

Razorback Sucker Studies on Lake Mead, Nevada

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*Razorback Sucker spawning aggregation,
Echo Bay, March, 1999.*



*Images captured from boat-operated
underwater video camera.*

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 third year (July 1998 to June 1999) of the Lake Mead razorback sucker study, emphasis shifted from trammel netting and sonic telemetry to sampling for juveniles and larvae, and aging techniques. Trammel netting for adult fish continued, but effort was reduced during the spawning period out of concern for stressing the fish. During the third year, 25 adult razorback sucker were captured, including 5 in Las Vegas Bay and 20 in Echo Bay. Of the 25 total collected, 14 were recaptures, a recapture rate similar to the second study year's rate. One of the recaptures was a 563-mm total length (TL) razorback sucker that had been collected in Lake Mead by NDOW as a larvae in 1995 and repatriated to the lake in 1996 as a 199-mm TL juvenile. During the first 3 years of the study, 95 individual razorback sucker were captured, not counting larvae.

During March 1999, razorback sucker spawning activity was recorded on video tape at Echo Bay. A group of six or seven fish was filmed for several hours over 3 days. In addition to egg deposition and fertilization, predation on freshly laid eggs by channel catfish was also filmed. This video allowed documentation of actual spawning, size and appearance of a spawning area, and actual nonnative fish predation.

Aerial spawning surveys conducted with the BOR helicopter around the entire perimeter of the lake also occurred in March 1999 and did not locate any razorback sucker.

Recaptured razorback sucker from Lake Mead again showed relatively high growth rates. The fish that was captured as a larvae and returned to the lake had a growth rate of 161 mm per year, an unusually high growth rate for a juvenile fish of any species. This fish illustrates the growth potential of the Las Vegas Bay area. Two larger fish showed growth rates of only about 2 to 3 mm per year, suggesting that some of the larger and older fish in the present populations in Lake Mead are no longer growing to any measurable amount.

Sonic telemetry of razorback sucker showed similar use patterns to those identified during the past 2 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 third study year because of mud flats near its mouth, so telemetry was not conducted in the wash.

Larval sampling was continued at Las Vegas Bay and Echo Bay in spring 1999. Similar numbers and catch rates of larvae were found at Las Vegas Bay compared with previous years, but numbers and catch rates at Echo Bay continued to decline compared with those from the first study year. The highest catch rate for an individual night was near the inflow of Las Vegas Wash. This information, along with sonic tracking showing relatively heavy use of this portion of Las Vegas Bay, suggests that spawning may be occurring in the wash near its confluence with the bay.

Larval sampling was emphasized during the third 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. Approximately 75 percent of the lake was sampled for larvae in spring 1999 in an attempt to locate larvae. One larvae was collected at each of two sites, one about 8 miles east of Blackbird Point in Swallow Bay, and the other about 5 miles north of Echo Bay in northern Rogers Bay. When only one larvae is located in an area, determining the reason for its presence is problematic. It is not known if these captures represent new spawning areas, or if they are fish that drifted far from known spawning sites.

Juvenile sampling in spring 1999 was intensified in Echo Bay and Las Vegas Bay with the use of fyke nets. No juvenile razorback sucker were found.

Development of techniques for aging razorback sucker without harming them was initiated in 1999. The goal was to develop a technique for aging the adult razorback sucker population in the lake by means other than otoliths, which requires sacrificing the fish. Fin rays proved valuable in aging fish in 1998 (as reported in the 1997-1998 annual report) from carcasses where otoliths were also available to verify age. Known-age fish that were collected as larvae in Echo Bay in 1997 and were being held by NDOW at a hatchery were used in the experiments. It was determined that a relatively small portion of a pectoral fin ray could be removed without harm to the fish, and the fin ray was a good aging medium.

Emphasis in 1999-2000 will continue to focus on locating other razorback sucker populations in the lake by searching for larvae. 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 the razorback sucker and the 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 which have successfully established in the river have also contributed to their decline. Razorback suckers have persisted in many of the reservoirs that were constructed in the lower Colorado River Basin, with the largest population occurring in Lake Mohave, Arizona and Nevada (Minckley et al. 1991). However, these populations are comprised primarily of adult fish with little natural recruitment. Adult razorback sucker are most evident in these reservoirs 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 same trend as other lower Colorado River Basin reservoirs, with recruitment to these populations occurring only near the time of reservoir creation. The population of long-lived adults then disappeared 40 to 50 years following reservoir creation and the initial recruitment period (Minckley 1983). 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 the lake (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 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), the 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, the 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 PIT-tagged, 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 the NDOW, initiated a cooperative study to attempt to answer some of these questions about the Lake Mead razorback sucker population. BIO/WEST, Inc. 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 specifies the terms of the agreement and extended the study period into 2000.

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

STUDY AREAS

The majority of 1998-1999 study activities occurred at the same locations used in the 1996 to 1998 portion of the study (Holden et al. 1997, Holden et al. 1999). The two most frequented areas were Echo Bay and Las Vegas Bay. Sonic telemetry and netting were conducted in other parts of the lake, including the Overton and Muddy Arms, Boulder Basin, and Virgin Basin (Figure 1). New study areas were added for larval sampling that occurred in all major bays of the lake. Lake-wide larval sampling was conducted at roughly 1 mile intervals along the shoreline of the lake and is detailed in the methods and results sections of this report.

Aerial searches for spawning razorback sucker aggregations occurred in the same general locations as during the previous study year (Holden et al. 1999). These areas included the shores of Boulder Basin, Virgin Basin, Temple Basin, Gregg Basin, Grand Wash Bay, the Colorado River inflow area, and the Overton Arm (including the Muddy and Virgin River inflow areas) (Figure 1).

Elevation of the lake water level affected all study areas. When the study began in October 1996, the water level was about 1,190 feet above mean sea level (amsl) (Figure 2). October 1998 lake level peaked at about 1,216 feet amsl. This increase in lake elevation provided increased areas of inundated vegetation in all areas of the lake where tamarisk (*Tamarix chinensis*) and other vegetation covered the shoreline. At the end of the third study year (June 1999), the lake level had receded to about 1,206 feet amsl. All study activities occurred within the full pool elevation of Lake Mead, (1,229 feet amsl) including those activities that occurred within the flowing portion of Las Vegas Bay.

Considerable study activity was conducted at or near the confluence of Las Vegas Wash and Las Vegas Bay, an area that changes location with a change in lake elevation. Las Vegas Wash is herein defined as the portion of the channel with stream-like characteristics. This section is usually relatively narrow with obvious banks. Las Vegas Bay is defined to begin 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 (200-400 yards long) and is transitory between the wash proper and the bay. Since lake elevation effects 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 which is less heavily influenced by Las Vegas Wash).

METHODS

The same general study techniques were used for the third year of research that were used for the first 2 years (Holden et al. 1997, Holden et al. 1999). Trammel nets were the primary technique for collecting adults, and sonic telemetry was continued as the method to determine habitat use and movement of adults. No razorback sucker were implanted with sonic tags during the third year of the study. Spawning adults were searched for with larval sampling and via aerial observation as

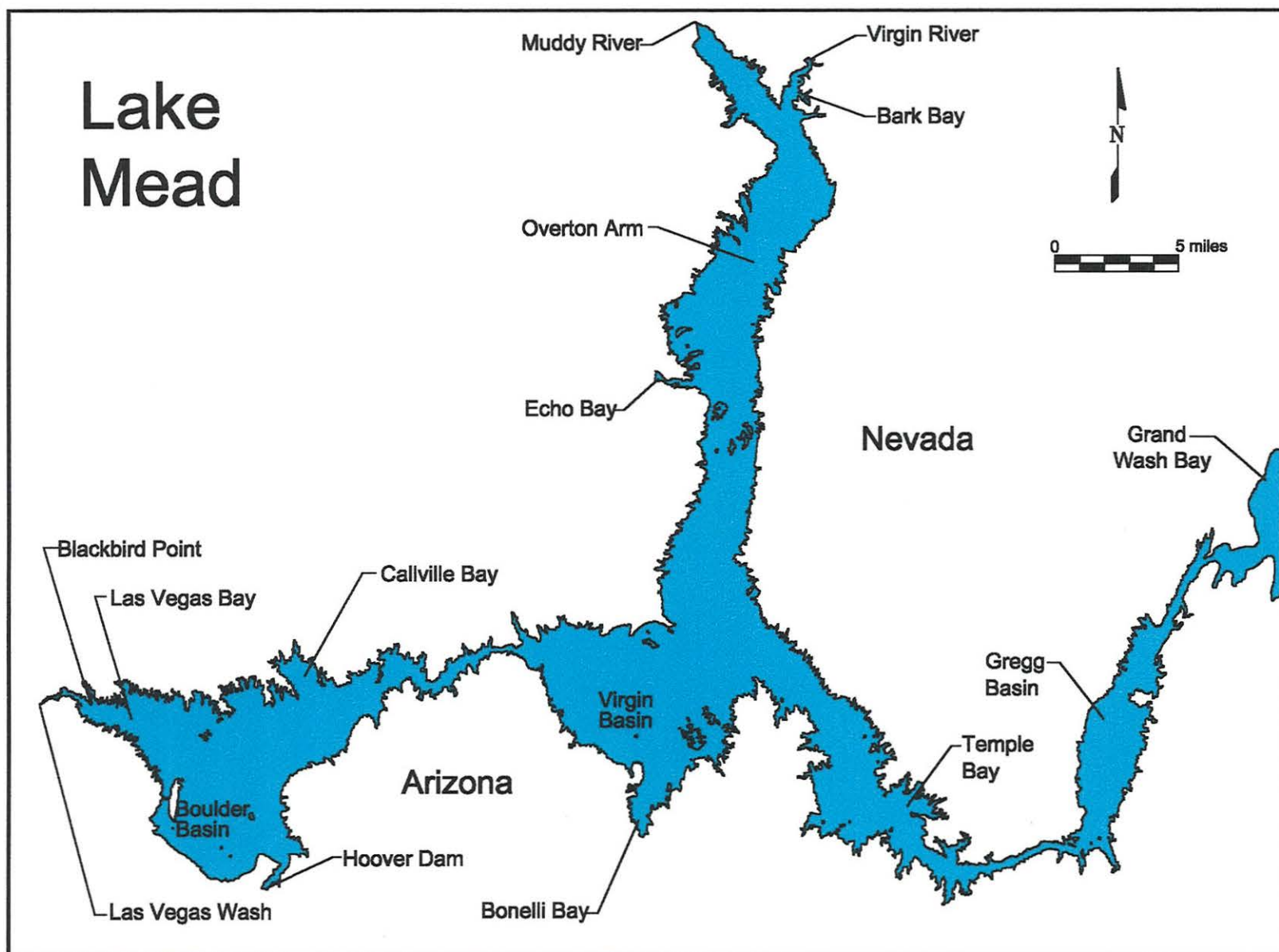


Figure 1. Map of Lake Mead showing general locations of study areas.

