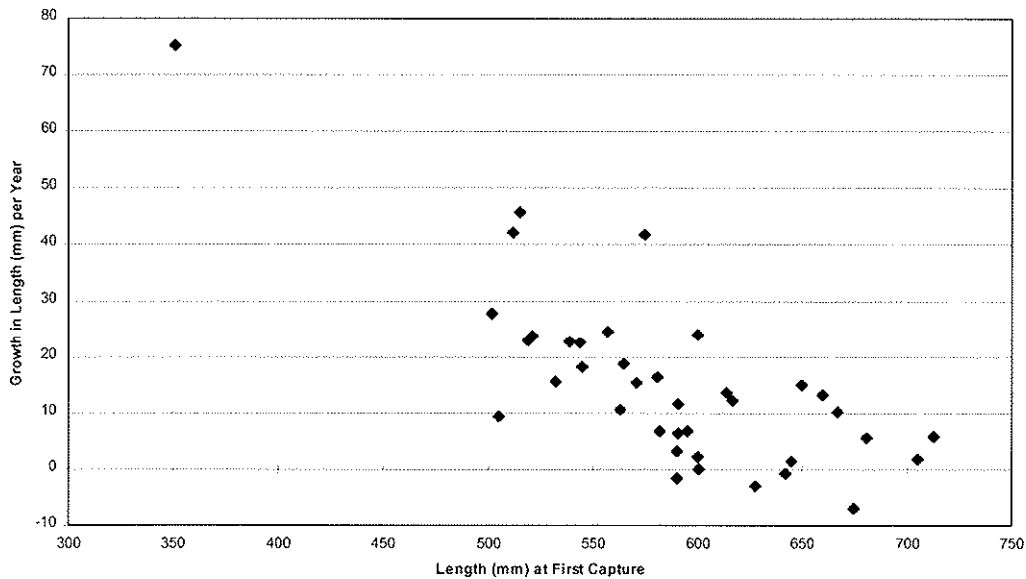


Figure 6. Relationship between length at first capture and growth for Lake Mead razorback sucker.

the length frequency distributions. The longest fish were Las Vegas Bay females which had an average length of 663 mm and a maximum length of 735 mm. Echo Bay females were only slightly shorter with an average length of 645 mm and a maximum length of 730 mm. Echo Bay males were the shortest fish with an average length of 570 mm and a maximum length of 630 mm. Las Vegas Bay males averaged 591 mm in length and attained a maximum length of 668 mm. The average length for the Las Vegas Bay population (males and females combined) was greater (627 mm) than that of the Echo Bay population (607 mm). Approximately 78% of male fish captured between 1996 and 2001 were between 551 and 650 mm in length (Figure 7). Most female fish were longer than male fish with 55% greater than 651 mm. No male fish were greater than 700 mm in length while 24% of females exceeded this length.

Male and female fish from Las Vegas Bay captured between 1996 and 2001 exhibited faster growth rates than their counterparts at Echo Bay. Average growth per year for fish captured at Las Vegas Bay was 18.1 mm for females and 13.6 mm for males. Echo Bay males grew an average of 11.9 mm per year, where as females grew an average of 13.6 mm per year.

Sonic Tagging and Telemetry

During the first study year, 20 sonic tags (sixteen 14-month tags and four 48-month tags) were used to tag 21 adult razorback sucker (Holden et al. 1997). During the second study year, 13 razorback sucker were implanted using two 60-day tags and eleven 48-month tags. Tags in 13 of these razorback sucker were active at the beginning of the third study year, and no new razorback sucker were implanted. At the beginning of the fourth study year, four previously implanted 48-month tags were active, and one 48-month tag was externally attached to a female razorback sucker after

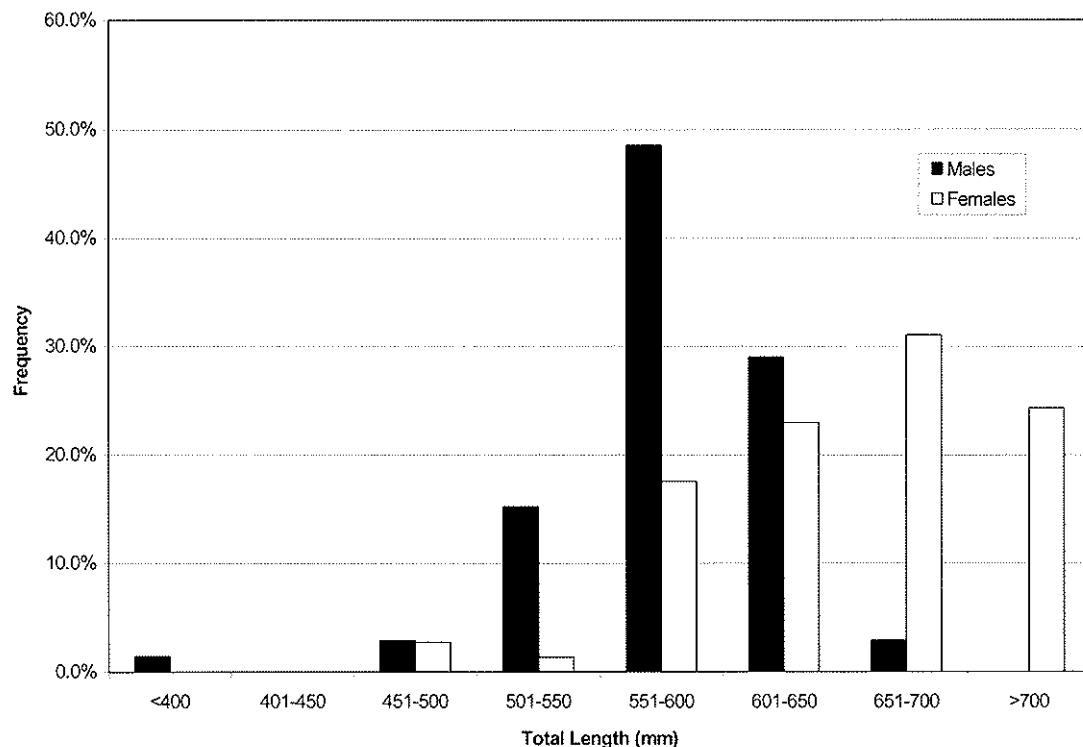


Figure 7. Length frequency (total length) of male and female razorback sucker collected from Lake Mead from 1996-2001.

the 2000 spawning season. At the beginning of the fifth study year there were two previously tagged 48-month tags still active at Las Vegas Bay (one internally implanted and one externally implanted) and one 48-month tag still active at Echo Bay. Echo Bay and Las Vegas Bay telemetry results from the fifth study year for individual sonic-tagged fish are discussed below.

Las Vegas Bay

Tag 247

Tag 247 (48-month life expectancy) was implanted at the end of the second study year on May 7, 1998, into a 532-mm TL male captured at Blackbird Point. This fish was found May 12, 13, and 16 in the non-flowing portion of Las Vegas Bay (Figure 8). Throughout the third study year, fish 247 was found on an almost-monthly basis in the non-flowing and flowing portions of Las Vegas Bay. Fish 247 was found a total of 12 times during the fourth study year. All contacts were located either in the flowing or non-flowing portion of Las Vegas Bay. Nine of the 12 locations were recorded between September 11, 1999, and November 29, 1999, in the flowing and non-flowing portions of Las Vegas Bay, with the September 11 position identified 1,000 feet upstream of the Las Vegas Wash inflow area. The last three recordings of fish 247 during the fourth study year were on May 5, 11, and June 15, 2000; the fish was found in the non-flowing portion of Las Vegas Bay on all three dates (Figure 8).

