

Razorback Sucker Studies on Lake Mead, Nevada

1999-2000 ANNUAL REPORT

PR-578-4

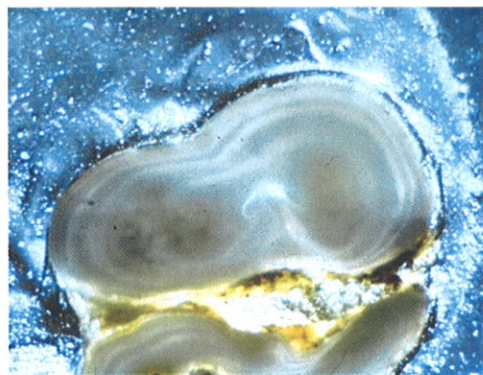
December 2000



Top: Fisheries biologist removes pectoral fin ray section from a razorback sucker.

Bottom left: A sectioned fin ray segment as viewed through a microscope for aging.

Bottom right: Healing of pectoral fin ray where section was removed for aging.



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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 fourth year (July 1999 to June 2000) of the Lake Mead razorback sucker study, emphasis was placed on locating new populations within the lake using lakewide larval sampling and on aging the two known populations. Trammel netting for adult fish continued, and effort was increased in February 2000 to aid the USFWS in collecting adult razorback sucker for toxicological studies. During the fourth year, 39 adult razorback sucker were captured, including 15 in Las Vegas Bay and 24 in Echo Bay. Of the 39 total collected, 25 were recaptures, a recapture rate that is similar to the second study year's rate. During the first 4 years of the study, 115 individual razorback sucker were captured, not counting larvae.

Trammel netting and removing small sections of fin rays for aging likely resulted in the mortality of one adult razorback sucker that had been sonic tagged in 1998 and followed for nearly 2 years. The fish was captured in December 1999 and a fin section was removed. It was again collected in January 2000, and the fin that had been sectioned had been rubbed raw and the fin ray was exposed. After release, the sonic tag did not move, suggesting the fish had died. Three other fin-sectioned adults were recaptured, one had rubbed its fin ray and the other two were almost completely healed with no apparent rubbing.

During March 1999, razorback sucker spawning activity was recorded on video tape at Echo Bay. This prompted more use of the video camera in 2000 to attempt to locate sonic-tagged fish and to document spawning. A spawning sequence was again filmed in March 2000 in Echo Bay, but attempts to locate a spawning site at Blackbird Point were not successful.

Recaptured razorback sucker from Lake Mead again showed relatively high growth rates. Average annual growth for 12 recaptured fish at Echo Bay was 8.3 mm, and for 6 fish at Las Vegas Bay it was 10.8 mm. A growth analysis of four adult razorback sucker that had been captured twice in 60 days or less showed that all such fish exhibited negative growth, suggesting the stress of capture in trammel nets may cause growth to stop, and even recede, for a period of time.

Sonic telemetry of razorback sucker showed use patterns similar to those identified during the past 3 years. Las Vegas Bay fish tended to use the area around the Las Vegas Wash inflow and Blackbird Point during the spawning period and extended their range out to the Boulder Basin area during the summer. Echo Bay was used heavily during the spawning period, but use of Rogers Bay

and other bays between Rogers Bay and Echo Bay occurred throughout the year. Las Vegas Wash itself became inaccessible for most of this fourth study year because of mud flats near its mouth, so telemetry was not conducted in the wash. One adult razorback sucker was fitted with an external sonic tag in June 2000 but insufficient time has elapsed to determine the success of that technique.

Larval sampling was continued at Las Vegas Bay and Echo Bay during spring 2000. Smaller numbers and catch rates of larvae resulted at both sites, compared with previous years. No larvae were found near the wash inflow area in 2000.

Lakewide larval sampling was emphasized during the fourth study year in an attempt to determine if other razorback sucker populations occur in the lake besides those at Echo Bay and Las Vegas Bay. Nearly the entire lake was sampled for larvae in spring 2000 in an attempt to locate larvae. Eleven larvae were found in the upper end of Lake Mead near the Colorado River inflow in late April and early May 2000, suggesting that a spawning area likely exists there. Trammel netting was conducted in that portion of the lake in mid-May in an attempt to locate razorback sucker adults for sonic telemetry, but none were collected.

Juvenile sampling in spring 2000 was intensified in Echo Bay and Las Vegas Bay with the use of fyke nets, gill nets, minnow traps, and electrofishing. No juvenile razorback sucker were found.

Using techniques developed in 1998 and 1999, fin ray segments from 12 adult razorback sucker were obtained and aged during 2000. The ages were scattered and ranged from 12 to 19+ years. Additional refinement of some of the fin ray segments is ongoing.

Emphasis in 2000-2001 will focus on locating adult razorback sucker in the upper lake by initially searching for larvae and then trammel netting and sonic-tagging adults. In addition, all larger razorback sucker collected by trammel netting will be aged using pectoral fin ray sections. Also, additional studies will be targeted at Las Vegas Wash and the flowing portion of Las Vegas Bay, including trammel netting, sonic tagging, drift netting, and larval sampling, 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 is 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 nonnative fishes that have successfully established in the Colorado River and its reservoirs have also contributed to their decline. Razorback suckers 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 nonnative 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 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 include: the Bureau of Reclamation (BOR), providing funding, storage facilities, and technical support; the National Park Service, providing residence facilities in their campgrounds; the Colorado River Commission of Nevada; and the U.S. Fish and Wildlife Service (USFWS).

The primary objectives of the project are:

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.
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 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). 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.
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. 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.

This Annual Report presents the results of the study from July 1999 through June 2000, with information and data from previous years (October 1996-June 1999) included where applicable. Previous annual reports have been completed for 1996-1997 (Holden et al. 1997), 1997-1998 (Holden et al. 1999), and 1998-1999 (Holden et al. 2000).

STUDY AREAS

The majority of 1999-2000 study activities occurred at the same locations used in the 1996 to 1999 portion of the study (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). 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, Boulder Basin, and Virgin Basin (Figure 1). Study areas throughout the lake that were added for larval sampling in 1999 were sampled again for larvae in 2000 (Holden et al. 2000). Trammel netting was conducted at both Las Vegas Bay and Echo Bay as during previous years. Additionally, trammel netting was conducted at the Colorado River inflow area and at the southern end of Grand Wash Bay for the first time.

Elevation of the lake affected all study areas. When the study began in October 1996, the average lake elevation was about 1,190 feet above mean sea level (amsl) (Figure 2). The October 1998 average lake elevation peaked at about 1,216 feet amsl. This increase in lake elevation provided increased inundated vegetation areas in all lake areas where tamarisk (*Tamarix chinensis*) and other vegetation covered the shoreline. At the end of the third study year (June 1999), the average monthly lake elevation had receded to about 1,206 feet amsl. Lake elevation throughout the fourth study year varied by month. The July 1999 average monthly lake elevation was about 1,207 feet amsl, after which it increased to a high of 1,214 feet amsl by January 2000. After January 2000 lake elevation decreased steadily, averaging 1,204 feet amsl for June 2000. Most study activities for the fourth study year occurred within the full pool elevation of Lake Mead, (1,229 feet amsl) and the flowing portion of Las Vegas Bay. The only activity that occurred above the full pool elevation of the lake was 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.

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 and wash flows. When the study began in 1996, the lake elevation was at its lowest point during the study, allowing for a substantial wetland-type area with bulrushes (*Scirpus* sp.) and inundated tamarisk 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 the lake-induced back-flow effect. Lake elevation rose approximately 20 feet during 1996 and 1997, thereby inundating this area and causing a delta

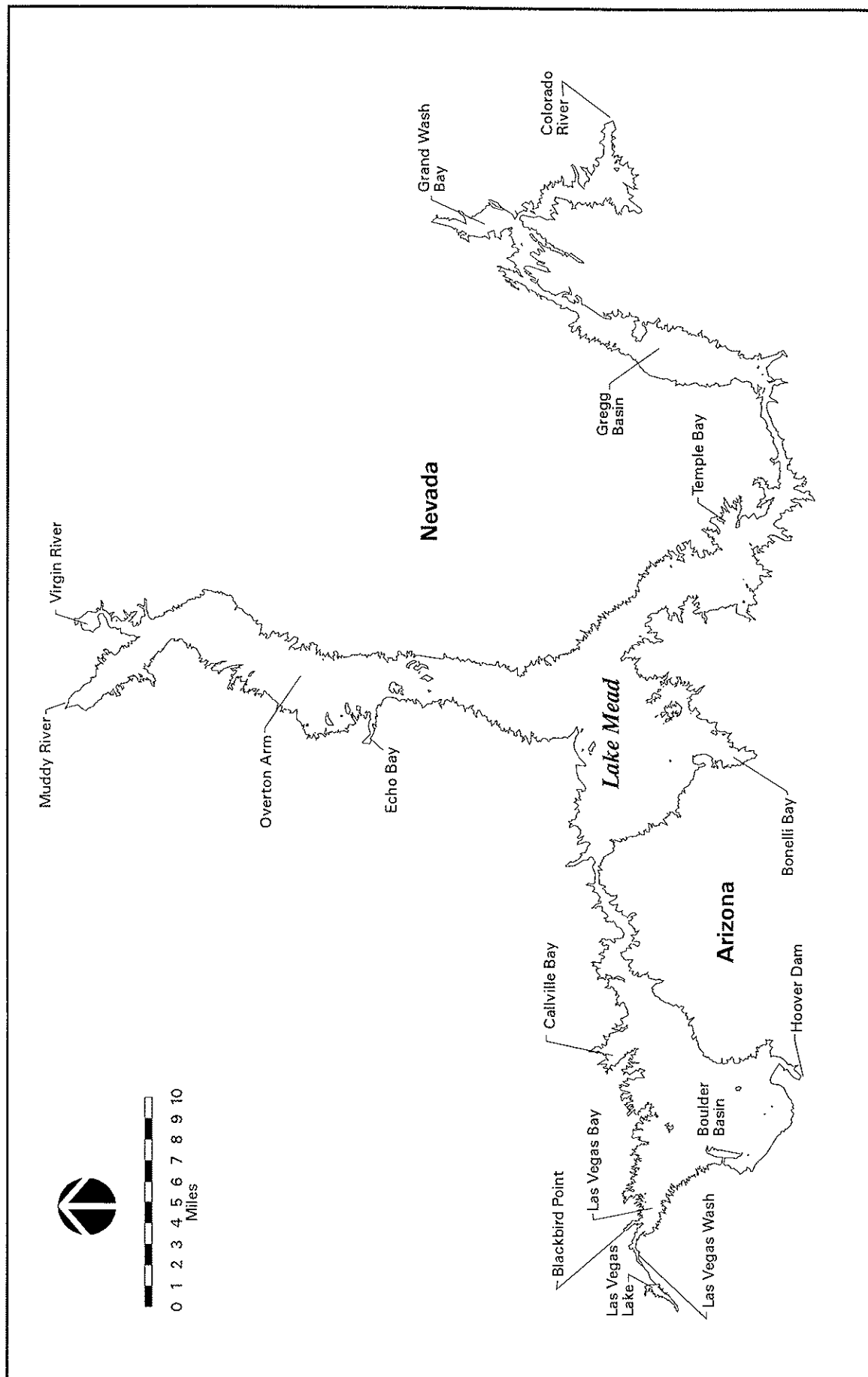


Figure 1. Map of Lake Mead showing general study area locations.

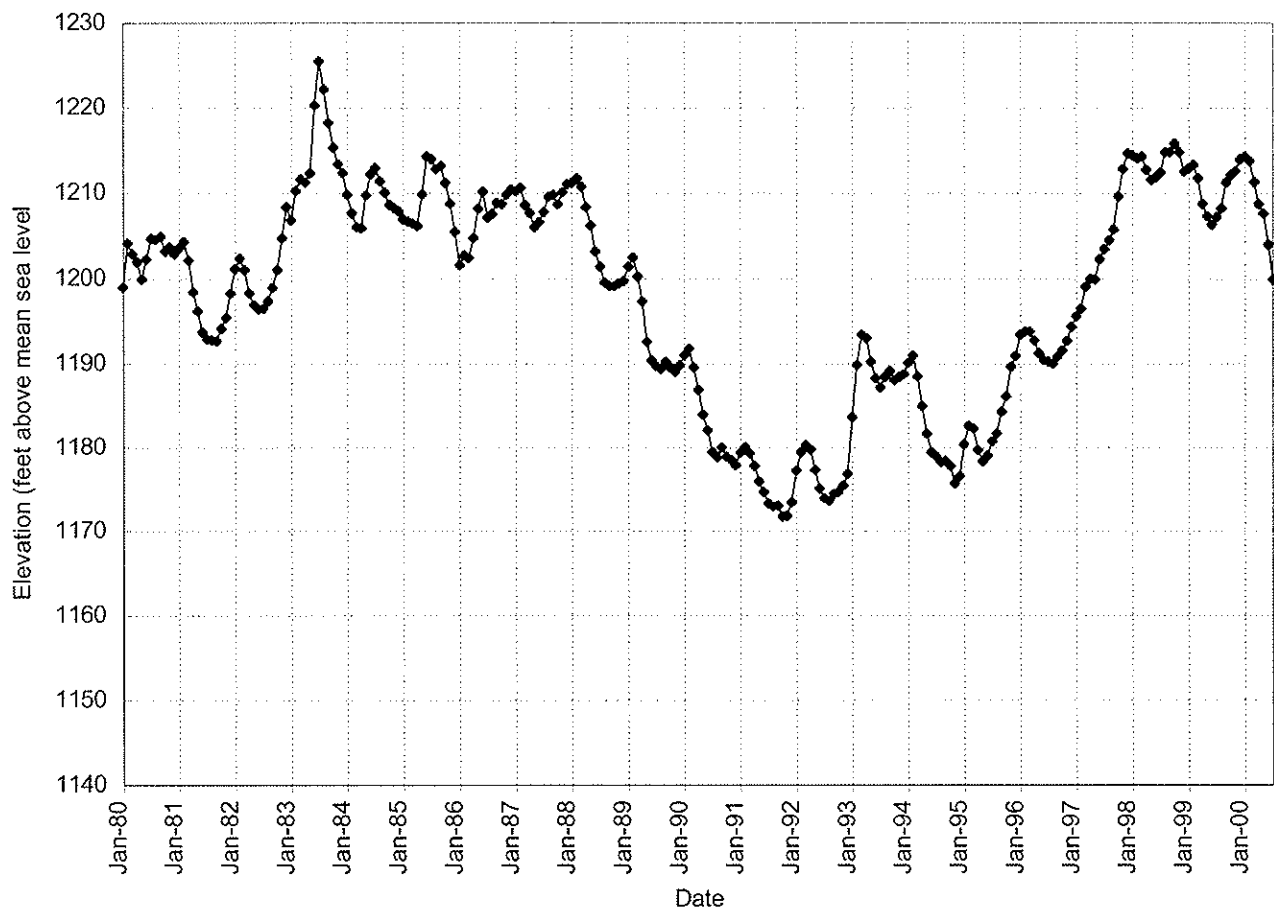


Figure 2. Lake Mead month-end elevations, January 1980 to July 2000.

to form farther upstream at a relatively new inflow area. As the lake began to decrease in late 1999 and early 2000, increased amounts of sediments 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 has formed, thus further limiting boat travel into the flowing channelized portion of the wash.