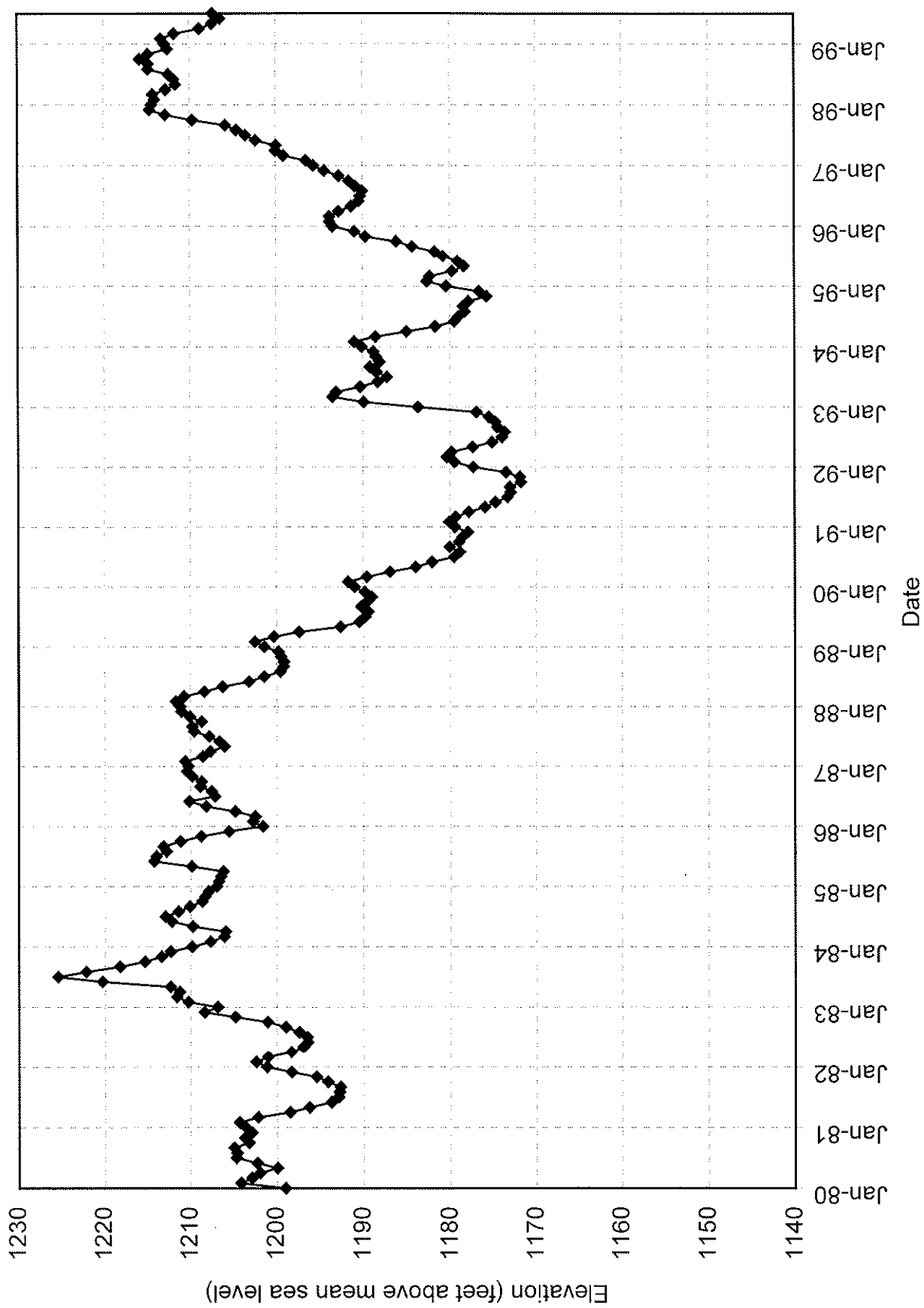


Figure 2. Lake Mead month-end elevations, 1980 to 1999.

described in the previous annual report (Holden et al. 1999). SCUBA was also used to reconnoiter spawning locations and to search for spawning aggregations.

One new method used to observe spawning adults was an underwater video camera. The camera was manufactured by FISHEYE, Inc., of Everett, Washington, and had a fixed focus, wide-angle lens with an automatic exposure control that immediately corrected for available light levels. The camera was lowered on a wire that transmitted images to a video monitor/recorder and allowed an operator to observe underwater activity from the boat. The camera had 150 feet of cable and could be rotated to observe a 360-degree radius. The camera was used at both Echo Bay and Las Vegas Bay to search for spawning adults or spawning areas.

Larval sampling methods of the previous two study years were modified to include standardization of sampling sites at Echo Bay and Las Vegas Bay. Six standardized sites were located at both Echo Bay and Las Vegas Bay and were situated around the two areas where larvae were collected during the previous two spawning seasons. At Echo Bay, three sites were located near the back of the bay where spawning had been documented previously. The other three sites were located near the mouth of the bay where larvae moving out of the bay would be found. At Las Vegas Bay, three sites were located around Blackbird Point: one in a small cove just east of Gypsum Wash (about .25 mile east of Blackbird Point), and two across the bay from Blackbird Point in the Pitch Fork Cove area where larvae had been collected in 1998. Larvae were sampled as during previous years for a standardized 15 minutes (Holden et al. 1997, Holden et al. 1999). In addition to the standardized sites, sampling was conducted in the surrounding areas to discern different spawning areas, amount of larval drift, direction of drift, and use of habitat by larvae.

A major new effort in the study that was initiated in 1998 was the search for other populations of razorback sucker within the lake. Based on past experience with the lake, it was determined that larval sampling was likely a better way to find other populations than 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 1999, a more-thorough coverage of the lake was planned. This was done by conducting larval sampling at 1.0-mile increments along the entire shoreline of the lake (0.5-mile increments along the northwestern shore of Overton Arm). A Landsat image was prepared using ArcInfo software that established sampling points at 1.0-mile intervals. Larval sampling from the previous 2 years revealed that the deepest coves tended to hold the most larvae for the longest amounts of time. For this reason sampling sites at each designated point were the deepest cove in the immediate area. These locations were sampled for 15 minutes each, which allowed for up to 10 sites to be sampled each night.

Larval drift sampling was also attempted once in the lower, flowing portion of Las Vegas Bay, using a 1.5-ft² rectangular mouth, 9-meter long, 560-micron mesh, conical drift net, set near dawn. Sampling for juvenile razorback sucker was intensified in 1999 and fyke nets (3' x 4' x 3/8") became the primary sampling method. Limited seining and experimental gill netting was also used.

During 1997-1998, aging of two razorback sucker was conducted using otoliths and fin rays (Holden et al. 1999). Fin rays proved to be an accurate aging structure. During 1998-1999, the potential to use fin rays as a non-lethal and non-destructive technique to age razorback sucker in Lake Mead continued to be investigated. Various-sized portions of fin rays were removed from hatchery-reared

razorback sucker that had been collected as larvae in Echo Bay during 1997. The fish were then either sacrificed for otolith collection and aging, or returned to a live tank to observe the healing process.

During the first 2 years of the Lake Mead study, estimates of the razorback sucker populations at Las Vegas Bay and Echo Bay were made using the program CAPTURE. During 1998-1999, trammel netting of adults was reduced and, hence, smaller numbers of captured fish were available for a population estimate. Therefore, no new population estimate was made. In addition, prior population estimates have indicated a population of less than 100 at Echo Bay and between 200 and 400 at Las Vegas Bay, and it is suspected that further estimates will not dramatically change those numbers.

RESULTS

Adult Sampling

Trammel Netting

Table 1 shows the trammel net effort that was expended from July 1998 to June 1999, and Figures 3 and 4 show the location of trammel net sets in the two primary study areas for the same time period. A total of 92 trammel net nights (one net night is comprised of one overnight net set) were utilized during the third study year, with 50 net nights used in the Las Vegas Bay/Boulder Basin area and 42 net nights used in the Echo Bay/Overton Arm area.

Table 1. Trammel netting effort (net nights) on Lake Mead by month from July 1998 to June 1999.

MONTH	LAS VEGAS BAY/ BOULDER BASIN	ECHO BAY/ OVERTON ARM	TOTAL
1998			
July	0	0	0
August	0	0	0
September	4	10	14
October	0	0	0
November	7	8	15
December	10	10	20
1999			
January	8	10	18
February	0	4	4
March	0	0	0
April	0	0	0
May	0	0	0
June	21	0	21
Total	50	42	92

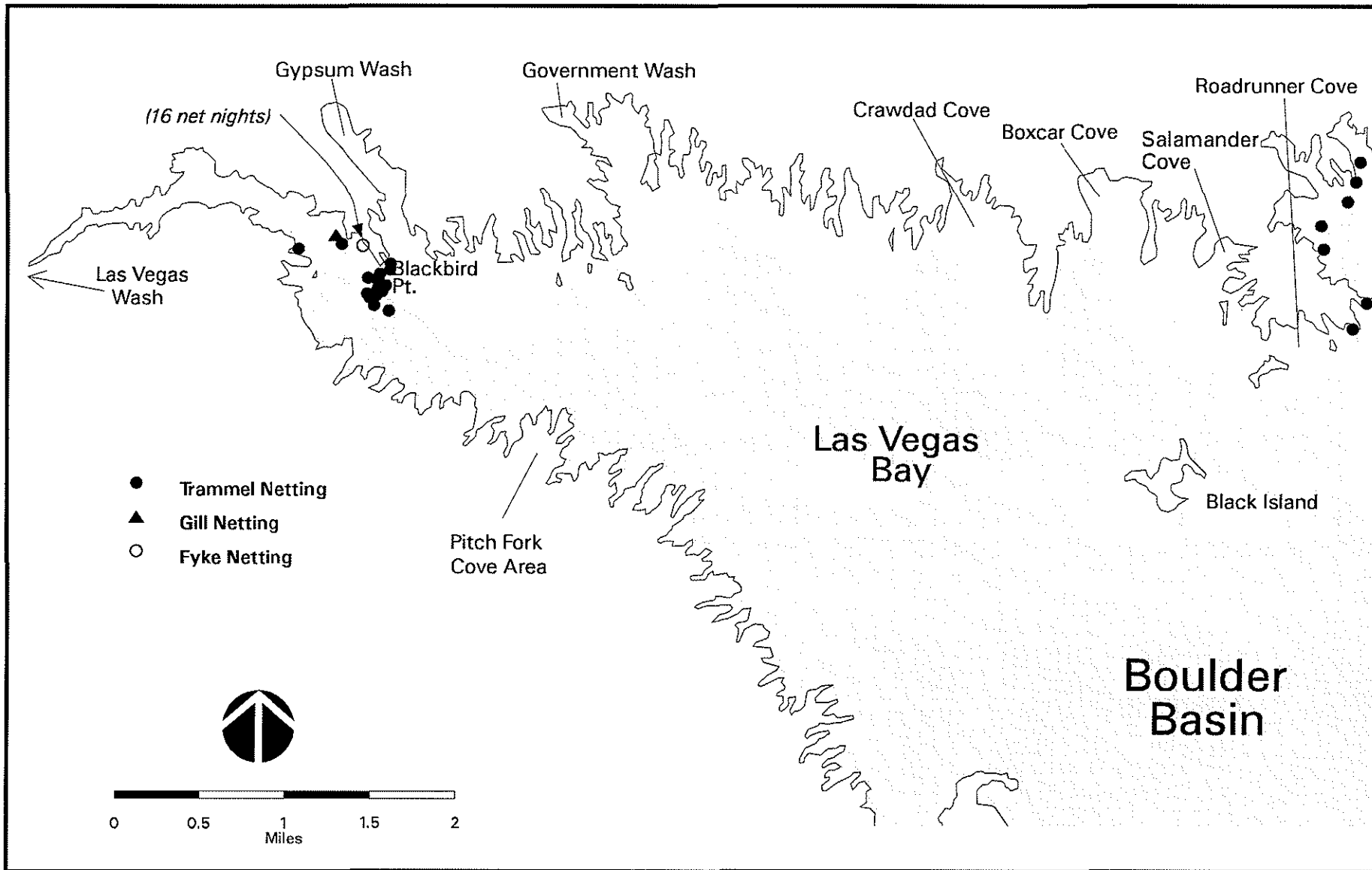


Figure 3. Las Vegas Bay study area showing location of trammel netting, gill netting, and fyke netting.