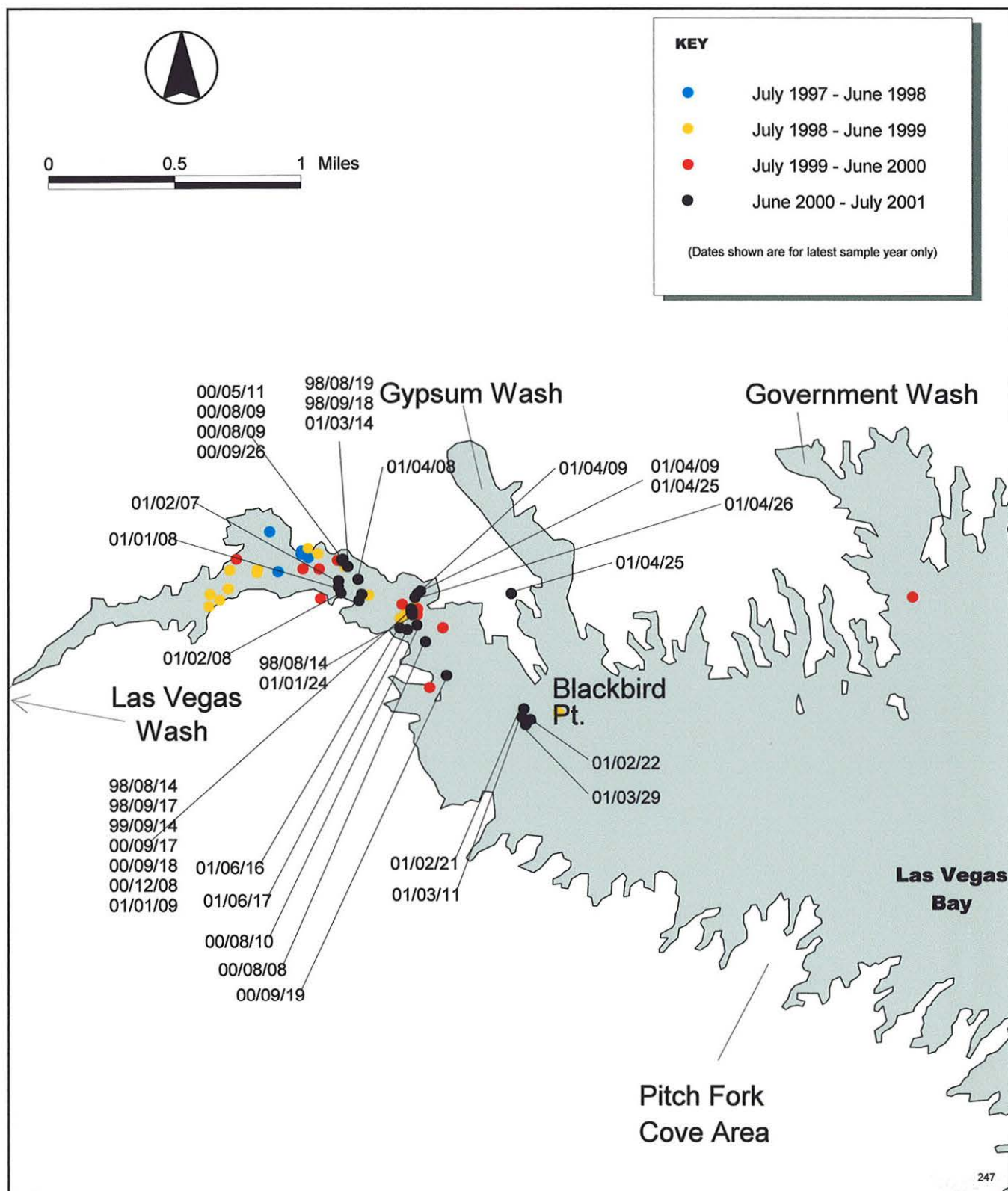


Figure 8. Distribution of fish number: 247.

Fish 247 was located 28 times during the fifth study year. All contacts were made in Las Vegas Bay between Blackbird Point and the flowing and non-flowing portion of Las Vegas Bay during most months of the study year. At the beginning of August, this fish was located either directly adjacent to the constricted center of the non-flowing portion of Las Vegas Bay or north of that area and about 250 meters south of the inflow area of the Las Vegas Wash. On September 17 and 18, fish 247 was found at the east shore of the constricted center of the non-flowing portion of Las Vegas Bay. On September 19 this fish was found 200 meters north of Las Vegas Bay Marina, and then on September 26 it was located about 200 meters below the inflow of Las Vegas Wash. On December 8 it was found at the constricted center of the non-flowing portion of Las Vegas Bay, and then on January 8 it was found at the inflow pool of Las Vegas Wash. This pool was about 7 feet deep and had turbid water from the wash flowing directly into it. On three other days during January it was found between the constricted center and the inflow area of the wash. Fish 247 was again located at the Las Vegas Wash inflow area at the beginning of February and then located in the Blackbird Point area at the end of the month. On March 11 it was located at Blackbird Point, on March 14 it was back at the inflow pool of Las Vegas Wash, and on March 29 it was back in the Blackbird Point area. In April fish 247 was found six times, in various locations, between the constricted center of the non-flowing portion of Las Vegas Bay and the Las Vegas Wash inflow area. During June fish 247 was found two additional times in the same general area.

Tag 3434

This 687-mm TL female razorback sucker had sonic tag 3434 (48-month life expectancy) externally attached on June 14, 2000, at Blackbird Point. Only two contacts were reported previously for this fish because the tagging was completed at the end of the fourth study year. On June 14, approximately 2 hours after the surgery, the fish was located in the general release area, and on June 15 fish 3434 was located 820 feet north of the Las Vegas Bay Marina, thereby indicating it had moved from the post-surgery release site.

At the beginning of the fifth study year the fish had moved east to Salamander Cove. Shortly after this fish was found in Salamander Cove and we determined that the tag had become stationary. Because this fish was externally tagged, it is likely that the tag became unattached from the fish rather than the fish dying.

Echo Bay

Tag 79

This 630-mm TL male razorback sucker was implanted with tag 79 (48-month life expectancy) on January 15, 1998. Sixteen contacts with this fish were made at Rogers Bay, Calico Bay, and Echo Bay during the second study year; during the third study year, this fish was located 47 times at locations in Echo Bay and Pumphouse Bay (Figure 9). During the fourth study year, fish 79 was located 0.5 mile north of Echo Bay in the Overton Arm on September 16 and 17, 1999. Then, on September 28, 29, and 30, it was located at the mouth of Echo Bay, after which it was located in the middle of Echo Bay on October 16 and at the mouth of Echo Bay on October 18, 1999. On December 2 and 3, fish 79 was located near the spawning area in Echo Bay and at the center of Echo Bay, respectively. On January 8 and 27, February 8 and 24, and March 9, 2000, this fish was located on or near the Echo Bay spawning area. During the fifth study year, fish 79 was located

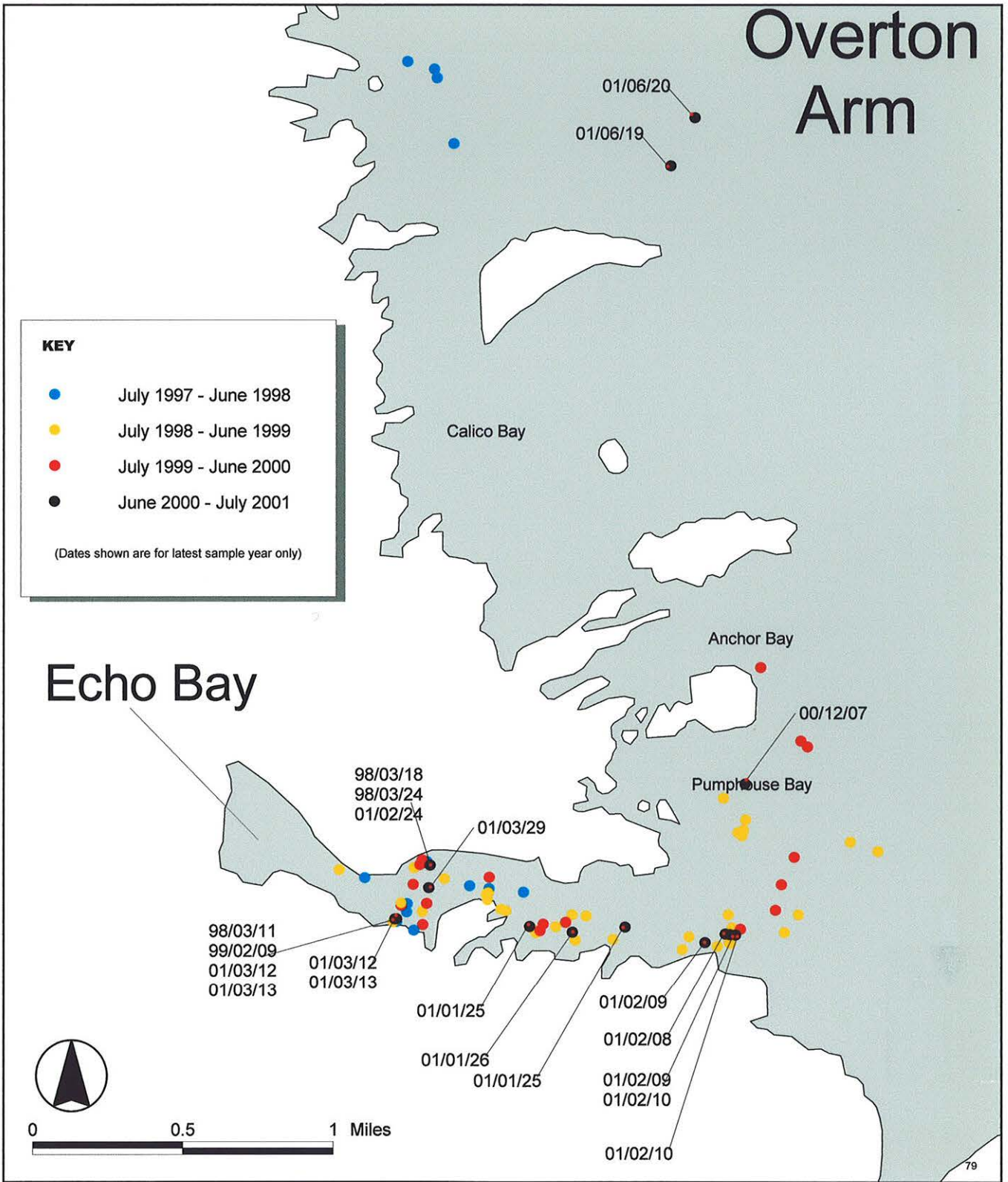


Figure 9. Distribution of fish number: 79.