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 has 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 habitats sampled

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 discolored 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 3 years of research were used during the fourth year of research (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). Trammel nets were the primary sampling gear for collecting adults, and sonic telemetry was continued as the method with which adult habitat use and movement was determined. During February 2000 special trammel net sampling was conducted to acquire razorback sucker for blood and sperm samples for the USFWS to investigate toxic loading in the fish. Spawning adults were found via larval sampling and through use of an underwater video camera, similar to techniques used for observation during the previous 2 years.

Sonic telemetry was conducted similarly to previous years (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000), except that one sonic transmitter was externally attached to an adult razorback sucker rather than surgically implanted. External attachment methods were developed from methods used by Muller and Marsh (1998) on razorback sucker in Lake Mohave and Lake Powell. These methods incorporated some internal tagging protocols used previously during this study and outlined in Holden et al. (1997). The same 48-month tags used in previous implants were used for external tagging, and the tags had pre-drilled holes perpendicular to the longitudinal axis at both ends. Once the fish was anesthetized, the tag was attached to the dorsal keel area of the fish using 20-pound test nylon fishing line through the pre-drilled holes. Both ends of the line were inserted through the body of the fish using sterilized needles and tied against a backing plate (plastic button) on the opposite side of the fish, thus pulling the tag firmly against the side of the fish just below the dorsal keel. Separate lines and backing plates were used at each end of the tag. Once each end of the tag was secured, the knots were treated with Superglue® to prevent them from untying and also to fasten them to the backing plate. The fish was allowed to recover in the live well, then released at the point of capture within an hour of tag placement.

Larval Sampling

Spring 2000 larval sampling was conducted with the same methods used during the third study year. Larval sampling was conducted at the 12 standard spring 1999 larval sampling (Holden et al. 2000) sites located in Echo and Las Vegas Bay. Larvae were sampled, as during previous years, for a standardized 15 minutes (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). 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 use of habitat.

Initiated in 1998, a major new study effort was the search for other razorback sucker populations within the lake. Based on past Lake Mead experience, it was determined that larval sampling was a better method of finding other populations than was adult sampling. In 1998, larval sampling occurred in Las Vegas Bay, the Overton Arm, and the Gregg Basin areas thought to harbor razorback sucker (Holden et al. 1999). In spring 1999, a more-thorough coverage of the lake was conducted, and this sampling was repeated in spring 2000. This sampling was conducted using the same methods used in 1999 (Holden et al. 2000). Larval sampling was conducted at 1.0-mile increments along the entire shoreline of the lake (0.5-mile increments along the northwestern shore of Overton Arm). Spring 2000 sampling locations were placed in between the locations used in 1999. Using this alternate placement method resulted in a final, 2-year lake wide sampling coverage of 0.50 mile around the lake's perimeter and a 0.25 mile sampling coverage along the northwestern shore of Overton Arm (Holden et. al 1999, Holden et al. 2000).

In addition to the lakewide and standard larval sampling, limited drift netting was conducted at the Las Vegas Wash inflow, and light trapping was conducted upstream and downstream of the North Shore Road bridge that crosses Las Vegas Wash. Drift netting and larval light trapping were conducted as described in previous annual reports (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). However, larval light trapping was conducted from shore in depths that were generally shallower (1-6 inches) than those done in other parts of the lake.

Other sampling conducted during the fourth year included larval drift netting and juvenile sampling. Larval drift netting was conducted in the flowing portion of Las Vegas Bay, and limited 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. 2000).

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. 2000). During 1999-2000, information gained from previous aging investigations was incorporated into a non-lethal aging technique. This technique was then used to age adult razorback sucker from Echo and Las Vegas Bays. Select razorback sucker caught in trammel nets were anesthetized, and approximately 0.25 inch segments of the 2nd and 3rd left pectoral fin rays were surgically removed. These segments were embedded in epoxy, sectioned with a fine-tooth jeweler saw, sanded and polished, and read under a stereo-zoom microscope. If a fish appeared overly stressed from netting, it was excluded from the procedure.

RESULTS

Adult Sampling

Trammel Netting

Table 1 shows the trammel netting effort that occurred from July 1999 to June 2000, 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 123 trammel net nights (one net night is comprised of one overnight net set) were conducted during the fourth study year, with 57 net nights spent in the Las Vegas Bay/Boulder Basin area, 46 net nights spent in the Echo Bay/Overton Arm area, and 20 net nights spent in the Grand Wash/Colorado River inflow areas.

Table 1. Trammel netting effort (net nights) on Lake Mead by month from July 1999 to June 2000.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY/ OVERTON ARM	COLORADO RIVER INFLOW AREA	TOTAL
1999				
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	8	15	0	23
December	5	0	0	5
2000				
January	10	10	0	20
February	30	17	0	47
March	0	0	0	0
April	0	0	0	0
May	0	0	20	20
June	4	4	0	8
Total	57	46	20	123

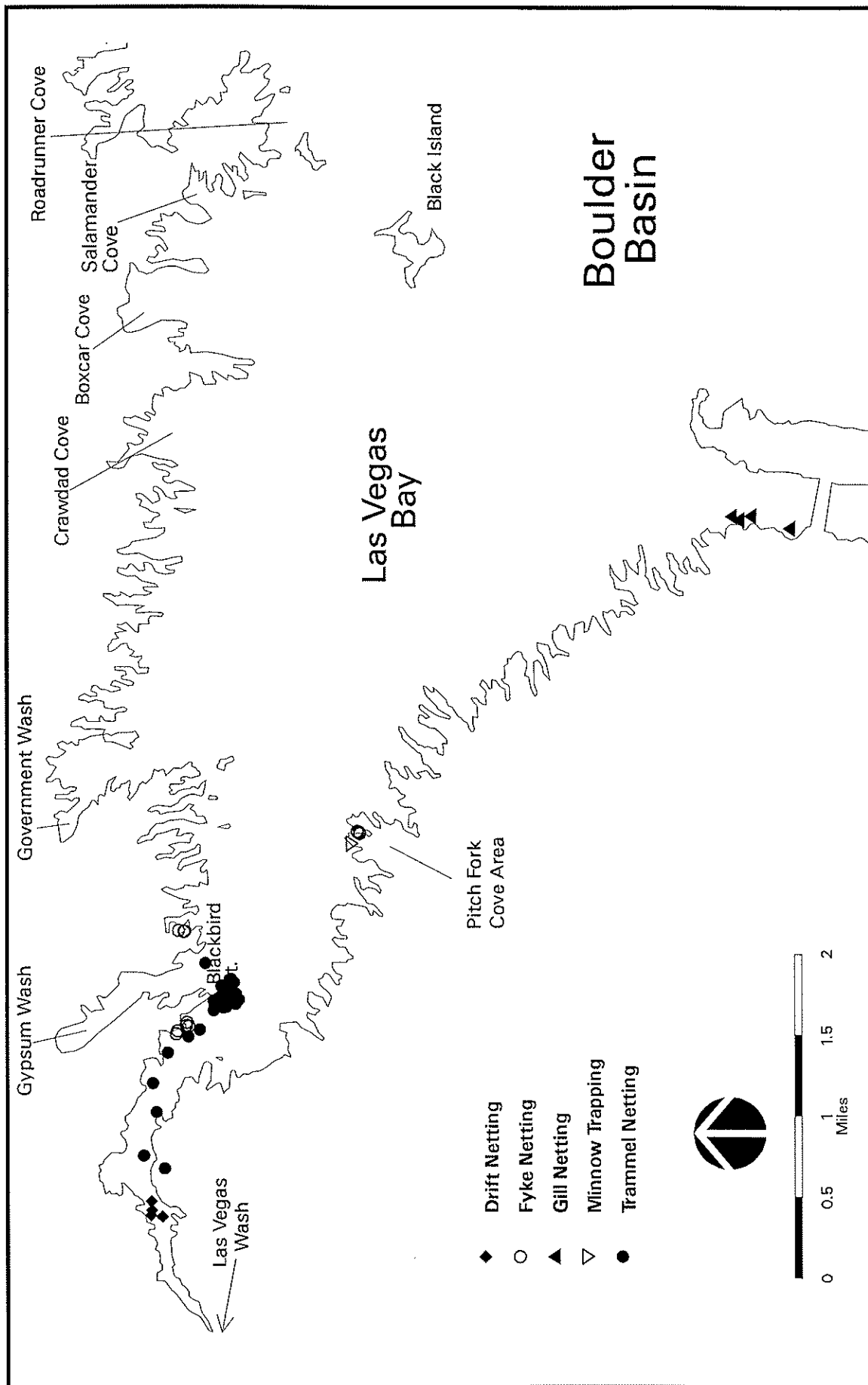


Figure 3. Las Vegas Bay study area showing locations of drift netting, fyke netting, gill netting, minnow trapping, and trammel netting.

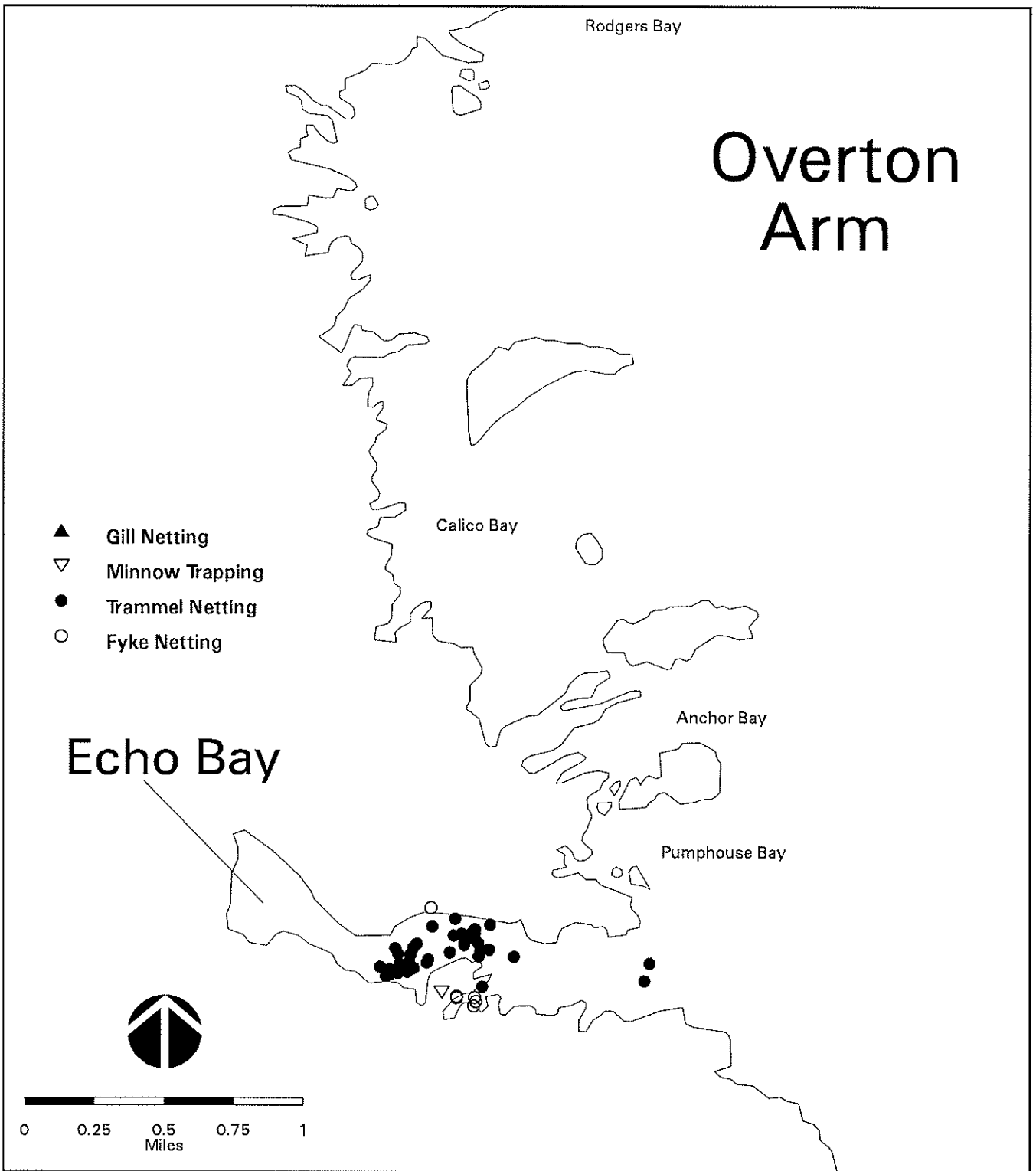


Figure 4. Echo Bay/Overton Arm study area showing location of gill netting, minnow trapping, and trammel netting.