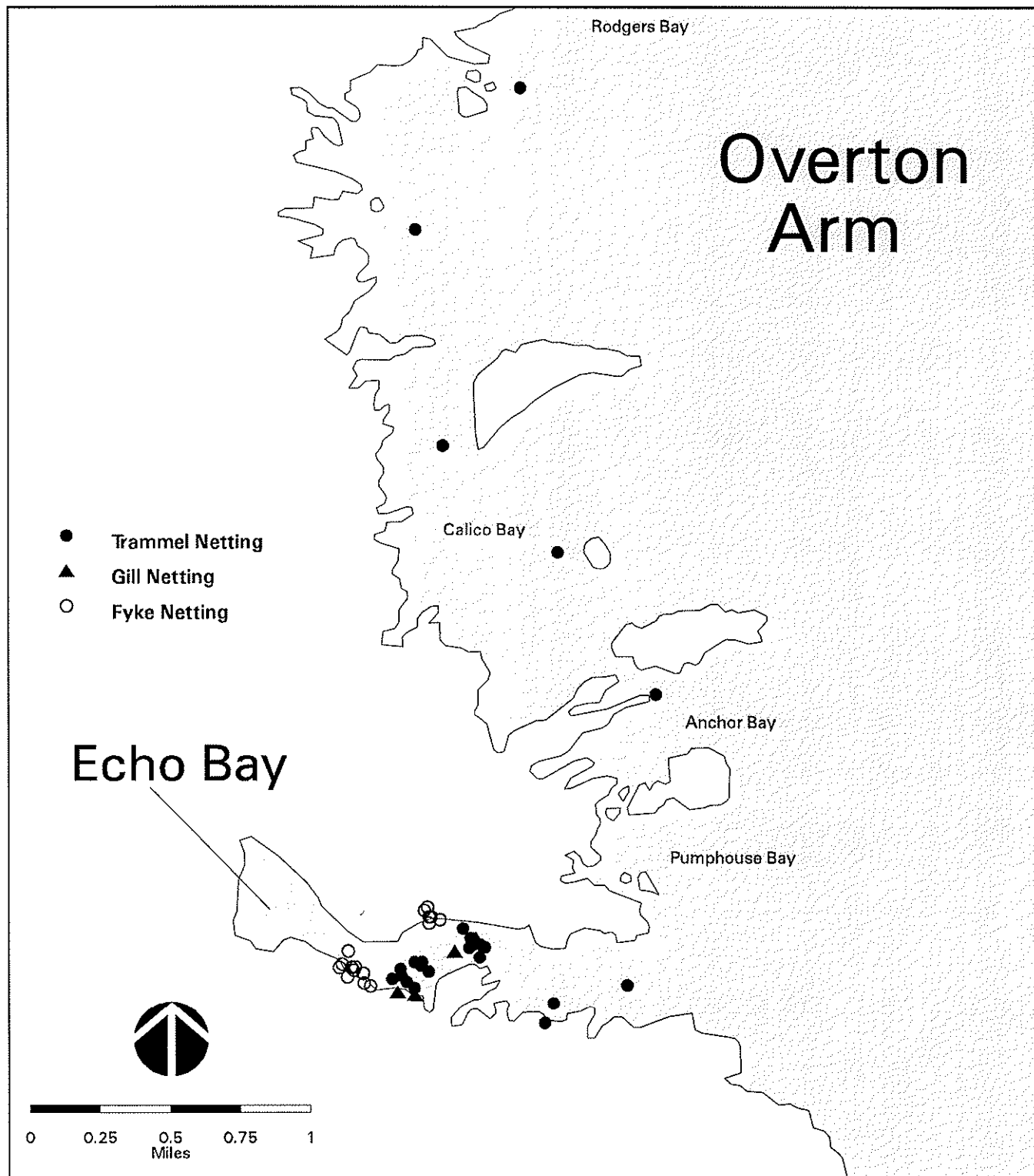


Figure 4. Echo Bay/Overton Arm study area showing location of trammel netting, gill netting, and fyke netting.

The timing of trammel netting for the third study year was coordinated with seasonal differences in water and air temperature, and with spawning season. Netting during the previous two 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 third study year was not conducted in July and August (warm months) or March, April, and May (spawning season).

Similar to the previous two study years, trammel netting effort during the third study year was concentrated in the Blackbird Point area in Las Vegas Bay (Figure 3) 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.

At Las Vegas Bay, the five adult razorback sucker captured during the third study year were all sampled from the deepest portion of the Blackbird Point area. This is the portion of Blackbird Point where nets were located to run into the deep channel just off the end of Blackbird Point, thereby sampling at depths of 60 to 80 feet. Limited trammel netting occurred in the back portion of Las Vegas Bay near the confluence with Las Vegas Wash. Sampling consisted of four net nights at various locations within the flowing and non-flowing portion of the bay. Although sonic-tagged razorback sucker were located in the area, no razorback sucker were caught in nets. In the Boulder Basin, trammel netting occurred in the Swallow Bay area after sonic-tagged razorback sucker were located there and because a larval razorback sucker was collected there during spring 1999 larval sampling. No razorback sucker were captured in Swallow Bay during 16 net nights. Catch rates for trammel netting at the Las Vegas Bay area, not including sampling near the confluence with Las Vegas Wash and Swallow Bay, were 0.20/net night for the third sampling year. If results for all trammel netting in the Boulder Basin and Las Vegas Bay are combined, the catch rate decreases to 0.10/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 portion of the bay. During 37 trammel net nights, 20 razorback sucker were captured. In Overton Arm, limited netting occurred at Rogers Bay, Calico Bay, and Anchor Cove after several sonic-tagged razorback sucker were located in those areas. No razorback sucker were captured during five net nights. Catch rates for trammel netting at Echo Bay, not including other bays sampled in Overton Arm, were 0.54/net night. If sampling results for all trammel netting that occurred in Overton Arm are combined, the catch rate decreases slightly to 0.48/net night.

Limited trammel netting was conducted during the 1999 spawning season compared with the past two sampling seasons. However, ripe male razorback sucker were caught prior to the actual spawning season beginning in mid November and continuing through early February. The first male with breeding tubercles was captured on November 17, 1998, at Blackbird Point, and the first male expressing milt was caught at Blackbird Point on November 19, 1998. Female razorback sucker expressing eggs were not captured during the third sampling season (Table 2).

Table 2. Location, tagging, and size information related to razorback sucker collected in Lake Mead from October 1996 to June 1999.

<u>Date</u>	<u>Location</u>	<u>Sonic Tag No.</u>	<u>PIT Tag No.</u>	<u>Recap.</u>	<u>TL (mm)</u>	<u>FL (mm)</u>	<u>SL (mm)</u>	<u>Weight (g)</u>	<u>Sex</u>	<u>Ripe</u>
10/23/1996	Blackbird Point	Not Implanted	1F4B1F5621	No	495	460		1,530	U	
10/23/1996	Blackbird Point	Not Implanted	1F4A173D43	No	588	547		2,600	U	
10/24/1996	Echo Bay	Not Implanted	1F4A30392E	No	704	651	594	4,082	F	
10/24/1996	Echo Bay	Not Implanted	7F7D22242B	Yes	595	555	499	2,700	F	
11/18/1996	Blackbird Point	249	1F483F0D4D	Yes	576	530	485	2,130	F?	TU ^a
11/20/1996	Echo Bay	357	7F7B012325	Yes	591	550	489	2,710	F	TU
11/20/1996	Echo Bay	348	7F7D152A5D	Yes	569	533	471	2,270	M	TU
11/20/1996	Echo Bay	258	7F7D515B6E	No	585	540	479	2,871	F	TU
11/20/1996	Echo Bay	267	7F7D2B330C	Yes	588	545	485	2,235	M	TU
11/20/1996	Echo Bay	285	7F7D165D68	Yes	606	564	502	2,604	M	TU
12/18/1996	Blackbird Point	276	7F7D3B6539	No	713	664	605	4,507	F	
12/18/1996	Blackbird Point	339	7F7D4B7052	No	492	459	410	1,637	M	
1/27/1997	Echo Bay	2255	7F7D4D6F34	No	585	545		2,475	M	TU
1/27/1997	Echo Bay	Not Implanted	7F7D2B2D5F	Yes	590	548		2,638	M	TU
1/27/1997	Echo Bay	Not Implanted	7F7D222A48	Yes	545	510		2,055	M	TU
1/27/1997	Echo Bay	2228	7F7D22351B	Yes	695	645		4,245	F	
1/27/1997	Echo Bay	2246	7F7D4D7777	No	590	550		2,610	M	TU
1/28/1997	Blackbird Point	384	7F7D4A7E47	No	512	483		1,603	F	
1/29/1997	Blackbird Point	2237	7F7D28296B	No	735	695	640	4,763	F	
1/29/1997	Blackbird Point	2264	7F7D4B7C2E	No	560	520	465	2,222	M	TU
2/10/1997	Blackbird Point	294	7F7D4B7A54	No	617	578	525	2,375	M	MI ^b
2/25/1997	Blackbird Point	276R	7F7D3B6539	Yes	713	664		3,855	F	EG ^c
2/25/1997	Blackbird Point	Not Implanted	7F7D4D6275	No	502	467	428	1,599	M	MI
2/25/1997	Blackbird Point	Not Implanted	7F7D51716D	No	659	605	550	3,600	F	
2/25/1997	Blackbird Point	Not Implanted	7F7D481D76	No	671	620	560	3,742	F	
2/28/1997	Echo Bay	357	7F7B012325	Yes	597	550	485	2,668	M	
2/28/1997	Echo Bay	Not Implanted	7F7D1A2B3C	Yes	576	538	481		M	
2/28/1997	Echo Bay	Not Implanted	1F4A592D11	Yes	681	642	573	3,390	F	
2/28/1997	Echo Bay	Not Implanted	7F7D462104	No	661	620	555	3,432	F	
3/8/1997	Echo Bay	Not Implanted	1F4A157B07	Yes	571	531	467	2,434	M	MI
3/10/1997	Blackbird Point	Not Implanted	7F7D51716D	Yes	659	610	560	3,625	F	
3/10/1997	Blackbird Point	Not Implanted	7F7D4A0478	No	600	552	495	2,718	M	MI
3/10/1997	Blackbird Point	Not Implanted	7F7D51650E	No	565	555	500	2,363	M	MI
3/10/1997	Blackbird Point	Not Implanted	1F7A3E1A0F	No	722	670	610	4,139	F	EG
3/10/1997	Blackbird Point	Not Implanted	7F7D481D76	Yes	670	612	555	3,515	F	EG
3/12/1997	Echo Bay	Not Implanted	201D5F2A3A	No	645	591	525	3,095	F	SP ^d
3/12/1997	Echo Bay	Not Implanted	1F7A26625F	No	560	519	460	2,422	M	MI
3/12/1997	Echo Bay	Not Implanted	7F7D1A2E1A	Yes	584	535	481	2,461	M	MI
3/12/1997	Echo Bay	Not Implanted	1F7A39743A	No	590	538	482	2,853	M	MI
3/12/1997	Echo Bay	357	7F7B012325	Yes	600	552	496	2,649	M	TU
4/5/1997	Blackbird Point	Not Implanted	203726295A	No	702	648	590	4,564	F	
4/5/1997	Blackbird Point	Not Implanted	1F7B03796A	No	612	563	505	2,211	M	TU
4/5/1997	Blackbird Point	2264 -2nd Time	201D5B1751	No	581	529	475	2,438	M	MI
4/17/1997	Blackbird Point	2525	201D61560C	No	662	605	545	3,150	M	MI

Table 2. (cont.).