14 times at either Echo Bay or north of Echo Bay along the western shore of Overton Arm. The first contact with this fish during the fifth study year was on December 7, 2000. This fish was located north of Echo Bay in the center of Pumphouse Bay. In January, fish 79 was located on three different dates in the outer portion of Echo Bay, north of the lower Echo Bay campground and the Echo Bay Marina gas docks. February locations for this fish included the area around the tire break wall on 3 days at the beginning of the month, and by February 24 this fish was found in the back of Echo Bay at the north shore across from razorback cove. This fish was found at the Echo Bay spawning site on March 12 and 13 and just north of that location on March 29. On June 19 and 20, 2001, this fish was found in the southeast quadrant of Rogers Bay; it had moved on the second day, indicating it was still active.

Telemetry Summary

Sonic telemetry results for the fifth study year indicated that habitat used by sonic-tagged razorback sucker was similar to the previous four study years (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b). Similar to past years, these razorback sucker were located relatively close to shore (usually within 200 yards). However, average depth where these razorback sucker were located was slightly greater for this year compared with last year (56 feet verses 51 feet) for fish 79 and slightly less for this year compared with last year (23 feet verses 30 feet) for fish 247. The difference between these two fish is likely a result of fish 79 being found not only close to the spawning area but many times in the deeper areas of Echo Bay and Pumphouse Bay. Conversely, fish 247 was found most often in shallow water near the inflow area of Las Vegas Wash and was only located a few times in the deeper water near Blackbird Point.

General trends exhibited by sonic-tagged razorback sucker during pre- and post-spawning times versus the actual spawning season were difficult to discern because of the limited number of tagged fish that were available to follow. However, the fish that were followed exhibited habitat-use patterns similar to those observed during the previous study year. The last contact made with the only Echo Bay sonic-tagged fish (79) during the previous study year was during March 2000. No contacts were made with this fish during April, May, or June 2000; resultantly, it was assumed that this tag had possibly expired prematurely. This fish was not located during the fifth study year until December 2000, when it was found in the center of Pumphouse Bay in Overton Arm. It is not known what areas this fish was using during the time in which contact was lost. However, telemetry data gathered over the past four years indicate that this fish was likely along the western shore of Overton Arm. This area was frequented by several of the razorback sucker that were previously sonic tagged at Echo Bay.

Las Vegas Bay tag 247 was located in the non-flowing portion of Las Vegas Bay during the pre-spawning period in 2000 and the post-spawning period in 2001. It is clear that this razorback sucker did not have the same habitat use as other previously tagged razorback sucker. The trend exhibited by the majority of sonic-tagged razorback sucker at the Las Vegas Bay study site was to spend most of their time along the north shore of Las Vegas Bay with infrequent returns to Blackbird Point from the months of May and June through early fall of each year. Conversely, fish 247 was always found between Blackbird Point and the inflow area of Las Vegas Wash. Reasons for this are not known. Sonic-tagged fish 3434 provided a limited amount of information prior to becoming stationary. This fish exhibited a habitat-use pattern similar to other sonic-tagged

razorback sucker from Las Vegas Bay. The fact that the tag became stationary soon after sonic-tagging indicated that the external attachment method used was not adequate for the intended application. This method will be revised before it is used on other razorback sucker.

Collectively, the fifth year of sonic telemetry at Echo Bay and Blackbird Point of Las Vegas Bay has provided additional habitat-use locations that generally support trends found during the first 3 years of the study. These trends include: sonic-tagged fish from the two study areas did not overlap in distribution during any study year, spawning areas at Echo Bay and Blackbird Point are the only known spawning areas for razorback sucker in Lake Mead (aside from some presumed spawning activity in the Colorado River inflow area/Grand Wash Basin), and the areas of the lake adjacent to Echo Bay and Blackbird Point are important habitat to razorback sucker during the non-spawning season (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a). Although relatively few sonic-tagged fish were available for telemetry at Las Vegas Bay, fifth study year data support the general trends that some razorback sucker use the non-flowing portion of Las Vegas Bay during the non-spawning period, and others move into areas along the northern shore of Las Vegas Bay. Additionally, the flowing portion of Las Vegas Bay is likely important to razorback sucker during the spawning period.

Larval Sampling

Echo Bay and Las Vegas Bay

Sampling for razorback sucker larvae was initiated in late February 2001, and larvae were first collected on March 11 at Las Vegas Bay along the north shore near the Las Vegas Wash-Lake Mead interface. At Echo Bay the first razorback sucker larvae were collected on March 12, 2001. The last larval razorback sucker was collected on April 25 at Echo Bay (Tables 6 and 7). Six standardized monitoring sites at each known spawning area were sampled bi-weekly during March and April 2001. Additional sampling effort was expended on Las Vegas Wash during 2001, both in the wash proper and at the inflow area of Las Vegas Bay. Tables 6 and 7 show larval sampling results for the general locations of areas other than the standard sites sampled in 2001. The number of razorback sucker larvae collected within Las Vegas Bay was slightly higher in 2001 than in 2000 (40 and 32, respectively), as was the catch per minute (number of fish captured per minute of sampling [CPM]) (0.04 and 0.02, respectively; Table 6). The highest CPM at Las Vegas Bay during 2001 was 0.73. In 2001 silt from Las Vegas Wash and frequent green algae blooms limited visibility to less than 6 inches in many areas of Las Vegas Bay, especially from Blackbird Point to the wash inflow delta. This made larval sampling in this area of the lake problematic and probably reduced larval catch. The larval razorback sucker sampled and their capture locations are shown for Las Vegas Bay in Figure 10.

The number of larvae collected at Echo Bay was much greater in 2001 than in 2000. Nine hundred eighty-seven razorback sucker larvae were collected during 2001, compared with 73 in 2000, 95 in 1999, and 197 during 1998. The 2001 CPM at Echo Bay was much higher than in 2000 (0.89 and 0.09, respectively). The number of larvae captured and the CPM were higher in 2001 than all other study years (1998, 1999, 2000) except 1997. Larvae in Echo Bay were collected throughout the sampling period but appeared to have a distinct peak in numbers during mid April (Table 7). The highest CPM at any Echo Bay site during 2001 was 15.67 on March 11. The larval razorback sucker sampled and their capture locations are shown for Echo Bay in Figure 11.

Table 6. Number of razorback sucker larvae collected at Las Vegas Bay, Lake Mead, during 2001.

DATE	STANDARD LARVAL SAMPLING SITES			WASH INFLOW AREA			WASH		
	Minutes Sampled	Larvae Collected	CPM ^a	Minutes Sampled	Larvae Collected	CPM	Minutes Sampled	Larvae Collected	CPM
2/22/01	90	0	0.00						
3/11/01	90	0	0.00	45	1	0.02			
3/14/01	90	1	0.01	60	0	0.00			
3/25/01	90	1	0.01	30	1	0.03			
4/08/01	90	0	0.00	30	0	0.00			
4/09/01	90	0	0.00	30	0	0.00			
4/12/01							70	0	0.00
4/25/01	90	23	0.26	30	13	0.43			
4/26/01							60	0	0.00
Totals	630	25	0.04	225	15	0.08	130	0	0.00

^a CPM = catch per minute.

Table 7. Number of razorback sucker larvae collected at Echo Bay, Lake Mead during 2001.