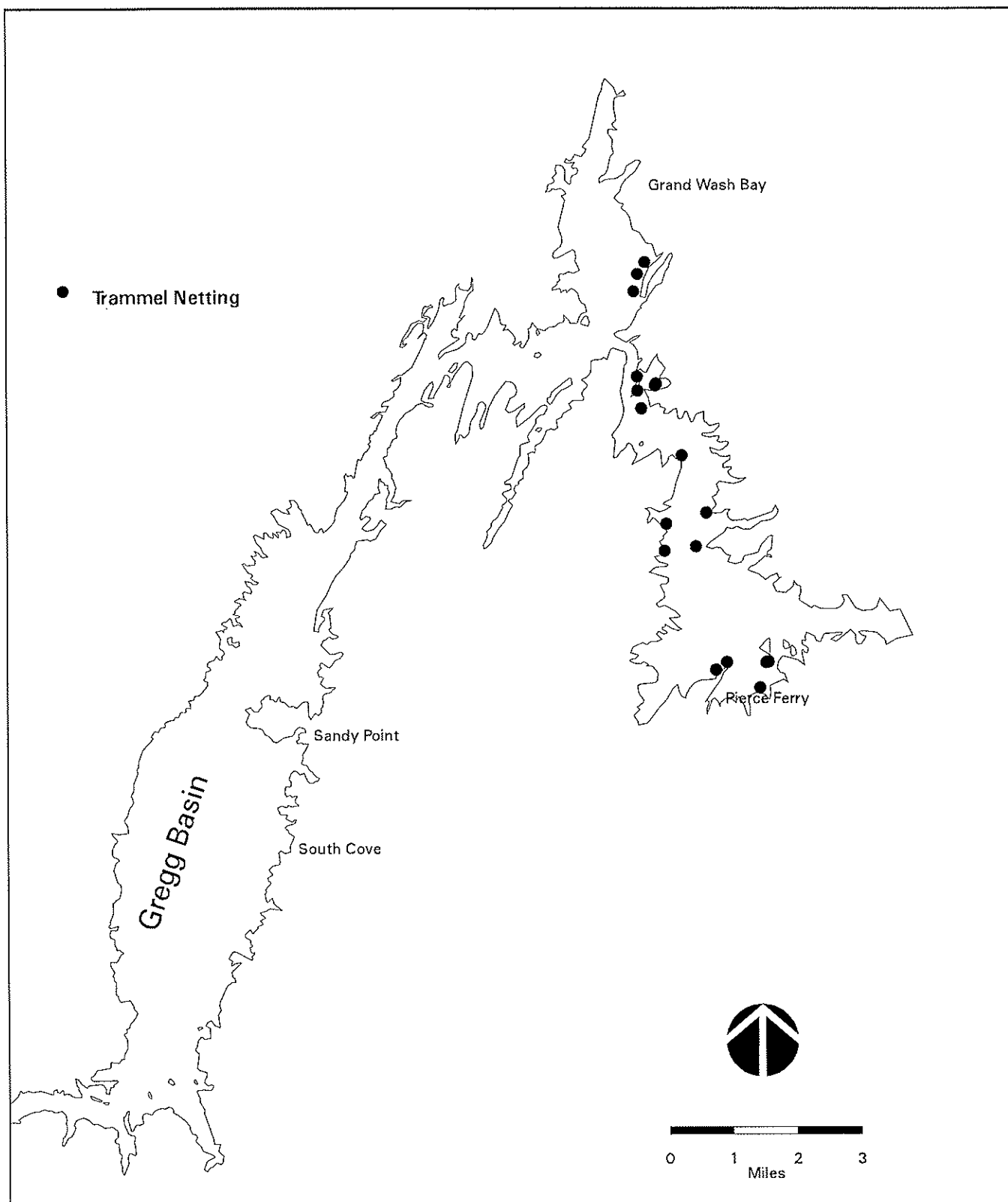


Figure 5. Grand Wash/Colorado River inflow areas showing location of trammel netting.

Similar to previous study years, trammel netting effort during the fourth study year was concentrated in the Blackbird Point area in Las Vegas Bay (Figure 3), including the flowing and non-flowing portions of Las Vegas Bay, and in the back part of Echo Bay (Figure 4) (Holden et al. 1997, Holden et al. 1999). Net locations outside the two primary study sites were selected based on the locations used by sonic-tagged fish and areas suspected of containing other spawning locations for razorback sucker, such as near the Grand Wash and Colorado River inflow areas.

As with the previous study year, the timing of trammel netting for the fourth 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 fourth study year was not conducted from July to October (warm months). With the exception of netting conducted during May at the Grand Wash and Colorado Inflow areas, netting was not conducted during March, April, and May (spawning season). 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 to attempt to locate adult razorback sucker utilizing the area.

Netting was intensified in the two primary study areas in February 2000, when BIO/WEST crews assisted the USFWS in collecting adult razorback sucker for toxicological analysis. The USFWS collected samples of blood and milt for further analysis from adults collected at Blackbird Point and Echo Bay.

At Blackbird Point in Las Vegas Bay, 15 adult razorback sucker were captured during 51 net nights in the fourth study year. This is the same general area where most of the Las Vegas Bay razorback sucker were captured during previous years. Limited trammel netting occurred in the northwestern corner of Las Vegas Bay between Blackbird Point and the inflow area of Las Vegas Wash. Sampling consisted of six net nights at various locations within the non-flowing portion of the bay. Although sonic-tagged razorback sucker were located in the area, no razorback sucker were caught in nets. Razorback sucker catch rates for trammel netting at the Las Vegas Bay area, not including sampling near the confluence with Las Vegas Wash, were 0.29/net night for the fourth sampling year. If results for all trammel netting in Las Vegas Bay are combined, the razorback sucker catch rate decreases slightly to 0.25/net night.

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 trammel netting efforts and where sonic-tagged razorback sucker were previously located. This was the area starting mid-way back into the bay and extending to the western-most shore of the bay. During 40 net nights, 24 razorback sucker were captured. The razorback sucker catch rate for trammel netting at Echo Bay was 0.58/net night.

Limited trammel netting was conducted near the inflow area of the Colorado River and in Grand Wash Bay in May 2000 after 11 razorback sucker larvae were found in this area. Twenty net nights were conducted from May 22 to 26 and distributed over the 7-mile reach between the southern portion of Grand Wash Bay and Pierce Ferry. No razorback sucker were captured during this netting effort.

Similar to the previous study year, limited trammel netting was conducted during the spawning season. However, ripe male razorback sucker were caught prior to the actual spawning season, beginning in mid December and continuing through late February. The first male with breeding tubercles was captured on December 13, 1999, at Blackbird Point, and the first male expressing milt was caught at Echo Bay on January 27, 2000. A female razorback sucker expressing eggs was first captured on February 25, 2000 (Table 2).

Recapture rates varied between study locations. Several fish were caught twice during the fourth study year, and several recaptures from previous years were also caught. At Las Vegas Bay, 7 of the 15 razorback sucker caught were recaptures. At Echo Bay, 18 of the 24 razorback sucker caught were recaptures.

At Echo Bay, 39 individual razorback sucker have been captured and PIT-tagged during the 4 study years. In addition, 26 other razorback sucker previously PIT-tagged by NDOW were captured. Hence, 65 individual PIT-tagged razorback sucker were handled at Echo Bay during the first 4 years of the study.

At Las Vegas Bay, 43 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, 50 unique PIT-tagged razorback sucker have been handled at Las Vegas Bay during the first 4 years of this study. Lakewide, 115 individual razorback sucker were handled during the first 4 years of the study.

Video Surveillance

Underwater video surveillance was used to observe razorback sucker spawning activity at Echo Bay during spring 2000. The spawning ground was located during the previous spawning season with the underwater camera and SCUBA, and was located at the southwestern corner of Echo Bay, along a cliff that rises about 50 feet out of the water (Holden et al. 2000). Water depth at the spawning area during spring 2000 was approximately 17 feet, and it was turbid enough to obscure the bottom from direct surface observation. Depth and water turbidity conditions were similar to the 1999 spawning season.

Table 2. Location, tagging, and size information for razorback sucker collected in Lake Mead from October 1996 to June 2000.

Date	Trip No.	Location	Sonic Tag No.	Freq. (kHz)	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight(g)	Sex	Ripe*
10/23/1996	1	Blackbird Point	Not Implanted		1F4B1F5621	No	495	460		1530	U	
10/23/1996	1	Blackbird Point	Not Implanted		1F4A173D43	No	588	547		2600	U	
10/24/1996	1	Echo Bay	Not Implanted		1F4A30392E	No	704	651	594	4082	F	
10/24/1996	1	Echo Bay	Not Implanted		7F7D22242B	Yes	595	555	499	2700	F	
11/18/1996	2	Blackbird Point	249	75	1F483F0D4D	Yes	576	530	485	2130	F?	TU
11/20/1996	2	Echo Bay	357	75	7F7B012325	Yes	591	550	489	2710	F	TU
11/20/1996	2	Echo Bay	348	75	7F7D152A5D	Yes	569	533	471	2270	M	TU
11/20/1996	2	Echo Bay	258	75	7F7D515B6E	No	585	540	479	2871	F	TU
11/20/1996	2	Echo Bay	267	75	7F7D2B330C	Yes	588	545	485	2235	M	TU
11/20/1996	2	Echo Bay	285	75	7F7D165D68	Yes	606	564	502	2604	M	TU
12/18/1996	4	Blackbird Point	276	75	7F7D3B6539	No	713	664	605	4507	F	
12/18/1996	4	Blackbird Point	339	75	7F7D4B7052	No	492	459	410	1637	M	
1/27/1997	6	Echo Bay	2255	77	7F7D4D6F34	No	585	545		2475	M	TU
1/27/1997	6	Echo Bay	Not Implanted		7F7D2B2D5F	Yes	590	548		2638	M	TU
1/27/1997	6	Echo Bay	Not Implanted		7F7D222A48	Yes	545	510		2055	M	TU
1/27/1997	6	Echo Bay	2228	77	7F7D22351B	Yes	695	645		4245	F	
1/27/1997	6	Echo Bay	2246	77	7F7D4D7777	No	590	550		2610	M	TU
1/28/1997	6	Blackbird Point	384	75	7F7D4A7E47	No	512	483		1603	F	
1/29/1997	6	Blackbird Point	2237	77	7F7D28296B	No	735	695	640	4763	F	
1/29/1997	6	Blackbird Point	2264	77	7F7D4B7C2E	No	560	520	465	2222	M	TU
2/10/1997	7	Blackbird Point	294	75	7F7D4B7A54	No	617	578	525	2375	M	MI
2/25/1997	9	Blackbird Point	276		7F7D3B6539	Yes	713	664		3855	F	EG
2/25/1997	9	Blackbird Point	Not Implanted		7F7D4D6275	No	502	467	428	1599	M	MI
2/25/1997	9	Blackbird Point	Not Implanted		7F7D51716D	No	659	605	550	3600	F	
2/25/1997	9	Blackbird Point			7F7D481D76	No	671	620	560	3742	F	
2/28/1997	9	Echo Bay	357		7F7B012325	Yes	597	550	485	2668	M	
2/28/1997	9	Echo Bay	Not Implanted		7F7D1A2B3C	Yes	576	538	481		M	
2/28/1997	9	Echo Bay	Not Implanted		1F4A592D11	Yes	681	642	573	3390	F	
2/28/1997	9	Echo Bay	Not Implanted		7F7D462104	No	661	620	555	3432	F	
3/8/1997	10	Echo Bay	Not Implanted		1F4A157B07	Yes	571	531	467	2434	M	MI
3/10/1997	10	Blackbird Point	Not Implanted		7F7D51716D	Yes	659	610	560	3625	F	
3/10/1997	10	Blackbird Point	Not Implanted		7F7D4A0478	No	600	552	495	2718	M	MI
3/10/1997	10	Blackbird Point	Not Implanted		7F7D51650E	No	565	555	500	2363	M	MI
3/10/1997	10	Blackbird Point	Not Implanted		1F7A3E1A0F	No	722	670	610	4139	F	EG
3/10/1997	10	Blackbird Point	Not Implanted		7F7D481D76	Yes	670	612	555	3515	F	EG
3/12/1997	10	Echo Bay	Not Implanted		201D5F2A3A	No	645	591	525	3095	F	SP
3/12/1997	10	Echo Bay	Not Implanted		1F7A26625F	No	560	519	460	2422	M	MI
3/12/1997	10	Echo Bay	Not Implanted		7F7D1A2E1A	Yes	584	535	481	2461	M	MI
3/12/1997	10	Echo Bay	Not Implanted		1F7A39743A	No	590	538	482	2853	M	MI
3/12/1997	10	Echo Bay	357		7F7B012325	Yes	600	552	496	2649	M	TU
4/5/1997	12	Blackbird Point	Not Implanted		203726295A	No	702	648	590	4564	F	
4/5/1997	12	Blackbird Point	Not Implanted		1F7B03796A	No	612	563	505	2211	M	TU
4/5/1997	12	Blackbird Point	2264 -2nd Time	77	201D5B1751	No	581	529	475	2438	M	MI
4/17/1997	13	Blackbird Point	2525	76	201D61560C	No	662	605	545	3150	M	MI
4/20/1997	13	Echo Bay	3344	76	1F7B477827	No	573	484	334	1989	M	MI
4/20/1997	13	Echo Bay	2273	77	1F7B0D2435	No	559	516	464	2006	M	MI
4/20/1997	13	Echo Bay	2336	76	201D5B6107	No	632	586	536	3011	F	EG
4/20/1997	13	Echo Bay	Not Implanted		1F7A39743A	Yes	582	530	485	2497	M	MI
4/20/1997	13	Echo Bay	Not Implanted		1F7B5A503C	No	472	442	387	1194	M	MI
4/20/1997	13	Echo Bay	Not Implanted		2037132A6C	No	637	585	542	3142	F	EG
4/20/1997	13	Echo Bay	Not Implanted		1F7A721C59	No	582	540	493	2133	M	CO
4/21/1997	13	Blackbird Point	Not Implanted		1F7B03796A	Yes	604	555	508	2100	M	MI
4/21/1997	13	Blackbird Point	Not Implanted		7F7D4C0651	No	605	558	505	2360	M	MI
4/21/1997	13	Blackbird Point	2264R		201D5B1751	Yes	577	525	473	2400	M	MI
4/21/1997	13	Blackbird Point	Not Implanted		7F7D3F6F5C	No	552	507	458	2127	M	MI
4/21/1997	13	Blackbird Point	Not Implanted		7F7D483714	No	515	474	426	1532	M	MI
4/21/1997	13	Blackbird Point	2444	76	7F7D4D6275	Yes	508	465	419	1330	M	MI
5/19/1997	16	Echo Bay	Not Implanted		7F7D301A27	No	499	468		1205	M	SP
5/19/1997	16	Echo Bay	Not Implanted		7F7D3B3240	No	667	623	576	3300	F	SP

Table 2 (cont.).