<u>Date</u>	<u>Location</u>	<u>Sonic Tag No.</u>	<u>PIT Tag No.</u>	<u>Recap.</u>	<u>TL (mm)</u>	<u>FL (mm)</u>	<u>SL (mm)</u>	<u>Weight (g)</u>	<u>Sex</u>	<u>Ripe</u>
4/20/1997	Echo Bay	3344	1F7B477827	No	573	484	334	1,989	M	MI
4/20/1997	Echo Bay	2273	1F7B0D2435	No	559	516	464	2,006	M	MI
4/20/1997	Echo Bay	2336	201D5B6107	No	632	586	536	3,011	F	EG
4/20/1997	Echo Bay	Not Implanted	1F7A39743A	Yes	582	530	485	2,497	M	MI
4/20/1997	Echo Bay	Not Implanted	1F7B5A503C	No	472	442	387	1,194	M	MI
4/20/1997	Echo Bay	Not Implanted	2037132A6C	No	637	585	542	3,142	F	EG
4/20/1997	Echo Bay	Not Implanted	1F7A721C59	No	582	540	493	2,133	M	CO ^o
4/21/1997	Blackbird Point	Not Implanted	1F7B03796A	Yes	604	555	508	2,100	M	MI
4/21/1997	Blackbird Point	Not Implanted	7F7D4C0651	No	605	558	505	2,360	M	MI
4/21/1997	Blackbird Point	2264	201D5B1751	Yes	577	525	473	2,400	M	MI
4/21/1997	Blackbird Point	Not Implanted	7F7D3F6F5C	No	552	507	458	2,127	M	MI
4/21/1997	Blackbird Point	Not Implanted	7F7D483714	No	515	474	426	1,532	M	MI
4/21/1997	Blackbird Point	2444	7F7D4D6275	Yes	508	465	419	1,330	M	MI
5/19/1997	Echo Bay	Not Implanted	7F7D301A27	No	499	468		1,205	M	SP
5/19/1997	Echo Bay	Not Implanted	7F7D3B3240	No	667	623	576	3,300	F	SP
5/19/1997	Echo Bay	Not Implanted	1F476B7936	Yes	581	539	481	2,178	F	SP
5/19/1997	Echo Bay	Not Implanted	7F7D1A2B3C	Yes	578	537	480	2,166	M	SP
7/16/1997	Echo Bay	Not Implanted	1F476B7936	Yes	574	536	487	2,300	M	
8/20/1997	Rogers Bay	2246	7F7D4D7777	Yes	598	560	502	2,979	M	
8/20/1997	Rogers Bay	Not Implanted	1F7B634E35	No	725	670		4,226	F	
8/20/1997	Rogers Bay	Not Implanted		?	596	560	500	2,641	M	
8/20/1997	Rogers Bay	Not Implanted		?	598	562	505	2,716	U	
10/23/1997	Echo Bay	Not Implanted	7F7D22341E	Yes	625	575	530	3,202	M	TU
11/10/1997	Blackbird Point	Not Implanted	7F7D3A5B2D	No	621	580	540	3,288	F	
11/11/1997	Blackbird Point	Not Implanted	7F7D7D492C	Yes	684	643	565	3,695	F	
11/12/1997	Echo Bay	Not Implanted	7F7D47300C	No	354	327	290	437	I	
12/9/1997	L.V. Wash Inflow	Not Implanted	7F7D4B771D	No	650	615	560	3,288	M	TU
12/9/1997	L.V. Wash Inflow	238	7F7D516462	No	692	645	588	4,479	F	
12/10/1997	Echo Bay	365	7F7D2F320A	Yes	595	550	495	2,362	M	TU
12/10/1997	Echo Bay	88	7F7D516F6E	No	318	296	258	305	I	
1/5/1998	Blackbird Point	347	7F7D467310	No	595	550	495	2,559	M	TU
1/5/1998	Blackbird Point	464	7F7D4A0478	Yes	604	555	500	3,047	M	MI
1/15/1998	Echo Bay	79	7F7D481E44	No	630	588	525	2,985	M	MI
1/15/1998	Echo Bay	555	7F7D302048	No	381	353	310	575	I	
2/10/1998	Echo Bay	Not Implanted	7F7D4C302B	No	347	321	281	417	I	
2/10/1998	Echo Bay	Not Implanted	7F7D482104	No	675	632	567	3,232	F	
2/10/1998	Echo Bay	Not Implanted	1F4A157B07	Yes	585	536	488	2,550	M	TU
2/12/1998	Blackbird Point	384	7F7D4A7E47	Yes	555	520	465	1,898	F	
3/9/1998	Blackbird Point	Not Implanted	1F78022047	No	680	628	581	3,559	F	EG
3/9/1998	Blackbird Point	Not Implanted	1F783F2109	No	662	605	540	2,624	M	
3/9/1998	Blackbird Point	Not Implanted	201D633030	No	564	525	465	1,943	F	
3/9/1998	Blackbird Point	Not Implanted	7F7D4B7A54	Yes	630	581	522	2,295	M	MI
3/9/1998	Blackbird Point	Not Implanted	1F4A46272A	Yes	575	529	481	1,935	M	MI
3/9/1998	Blackbird Point	Not Implanted	1F783D4369	No	578	536	489	2,274	M	
3/9/1998	Blackbird Point	Not Implanted	1F78123225	No	627	574	519	3,177	M	MI
3/9/1998	Blackbird Point	Not Implanted	7F7D4A7E47	Yes	555	523	472	1,851	F	
3/9/1998	Blackbird Point	Not Implanted	7F7D770148	Yes	668	605	557	3,192	M	MI

Table 2. (cont.).

<u>Date</u>	<u>Location</u>	<u>Sonic Tag No.</u>	<u>PIT Tag No.</u>	<u>Recap.</u>	<u>TL (mm)</u>	<u>FL (mm)</u>	<u>SL (mm)</u>	<u>Weight (g)</u>	<u>Sex</u>	<u>Ripe</u>
3/11/1998	Echo Bay	Not Implanted	7F7D222A48	Yes	565	520	476	2,094	M	TU
3/11/1998	Echo Bay	Not Implanted	7F7D4C302B	Yes	351	323	290	411	I	
3/11/1998	Echo Bay	Not Implanted	7F7D133272	Yes	604	560	510	2,779	M	TU
3/11/1998	Echo Bay	Not Implanted	1F78205673	No	592	553	494	2,320	F	EG
3/12/1998	Echo Bay	Not Implanted	7F7D2B2D5F	Yes	594	553	512	2,492	M	MI
3/12/1998	Echo Bay	Not Implanted	7F7D3B3240	Yes	664	620	560	3,648	F	EG
3/12/1998	Echo Bay	357R	7F7B012325	Yes	606	562	510	2,711	M	TU
5/7/1998	Blackbird Point	247	1F4A40391E	Yes	532	480	430	1,620	M	SP
5/7/1998	Blackbird Point	2444	7F7D4D6275	Yes	544	500	453	1,616	M	
5/7/1998	Blackbird Point	Not Implanted	1F782C4F6E	No	728	670	620	4,608	F	EG
5/7/1998	Blackbird Point	374	1F7B5E3553	No	588	541	498	1,940	M	MI
5/7/1998	Blackbird Point	283	7F7D483714	Yes	562	515	475	1,844	M	SP
5/20/1998	Echo Bay	274	7F7D222A48	Yes	564	510	462	1,876	M	RI
5/20/1998	Echo Bay	455	7F7D4D5405	No	553	513	460	1,833	F	SP
6/3/1998	Echo Bay	2543	1F78205673	Yes	597	556	510	2,175	F	
9/14/1998	Echo Bay	Not Implanted	2037143E57	No	610	575	512	2,723	M	
9/14/1998	Echo Bay	357	1F780B3925	Yes	615	570	507	2,941	M	
9/14/1998	Echo Bay	Not Implanted	2037096F31	No	600	559	504	2,199	F	
9/14/1998	Echo Bay	Not Implanted	1F4A457C56	Yes	505	475	422	1,791	F	
9/14/1998	Echo Bay	365	7F7D2F320A	Yes	600	554	505	2,402	M	
9/16/1998	BBP-south end	Not Implanted	1F7A3C0625	No	625	568	514	2,715	F	
11/17/1998	Blackbird Point-Deep Set	Not Implanted	2038547361	Yes	563	518	376	2,211	M	TU
11/19/1998	Blackbird Point-Deep Set	Not Implanted	1F7815490B	No	642	593	530	3,515	M	TU
11/19/1998	Blackbird Point-Deep Set	Not Implanted	201D5B2345	No	645	603	539	3,203	M	MI
11/22/1998	Echo Bay-S. shore	Not Implanted	1F7A77640C	No	494	452	402	1,275	F	
12/7/1998	Echo Bay	Not Implanted	1F782D516B	No	498	463	412	1,219	M	TU
1/26/1999	Echo Bay - 285 set	Not Implanted	1F476B7936	Yes	616	566	550	2,760	F	
1/26/1999	Echo Bay - RZ cove	Not Implanted	7F7D2B2D5F	Yes	595	549	493	2,643	M	MI
1/26/1999	Echo Bay - @ cliff	Not Implanted	201D5F2A3A	Yes	642	585	527	3,322	F	
1/26/1999	Echo Bay - @ cliff	Not Implanted	1F4A457C56	Yes	514	484	435	1,562	M	MI
1/28/1999	Echo Bay - s. shore	Not Implanted	201D5F2A3A	Yes	642	585	527	3,322	F	
1/28/1999	Echo Bay - s. shore	Not Implanted	201D576408	No	519	486	430	1,872	M	MI
1/28/1999	Echo Bay - 2 lobe	Not Implanted	7F7D164F08	Yes	601	565	504	2,523	M	MI
1/29/1999	Black Bird Point- shallow	Not Implanted	1F7D66324C	Yes	563	523		2,105	M	MI
2/9/1999	Echo Bay-s. shore	Not Implanted	2037175B37	No	625	580	520	3,156	M	MI
2/9/1999	Echo Bay-s. shore	Not Implanted	1F78392D03	No	610	567	509	2,571	M	MI
2/9/1999	Echo Bay-RZ cove	Not Implanted	7F7D482104	Yes	668	626	555	3,567	F	CO
2/9/1999	Echo Bay-RZ cove	Not Implanted	203718652C	No	703	652	589	4,305	F	CO
2/9/1999	Echo Bay-s. shore	Not Implanted	201D5F2A3A	Yes	649	591	526	3,248	F	CO
2/9/1999	Echo Bay-s. shore	Not Implanted	7F7D15463D	Yes	660	614	550	3,076	F	CO

^a TU = tubercles present, ^b MI = expressing milt, ^c EG = expressing eggs, ^d SP = spawned out, ^e CO = spawning coloration

Recapture rates varied between study locations. Several fish were caught twice, and several recaptures from previous years were also caught during the third year of the study. At Las Vegas Bay, two of the five razorback sucker caught were recaptures. Interestingly, one of the recaptures was a fish originally captured as a larvae by NDOW in 1995, reared in their facilities, and repatriated to the lake in 1996 as a 199-mm TL juvenile. When recaptured, it had grown to 563-mm total length (TL). At Echo Bay, 12 of the 20 razorback sucker caught were recaptures. Three of these recaptured fish were stocked April 25, 1995, by NDOW, and of these three, two had been previously recaptured. Seven of the twelve razorback sucker recaptured at Echo Bay were originally PIT-tagged during this study, and one fish was caught three times, accounting for three of these seven recaptures. Initial capture dates could not be found in NDOW records for one of the twelve recaptured razorback sucker from Echo Bay, which also had been captured earlier during this study.

At Echo Bay, 33 individual razorback sucker have been captured and PIT-tagged during the 3 years of the study. In addition, 20 other razorback sucker previously PIT-tagged by the NDOW were captured. Hence, 53 individual PIT-tagged razorback sucker were handled at Echo Bay during the first 3 years of the study. At Las Vegas Bay, 35 individual razorback sucker have been captured and PIT-tagged. In addition, seven razorback sucker previously PIT-tagged by the NDOW were captured during this study. Consequently, 42 unique PIT-tagged razorback sucker have been handled at Las Vegas Bay during the first 3 years of this study. Lakewide, 95 individual razorback sucker were handled during the first 3 years of the study.

Video Surveillance and SCUBA

Underwater video surveillance was successful in identifying the exact location of a spawning ground and in observing actual razorback sucker spawning activity at Echo Bay. The spawning ground was located at the southwestern corner of Echo Bay, along a cliff that rises about 20 feet out of the water. The cliff is composed of a loose conglomerate rock and, through erosion, has supplied the area below the cliff with clean substrate. The substrate was composed of small and large cobbles and was cleaned of silt and sand by spawning activity. The water at the spawning area was approximately 17 feet deep and was turbid enough to obscure the bottom from direct observation at the surface. This area was chosen for initial observation because several adult razorback sucker were captured with trammel nets in this location from 1996 through 1999. Also, a limited number of larval razorback sucker were captured from this location with larval light trapping techniques during the same time period (Holden et al. 1997, Holden et al. 1999).

Video surveillance was conducted at the Echo Bay spawning site on March 12, 17, and 18, 1999, and approximately 5 hours of razorback sucker spawning activity was recorded. On all three dates, spawning activity of approximately 6 to 7 individual razorback sucker was observed. Various markings and white coloration in the eye of one fish allowed for individual identification of most of the fish. It appeared that most of these individual fish were in the area each of the 3 days, and all fish appeared to participate in the spawning activity. The spawning group consisted of approximately two females and four to five males. Several different spawning sequences were recorded, after which several channel catfish (*Ictalurus punctatus*) were observed moving into the area and consuming the razorback sucker eggs that were just expelled. Although common carp (*Cyprinus carpio*) were seen swimming through the spawning area on occasion, they were never observed feeding on the substrate where eggs had been deposited. Subsequent video surveillance

during the week of March 21, 1999, did not reveal any razorback sucker on the Echo Bay cliff spawning site.

Video surveillance conducted at other locations in Echo Bay and at Blackbird Point in Las Vegas Bay did not reveal any other razorback sucker spawning aggregations or areas where it appeared that spawning activity had taken place. Other areas searched in Echo Bay included the western half of the southern shore. Surveillance conducted at Blackbird Point was not successful because bottom visibility was limited to less than 1 foot, which did not allow for successful viewing.

SCUBA was used to reconnoiter the spawning site at Echo Bay on March 25, 1999. This observation confirmed the size (approximately 20 x 20 feet) and condition of the spawning site, and the composition of the substrate. No razorback sucker were seen during the dive.