DATE	ECHO BAY STANDARDIZED SITES			ECHO BAY OTHER SITES		
	Minutes sampled	Larvae collected	CPM ^a	Minutes sampled	Larvae Collected	CPM
2/23/01	90	0	0.00			
3/12/01	90	16	0.18	45	15	0.33
3/13/01	90	21	0.23	30	6	0.20
3/29/01	90	79	0.88	45	45	1.00
3/30/01	90	47	0.52	45	18	0.40
4/10/01	90	119	1.32	30	13	0.29
4/11/01	90	264	2.93	30	194	6.47
4/23/01	90	34	0.38	30	30	6.47
4/24/01	90	61	0.68	30	25	0.83
Total	810	641	0.79	285	346	2.00

^a CPM = catch per minute.

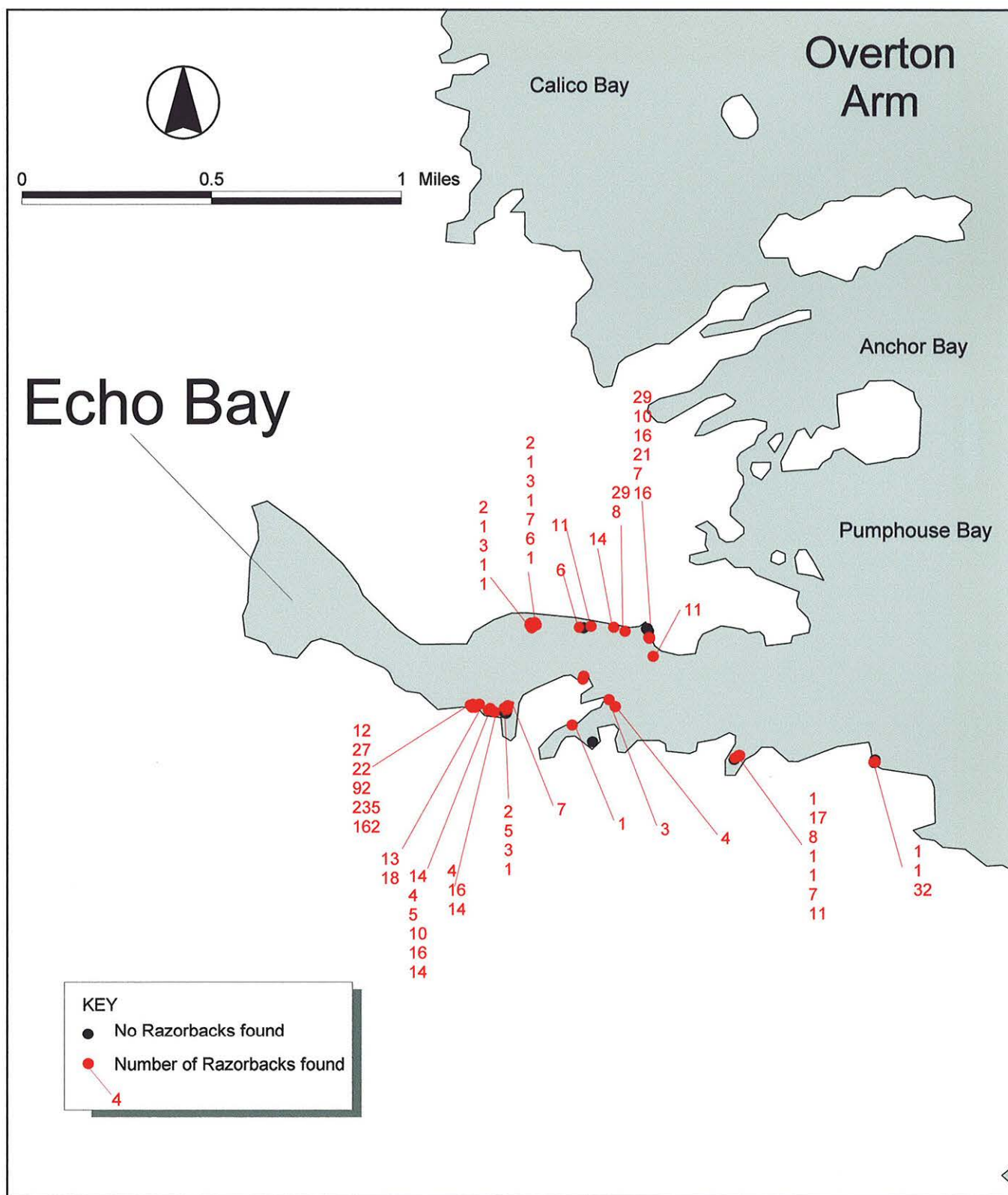


Figure 11. Echo Bay study area showing larval razorback sucker sample and capture locations.

Larval sampling in the flowing portion of the Las Vegas Wash was conducted on April 12 and on April 26, 2001. On April 12, small backwaters and eddies were sampled approximately 500 m below the North Shore Road bridge that spans Las Vegas Wash. On April 26, these same habitat types were sampled along the west shore of the wash below the Lake Mead campground. No larval razorback sucker were captured during 130 minutes of sampling; however, juveniles and adults of two non-native species, red shiner (*Cyprinella lutrensis*) and mosquitofish (*Gambusia affinis*), were collected.

Razorback sucker larvae were again collected in locations somewhat removed from presumptive spawning sites. At Las Vegas Bay, larvae were collected up to 1.5 miles from the presumed spawning site at Blackbird Point. On a single night in late April, four larvae were collected around the Pitch Fork Cove area, and one larval razorback was collected just East of Gypsum Wash. Fifteen razorback sucker larvae were collected within the inflow area of Las Vegas Wash, whereas no larvae were collected at this location in 2000. Most larvae collected at the wash inflow were captured in the non-flowing portion of Lake Mead within 400 m of the wash delta. Several larvae, however, were captured or observed in eddies along the south and north shores within 100 m of the wash delta.

Dispersion through wind and wave action is one explanation for collecting larvae in areas removed from spawning sites. Historic wind data for Echo Bay and Las Vegas Bay were obtained from the National Park Service in an attempt to examine larval drift during 2001 and previous study years. The wind data were of limited use in interpreting larval drift because wind direction was recorded only once during each day and wind speed was estimated by the observer. Wind direction and speed can change numerous times throughout a single day at both Echo and Las Vegas bays. For example, on April 9, 2001, at Las Vegas Bay, the wind blew from three different directions; north, south, and east. Changing wind direction and speed during a single day and from one day to the next can limit the usefulness of wind data in determining larval drift patterns. Detailed wind data that provide wind speed and wind direction at regular intervals over a single day could be very useful in reconstructing larval drift patterns, thereby aiding in the location of general spawning areas for razorback sucker populations in Lake Mead.

Grand Wash Bay and the Colorado River Inflow Area

Larval sampling outside of the Echo Bay and Las Vegas Bay areas during spring 2001 was conducted entirely at the Grand Wash Bay and Colorado River inflow areas. To provide the best chance of finding spawning sites in this area, sampling began prior to the period where larvae are typically found at Echo and Las Vegas bays. Sampling began on March 5, 2001, and concentrated on the areas where razorback sucker larvae were found during the previous sampling year. Once sampling began, however, site selection was broadened to encompass the area from the boundary of Grand Canyon National Park and Lake Mead to the western portion of Grand Wash Bay near Iceberg Canyon. This area was sampled in a random fashion from the beginning of the spawning period until larvae were found. From this point, the areas in which larvae were captured and other nearby areas were sampled more intensively until the end of the spawning period. Larval sampling lasted through May 15, 2001.

Twenty-two razorback sucker larvae were collected in four main areas on Grand Wash Basin. The first larvae in the Grand Wash/Colorado River inflow area were collected April 29 and 30, 2001, near Lava Point. Other collections included three razorback sucker larvae from the Driftwood Island area, seven razorback sucker larvae from Bradley Bay, and one from the Twin Coves area. Voucher specimens were collected for verification in the lab by BIO-WEST. These specimens were later verified as razorback sucker larvae by D. Snyder, Colorado State University Larval Fish Lab. Total effort to capture these larvae included 257 sampling sites and 4,445 minutes of sampling with two crappie lights and two netters. Water temperatures where larval razorback sucker were collected ranged from 64 to 74 ° F and were substantially higher than collection temperatures at Echo Bay and Las Vegas Bay which, during this and past study years, have ranged from 57 to about 71 ° F during the most active part of the larval production period.

During the previous year, 11 larval razorback sucker were found at three of the 63 sites sampled in the Grand Wash Basin/Colorado River inflow area. Six larvae were first found on April 29, 2000, near the mouth of Grand Wash Canyon just east of Grand Wash Bay (Figure 12). Incidentally, this is the same day on which larvae were first found in 2001 in this area.