Date	Trip No.	Location	Sonic Tag No.	Freq. (kHz)	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight(g)	Sex	Ripe*
5/19/1997	16	Echo Bay	Not Implanted		1F476B7936	Yes	581	539	481	2178	F	SP
5/19/1997	16	Echo Bay	Not Implanted		7F7D1A2B3C	Yes	578	537	480	2166	M	SP
7/16/1997	19	Echo Bay	Not Implanted		1F476B7936	Yes	574	536	487	2300	M	
8/20/1997	21	Rogers Bay	2246R	77	7F7D4D7777	Yes	598	560	502	2979	M	
8/20/1997	21	Rogers Bay	Not Implanted		1F7B634E35	No ?	725	670		4226	F	
8/20/1997	21	Rogers Bay	Not Implanted			?	596	560	500	2641	M	
8/20/1997	21	Rogers Bay	Not Implanted			?	598	562	505	2716	U	
10/23/1997	23	Echo Bay	Not Implanted		7F7D22341E	Yes	625	575	530	3202	M	TU
11/10/1997	24	Blackbird Point	Not Implanted		7F7D3A5B2D	No	621	580	540	3288	F	
11/11/1997	24	Blackbird Point	Not Implanted		7F7D7D492C	Yes	684	643	565	3695	F	
11/12/1997	24	Echo Bay	Not Implanted		7F7D47300C	No	354	327	290	437	I	
12/9/1997	25	Las Vegas Wash Inflow	Not Implanted		7F7D4B771D	No	650	615	560	3288	M	TU
12/9/1997	25	Las Vegas Wash Inflow	238	76	7F7D516462	No	692	645	588	4479	F	
12/10/1997	25	Echo Bay	365	76	7F7D2F320A	Yes	595	550	495	2362	M	TU
12/10/1997	25	Echo Bay	88	73	7F7D516F6E	No	318	296	258	305	I	
1/5/1998	28	Blackbird Point	347	76	7F7D467310	No	595	550	495	2559	M	TU
1/5/1998	28	Blackbird Point	464	75	7F7D4A0478	Yes	604	555	500	3047	M	MI
1/15/1998	29	Echo Bay	79	77	7F7D481E44	No	630	588	525	2985	M	MI
1/15/1998	29	Echo Bay	555	73	7F7D302048	No	381	353	310	575	I	
2/10/1998	31	Echo Bay	Not Implanted		7F7D4C302B	No	347	321	281	417	I	
2/10/1998	31	Echo Bay	Not Implanted		7F7D482104	No	675	632	567	3232	F	
2/10/1998	31	Echo Bay	Not Implanted		1F4A157B07	Yes	585	536	488	2550	M	TU
2/12/1998	31	Blackbird Point	384R	75	7F7D4A7E47	Yes	555	520	465	1898	F	
3/9/1998	34	Blackbird Point	Not Implanted		1F78022047	No	680	628	581	3559	F	EG
3/9/1998	34	Blackbird Point	Not Implanted		1F783F2109	No	662	605	540	2624	M	
3/9/1998	34	Blackbird Point	Not Implanted		201D633030	No	564	525	465	1943	F	
3/9/1998	34	Blackbird Point	Not Implanted		7F7D4B7A54	Yes	630	581	522	2295	M	MI
3/9/1998	34	Blackbird Point	Not Implanted		1F4A46272A	Yes	575	529	481	1935	M	MI
3/9/1998	34	Blackbird Point	Not Implanted		1F783D4369	No	578	536	489	2274	M	
3/9/1998	34	Blackbird Point	Not Implanted		1F78123225	No	627	574	519	3177	M	MI
3/9/1998	34	Blackbird Point	Not Implanted		7F7D4A7E47	Yes	555	523	472	1851	F	
3/9/1998	34	Blackbird Point	Not Implanted		7F7D770148	Yes	668	605	557	3192	M	MI
3/11/1998	34	Echo Bay	Not Implanted		7F7D222A48	Yes	565	520	476	2094	M	TU
3/11/1998	34	Echo Bay	Not Implanted		7F7D4C302B	Yes	351	323	290	411	I	
3/11/1998	34	Echo Bay	Not Implanted		7F7D133272	Yes	604	560	510	2779	M	TU
3/11/1998	34	Echo Bay	Not Implanted		1F78205673	No	592	553	494	2320	F	EG
3/12/1998	34	Echo Bay	Not Implanted		7F7D2B2D5F	Yes	594	553	512	2492	M	MI
3/12/1998	34	Echo Bay	Not Implanted		7F7D3B3240	Yes	664	620	560	3648	F	EG
3/12/1998	34	Echo Bay	357		7F7B012325	Yes	606	562	510	2711	M	TU
5/7/1998	42	Blackbird Point	247	77	1F4A40391E	Yes	532	480	430	1620	M	SP
5/7/1998	42	Blackbird Point	2444		7F7D4D6275	Yes	544	500	453	1616	M	
5/7/1998	42	Blackbird Point	Not Implanted		1F782C4F6E	No	728	670	620	4608	F	EG
5/7/1998	42	Blackbird Point	374	75	1F7B5E3553	No	588	541	498	1940	M	MI
5/7/1998	42	Blackbird Point	283	77	7F7D483714	Yes	562	515	475	1844	M	SP
5/20/1998	44	Echo Bay	274	77	7F7D222A48	Yes	564	510	462	1876	M	RI
5/20/1998	44	Echo Bay	455	75	7F7D4D5405	No	553	513	460	1833	F	SP
6/3/1998	46	Echo Bay	2543	75	1F78205673	Yes	597	556	510	2175	F	
9/14/1998	56	Echo Bay			2037143E57	No	610	575	512	2723	M	
9/14/1998	56	Echo Bay	357		1F780B3925	Yes	615	570	507	2941	M	
9/14/1998	56	Echo Bay			2037096F31	No	600	559	504	2199	F	
9/14/1998	56	Echo Bay			1F4A457C56	Yes	505	475	422	1791	F	
9/14/1998	56	Echo Bay	365		7F7D2F320A	Yes	600	554	505	2402	M	
9/16/1998	56	Blackbird Point-south end			1F7A3C0625	No	625	568	514	2715	F	
11/17/1998	61	Blackbird Point-Deep Set			2038547361	Yes	563	518	376	2211	M	TU
11/19/1998	61	Blackbird Point-Deep Set			1F7815490B	No	642	593	530	3515	M	TU

Table 2 (cont.).

Date	Trip No.	Location	Sonic Tag No.	Freq. (kHz)	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight(g)	Sex	Ripe ^a
11/19/1998	61	Blackbird Point-Deep Set			201D5B2345	No	645	603	539	3459	M	MI
11/22/1998	61	Echo Bay-south shore			1F7A77640C	No	494	452	402	1275	F	
12/7/1998	63	Echo Bay			1F782D516B	No	498	463	412	1219	M	TU
1/26/1999	68	Echo Bay - 285 set			1F476B7936	Yes	616	566	550	2760	F	
1/26/1999	68	Echo Bay - RZ cove			7F7D2B2D5F	Yes	595	549	493	2643	M	MI
1/26/1999	68	Echo Bay - @ cliff			201D5F2A3A	Yes	642	585	527	3322	F	
1/26/1999	68	Echo Bay - @ cliff			1F4A457C56	Yes	514	484	435	1562	M	MI
1/28/1999	68	Echo Bay - south shore			201D5F2A3A	Yes	642	585	527	3322	F	
1/28/1999	68	Echo Bay - south shore			201D576408	No	519	486	430	1872	M	MI
1/28/1999	68	Echo Bay - 2 lobe			7F7D164F08	Yes	601	565	504	2523	M	MI
1/29/1999	68	Blackbird Point- shallow			1F7D66324C	Yes	563	523		2105	M	MI
2/9/1999	70	Echo Bay-south shore			2037175B37	No	625	580	520	3156	M	MI
2/9/1999	70	Echo Bay-south shore			1F78392D03	No	610	567	509	2571	M	MI
2/9/1999	70	Echo Bay-RZ cove			7F7D482104	Yes	668	626	555	3567	F	CO
2/9/1999	70	Echo Bay-RZ cove			203718652C	No	703	652	589	4305	F	CO
2/9/1999	70	Echo Bay-south shore			201D5F2A3A	Yes	649	591	526	3248	F	CO
2/9/1999	70	Echo Bay-south shore			7F7D15463D	Yes	660	614	550	3076	F	CO
11/30/1999	93	Blackbird Point- 400 m south	276		7F7D3B6539	Yes	730	684	616	4706	F	
12/13/1999	94	Blackbird Point - set to south	464		7F7D4A0478	Yes	606	554	507	3062	M	TU
12/13/1999	94	Blackbird Point - set to south			1F7A217F47	No	539	492	442	1826	M	TU
12/13/1999	94	Blackbird Point - set to south			201D697169	No	705	656	591	4536	F	
1/7/2000	95	Blackbird Point - 400m south	464		7F7D4A0478	Yes	Meas.	not	taken		M	
1/7/2000	95	Blackbird Point - 600m south			1F780E2239	No	650	612	562	3975	M	TU
1/8/2000	95	Echo Bay - north shore larval site 3			7F7D2B2D5F	Yes	599	562	512	2665	M	TU
1/8/2000	95	Echo Bay - north shore larval site 3			1F4A59231B	Yes	553	495	467	2098	M	TU
1/8/2000	95	Echo Bay - south shore '99 spawning site			1F4A457C56	Yes	527	493	450	2013	M	TU
1/8/2000	95	Echo Bay - south shore '99 spawning site			201D576408	Yes	550	499	471	2041	M	TU
1/27/2000	96	Echo Bay - south shore 2 lobe cove			20371A3B54	No	544	505	468	1761	M	MI
1/27/2000	96	Echo Bay - south shore '99 spawning site			1F7A252D15	No	557	516	464	1955	M	TU
1/27/2000	96	Echo Bay - south shore '99 spawning site			203718652C	Yes	710	655	605	4321	F	
2/7/2000	97	Blackbird Point-deep set			7F7D78472F	No	628	584	530	3288	M	MI
2/9/2000	97	Echo Bay-south shore, 285 set			2037096F31	Yes	633	601	543	2835	F	
2/9/2000	97	Echo Bay-south shore, 285 set			7F7D15463D	Yes	673	629	569	3175	F	
2/9/2000	97	Echo Bay-mouth of RZ cove			7F7D3B3240	Yes	694	652	603	4196	F	
2/9/2000	97	Echo Bay-cliff set			201D5F2A3A	Yes	649	599	538	3232	M	
2/9/2000	97	Echo Bay-cliff set			7F7D164F08	Yes	601	563	503	2381	M	
2/9/2000	97	Echo Bay-cliff set			1F7A39743A	Yes	585	541	492	3062	M	
2/10/2000	97	Blackbird Point-deep set			7F7D51650E	Yes	619	571	519	3175	M	MI
2/10/2000	97	Blackbird Point-deep set			1F783E0625	No	619	568	518	3005	M	MI
2/22/2000	98	Blackbird Point-deep set			1F7D66324C	Yes	574	539	484	1983	M	TU
2/22/2000	98	Blackbird Point-deep set			1F7815490B	Yes	641	591	553	3288	M	MI
2/22/2000	98	Blackbird Point-deep set	2444	76	7F7D4D6275	Yes	584	540	509	2325	M	MI
2/23/2000	98	Blackbird Point-deep set			203859034C	No	530	494	454	1981	M	MI
2/23/2000	98	Blackbird Point-deep set			7F7D7B2741	No	591	541	495	2162	M	MI
2/25/2000	98	Echo Bay- at cliff			1F7A252D15	Yes	553	511	462	1946	M	MI
2/25/2000	98	Echo Bay- at cliff			2037260E75	No	621	581	526	2660	M	MI
2/25/2000	98	Echo Bay- at cliff			201D5F2A3A	Yes						
2/25/2000	98	Echo Bay- at cliff			7F7D2B2D5F	Yes	592	550	493	2491	M	MI
2/25/2000	98	Echo Bay- at cliff			2037194749	No	575	533	487	2193	F	
2/25/2000	98	Echo Bay-RZ cove			1F78417335	No	704	665	604	4196	F	EG
2/25/2000	98	Echo Bay-RZ cove			203718652C	Yes	706	645	592	3742	F	EG
2/25/2000	98	Echo Bay-RZ cove			1F7A39743A	Yes	579	535	483	2948	M	MI
2/25/2000	98	Echo Bay-RZ cove			7F7D1A366E	Yes	602	547	493	2647	M	MI
2/25/2000	98	Echo Bay-RZ cove			7F7D24083F	Yes	604	567	503	2671	M	MI
2/25/2000	98	Echo Bay-RZ cove			1F7B083727	No	521	483	436	1674	M	MI
6/13/2000	112	Blackbird Point	3434	74	2037205732	No	687	634	583	3742	F	

^a TU = tubercles present, MI = expressing milt, EG = expressing eggs, SP = spawned out.

Video surveillance was conducted in Echo Bay on three dates in 2000. January 27, 2000, surveillance was conducted along the north shore of Echo Bay in an attempt to locate sonic-tagged fish 79 and gain information about habitat use and physical condition of the fish. Although the sonic receiver had detected the signal and pinpointed a location, the fish was not located after searching for about 1 hour. On March 9, 2000, surveillance was conducted to monitor condition and usage of the previously identified spawning location along the southeast shore of Echo Bay (Holden et al. 2000). Turbidity was high at the time observations were made, with only 2-3 feet of visibility at 16 feet of depth. During 30 minutes of observation, one spawning sequence was recorded and two individual razorback sucker that were clipped for fin ray samples were also identified. These fish were behaving normally and did not appear to have any problems using the fins that had sections removed.

The spawning site area at Echo Bay was monitored at the end of the spawning season to determine its general condition and if it was currently being used. Surveillance for 10 minutes determined that no spawning activity was taking place and that it was beginning to silt over.

No observations were made at the suspected spawning area at Las Vegas Bay because of the high turbidity present during most of the 2000 spawning season.

Growth

Nineteen individual fish were recaptured during the fourth study year, 13 at Echo Bay and 6 at Las Vegas Bay. The difference in total length (TL) between the first and most-recent capture 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 9.1 mm. The combined mean annual growth of recaptured fish the previous year was 22.0 mm (Holden et al. 2000); however, there was one fish with extremely high growth (161.6 mm). Without this fish, mean annual growth of the previous year was 7.9 mm. Mean annual growth of recaptured fish at Echo Bay was 8.3 mm and ranged from -3.7 mm to 32.8 mm. Razorback sucker recaptured at Las Vegas Bay had a mean annual growth of 10.8 mm and ranged from -0.7 mm to 27.4 mm. These growth rates continue to be substantially higher than those of other razorback sucker populations.

One recapture was not included in the growth calculation shown in Table 3. This was a razorback sucker initially captured on January 27, 2000, at Echo Bay, and recaptured on February 25, 2000. In the 29 days between captures, this fish lost 4 mm in TL, which would result in a mean annual growth of -50.4 mm. 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. Table 4 shows those razorback sucker collected more than one time during 1999-2000 sampling year. The days between capture ranged from 16 to 48, 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.

Table 3. Lake Mead recaptured razorback sucker growth from July 1999 through June 2000.

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							
1F7A39743A	03/12/97	590	02/25/00	579	-11	1,080	-3.7
201D5F2A3A	03/12/97	645	02/09/99	649s	4	1,064	1.4
203718652C	2/09/99	703	02/25/00	706	3	381	2.9
7F7D1A366E	03/18/92	556	02/25/00	602	46	2,892	5.8
7F7D2B2D5F	01/27/97	590	02/25/00	592	2	1,124	0.6
2037096F31	09/14/98	600	02/09/00	633	33	513	23.4
7F7D15463D	03/20/92	646	02/09/00	673	27	2,881	3.4
7F7D164F08	01/28/99	601	02/09/00	601	0	377	0
7F7D3B3240	05/19/97	667	02/09/00	694	27	1,050	9.4
1F4A457C56	09/14/98	505	01/08/00	527	22	481	16.7
201D576408	01/28/99	519	01/08/00	550	31	345	32.8
1F4A59231B	05/26/94	517	01/08/00	553	36	2,052	6.4
Mean annual growth							8.3
Las Vegas Bay							
7F7D4A0478	03/10/97	600	12/13/99	606	6	1,008	2.2
1F7D66324C	11/25/98	560	02/22/00	574	14	454	11.3
7F7D3B6539	12/18/96	713	11/30/99	730	17	1,077	6.2
1F7815490B	11/19/98	642	02/22/00	641	-1	460	-0.7
7F7D4D6275	02/25/97	502	02/22/00	584	82	1,092	27.4
7F7D51650E	03/10/97	565	02/10/00	619	54	1,067	18.6
Mean annual growth							10.8

Table 4. Growth of recaptured Lake Mead razorback sucker collected twice within 48 days of previous capture.