Aerial Spawning Surveys

A helicopter flight was conducted on March 24, 1999, in order to identify new aggregations of razorback sucker by visually searching for potential spawning groups. Conditions for the flight were near ideal with no wind, clear sunny skies, no waves, and extremely low turbidity for the majority of the lake. Turbidity was much higher at the Colorado River inflow, so no viable observations were made upstream of Grand Wash Bay.

Searching began at 08:30 and extended along the west shore of Lake Mead from Horsepower Cove north to Las Vegas Bay and around the bay (Figure 5). Searching continued from Las Vegas Bay north along the west shores of Boulder Basin, Virgin Basin, Overton Arm, and all of the Muddy River Arm. The flight then proceeded towards Mesquite, Nevada, to refuel, and the Virgin Arm and Virgin Bowl were searched en route.

After refueling, the search continued (11:05), covering the east shore of Overton Arm and heading south from Echo Bay, including Virgin Basin and Temple Basin. Searching then continued covering the west shore of Gregg Basin east to Grand Wash Bay. After searching the eastern parts of the lake, the east shore of Gregg Basin, the south shores of Temple and Virgin basins, the narrows, and the eastern shore of Boulder Basin were searched. The flight concluded at approximately 17:15 at Boulder City Airport. During the searches, the only fish that were seen were common carp in various areas of the lake. No razorback sucker were seen.

Growth

Although 14 recaptures occurred in 1998-1999, only 11 individual fish were recaptured since one was caught three times and another twice. The difference in TL between the first and most-recent capture was used to determine mean annual growth for the 11 recaptures (Table 3). Mean annual growth of recaptured fish at Echo Bay was 7.0 mm and ranged from 2.0 mm to 21.4 mm. Only two fish from Las Vegas Bay were recaptured, and they had annual growth of 16.8 mm and 161.6 mm. The high growth rate of 161.6 mm was from a wild razorback sucker larvae collected by the NDOW in 1995 that was captive reared and released back into Las Vegas Bay at 199 mm in 1996. No meaningful average can be determined from the two fish recaptured from Las Vegas Bay; however, the 7.0 mm mean annual growth from Echo bay is 3.3 mm less than calculated from recaptures the previous year (Holden et al. 1999). This lower growth rate was because of the low growth of three of the largest fish recaptured (last three fish in Table 3).

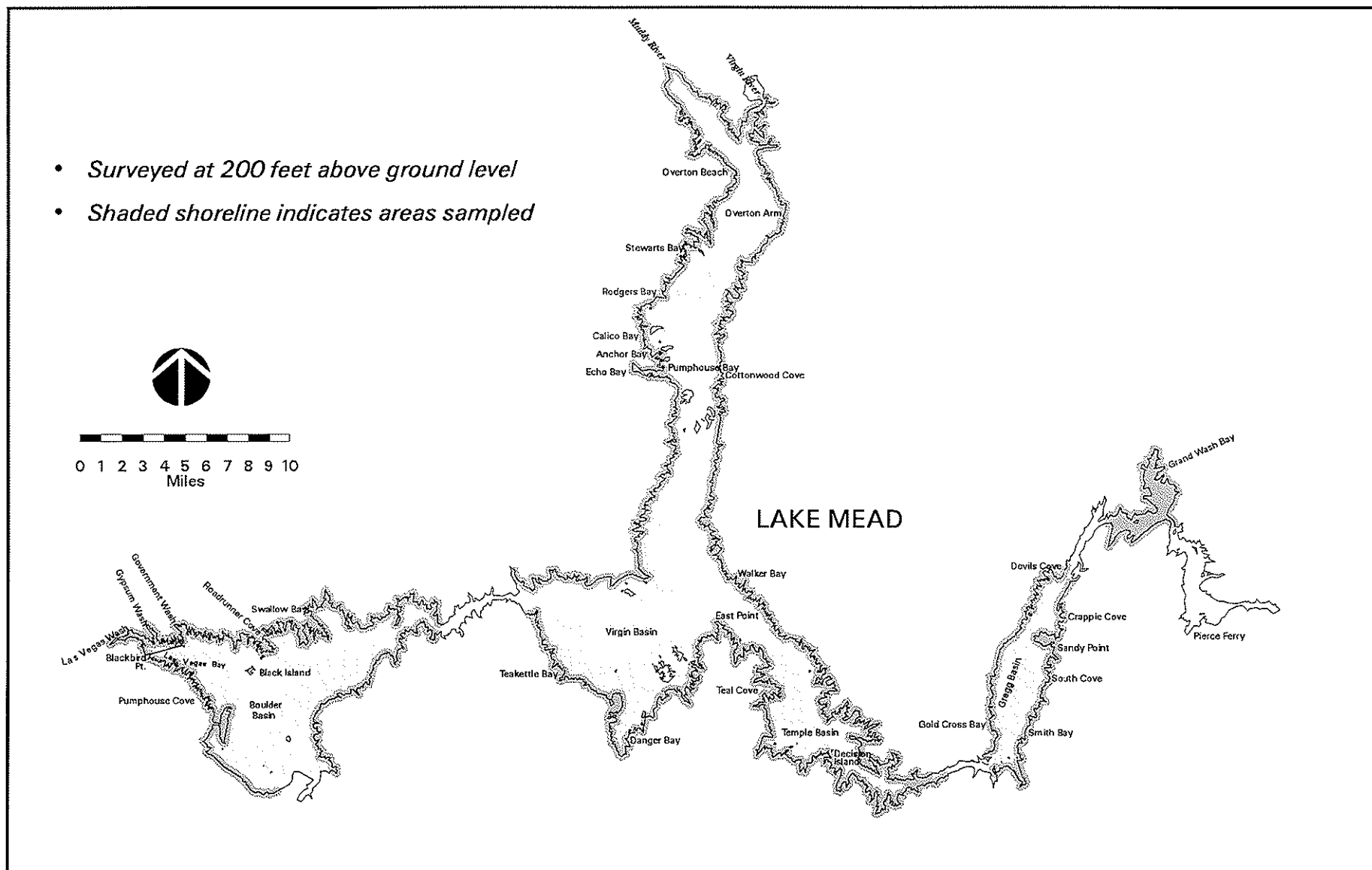


Figure 5. Portions of Lake Mead shoreline surveyed by helicopter for adult razorback sucker on March 24, 1999.

Table 3. Growth of recaptured razorback sucker in Lake Mead from July 1998 through June 1999.

PIT TAG NO.	CAPTURE DATE	SIZE TL (MM)	RECAPTURE DATE	SIZE TL (MM)	TOTAL GROWTH (MM)	DAYS BETWEEN MEASUREMENTS	GROWTH PER YEAR (12 MO.) (MM)
Echo Bay							
1F780B3925	04/02/93	555	09/14/98	615	60	1,990	11.0
7F7D2F320A	12/10/97	595	09/14/98	600	5	278	6.6
1F476B7936	07/25/95	541	01/26/99	616	75	1,280	21.4
7F7D2B2D5F	04/02/93	574	01/26/99	595	21	2,124	3.6
1F4A457C56	04/25/95	488	01/26/99	514	26	1,236	7.7
7F7D164F08	03/19/92	572	01/28/99	601	29	2,296	4.6
7F7D482104	02/28/97	661	02/09/99	668	7	711	3.6
201D5F2A3A	03/12/97	645	02/09/99	649	4	699	2.1
7F7D15463D	03/20/92	646	02/09/99	660	14	2,516	2.0
Mean Annual Growth							7.0
Las Vegas Bay							
2038547361	08/17/96	199	11/17/98	563	364	822	161.6
1F7D66324C	11/25/98	560	01/29/99	563	3	65	16.8

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 11 48-month tags. Tags in 13 of these razorback sucker were active at the beginning of the third study year. No new razorback sucker were implanted during the third study year. Telemetry results for individual sonic-tagged fish for both Echo Bay and Las Vegas Bay are discussed below. Unless otherwise stated, the sonic tags that became stationary or were recovered represent sonic tag-implanted razorback sucker that either expelled their tags or died and thereby deposited their sonic tags on the lake bottom.

Las Vegas Bay

Tag 238

Tag 238 (48-month life expectancy) was implanted on December 9, 1997, into a 692-mm TL female captured at the flowing portion of Las Vegas Bay. This fish was not found for over a year and then was first located on December 17, 1998, at the west shore of Government Wash. Fish 238 remained stationary at the Government Wash position (Figure 6). Although Government Wash was occasionally checked for sonic-tagged fish, it is possible that the tag was located in this area for the intervening year and not found.

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. Throughout the third study year, fish 247 was continually found on an almost monthly basis in the non-flowing and flowing portions of Las Vegas Bay. On July 9, 1998, this fish was found just south of Blackbird Point. Then from August 19 through September 18, on eight separate days, this fish was found in the northern half of the non-flowing portion of Las Vegas Bay. At the end of October, fish 247 was located on four consecutive days (October 27-30) in the flowing portion of Las Vegas Bay. The next time (February 16, 1999) this fish was located it was found in the same general area. Subsequent searches in March, May, and June 1999 located fish 247 in the northern half of the non-flowing portion of Las Vegas Bay (Figure 7).

Tag 283

Tag 283 (48-month life expectancy) was implanted May 7, 1998, into a 562-mm TL male at Blackbird Point. During the third study year, this fish was found in three distinct locations within Las Vegas Bay including: the area near the confluence with Las Vegas Wash, west of Government Wash, and at Boxcar Cove (Figure 8). On July 15, 1998, this fish was found approximately 0.5 mile east of Blackbird Point. On August 11, 1998, fish 283 was located near Boxcar Cove, and then on August 19 and 21 it was located in the non-flowing portion of Las Vegas Bay. On August 25 it was again found back at Boxcar Cove, and on September 9, 1998, it was located back in the non-flowing portion of Las Vegas Bay. On September 15, 1998, fish 283 was found in the flowing portion of Las Vegas Bay, and then it was found on September 17 in Boxcar Cove again. On October 28, 1999, this fish was found along the north shore of Las Vegas Bay, two coves west of Government Wash. Subsequent searches repeatedly located this fish in the same position and determined that it was stationary.

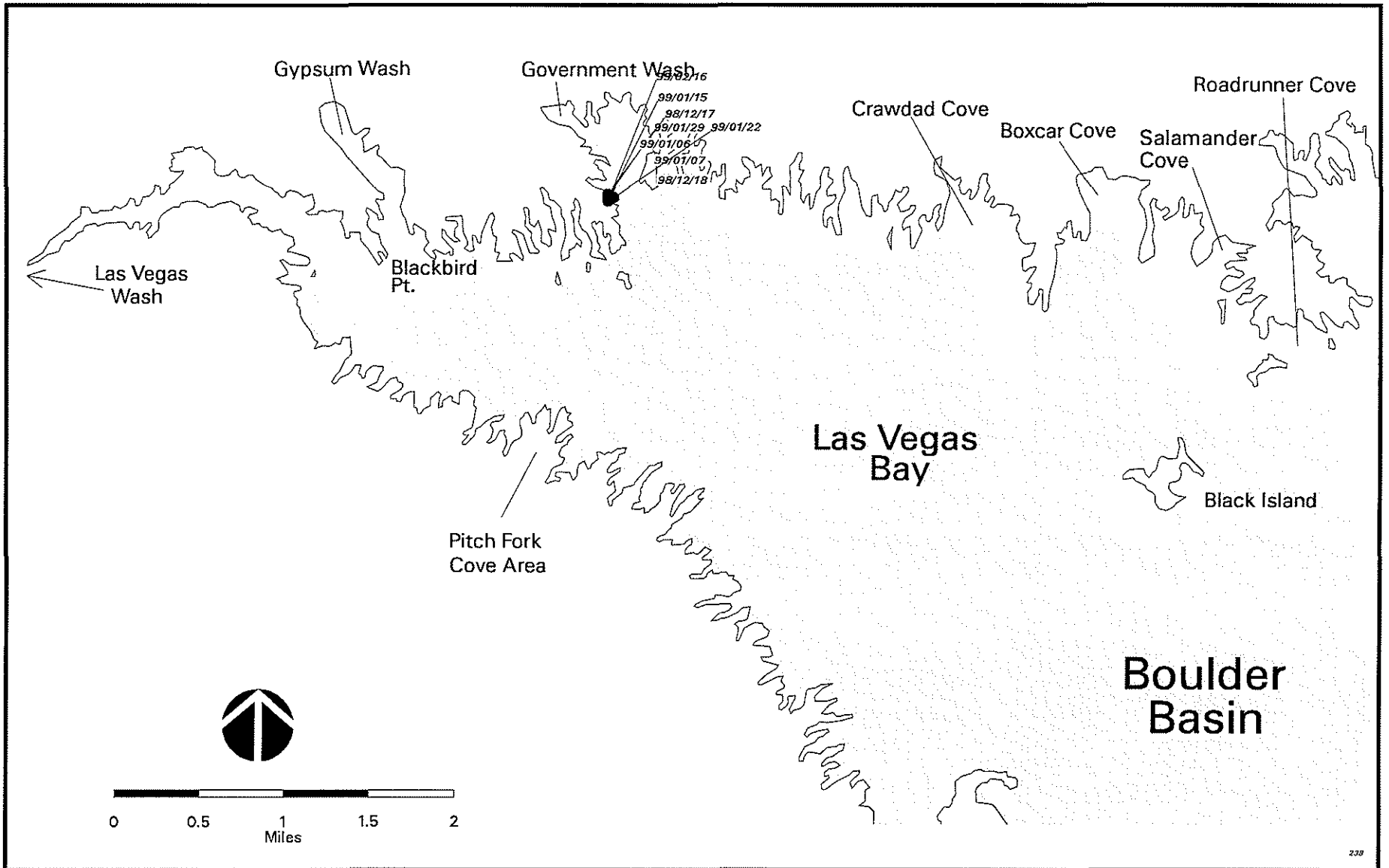


Figure 6. Distribution of fish number: 238.