Water temperature at time of sampling was 67° F. Other larval razorback sucker collected during 2000 included four larval razorback sucker captured 0.25 mile south of the Colorado River inflow near Perce Ferry (Figure 12) on April 30 with a water temperature of 66° F. Finally, on May 14, 2000, one larval razorback sucker was collected at God's Pocket, near the site where larvae were found on April 29 (Figure 12), with water a temperature of 66° F.

Juvenile Sampling

Table 8 shows sampling effort specifically targeting juvenile razorback sucker. No juvenile razorback sucker were collected during the report period (July 2000 through June 2001). Fyke nets, gill nets, and minnow traps were used to sample for juvenile fish at Echo Bay. Fyke nets again proved effective for collecting smaller sizes of non-native fish species. In 2001, 1,005 individual fish, representing 9 species, were captured at Echo Bay. The relative abundance of each species is as follows: red shiner 50.8%, threadfin shad (*Dorosoma petenense*) 23.1%, largemouth bass (*Micropterus salmoides*) 12.6%, bluegill (*Lepomis macrochirus*) 9.7%, green sunfish (*Lepomis cyanellus*) 1.9%, striped bass (*Morone saxatilis*) 1.6%, mosquitofish 0.1%, common carp (*Cyprinus carpio*) 0.1%, and channel catfish (*Ictalurus punctatus*) 0.1%. The species composition and abundance of non-native fishes from fyke net samples at Echo Bay were similar to the previous sampling years. Gill nets and minnow traps were not very effective at capturing small fishes. Only four species were collected with gill nets, totaling fewer than 55 fish (threadfin shad, 44; channel catfish, 4; bluegill, 2; common carp, 2). No fish were captured in minnow traps.

Aging Razorback Sucker

Aging Lake Mead razorback sucker was added to the project in 1998 when a juvenile 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 2000-2001 involved collection of fin ray sections from razorback sucker for aging.

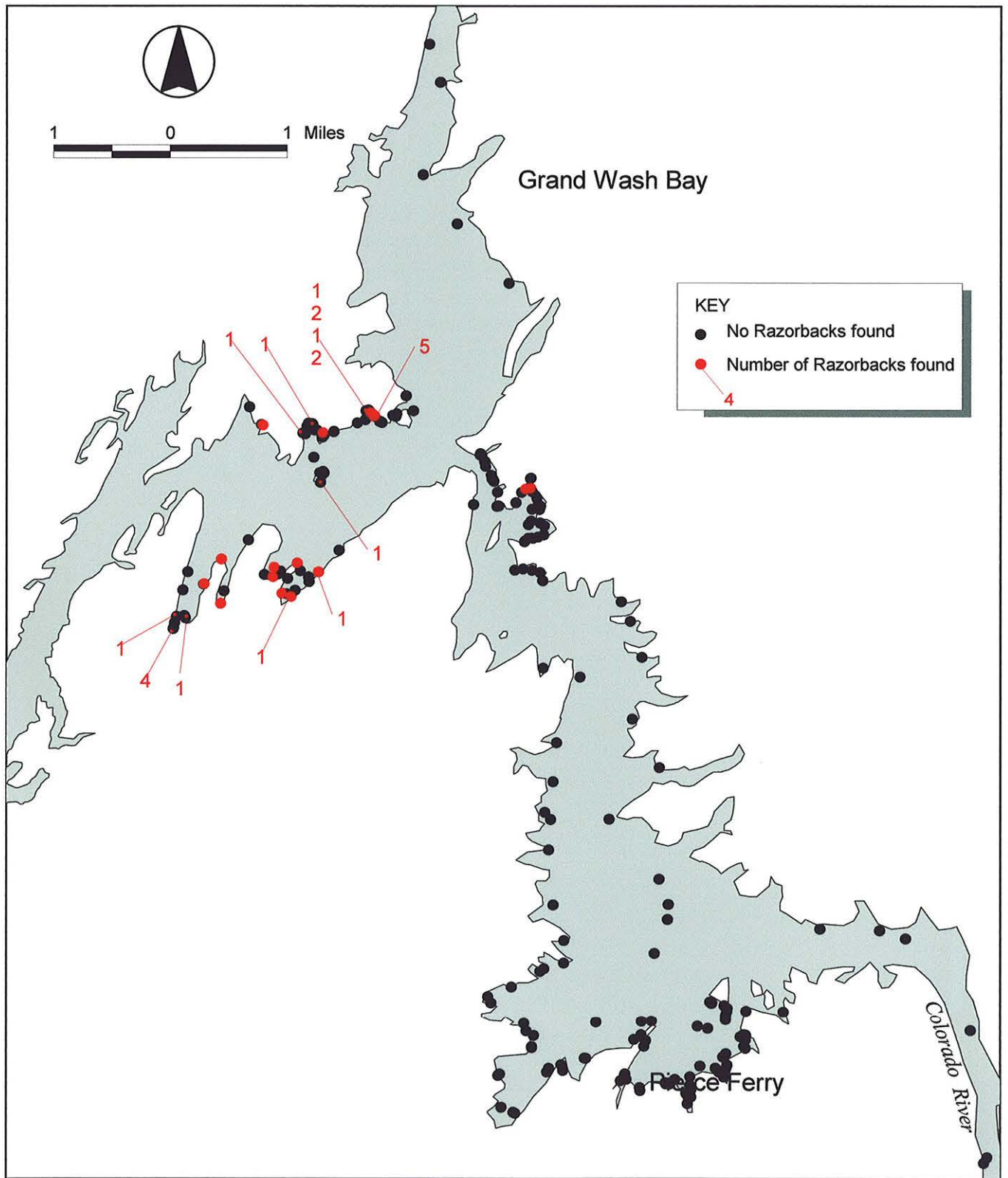


Figure 12. Gand Wash Bay and Colorado River inflow study area showing larval razorback sucker sample and capture locations.

Table 8. Sampling effort for juvenile razorback sucker in Lake Mead at each site by gear type, July 2000 through June 2001.

GEAR TYPE	EFFORT
	Echo Bay
Fyke nets 3 feet x 4 feet x 15 feet, 3/8 inch mesh	24 net nights
Gill nets 100 feet x 4 feet, experimental mesh ^a	35 hours
Minnow traps 0.125 inch nylon mesh	30 net nights

^aMesh size starts at 0.5 inch and increases to 2.0 inches.

Eight of the razorback sucker collected during trammel netting on Lake Mead during the 2000-2001 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 site, and all fish quickly regained equilibrium and swam off normally when released. Seven razorback sucker that had been fin clipped in the previous study year were recaptured in 2001. Sampled fins on all fish had completely healed. For three fish, the removal areas were almost entirely grown-in with new tissue with the sectioned areas barely noticeable (Figure 13). However, the other four fish had lost tissue and one to three fin rays from the sectioned area (Figure 14). Despite the loss of fin rays and fin tissue, these fish appeared to be in good condition.

Prior to aging the 2001 fish, all old fish fin ray sections and otoliths were reviewed and all previous ages were confirmed. A definitive age was obtained for seven of the eight razorback sucker processed, and an age range determined for the other fish (Table 9). Two specimens were aged at less than 10 years, four of them ranged from 11 to 15 years of age, and two of them were 18 years or older. One of the specimens was a 378 mm juvenile and was aged at 6 years. Another specimen was captured as a 347 mm juvenile at Echo Bay on January 5, 1998, and recaptured in 2001 as a 570 mm adult. Table 9 also includes an estimate of the year each fish hatched. Two of the 8 fish were likely spawned around 1982, one in 1985, two in 1987, one in 1989, one in 1992, and one in 1994. The results of aging efforts on 2 fish that were aged in 1998 and on 11 fish that were aged in 2000 are also given in Table 9. Figure 15 shows the number of fish spawned per year plotted against Lake Mead elevations from January 1935 to June 2001. All of the fish aged by BIO-WEST were spawned between 1978 and 1995, which coincides with high lake elevations for the period from 1963 to 2000.