DATE	LOCATION	PIT TAG NUMBER	RECAPTURE	TOTAL LENGTH (mm)
01/27/00	Echo Bay	1F7A252D15	No	557
02/25/00	Echo Bay	1F7A252D15	Yes	553
Total Growth				-4
02/09/00	Echo Bay	1F7A39743A	Yes	585
02/25/00	Echo Bay	1F7A39743A	Yes	579
Total Growth				-6
01/27/00	Echo Bay	203718652C	Yes	710
02/25/00	Echo Bay	203718652C	Yes	706
Total Growth				-4
01/08/00	Echo Bay	7F7D2B2D5F	Yes	599
02/25/00	Echo Bay	7F7D2B2D5F	Yes	592
Total Growth				-7

Sonic Tagging and Telemetry

During the first study year, 20 sonic tags were used to tag 21 adult razorback sucker, including 16 14-month tags and four 48-month tags (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 the 2000 spawning season. Echo Bay and Las Vegas Bay telemetry results from the fourth 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 6). 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 twelve 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 location being 1000 feet upstream of the Las

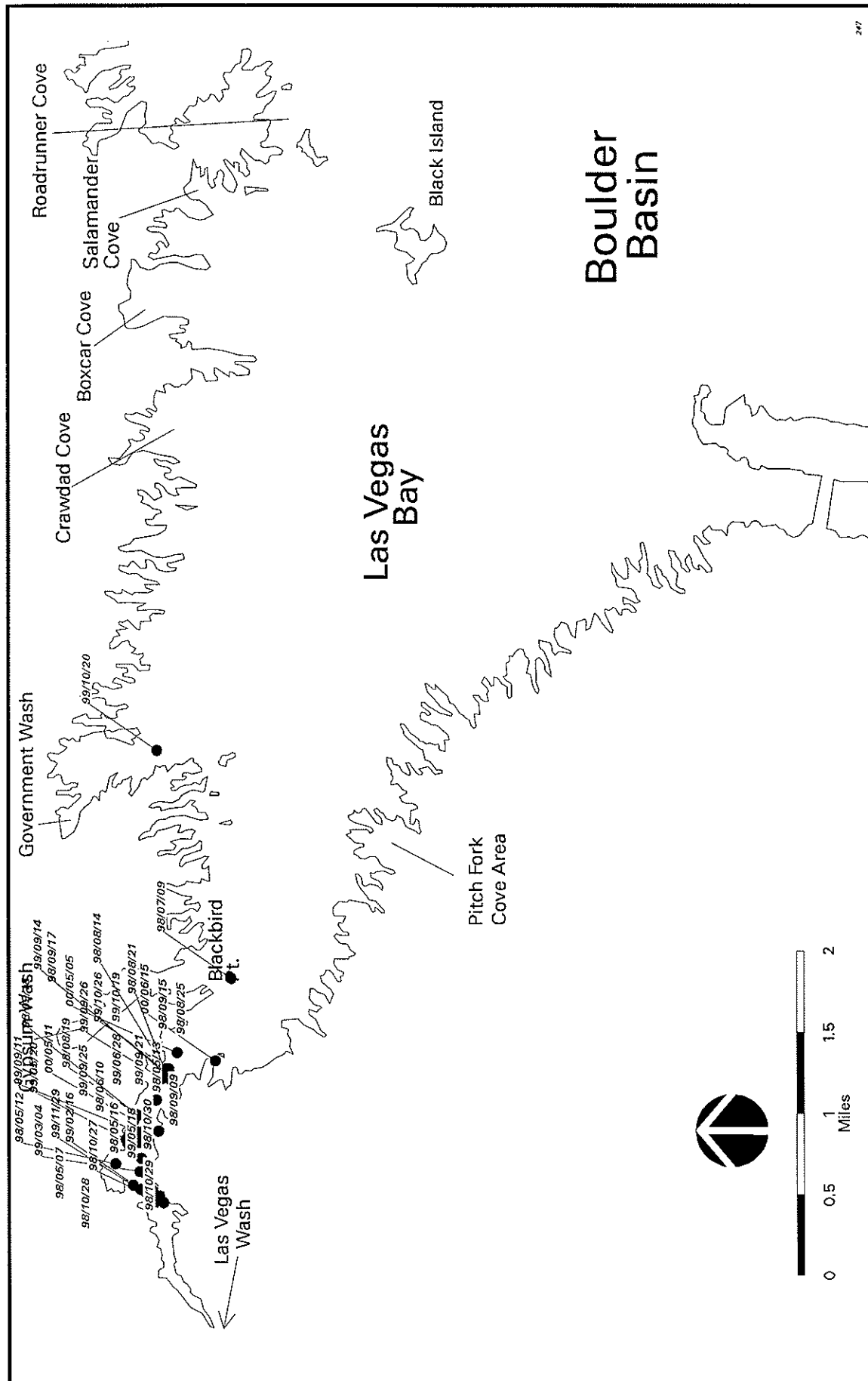


Figure 6. Distribution of fish number: 247.

Vegas Wash inflow area. The last three recordings of fish 247 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 6).

Tag 464

This 604-mm TL male razorback sucker was implanted with tag 464 (48-month life expectancy) and released at Blackbird Point on January 5, 1998. During the second and third study years, fish 464 was located 43 times in areas including Blackbird Point, Crawdad Cove, Boxcar Cove, and Roadrunner Cove (Figure 7). During the fourth study year, this fish was located 14 times: at Salamander Cove on September 12-15 and October 19, and then in the general Blackbird Point area on 5 days between October 19 and November 30.

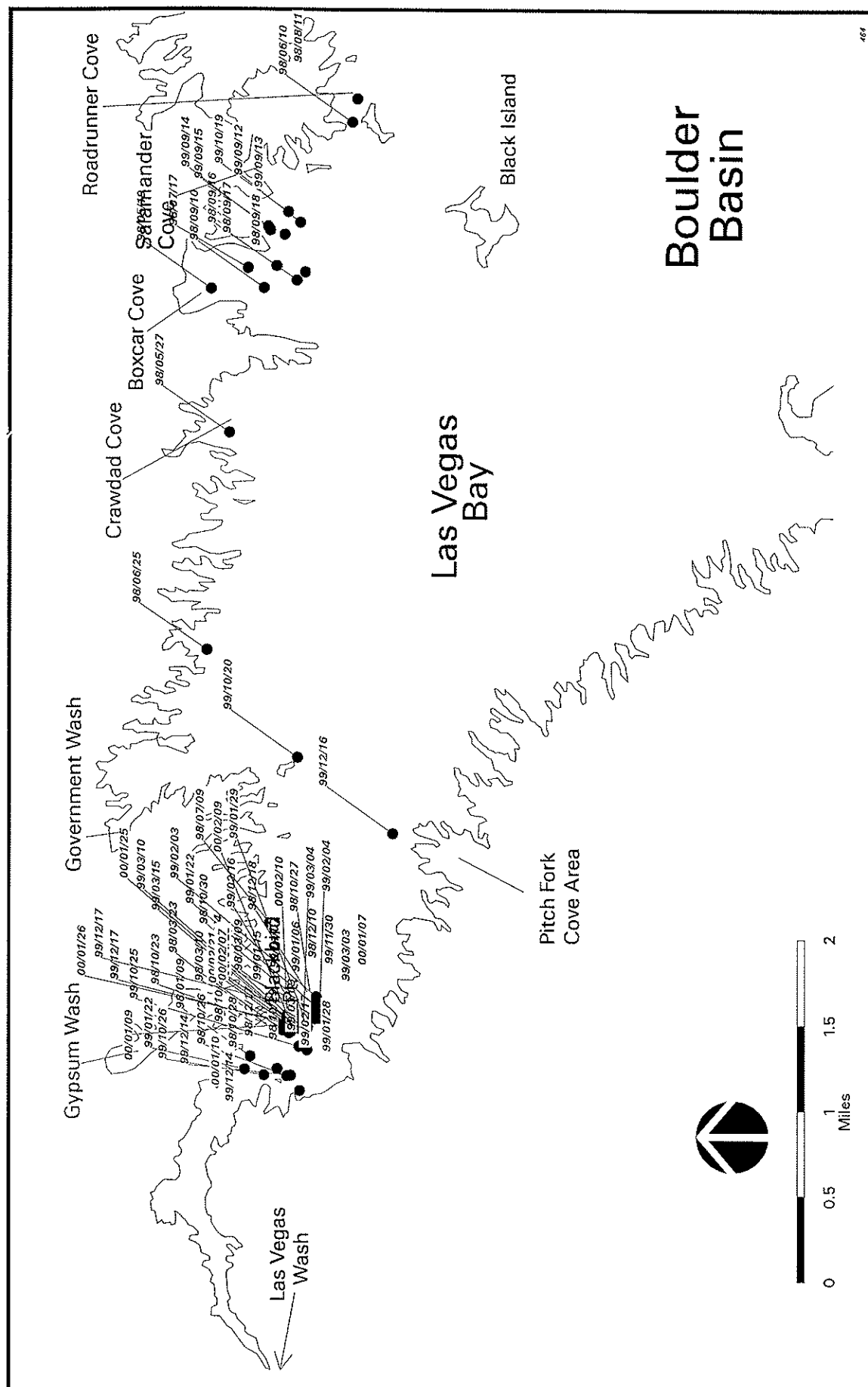
Tagged fish 464 was captured at Blackbird Point on December 13, 1999, during trammel netting and was used as a specimen for fin ray segment collection and aging. This fish was released in good condition. It was located on December 14 just north of Las Vegas Bay Marina, on December 16 just east of Pitch Fork Cove, and on December 17 at Blackbird Point (Figure 7). These variously located contacts indicated it was alive and moving. On January 7 this fish was recaptured at Blackbird Point. The clipped area on the fin was severely abraded, and the fish was stressed from being caught in the net. Because of its condition, it was placed in a chloramine-T bath to prevent infection of the abraded area. It was quickly released but was in poor condition. All subsequent contacts with this fish were made at the point of release at Blackbird Point with no further movement detected. Therefore, this fish likely died from the associated stress of repeat captures and fin clipping.

Tag 2444

This 508-mm TL male razorback sucker was implanted with tag 2444 (48-month life expectancy) on April 22, 1997, at Blackbird Point. Fish 2444 was located 56 times during the first, second, and third study years, in areas including the flowing and non-flowing portions of Las Vegas Bay, Blackbird Point, the mouth of Government Wash, Las Vegas Bay proper, Boxcar Cove, and Salamander Cove (Figure 8). During the fourth study year, fish 2444 was located four times, all of which were in the non-flowing portion of Las Vegas Bay. On September 13, 1999, fish 2444 was at the east side of the constricted center of the non-flowing area of Las Vegas Bay, and on September 14 it had moved further north to the inflow area of Las Vegas Wash. On October 25 and 26, 1999, this fish was found in the southeast quadrant of the non-flowing portion of Las Vegas Bay. It was not located after October 1999.

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 made with 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 (Figure 9). Since June the fish has moved east to



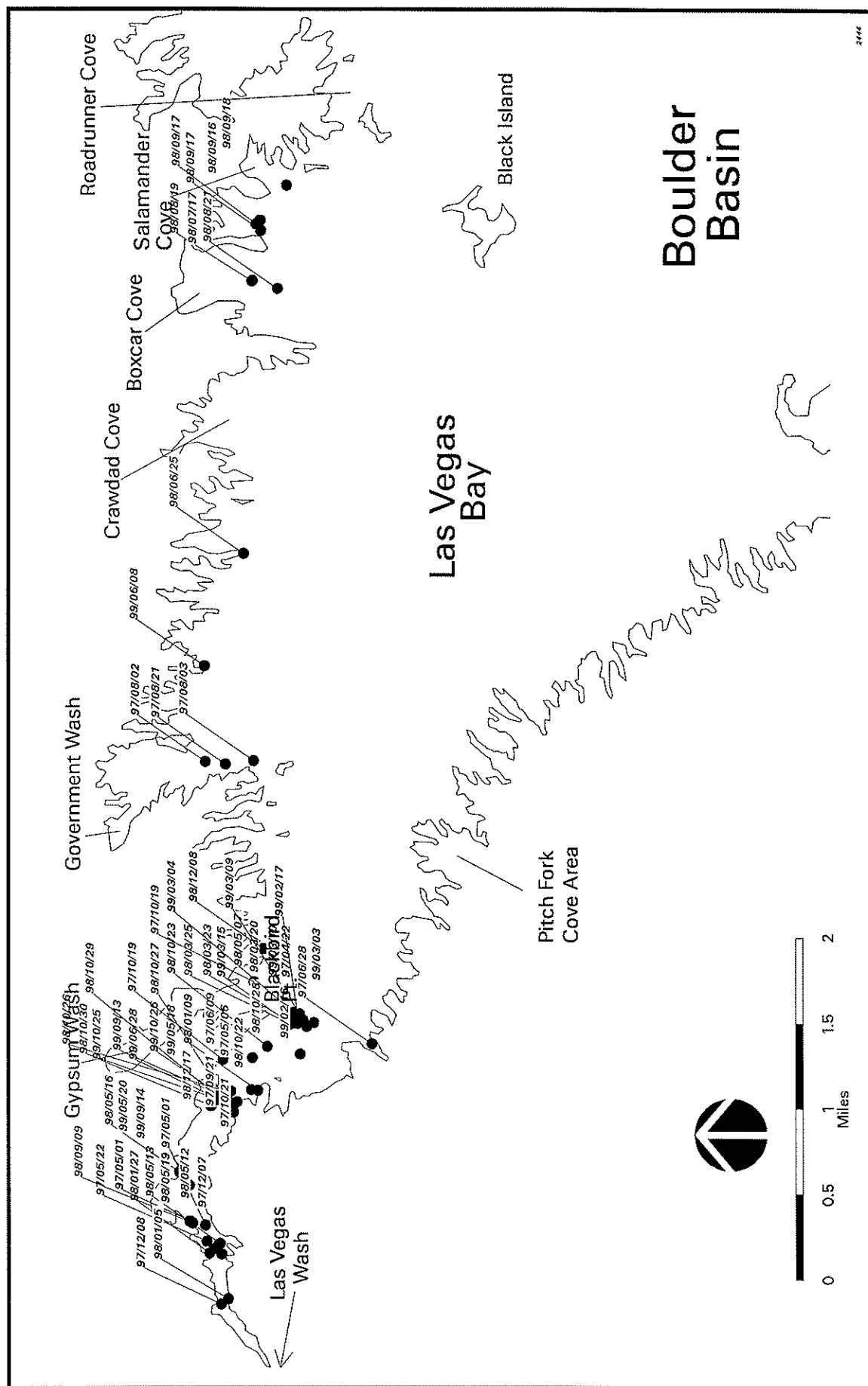


Figure 8. Distribution of fish number: 2444.