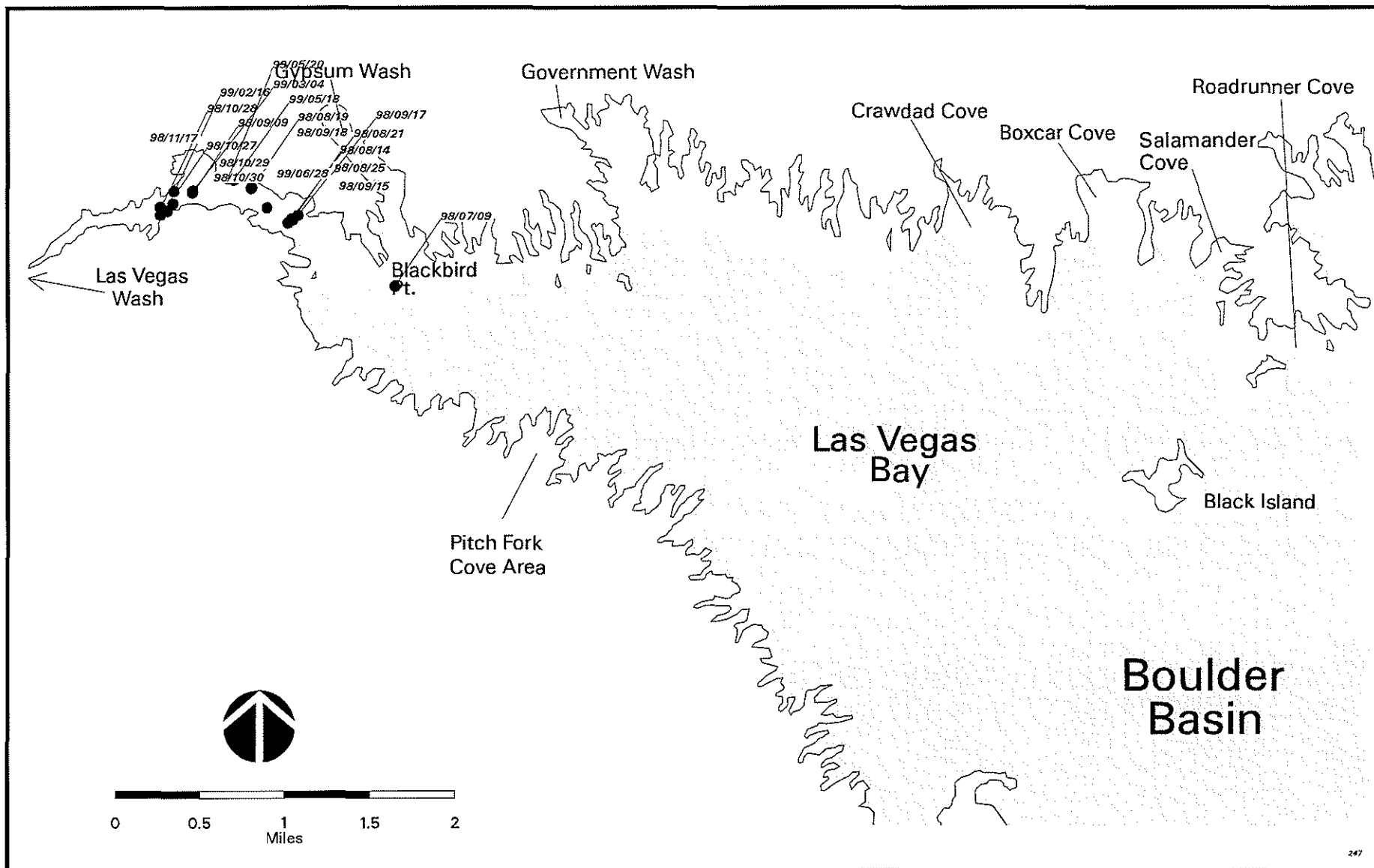


Figure 7. Distribution of fish number: 247.

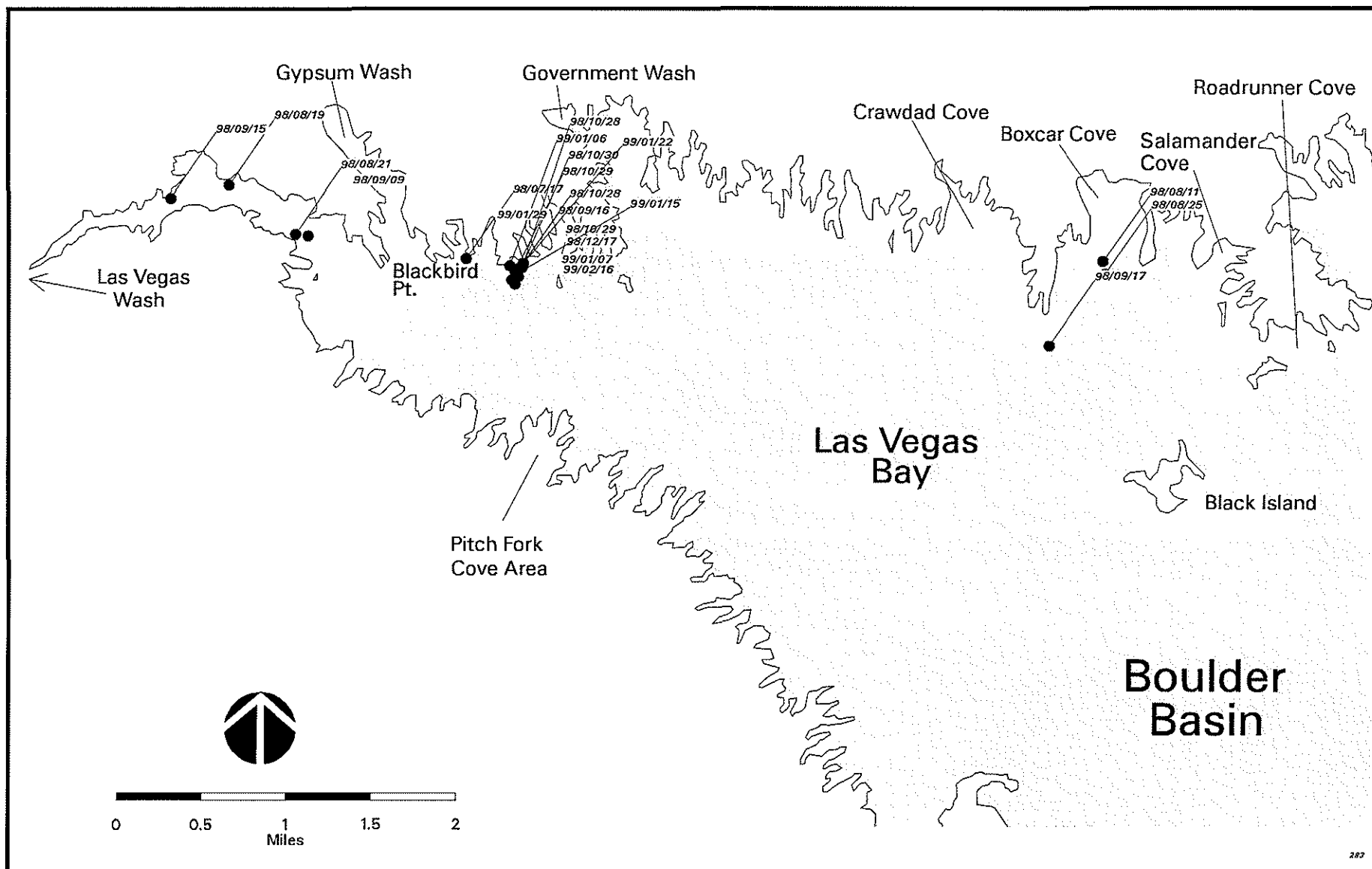


Figure 8. Distribution of fish number: 283

Tag 294

Tag 294 (14-month life expectancy) was implanted February 11, 1997, into a 617-mm TL male at Blackbird Point. During the first two study years, this fish was located 48 times in three general locations including: Blackbird Point, the non-flowing portion of Las Vegas Bay (0.5 mile north of Blackbird Point), and the flowing portion of Las Vegas Bay. During the third study year, fish 294 was located on five different dates in the same general areas as during the previous two study years (Figure 9). It was assumed that at some time shortly after the last location of this fish (on December 17, 1998) the tag in this fish expired. This tag transmitted for approximately 22 months.

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 study year, fish 464 was located eight times in areas including: Blackbird Point, Crawdad Cove, and Boxcar Cove. During the late summer months of 1998, this fish was located five times at Boxcar Cove and once as far east as Roadrunner Cove. During the month of October 1998 this fish was found either north of Las Vegas Bay Marina (approximately 300 m), or east of the marina near the tire break water. Then, from October 28, 1998 through March 15, 1999, fish 464 was found near the tire break water of the marina. It was not located after March 15 (Figure 10).

Tag 2264

On April 6, 1997, tag 2264 (14-month life expectancy) was implanted into a 581-mm TL male fish caught at Blackbird Point. Forty-two points of contact were made with fish 2264 during the first and second years of the study. During that time this fish was found at various locations along the northern shore of Las Vegas Bay including: the non-flowing portion of Las Vegas Bay, Blackbird Point, the area between Government Wash and Crawdad Cove, Salamander Cove, and Roadrunner Cove. During the third study year, fish 2264 was found at Crawdad Cove and near Las Vegas Bay Marina in mid July (Figure 11). On August 11, 1998, this tag was located at the southeastern corner of Roadrunner Cove, and it has remained stationary since that time.

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 27 times during the first and second study years, in areas including: the flowing and non-flowing portions of Las Vegas Bay, Blackbird Point, and the inlet area of Government Wash. During the third study year, this fish was extremely active and was contacted 29 times, primarily in Las Vegas Bay, Boxcar Cove, and Salamander Cove (Figure 12). On July 17, 1998, and August 19 and 21, fish 2444 was located at Boxcar Cove. Then, on September 9, it was located in the flowing portion of Las Vegas Bay, after which it was again located at or near Boxcar Cove on September 16-18. The remainder of contacts for this fish were made in the Las Vegas Bay/Blackbird Point area extending from October 22, 1998, through June 28, 1999.