Although recent recruitment has been documented in the Lake Mead population, length frequency analysis may indicate that the population has become older from 1996 to 2001. From the time period 1996-1998, the highest proportion of razorback sucker in Las Vegas Bay and Echo Bay were in the 551-600 mm length category; however, in the 1999-2001 time period, the highest proportion of individuals were in the 601-650 mm length category (Figures 16 and 17). In Echo Bay, 28.1% of the fish captured were 601 mm or longer for the 1996-1998 time period; however, the proportion almost doubles to 50.0% for the 1999-2001 time period (Figure 16). In Las Vegas

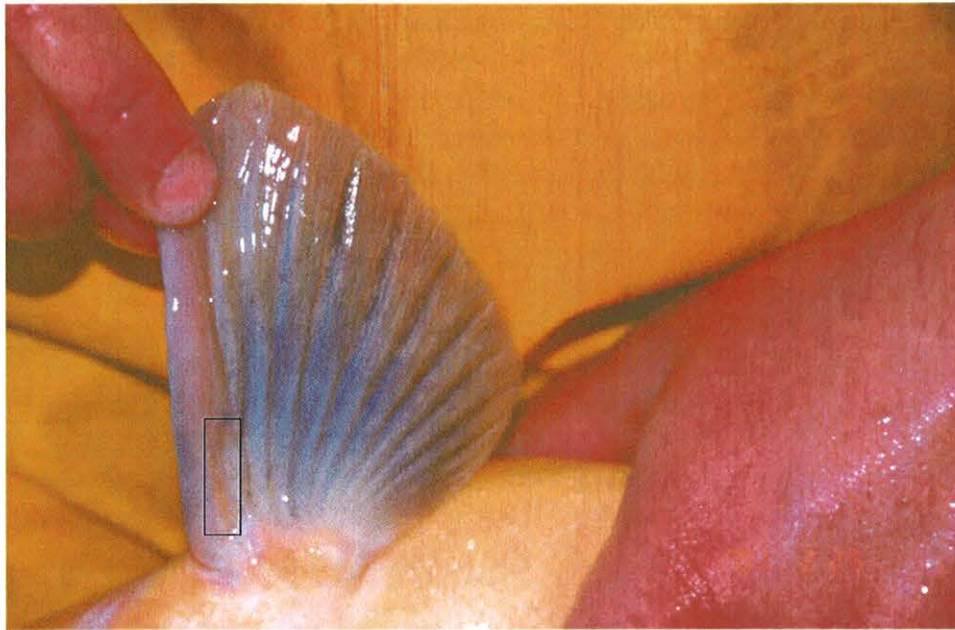


Figure 13. Recaptured razorback sucker with fin-clipped area completely healed and filled with new tissue (box encloses healed portion of pectoral fin).



Figure 14. Recaptured razorback sucker with fin-clipped area completely healed but with the first two leading rays of the pectoral fin missing.

Table 9. Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead (ages in bold were obtained from fin rays collected in 2001).

DATE COLLECTED	TOTAL LENGTH (mm)	AGE	PRESUMPTIVE YEAR SPAWNED
Las Vegas Bay			
05/10/98	588	10 ^a	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
Echo Bay			
01/22/98	381	5 ^a	1992
01/09/00	527	13	1986
01/09/00	550	13	1986
01/09/00	553	13	1986
01/09/00	599	12-14	1985-1987
01/27/00	557	13	1986
01/27/00	710	19+	1977-1980
02/09/01	641	13	1987
02/24/01	577	18+	1980-1982
02/24/01	570	8	1992
02/24/01	576	15	1985
02/24/01	553	18	1982

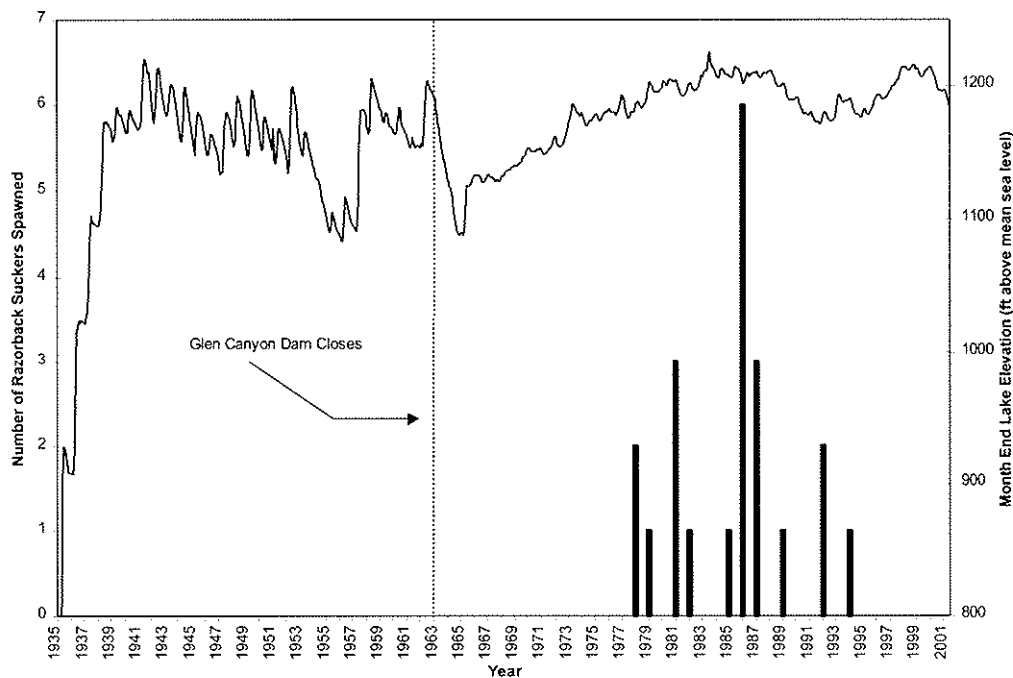


Figure 15. Lake Mead hydrograph from January 1935 to June 2001 with the number of razorback sucker hatched per year (determined from BIO-WEST's aging information).

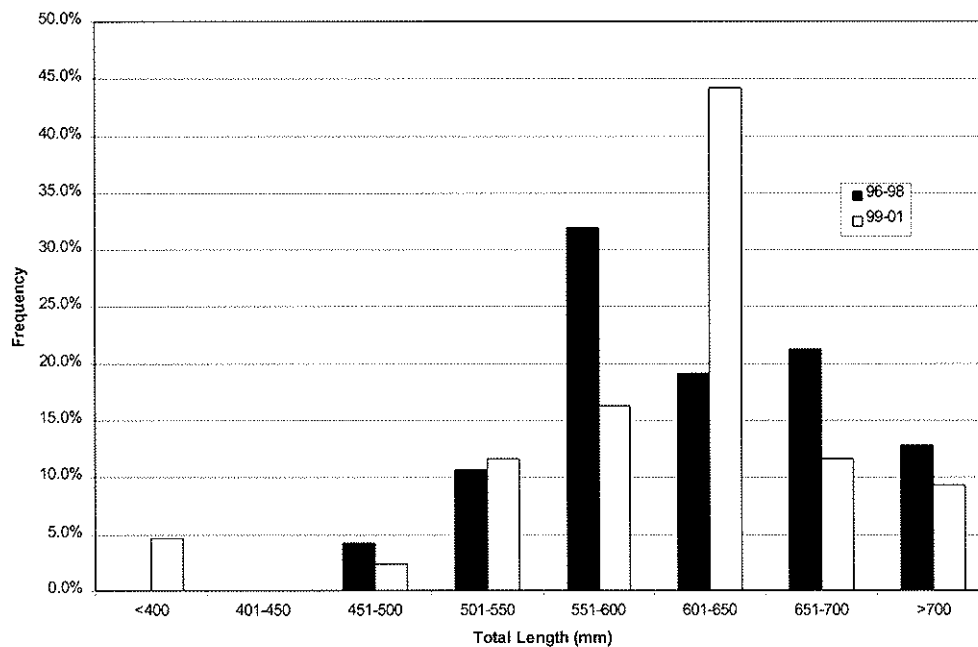


Figure 16. Length frequency (total length) for Echo Bay razorback sucker.

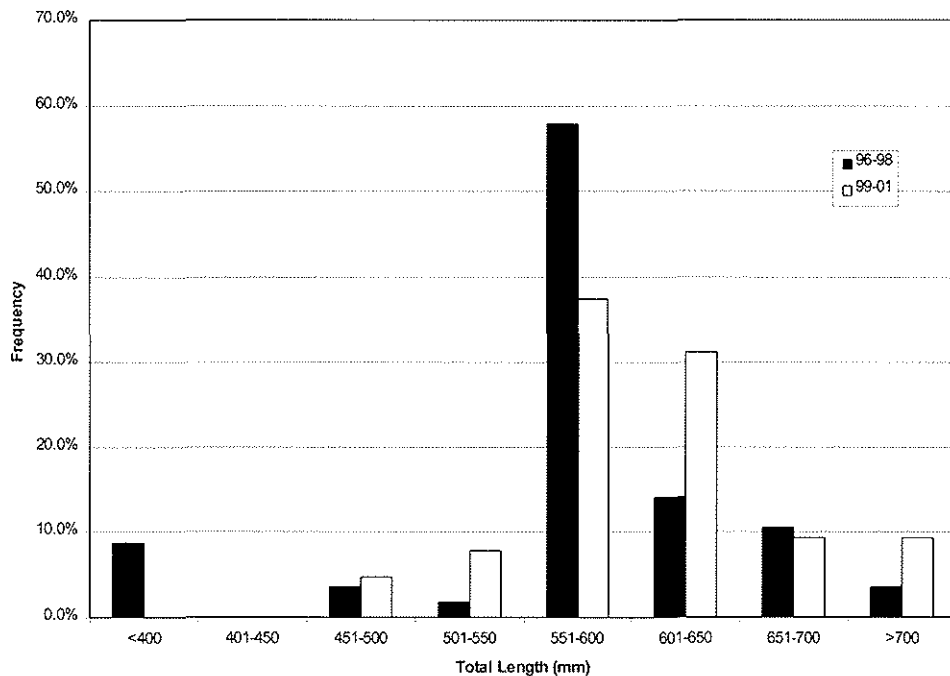


Figure 17. Length frequency (total length) for Las Vegas razorback sucker.