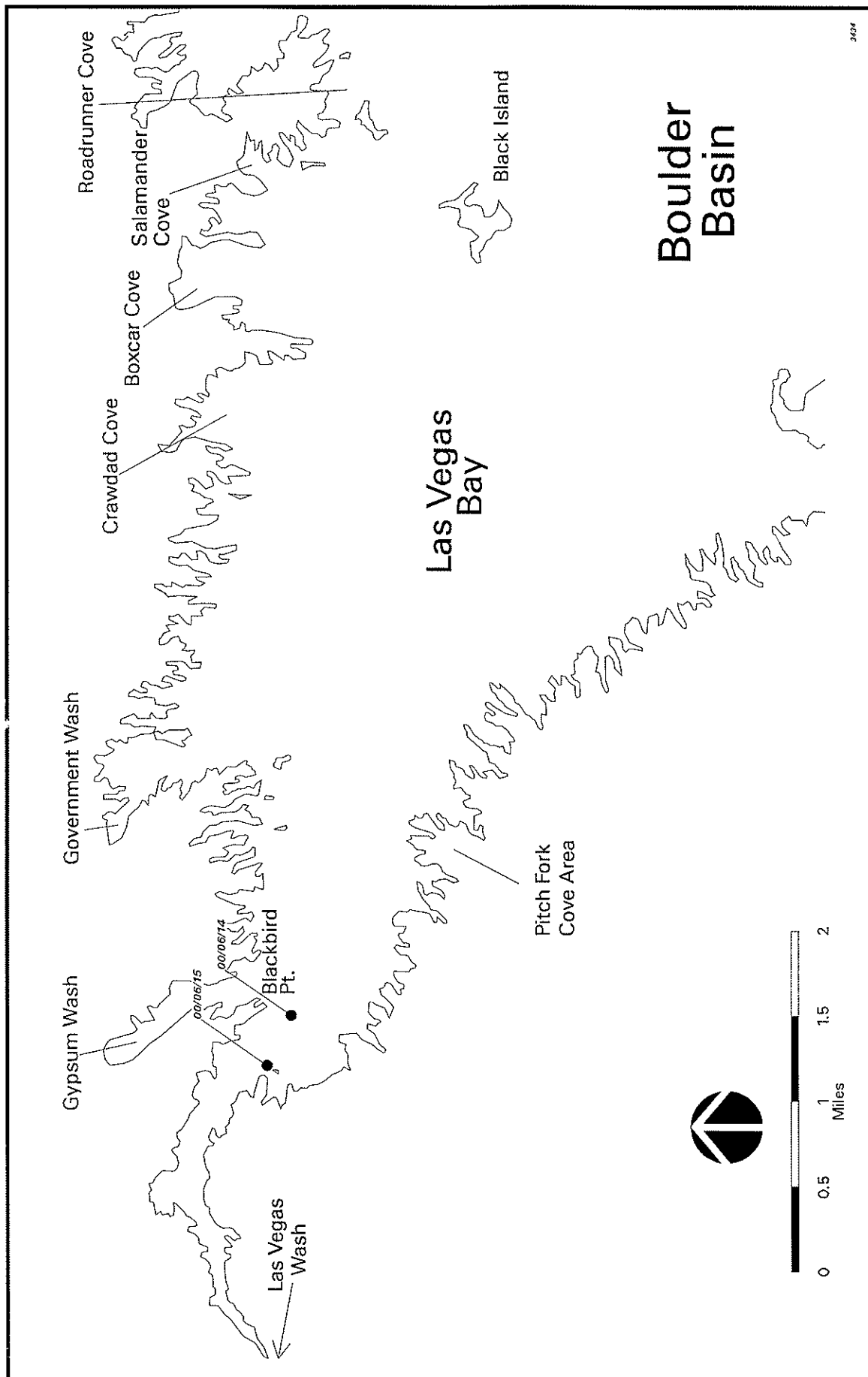


Figure 9. Distribution of fish number: 3434.

Salamander Cove. At publication time, it was not clear whether this tag was still attached to the subject.

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 10). During the fourth study year, fish 79 was located 0.5 mile north of Echo Bay in 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 near or directly at the Echo Bay spawning area.

Telemetry Summary

Sonic telemetry results for the fourth study year indicate sonic-tagged razorback sucker habitat use was similar to the previous three study years (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). These razorback sucker were located relatively close to shore (usually within 200 yards) at an average depth of less than 60 feet; most fish were stationary when located.

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 sole Echo Bay sonic-tagged fish (tag 79) was located close (within 0.5 mile) to the spawning area from October 1999 through March 2000 (Figure 10). Although this fish was not located during May and June 2000, past telemetry results had shown that, after spawning, sonic-tagged razorback sucker moved north along the western shore of Overton Arm but still made use of Echo Bay (Holden et al. 1999, Holden et al. 2000). It is possible that this tag expired prematurely.

Las Vegas Bay sonic-tagged razorback sucker tag 247 was located in the non-flowing portion of Las Vegas Bay during the pre-spawning period in 1999 and the post-spawning period in 2000. During the spawning period, limited telemetry did not locate this fish possibly indicating that it had moved into the flowing portion of Las Vegas Bay or Las Vegas Wash. Fish 464 was located at Salamander Cove during the post spawning period in fall 1999 and then it moved into the Blackbird Point area at the beginning of the 2000 spawning period. During the post-spawning season, this fish was continuously found in the Blackbird Point area, likely because of mortality from netting. The relatively few locations determined for fish 2444 were in the non-flowing portion of Las Vegas Bay during the pre-spawning period.

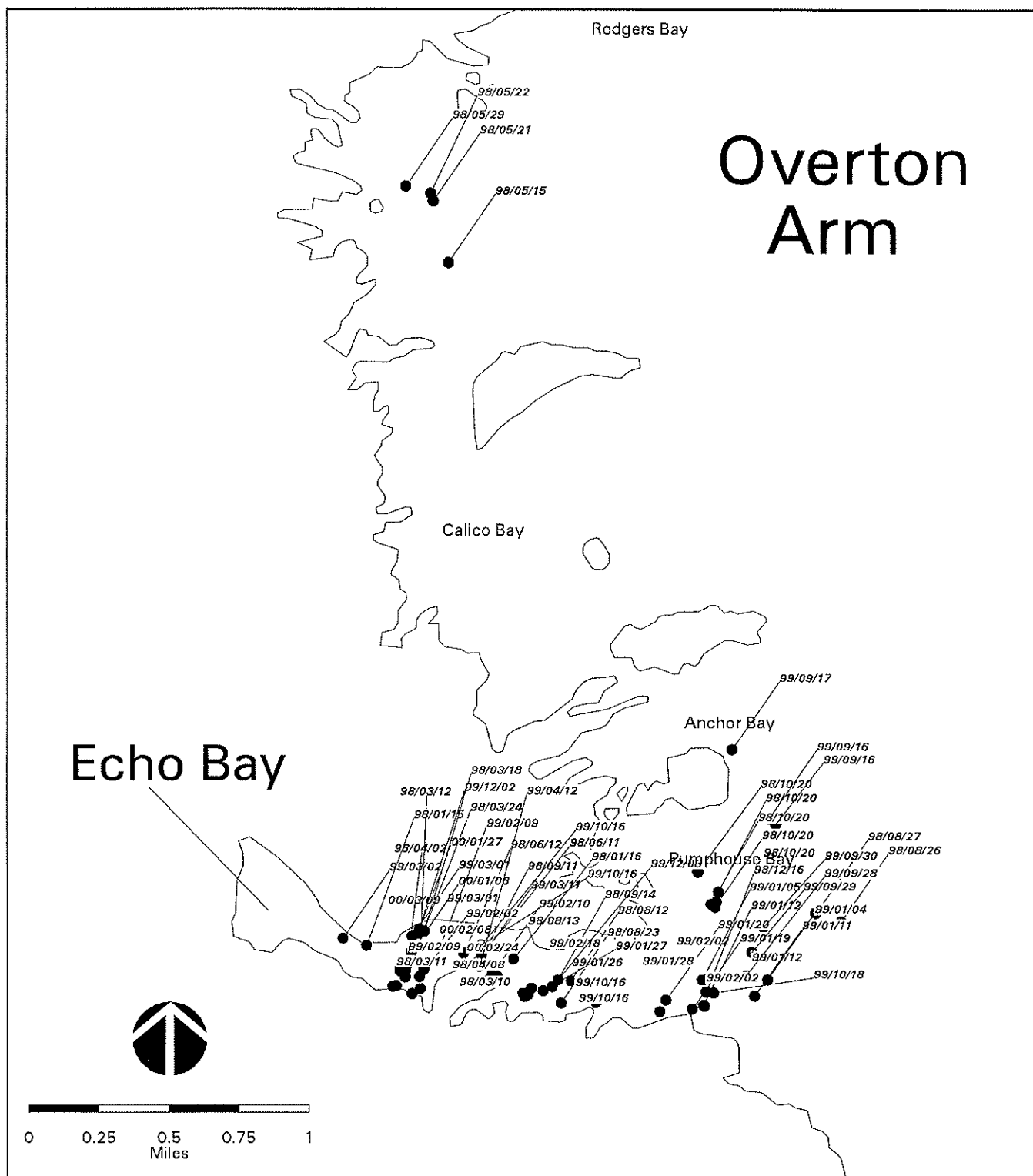


Figure 10. Distribution of fish number: 79.

Collectively, the fourth 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, and the areas of the lake adjacent to Echo Bay and Blackbird Point are important habitat to razorback sucker during the nonspawning season (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000). Although relatively few sonic-tagged fish were available for telemetry at Las Vegas Bay, fourth study year data support the general trends that some razorback sucker use the non-flowing portion of Las Vegas Bay during the nonspawning period and others move into areas along the northern shore of Las Vegas Bay (Figure 11). Additionally, the flowing portion of Las Vegas Bay is likely important to razorback sucker during the spawning period (Figure 12).

Larval Sampling

Echo Bay and Las Vegas Bay

Sampling for razorback sucker larvae was initiated in mid February 2000, and larvae were first collected on February 23 off the south shore toward the west end of Echo Bay. At Las Vegas Bay, the first razorback sucker larvae were collected on March 11, 2000. The last larval razorback sucker was collected on May 2 at Echo Bay (Tables 5 and 6). Six standardized monitoring sites at each known spawning area were sampled during 2000. These sites were sampled weekly (with a few exceptions resulting from personnel availability). Additional sampling effort was expended on Las Vegas Wash during 2000, both in the wash proper and at the inflow area of Las Vegas Bay. Tables 5 and 6 show the general locations of areas other than the standard sites sampled in 2000. The number of razorback sucker larvae collected within Las Vegas Bay (Table 5) was considerably lower in 2000 than in 1999 (32 and 145, respectively), as was the catch per minute (0.02 and 0.10, respectively).

The number of larvae collected at Echo Bay continued a downward trend. Seventy-three razorback sucker larvae were collected during 2000, compared with 95 in 1999 and 197 during 1998. The 2000 catch per minute at Echo Bay was similar to 1999 (0.09 and 0.08, respectively). Larvae in Echo Bay were collected throughout the sampling period but appeared to have distinct spikes in numbers during mid March and early- to-mid April (Table 6).

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. Eleven larvae were collected around the Pitch Fork Cove area over four different nights, and one larval razorback was collected just East of Gypsum Wash over the course of the sampling. No razorback sucker larvae were collected at the inflow area of Las Vegas Wash, whereas 21 were collected at this location in 1999. Drift net sampling was again attempted at the inflow area of Las Vegas Wash. Drift nets were set on three different nights during April 2000. On each night, two nets were set for 15 to 30 minutes each, depending on debris loads.

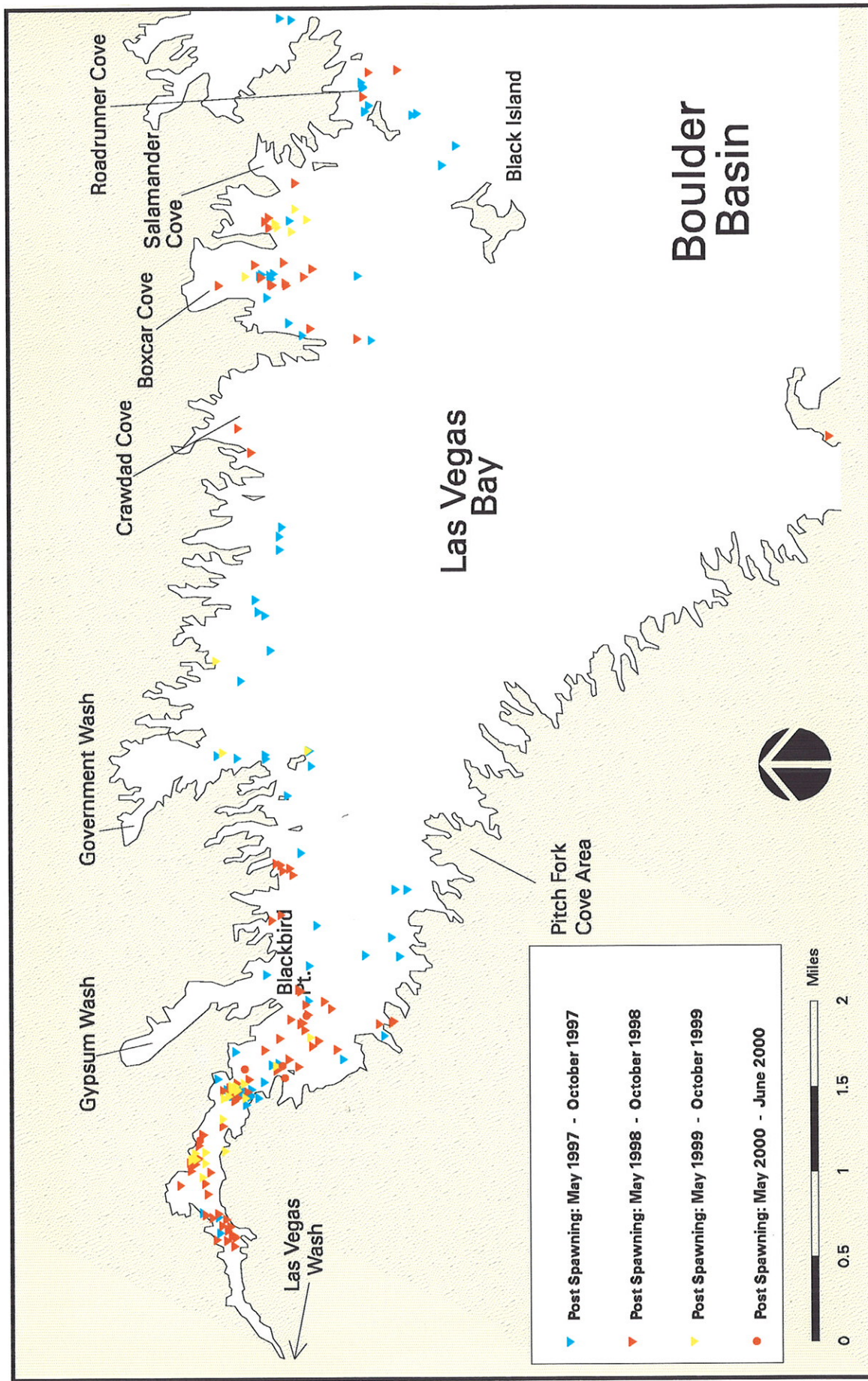


Figure 11. Post-spawning distributions for sonic-tagged fish, Blackbird Point/Las Vegas Bay.