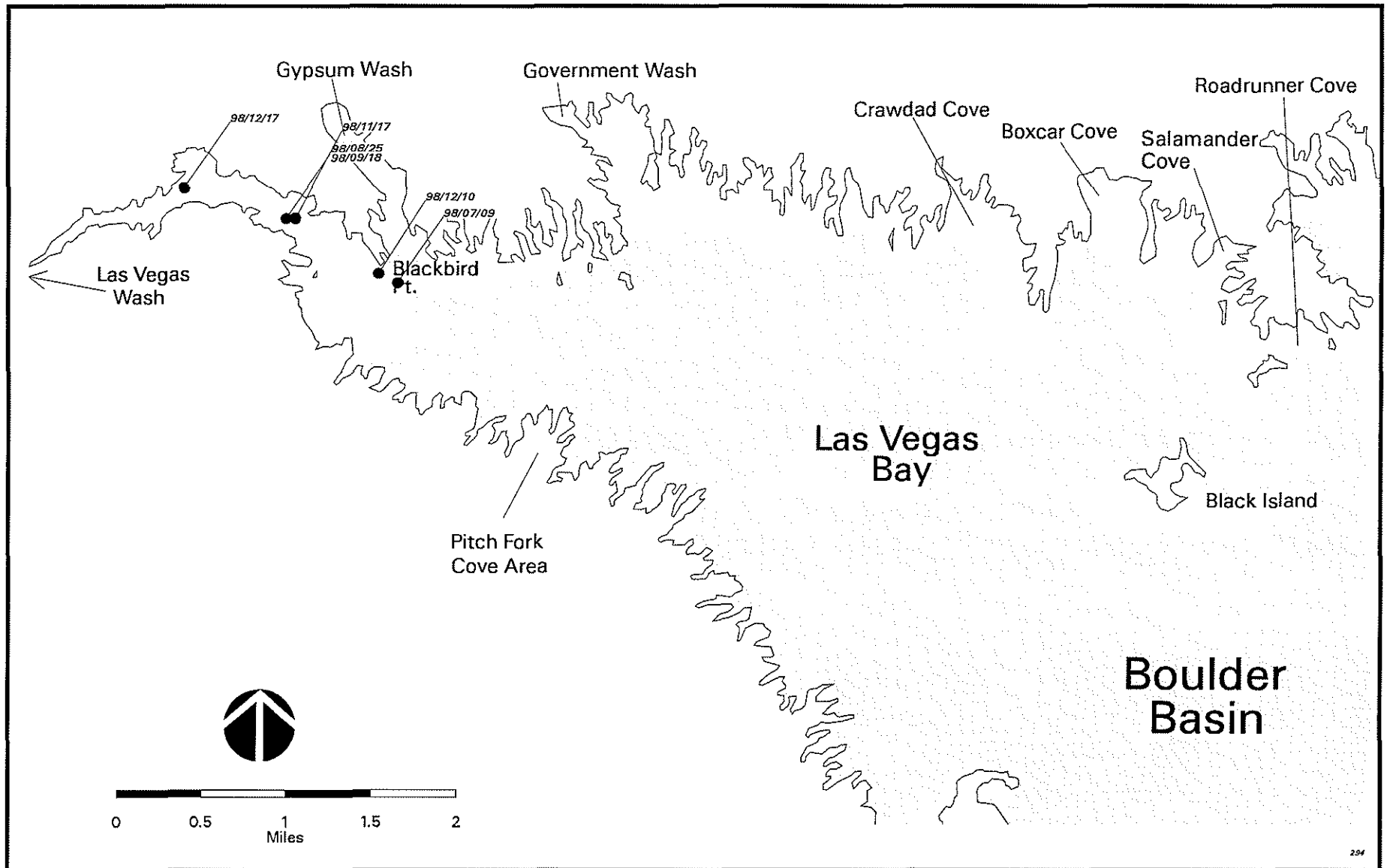


Figure 9. Distribution of fish number: 294.

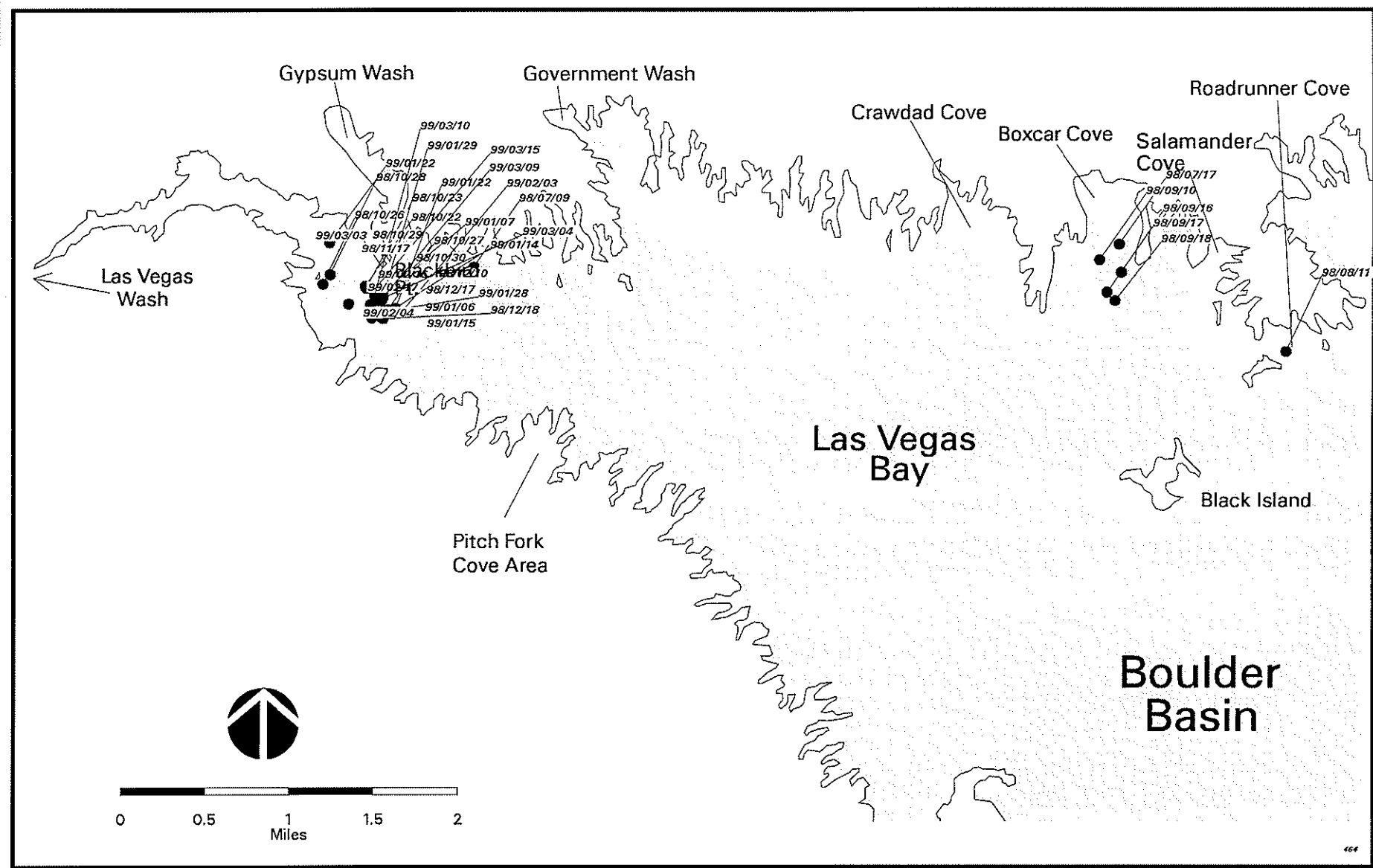
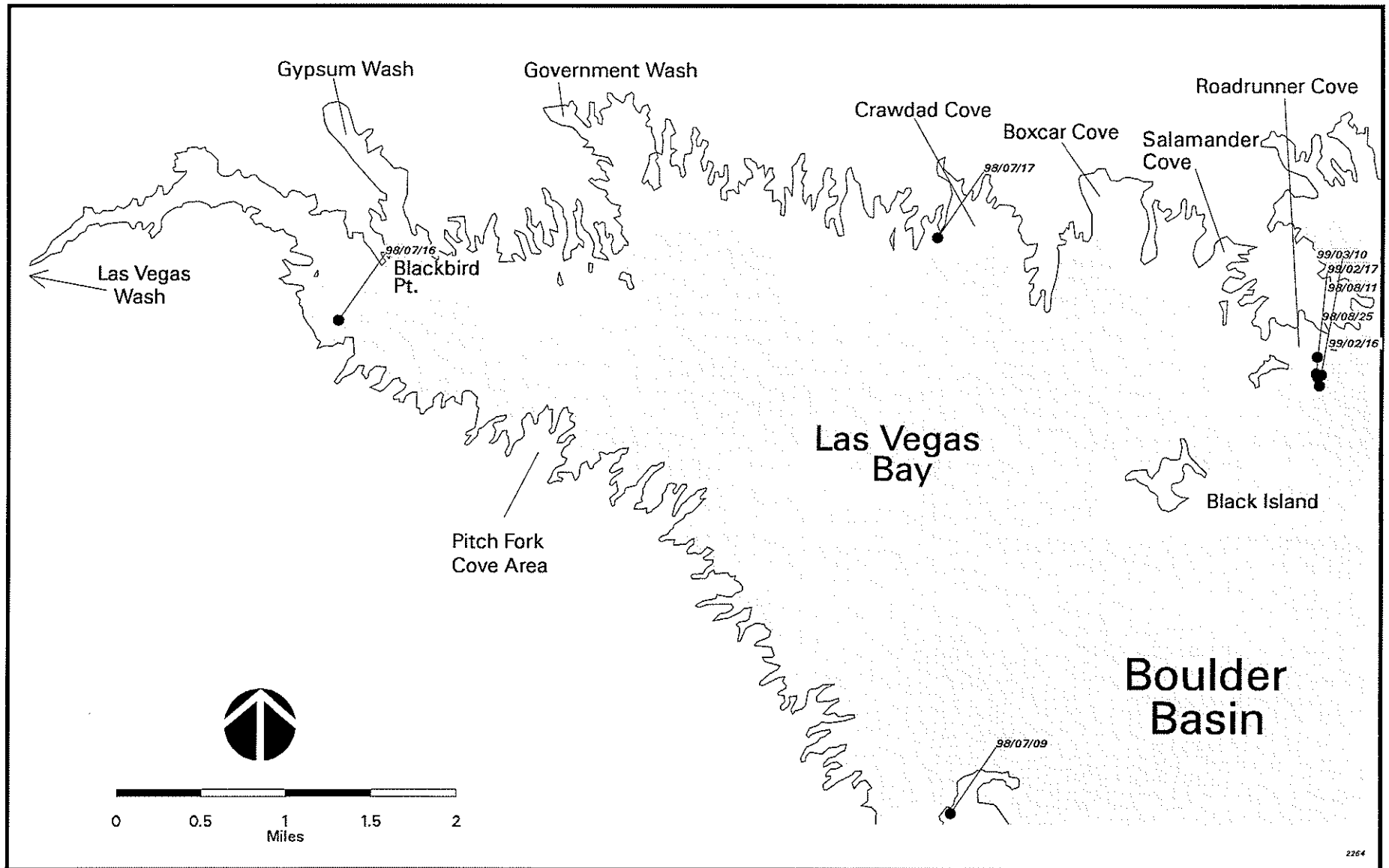


Figure 10. Distribution of fish number: 464.



2264

Figure 11. Distribution of fish number: 2264.