Bay, the proportion of fish 601 mm or longer increases from 53.2% in the 1996-1998 time period to 65.1% in the 1999-2001 time period (Figure 17).

Recapture rates for Lake Mead razorback sucker were calculated for fin-clipped fish and non-fin-clipped fish to determine if fin-clipped fish were recaptured at lower rates and to examine trends in recapture rates since the start of BIO-WEST's razorback sucker studies. Recapture rates were lowest during the first two study years with rates of 25.5% in 1998 and 10.3% in 1999. In 2000 and 2001 recapture rates were much higher with approximately 45% of the fish recaptured in each year (2000 = 45.5%, 2001 = 42.2%). The return rate for fin-clipped fish is available only for 2001 as fin clipping was first initiated in 2000. The return rate for fin-clipped fish in 2001 was 68.4%, whereas the return rate for non-fin-clipped fish was 7.1%.

Population Estimate

Capture data collected by BIO-WEST from 1996-2001 and USFWS in 2001 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 a 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 each consecutive 3-year period (1996-1998, 1997-1999, 1998-2000, 1999-2001) to investigate trends in abundance and to examine the consistency of the estimates. Two abundance estimators were used: Chao's M_h and Model M_0 . The Model M_0 typically produces the most-reliable estimates for endangered western fishes (Dr. Ron Ryel, consultant, pers. comm.), but assumes equal catchability of individuals. Chao's M_h is a good estimator for sparse data, but unlike

Model M_0 it assumes heterogeneity of capture probabilities. For each 3-year period, 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 10 shows the results of the population modeling using the two models from the program CAPTURE. From 1996-2001, the number of razorback sucker at Echo Bay ranged from a low of around 65 fish in the 1998-2000 period to a high around 90 fish in the 1997-1999 period. Similarly, the number of fish at Las Vegas Bay ranged from a low of 55 fish in the 1999-2001 period to a high of around 130 fish in the 1998-2000 period. Patterns in abundance were difficult to discern for each of the populations, as large differences were found between the two estimators for the 1999-2001 period for Echo Bay and the 1998-2000 period for Las Vegas Bay. However, the number of individuals over this time period appeared to fluctuate around 75-90 for each of the populations.

Table 10. Razorback sucker population estimates for Echo Bay and Las Vegas Bay using data from 1996-2001.

Echo Bay								
Estimator	1996-1998	95% C.I.	1997-1999	95% C.I.	1998-2000	95% C.I.	1999-2001	95% C.I.
Model M_0	74	55-114	84	66-123	65	53-92	58	50-77
Chao M_h	75	53-134	98	68-175	66	52-105	107	66-126

Las Vegas Bay								
Estimator	1996-1998	95% C.I.	1997-1999	95% C.I.	1998-2000	95% C.I.	1999-2001	95% C.I.
Model M_0	75	53-124	87	60-148	118	68-247	55	41-91
Chao M_h	78	52-151	98	61-201	148	72-382	55	39-104

DISCUSSION

The fifth year of razorback sucker studies on Lake Mead has expanded information on age, growth, and potentially new spawning areas and confirmed previously identified spawning area locations and habitat use observations made during the first 4 years of the study. Sonic telemetry, trammel netting, and collection of larvae at standard sampling sites continued to confirm the high importance of Echo Bay and Las Vegas Bay to spawning razorback sucker. Sonic telemetry results

from Echo Bay and Blackbird Point located sonic-tagged razorback sucker at and near these areas during the spawning season. Additional data on annual razorback sucker growth confirmed rates documented in previous years, and aging information on 8 adult razorback sucker were added to the 13 fish aged in 1998 and 1999. Larval razorback sucker collected in Grand Wash Basin further support the hypothesis that an additional spawning population may be present in Lake Mead.

Similar to data collected during previous years, sonic telemetry results showed that areas adjacent to Echo Bay and Blackbird Point continue to provide important habitat during both the spawning and non-spawning seasons. However, differences in overall habitat use can be seen for individual fish. Despite the minimal number of active sonic-tagged fish, it is apparent that fish 247 has an affinity for the flowing and non-flowing portions of Las Vegas Bay and potentially Las Vegas Wash below Lake Las Vegas. Echo Bay sonic-tagged razorback sucker 79 displayed similar habitat use characteristics compared with other Echo Bay sonic-tagged razorback sucker. However, it was generally found more often in Echo Bay than other sonic-tagged razorback sucker but still frequented areas north of Echo Bay along the western shore of Overton Arm.

External sonic-tagging of razorback sucker juveniles was conducted by Mueller et al. (1998) and Mueller and Marsh (1998) in Lake Mohave and Lake Powell, and they also had relatively poor success with the technique. Although the technique appears to be a viable tagging option since it does not supply the physical trauma and stress of internal tagging, Mueller and Marsh (1998) recommend it only for short term (2-4 week) studies. The attachment procedure for the fish tagged in 2000 caused no bleeding or excessive trauma, and the tag was attached firmly to the fish. Also, the fish recovered well and moved away from the post-surgery release site within 24 hours. The only limitation of external tagging may be durability and the resulting longevity associated with this type of attachment. Future tagging will employ the internal tagging methods used during the first 3 years of the study.

Trammel netting catch-per-effort (CPE) of razorback sucker for the fifth study year decreased at Echo Bay and Las Vegas Bay compared with the previous year. At Echo Bay/Overton Arm, CPE for the first, second, third, fourth, and fifth study years was 0.85, 0.32, 0.48, 0.58, and 0.33, respectively. At Las Vegas Bay, CPE for the first, second, third, fourth, and fifth study years was 0.29, 0.34, 0.10, and 0.25, 0.14, respectively. The primary reasons for the catch decrease observed at Las Vegas Bay and Echo Bay were the timing and location at which most of the sampling occurred. Sampling occurred at both of the standard sampling sites during the pre-spawning season when razorback sucker are slightly more concentrated than during summer. Also, sampling was not as intensive as in past study years during this pre-spawning period (January and February).

Unlike the previous 2 years, video surveillance was unsuccessful in documenting spawning activity at the Echo Bay site. High larval abundance at the Echo Bay spawning site indicated that spawning was occurring at this area. However, turbidity and shallow water at the spawning redd made extensive use of this sampling gear unproductive. Similarly, at Las Vegas Bay, high water turbidity resulting mostly from green algae blooms also limited the usefulness of this gear.

Consistently decreasing lake elevations during the fifth study year prevented access to the flowing portion of Las Vegas Bay and Las Vegas Wash near the end of the study year. The lowering lake

elevation increased the size of the delta that was formed during the previous study year. This prevented boat access, hindering our ability to monitor sonic-tagged fish in this area. These conditions may have made access to the wash difficult for razorback sucker as well. However sonic-tagged fish 247 was frequently found in the direct inflow pool of the wash. It is unclear if this fish was moving upstream into the wash, but it is doubtful because of the current geomorphic condition of the lower wash. Because of the sedimentation of the lower wash and the concurrent drop in lake level, the 0.25-mile portion directly above the inflow terminus of the wash was extremely flat and caused the wash to spread out over an approximately 400-foot-wide area. This resulted in very shallow water at the wash-lake interface, especially at times of low wash flow.

Larval sampling CPE for the 2001 spawning season increased at Echo Bay and was approximately the same at Las Vegas Bay compared with the previous year. The CPE and total number of larvae at Echo Bay in 2001 was higher than all study years except 1997. The high numbers of larvae at Echo Bay interrupted a trend of decreasing larval abundance at this site. At this time it is unclear why so many larvae were produced at Echo Bay. Potential reasons include lower and declining lake elevations at the time of sampling, which may have increased the effectiveness of the sampling gear, or environmental conditions in the bay may have enhanced egg viability, hatching success, or early larval survival.