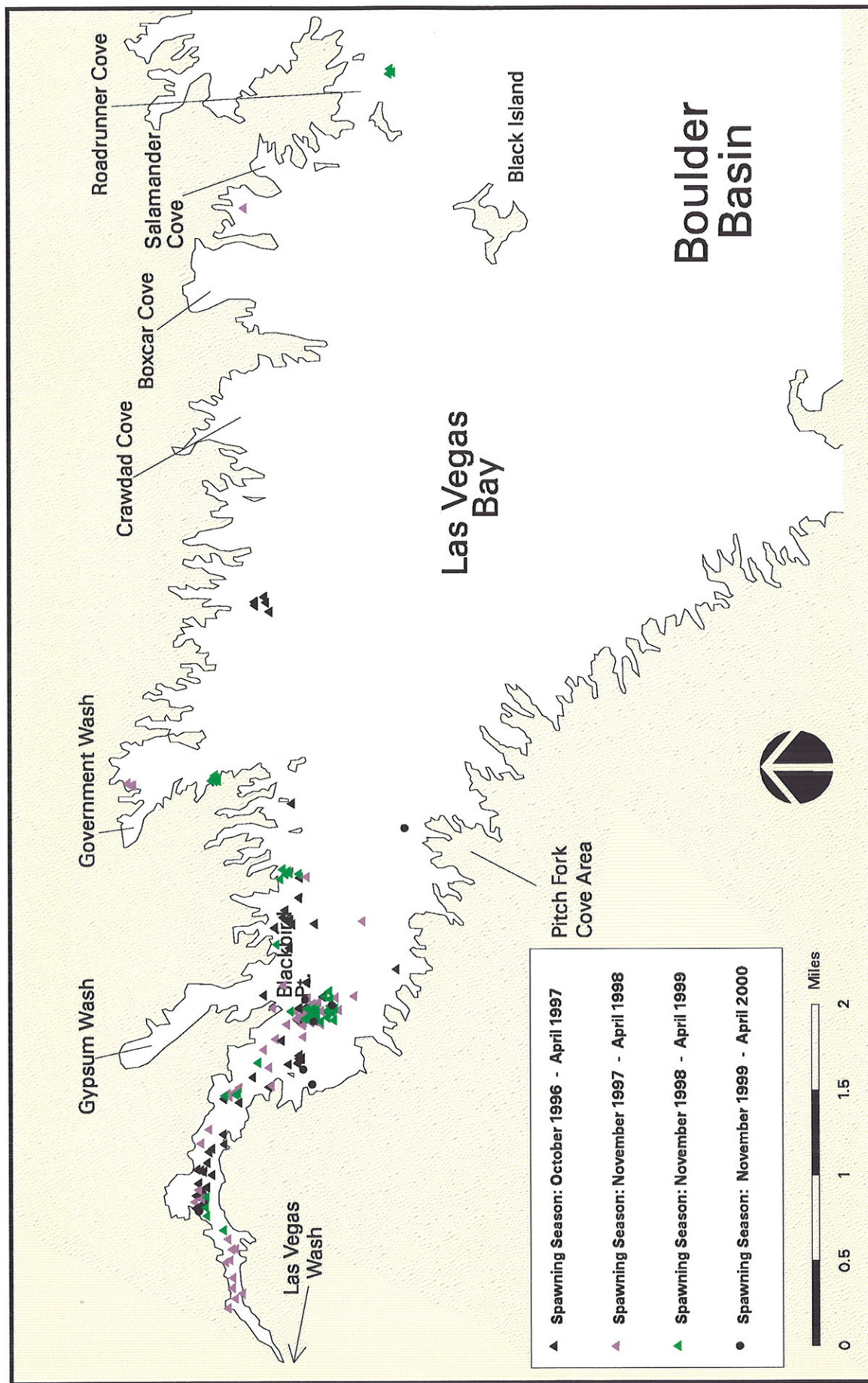


Figure 12. Spawning distributions for sonic-tagged fish, Blackbird Point/Las Vegas Bay.

Table 5. Number of razorback sucker larvae collected at Las Vegas Bay, Lake Mead, during 2000.

DATE	STANDARD LARVAL SAMPLING SITES			WASH INFLOW AREA			OTHER SITES		
	Minutes Sampled	Larvae Collected	CPM ^a	Minutes Sampled	Larvae Collected	CPM	Minutes Sampled	Larvae Collected	CPM
2/22/00	30	0	0						
2/26/00	90	0	0						
2/29/00	90	0	0						
3/04/00	90	0	0						
3/06/00	90	0	0						
3/09/00	45	0	0	15	0	0			
3/11/00	90	4	0.04						
3/19/00	90	0	0						
3/27/00	30	0	0	30	0	0	15 (cove N. of site 1)	0	0
3/30/00	60	0	0	15	0	0	15 (N. of marina)	0	0
							15 (3 coves S. of launch)	0	0
							90 (between Salamander and Govt. Wash)		
4/10/00	75	5	0.07				15 (between sites 1 & 2)	0	0
							15 (1 cove S. of launch)	0	0
4/11/00	90	2	0.02	30	0	0			
4/13/00	75	0	0	45	0	0			
4/24/00	90	6	0.06	15	0	0			
4/25/00	90	12	0.13				15 (below campground)	1	0.07
4/26/00	75	2	0.03	30	0	0			
5/04/00				285	0	0			
5/05/00	90	0	0	30	0	0			
Totals	1,290	31	0.02	495	0	0	180	1	0.005

^a CPM = catch per minute

Table 6. Number of razorback sucker larvae collected at Echo Bay, Lake Mead during 2000.

DATE	ECHO BAY STANDARDIZED SITES			ECHO BAY OTHER SITES		
	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM
2/23/00	30	1	0.33			
2/27/00	30	1	0.33			
3/07/00	90	1	0.01			
3/14/00	90	10	0.11			
3/18/00	90	4	0.04			
3/24/00	90	4	0.04			
3/28/00	75	5	0.07	15 (N. shore below upper campground)	1	0.07
3/29/00	90	11	0.12	15 (S. shore, west end of cliff)	7	0.47
4/12/00	90	19	0.21	30 (N.W. end of bay)	1	0.03
5/02/00	90	8	0.09			
Total	765	64	0.08	75	9	0.12

The sampling did not produce any larval fish, and as in the previous year, debris loads were extremely high, making the drift net use problematic.

Dispersion through wind and wave action is one explanation for collecting larvae in areas removed from spawning sites. However, wind direction recorded on data sheets does not always support wind dispersal. On two sampling dates when larvae were collected near the flowing portion of Las Vegas Bay (March 21, 1999 and March 22, 1999), wind direction was opposite of that expected to disperse larvae towards the wash (south winds vs. north), although larvae could have been dispersed by wind on prior days.

Lakewide

Lakewide larval sampling was conducted in all major Lake Mead bays and basins during March, April, and May 2000 (Figure 13). Prior to larval sampling, 223 sample sites were identified on the lake using the 1.0 mile criteria described in the methods section. Sampling was initiated only after reasonable amounts of larval razorback sucker were collected at the two standard sampling areas at Echo Bay and Las Vegas Bay. The first lakewide larval sampling night was March 25, 2000, at Boulder Basin, and the last night was May 15, 2000, at the Colorado River inflow area.

Eleven larval razorback sucker were found at three of the 258 sites sampled lakewide. Six larvae were found on April 29, 2000, near the mouth of Grand Wash Canyon just east of Grand Wash Bay (Figure 13). Conditions at time of sampling included 67° F water temperature, boulder substrate, low turbidity, and a depth of 8 feet. On April 30, 2000, four larval razorback sucker were found 0.25 mile south of the Colorado River inflow near Perce Ferry (Figure 13) with sampling conditions of 66° F water temperature, cobble substrate, high turbidity, and a depth of 3 feet. 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 13), with sampling conditions of 66° F water temperature, silt substrate, moderate turbidity, and a depth of 3 feet.

Juvenile Sampling

Table 7 shows sampling effort specifically targeting juvenile razorback sucker. No juvenile razorback sucker were collected during the report period (July 1999 through June 2000). Fyke nets, gill nets, minnow traps, and electrofishing were used to sample for juvenile fish.

Fyke nets again proved effective at collecting smaller sizes of nonnative fish species. The species composition and abundance of nonnative fishes from Fyke net samples were similar to the previous sampling year. Gill nets and minnow traps were not very effective at capturing small fishes, and electrofishing had mixed results because of equipment problems. All methods have the potential to capture juvenile razorback sucker, and should continue to be used.

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 nonlethal aging technique using fin ray sections during 1999 (Holden et al. 2000). A major emphasis of the effort in 1999-2000 involved collection of fin ray sections from razorback sucker for aging.

Twelve of the razorback sucker collected during trammel netting on Lake Mead during the 1999-2000 sampling period had approximately 0.25-inch sections of the second and third left pectoral fin rays 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. Four of these twelve razorback sucker were recaptured between 2 and 4 weeks after fin ray section removal. Sampled fins on two of the fish were healing, and the removal areas were almost entirely grown-in with new tissue. However, the other two fish had rubbed the first fin ray of the sampled fin, removing all tissue and exposing the fin ray. One of the two poorly healed razorback sucker had been sonic tagged in January 1998, and lack of movement after its second recapture in a month suggested it had died. It is likely that this fish was affected by the combined stress of fin ray sectioning and trammel netting recapture within a short period of time. It is also likely the sonic tag surgery was not a factor since the sonic tag suture had healed well and the fish behaved normally for 2 years.

LEGEND:

- Site sampled for larvae
- 8 — Number of larvae caught at that site
- 1 — Number of larvae caught outside of Blackbird Point or Echo Bay study areas.
- ▲ Arizona Game and Fish Razorback Sucker Capture, August 13, 1999

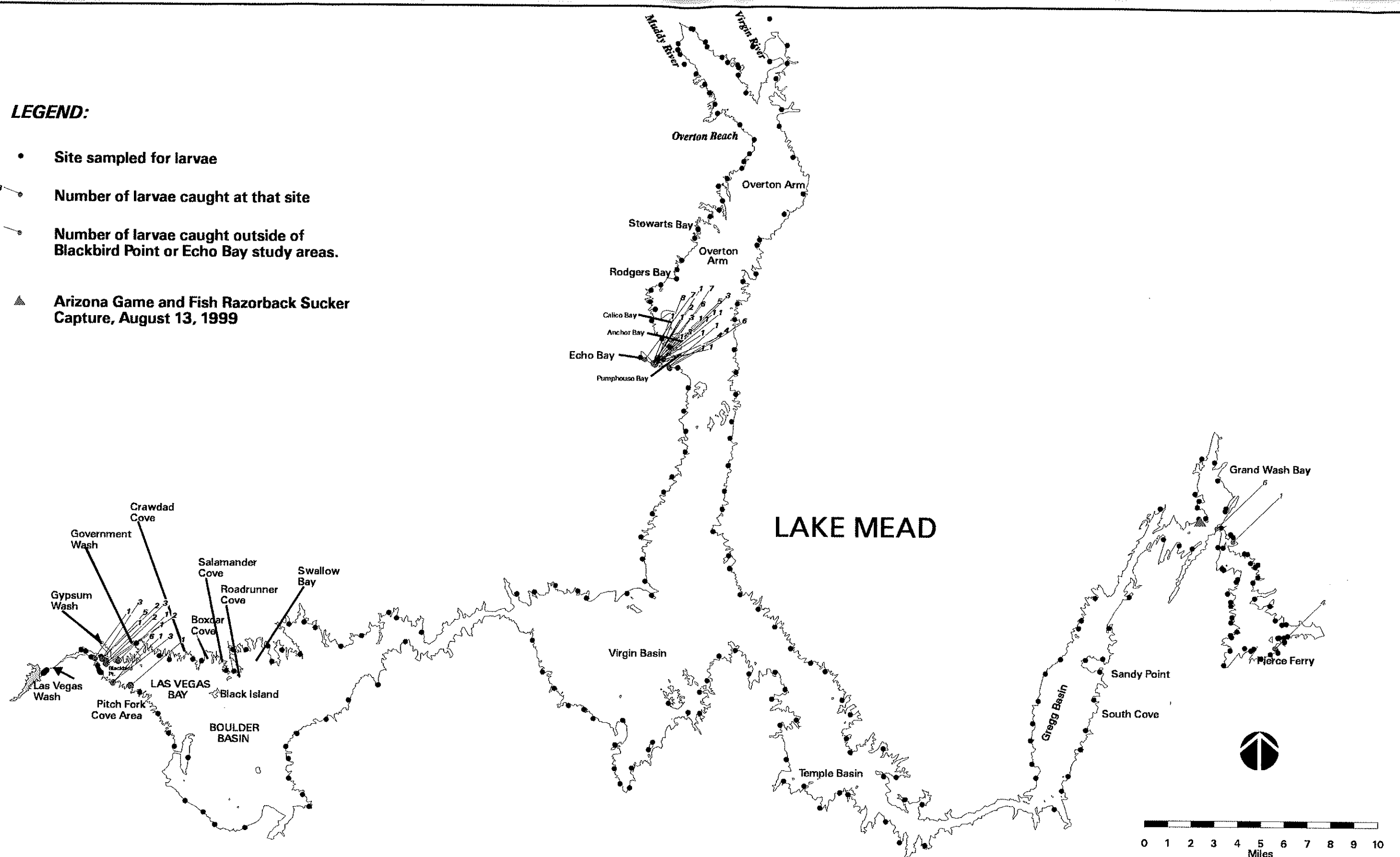


Figure 13. Lake Mead study area showing larval razorback sucker sampled and capture locations, spring 2000.

Table 7. Sampling effort for juvenile razorback suckers in Lake Mead at each site by gear type, July 1999 through June 2000.