Larval sampling in the Grand Wash Basin/Colorado River area during 2001 included the capture of larval razorback sucker in this portion of Lake Mead. These 22 larvae provide a second year of data that suggest that spawning occurred in the lake, either near the Colorado River inflow area of Lake Mead or in the lower Colorado River before it enters the lake. Extensive trammel netting in this area did not result in any juvenile or adult razorback sucker captures. However, razorback sucker are known to be difficult to capture even when the general location of an individual fish is known. During the past year of this study, trammel netting was conducted very near sonic-tagged razorback sucker in areas other than Echo Bay or Blackbird Point. There have been few instances where razorback sucker were captured outside of the two known spawning areas.

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 20.1 mm, compared with 8.3 mm the previous sampling year, and compared with about 2.0 mm per year for Lake Mohave (Pacey and Marsh 1998) and the Green River (McAda and Wydoski 1980, Tyus 1987). At Las Vegas Bay, mean annual growth was 9.1 mm, which is similar to previous years. Unlike past study years, Echo Bay fish showed greater growth rates than Las Vegas Bay fish. Razorback sucker growth in Lake Mead decreases as fish length increases with the slowest growth found for the longest length groups. This phenomenon is not surprising, but it has not been demonstrated for other populations of razorback sucker. However, it has been observed for other sucker species (Villa 1985, Dauble 1986). As in past years, razorback sucker recaptured within a short period of time from a previous capture usually had negative growth, thereby suggesting that netting and handling stress may have a negative effect on growth of these fish. However, a juvenile, non-spawning fish was captured during the spawning period on February 10, 1998, and again 1 on March 11, 1998, at Echo Bay. This fish grew 4 mm over the 31-day period. Most of the fish that exhibit negative growth are captured during the spawning period, which may suggest that spawning also plays a role in negative growth.

Male fish tended to be the smallest fish in the Lake Mead population and also exhibited the slowest growth. Modde et al. (1996) found that male fish in the Green River in Colorado and Utah also were smaller than female fish. This is also the case in Lake Mohave, Arizona (Minckley 1983). However, both sexes in Lake Mead (and in Lake Mohave) tended to be longer than their counterparts in the Green River. Most males in the Green River population were less than 550 mm and most females were less than 600 mm, whereas most males in the Lake Mead population exceeded 550 mm and most females exceeded 600 mm. Although slower growth in male fish than in female fish has not been documented for other razorback sucker populations, this phenomenon has been observed for other species of sucker (Moen et al. 1974, Nelson et al. 1974, Barton 1980). In 2 weeks of sampling at Echo and Las Vegas Bays during spring 2001, the USFWS captured 33 fish and obtained a 48.5% capture rate for previously uncaptured fish. BIO-WEST sampled during 5 weeks from December to February in 2001 and captured only 20 fish, 30.0% of which were new captures. The difference in numbers of fish and capture rates most likely resulted from the temporal differences in sampling. The USFWS sampled during the spawning period when most razorback sucker would be concentrated in both the Las Vegas Bay and Echo Bay populations. BIO-WEST sampled during the pre-spawning and early spawning periods in which 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 the fifth study year, aging efforts continued with fin clipping as the appropriate method for obtaining a hard structure for aging. Calculated ages ranged from 6- to 18+-years-old for the eight razorback sucker collected in 2001. Despite general success with the fin ray removal and aging process, successful regrowth of sectioned fins was mixed. Of the seven recaptured fin-clipped fish from the previous year, all fin rays had healed completely. However, several fish were missing one or more fin rays and surrounding tissue. Nonetheless, these fish appeared healthy. Recapture rates were high for fish fin-clipped fish in 2000, indicating that the fin-clipping process probably does not negatively influence fish survival.

Ages of the 8 fish aged in 2001 and the 12 fish aged in 2000 show that recruitment has occurred fairly regularly over the period from 1978 to 1994. The greatest recruitment occurred from 1985 to 1987. Several fish aged at 5-8 years indicate recent (during the 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 oldest fish aged by BIO-WEST was spawned around 1978. 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, this apparently did occur in the lake and the original razorback sucker population would have disappeared around 1980. 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. This would suggest that 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 fish from the relatively few fish that recruited in the later 1970s and early 1980s.

The comparison of Lake Mead's elevation with 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 feet in the mid-1960s as Lake Powell filled and then 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 and provided cover for many years 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.

Lake Mohave, where razorback sucker natural recruitment has not been documented, also has large annual fluctuations. Another ongoing study (Golden and Holden 2001) has shown that cover is more abundant in Lake Mead coves than in Lake Mohave coves. This information leads us to hypothesize 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. 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.

Large differences in abundance obtained from the two population estimators for a given 3-year period most likely resulted from effectively sampling the resident population of fish with the occasional capture of a fish from outside this population. This type of scenario causes Chao's M_h to produce a higher abundance estimate than Model M_o . In 1996, 1997, and 1998, adult netting was conducted during most of the spawning period, which would allow effective sampling of the entire population at both Echo and Las Vegas Bays. Close agreement between the two abundance estimators would most likely result and is found for both populations in the 1996-1998 period, and to a lesser extent for the 1997-1999 period. An explanation for the differences in abundance estimates for the 1999-2001 period at Echo Bay and the 1998-2000 period at Las Vegas Bay could be that many fish arrived late at the spawning sites (March-May) when BIO-WEST did not sample. A few non-resident fish would have been captured early in the spawning season, but many of the fish in each population would have resided outside the spawning areas and would not have been susceptible to capture. Sampling throughout the entire spawning period would provide a more-representative sample of the Echo Bay and Las Vegas Bay populations, thereby providing more-accurate and precise abundance estimates. In 2001 USFWS captured many fish with little sampling effort during March and April, when BIO-WEST did not sample, and many of these fish were new

captures. This evidence supports the assertion that sampling only during the pre-spawning and early-spawning periods may not provide a representative sample of the populations.

Large differences in fish abundance from one three-year period to the next could also be related BIO-WEST's sampling protocol. In 1996, 1997, and 1998, the populations were sampled during the entire spawning period. In 1999, 2000, and 2001, the populations were sampled only early in the spawning period. If fish were early to the spawning area during one time period, a good estimate for the entire population could be obtained. For example, if fish were late to the spawning area during the next time period, a good estimate of the resident population could be obtained, but a good estimate for the entire population would not be obtained. In this scenario, the population estimate would be higher (and probably more accurate) during the first time period and lower during the second time period. Another explanation could be that the population is declining in abundance. The largest changes in abundance are from the 1997-1999 time period to the 1998-2000 time period in Echo Bay and from the 1998-2000 time period to the 1999-2001 time period in Las Vegas Bay. At Echo Bay, the change in abundance is approximately 30 fish between the two time periods and close to 60 fish for Las Vegas Bay. Such a reduction in fish numbers seems unlikely in the absence of a catastrophic event. Such an event, although possible, was not observed for either of the two populations.

RECOMMENDATIONS FOR THE SIXTH YEAR OF STUDY

The general research objectives for the sixth year of the study 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 Grand Wash Basin and the Colorado River inflow area. Research objectives are as follows:

1. Continue focused trammel netting, electrofishing, and fyke netting at Echo Bay and Las Vegas Bay to locate additional adult and juvenile razorback sucker in Lake Mead, but extend the sampling into the spawning period to capture more of the populations;
2. Continue tracking sonic-tagged fish to determine the habitat use and life history characteristics of the Lake Mead population, maintaining no less than two sonic-tagged razorback sucker at Echo Bay and Las Vegas Bay;
3. Monitor the two previously identified spawning areas (Echo Bay and Blackbird Point) to determine larval production;
4. Search for a new razorback sucker spawning population in the Grand Wash Basin or Colorado River inflow area via larval light-trapping and trammel netting. Initiate sonic tagging and telemetry if adult razorback sucker are found;
5. Release four-to-ten sonic-tagged razorback sucker in Grand Wash Basin in hopes of following them to a wild spawning population of razorback sucker;

6. Collect pectoral fin ray sections from all razorback sucker collected in trammel nets and use them for aging;
7. Sample for adults and larvae in the flowing portion of Las Vegas Bay and in Las Vegas Wash. Access the wash on foot just below the Lake Las Vegas Dam and use larval light traps to search for larval razorback sucker. Conduct trammel netting, and perhaps electrofishing, in Las Vegas Wash if larvae are collected; and
8. Use weekly video surveillance to monitor spawning activities at Echo Bay and Las Vegas Bay, if possible, and attempt to locate actual spawning locations.
9. Collect samples of the fin rays and whole larvae for genetic analysis.

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