GEAR TYPE	EFFORT	
	Echo Bay	Las Vegas Bay
Fyke nets 3 feet x 4 feet x 15 feet, 3/8 inch mesh	25 net nights	32 net nights
Gill nets 100 feet x 4 feet, experimental mesh ^a		12 net hours
Minnow traps 0.125 inch nylon mesh	120 net nights	30 net nights
Electrofishing 30-60 Hertz pulsed Direct Current		167.5 minutes

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

Table 8 shows the results of aging efforts on fish that were aged in 1998 and 2000. Ages were determined for two fish that died in 1998 (Holden et al. 1999). One was a 381 mm juvenile collected at Echo Bay that was aged at 5 years. The other, a 588 mm adult that died following sonic tag surgery, was aged at 10 years. Fin rays from 12 razorback sucker collected in late 1999 and early 2000 were aged during 2000. Definitive ages were obtained for 5 of the 12 razorback sucker processed, as were potential ages or an age range for six fish, and one set of fin rays was unreadable. Five specimens were aged at 13 years, one had an age range of 12-14 years, and five of them were 17 years or older, with some refinement possible. One of the specimens was unreadable because both rays splintered upon removal from the fish. As with other attempts to age razorback sucker in Lower Colorado River Basin reservoirs, larger (and presumably older) fish were difficult to age accurately because of annuli crowding near the margins of the fin ray sections (McCarthy and Minckley 1987). In instances where only an age range was obtained, four of the five fish were larger fish, above 600 mm TL. Table 8 also includes an estimate of the year each fish hatched. Six of the 13 fish were likely born around 1986, five in or between 1977-1982, one in or between 1985-1987, one in 1998, and one in 1993.

DISCUSSION

The fourth 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 3 years of the study. Sonic telemetry, trammel netting, collection of larvae at standard sampling sites, and video surveillance 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

Table 8. Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead.

DATE COLLECTED	TOTAL LENGTH (MM)	AGE	PRESUMPTIVE YEAR SPAWNED
Las Vegas Bay			
05/10/98	588	10 ^a	1988
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
Echo Bay			
01/22/98	381	5 ^a	1993
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

^a carcasses recovered from lake, fin ray ages were confirmed with otoliths.

at and around these areas during the spawning season. Additional data on annual razorback sucker growth confirmed rates documented in previous years, and aging data were greatly expanded with new information for 10 adult razorback sucker. Larval razorback sucker collected near Grand Wash and the Colorado River inflow area indicate that an additional spawning area may be present in Lake Mead.

Similar to data collected during previous years, sonic telemetry results determined 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, whereas fish 464 did not frequent those areas but instead was found at Blackbird Point the majority of the time and occasionally along the northern shore of Las Vegas Bay. Reasons for these differences in habitat use are not clear or easily explained by past behavior of sonic-tagged razorback sucker.

Habitat use determined from past sonic telemetry of Las Vegas Bay razorback sucker generally included use of Las Vegas Bay (flowing and non-flowing), Blackbird Point, and other areas further out in Las Vegas Bay. Tagged fish 2264 and 283 were located in all habitats, including the flowing and non-flowing portions of Las Vegas Bay, the presumed spawning area at Blackbird Point, and areas along the northern shore of Las Vegas Bay. Tagged fish 276 and 384 were found in all of the same areas except for the flowing portion of Las Vegas Bay. Although neither fish 247 nor fish 464 used the variety of habitats used by fish during previous years, they did remain within a portion of the range used by razorback sucker in the past. This suggests that some fish may use only a portion of the range used by other razorback sucker in the lake.

External sonic-tagging of razorback sucker should be a viable option, without the physical trauma and associated stress of internal tagging. The attachment procedure for the one 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. At this point, it is too soon to tell if the tag will remain firmly attached for an extended period. Future monitoring via sonic telemetry and trammel netting will hopefully provide more information concerning longevity.

Trammel netting catch-per-effort (CPE) of razorback sucker for the fourth study year increased at Echo Bay and Las Vegas Bay compared with the previous year. At Echo Bay/Overton Arm, CPE for the first, second, third, and fourth study years was 0.85, 0.32, 0.48, and 0.58, respectively. At Las Vegas Bay, CPE for the first, second, third, and fourth study years was 0.29, 0.34, 0.10, and 0.25 respectively. The primary reasons for the catch increase 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 at locations where razorback sucker were previously captured. Also, sampling was fairly intensive during this pre-spawning period, especially in January and February. However, trammel netting was not conducted during the most important spawning season months of March, April, and May at either the presumptive spawning site in Las Vegas Bay or the known site at Echo Bay.

The loss of sonic-tagged fish 464 further confirms that trammel netting stress, in association with a recent fin clipping, can cause razorback sucker mortality. This fish was tagged on January 5, 1998, and was followed for almost 2 years before the tag became stationary at Blackbird Point. Prior to becoming stationary, the fish had a fin ray section removed, was captured two times in less than 1 month, and had complications with its fin ray wound. Clearly, fin ray sectioning was an added complication in this situation, but aside from the fin ray sectioning, this scenario is similar to the mortality of sonic-tagged fish 365 in Echo Bay (Holden et al. 2000). Trammel netting and sonic telemetry were de-emphasized in the study during the third study year and increased again only to collect razorback sucker for aging data. Because aging information may lead to a better understanding of conditions necessary for successful razorback sucker recruitment, it is necessary to continue with limited trammel netting at the two main study areas. Future efforts will encompass

greater care in timing and function for trammel netting at Blackbird Point and Echo Bay in order to alleviate netting mortalities.

Similar to last year, video surveillance was successful in documenting spawning activity at the Echo Bay site. This method continues to provide an efficient way to observe spawning razorback sucker at close range, without interfering with the spawning process. The major limitation of using this type of gear is the turbidity present in the water. Although some spawning activity was observed at the Echo Bay site, higher turbidity at this site and at Las Vegas Bay made extensive use of this sampling method unproductive.

Consistently decreasing lake elevations during the fourth study year made access to the flowing portion of Las Vegas Bay and Las Vegas Wash more difficult. In 1999, monthly averaged lake elevations were at a low of 1,206 feet amsl in July, which increased to 1,214 feet amsl in January 2000. Then, by June 2000, the monthly average was 1,204 feet amsl. These changing lake elevations, which decreased steadily throughout the spawning season, resulted in a major delta formation at the inflow area of Las Vegas Wash. Because of this, boat access was limited, and the sonic telemetry activity in this area was reduced during the fourth study year compared with the previous year. These conditions may have made access to the wash difficult for razorback sucker as well.

Larval sampling CPE for the 2000 spawning season was decreased at Las Vegas Bay and was approximately the same at Echo Bay compared with the previous year. Total number of larvae sampled has decreased since 1998 at Las Vegas Bay and since 1997 at Echo Bay. At this time it is unclear why consistently decreasing numbers of larval razorback sucker are being captured. Potential reasons include increased lake elevations (which may effect dispersion levels or habitat conditions), less adult razorback sucker are spawning or are available for spawning, or some other environmental parameter has effected some aspect of the reproduction and larval sampling process.

Lakewide larval sampling in 2000 included successful location of larval razorback sucker in the eastern portion of Lake Mead. These 11 larvae confirm that spawning occurred in the lake, either near the Colorado River inflow area or in the actual Colorado River before it enters the lake. Further evidence of razorback sucker activity in this area was confirmed by an Arizona Game and Fish adult razorback sucker capture on August 13, 1999. This fish was captured in the cove due west of Lava Point at the western side of the mouth of Grand Wash (Figure 13). This razorback sucker was 515 mm TL, weighed 1,470 g, and was in excellent condition with no visible PIT-tag scars, ulcers, or eye abnormalities. No equipment was present at time of capture to scan for, or implant, PIT tags. This fish was captured during sportfish gill netting surveys and does not represent a capture resulting from razorback sucker-specific sampling (K. Hilwig, Arizona Game and Fish Department). However, BIO/WEST's limited trammel netting (20 net nights) in areas near where larvae were captured did not capture any razorback sucker.

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 8.3 mm, compared with 7.0 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 10.8 mm, which is similar to previous years. As was noticed during past study years, Las Vegas Bay fish continue to show greater growth rates than Echo Bay fish. However, it was observed that those 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.

During the fourth study year, aging efforts were expanded from the experimental stage to the operational stage. Fin clipping was an appropriate method for obtaining a hard structure for aging, and calculated ages ranged between 10+ and 19+ years old for the 10 razorback sucker for which aging was possible. Despite general success with the fin ray removal and aging process, successful regrowth of sectioned fins was mixed. Of four recaptured fin-clipped fish, two had not healed 1 month after the surgery, and one of these two died from a combination of surgical and netting stress. The other two had almost complete tissue regrowth in 1.0 to 1.5 month's time. Because of these mixed results, sectioning techniques were re-evaluated, and a less-intrusive fin ray sectioning tool was developed that will be used for future fin ray removal.

Ages of the 12 fish analyzed to date suggest two apparent groups of successful recruitment events in Lake Mead, one in 1980-1983, another around 1986, with other individual fish successfully surviving from the 1992-1993, 1987-1990, and 1978-1980 time frames. Overall, this aging process has produced 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

RECOMMENDATIONS FOR THE FOURTH YEAR OF STUDY

The general research objectives for the fifth 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 near Grand Wash and the Colorado River Inflow area. Research objectives are as follows:

1. Continuation of focused trammel netting, electrofishing, and fyke netting at Echo Bay and Las Vegas Bay to locate additional juvenile razorback sucker in Lake Mead;
2. Continuation of tracking sonic-tagged fish to determine the habitat use and life history characteristics of the Lake Mead population;

3. Monitoring of the two previously identified spawning areas (Echo Bay and Blackbird Point) to determine larval production;
4. Searching for a new razorback sucker spawning population in the Grand Wash or Colorado River Inflow via larval light-trapping. Trammel netting, sonic tagging, and telemetry will be initiated if new concentrations of razorback sucker are found;
5. Aging of all razorback sucker collected in trammel nets using pectoral fin rays sections removed from the fish;
6. Sampling for adults and larvae in the flowing portion of Las Vegas Bay and in Las Vegas Wash. This will involve accessing the wash on foot just below the Lake Las Vegas Dam and using larval light traps to search for larval razorback sucker. Trammel netting, and perhaps electrofishing, will be conducted in Las Vegas Wash if larvae are collected; and
7. Using weekly video surveillance to monitor spawning activities at Echo Bay and Las Vegas Bay and attempting to locate new concentrations of razorback sucker.

REFERENCES

- Hilwig, K. 2000. Fisheries Technician RIII with Arizona Game and Fish Department, Kingman, Arizona. Personal communication (email) with Paul Abate of BIO/WEST, Inc. 9/2000.
- Holden, P.B. (BIO/WEST, Inc.). 1994. Razorback sucker investigations in Lake Mead, 1994. Las Vegas: Southern Nevada Water Authority. Final Report, PR-470-1.
- Holden, P.B. and C.B. Stalnaker. 1975. Distribution and abundance of mainstream fishes of the middle and upper Colorado River basins, 1967-1973. Transactions of the American Fisheries Society 104:217-231.
- Holden, P.B., P.D. Abate, and J.B. Ruppert. 1997. Razorback sucker studies on Lake Mead, Nevada. 1996-1997 Annual Report. Prepared for the Department of Resources, Southern Nevada Water Authority, by BIO/WEST, Inc., Logan, UT. PR-578-1.
- Holden, P.B., P.D. Abate, and J.B. Ruppert. 1999. Razorback sucker studies on Lake Mead, Nevada. 1997-1998 Annual Report. Prepared for the Department of Resources, Southern Nevada Water Authority, by BIO/WEST, Inc., Logan, UT. PR-578-2.
- Holden, P.B., P.D. Abate, and J.B. Ruppert. 2000. Razorback sucker studies on Lake Mead, Nevada. 1998-1999 Annual Report. Prepared for the Department of Resources, Southern Nevada Water Authority, by BIO/WEST, Inc., Logan, UT. PR-578-3.
- Joseph, T.W., J.A. Sinning, R.J. Behnke, and P.B. Holden. 1977. An evaluation of the status, life history, and habitat requirements of endangered and threatened fishes of the upper Colorado River system. Fort Collins: U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS Rep. 24, part 2. 183 p.
- Marsh, P. 2000. Professor, Arizona State University, email correspondence with Paul Holden concerning razorback sucker numbers in Lake Mohave, October, 2000.
- McAda, C.W. and R.S. Wydoski. 1980. The razorback sucker, *Xyrauchen texanus*, in the upper Colorado River basin. U.S. Fish and Wildlife Service Technical Paper 99:1-15.
- McCall, T. (Arizona Game and Fish Department). 1980. Fishery investigation of Lake Mead, Arizona-Nevada, from Separation Rapids to Boulder Canyon, 1978-79. Boulder City: Water and Power Resources Service. Final Report. Contract Number 8-07-30-X0025. 197 p.

- McCarthy, M.S. and W.L. Minckley. 1987. Age estimation for razorback sucker (Pisces: *Catostomidae*) from Lake Mohave, Arizona and Nevada. *Journal of the Arizona-Nevada Academy of Sciences* 21:87-97.
- Minckley, W.L. 1973. *Fishes of Arizona*. Phoenix: Arizona Game and Fish Department.
- Minckley, W.L. 1983. Status of the razorback sucker, *Xyrauchen texanus* (Abbott), in the Lower Colorado River Basin. *Southwestern Naturalist* 28:165-187.
- Minckley, W.L., P.C. Marsh, J.E. Brooks, J.E. Johnson, and B.L. Jensen. 1991. Management toward recovery of razorback sucker. *In*: W.L. Minckley and J.E. Deacon, editors. *Battle against extinction: native fish management in the American West*. Tucson: University of Arizona Press. p. 303-357.
- Muller, G. and P. Marsh. 1998. Post-stocking dispersal, habitat use, and behavioral acclimation of juvenile razorback suckers (*Xyrauchen texanus*) in two Colorado River Reservoirs. U.S. Department of the Interior, U.S. Geological Survey. P.24.
- Pacey, C.A. and P.C. Marsh. 1998. Growth of wild adult razorback suckers in Lake Mohave, Arizona-Nevada. Presented at 30th Annual Meeting, Desert Fishes Council, Page, Arizona. November 14, 1998.
- Sjoberg, J.C. 1995. Historic distribution and current status of the razorback sucker in Lake Mead, Nevada-Arizona. *Proceeding of the Desert Fishes Council* 26:24-27.
- Tyus, H.M. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1986. *Transactions of the American Fisheries Society* 116:111-116.
- U.S. Fish and Wildlife Service (USFWS). 1991. Endangered and threatened wildlife and plants; the razorback sucker (*Xyrauchen texanus*) determined to be an endangered species; Final rule. *Federal Register* 56 (23 October 1991):54957-54967.
- U.S. Fish and Wildlife Service (USFWS). 1997. Final Biological and Conference Opinion on Lower Colorado River Operations and Maintenance - Lake Mead to Southerly International Boundary. U.S. Fish and Wildlife Service, Phoenix, AZ.
- Wick, E.J., C.W. McAda, and R.V. Bulkley. 1982. Life history and prospects for recovery of the razorback sucker. *In*: W.H. Miller, H.M. Tyus, and C.A. Carlson, editors. *Fishes of the upper Colorado River System: present and future*. Bethesda (MD): American Fisheries Society, Western Division. p. 120-126.