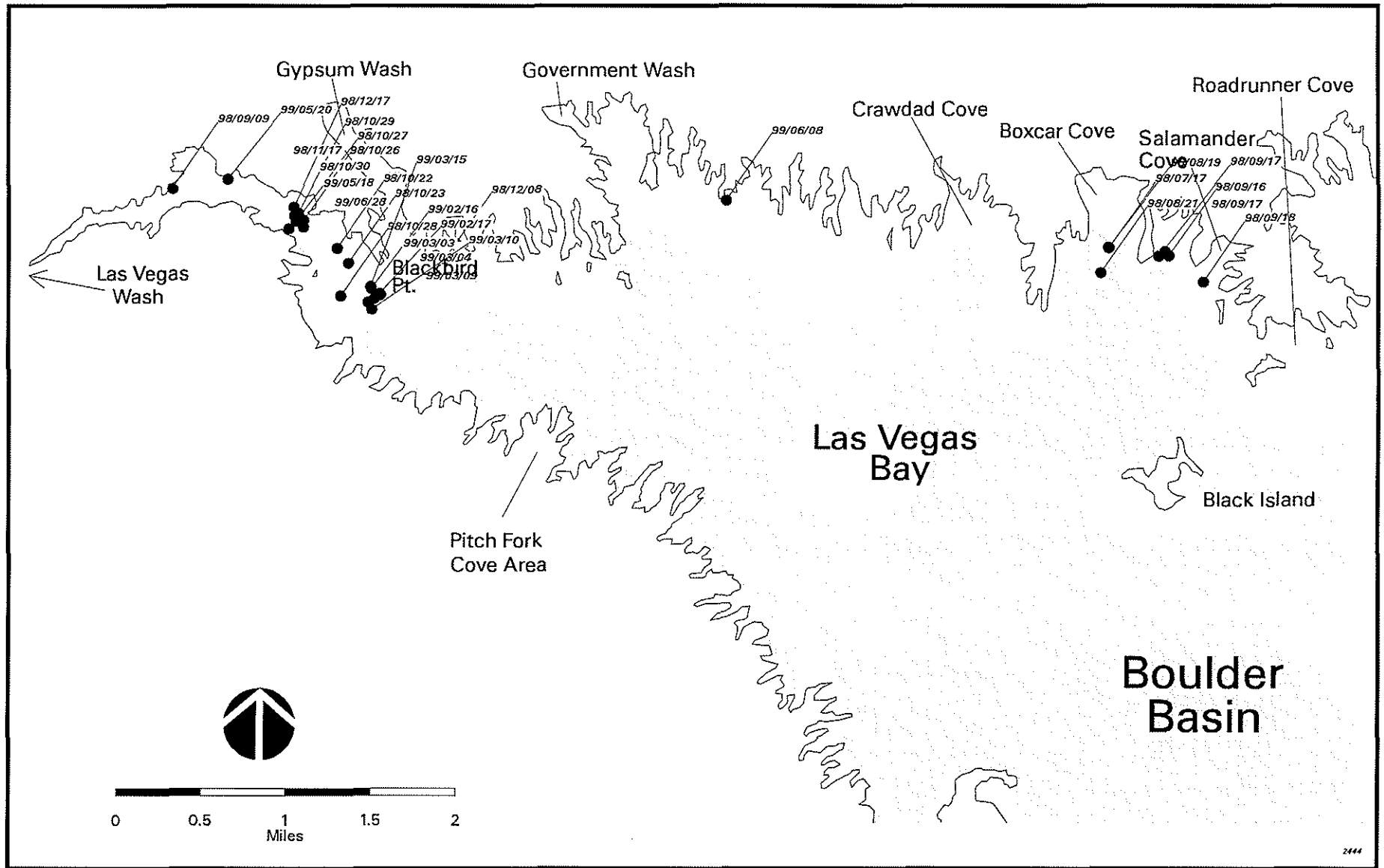


Figure 12. Distribution of fish number: 2444.

Tag 2525

This 662-mm TL male razorback sucker was implanted with tag 2525 (48-month life expectancy) on April 18, 1997, at Blackbird Point. During the first two study years, this fish was located 26 times in areas including: the flowing and non-flowing portions of Las Vegas Bay, Blackbird Point, the Boxcar Cove area, north of Black Island, and Swallow Bay. The last time fish 2525 was located was on March 9, 1998, in the Blackbird Point area. This tag was not relocated until October 26, 1998, when it was stationary in a cove directly south of Blackbird Point. After additional searching on October 29, tag 2525 was recovered in 0.5 m of water in the back of the cove where it had been located earlier (Figure 13). At the time the tag was recovered there was no sign of the implanted razorback sucker.

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 through June 1998. During the third study year, this fish was located 47 times at locations in Echo Bay and Pumphouse Bay (Figure 14).

Tag 357

This 591-mm TL female was captured in Echo Bay and implanted on November 11, 1996. Although this fish was implanted with a 14-month sonic tag, it was still providing locations during July 1998. Subsequently, it has been one of the most active fish of the study, with 62 locations recorded during the first two study years (through June 1998). During this time fish 357 was found almost exclusively in Echo Bay and Pumphouse Bay, with one location recorded in Rogers Bay. During the third study year, this fish was located nine times in, and just outside of, Echo Bay (Figure 15). The last location recorded for fish 357 was on September 14, 1998, in the center of Echo Bay. After this time it was assumed that the 14-month tag had expired, after being in service for approximately 22 months.

Tag 365

This 595-mm TL male razorback sucker was implanted with tag 365 (48-month life expectancy) on December 10, 1997. During the last 6 months of the second study year, this fish was located 33 times, primarily in Echo Bay, and four times in Rogers Bay. During the third study year, this fish was located 11 times in Echo Bay and Pumphouse Bay before being captured in a Echo Bay trammel net on September 14, 1998 (Figure 16). Fish 365 was found in good condition, but it was extremely red because of stress from being in the net. The tagging incision had completely healed and showed no signs of infection, but the tissue that healed the incision was thinner than that of the rest of the fish. The next location recorded for this fish was at the eastern portion of Echo Bay on October 20, 1998. This sonic location was very close to the location where this fish was captured in the trammel net. All subsequent telemetry determined that this tag was stationary at the October 20 location in approximately 75 feet of water. Because this tag was found to be stationary and very close to the location where the fish was netted and released, it is likely that netting stress caused this mortality.

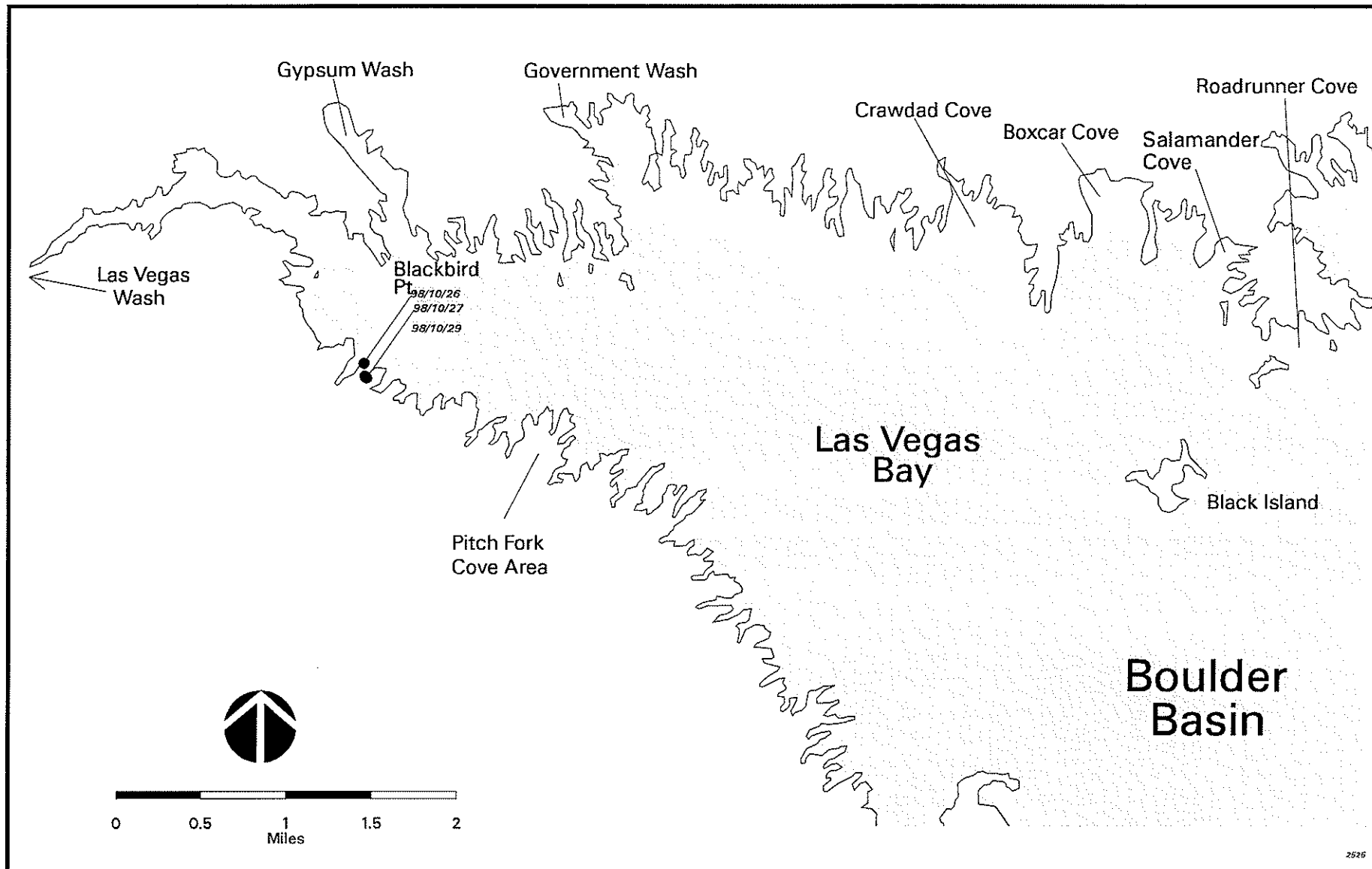


Figure 13. Distribution of fish number: 2525.

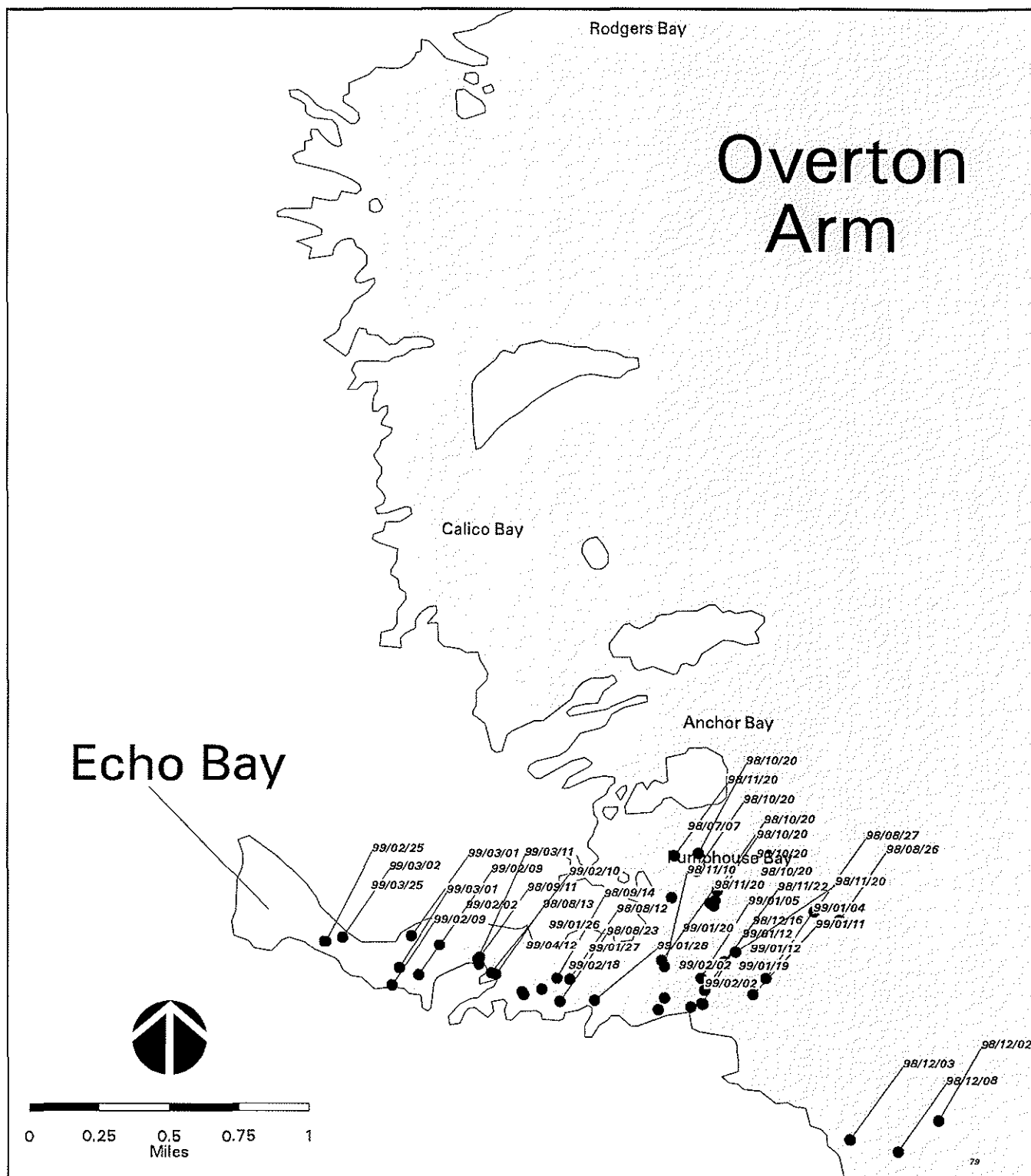


Figure 14. Distribution of fish number: 79.

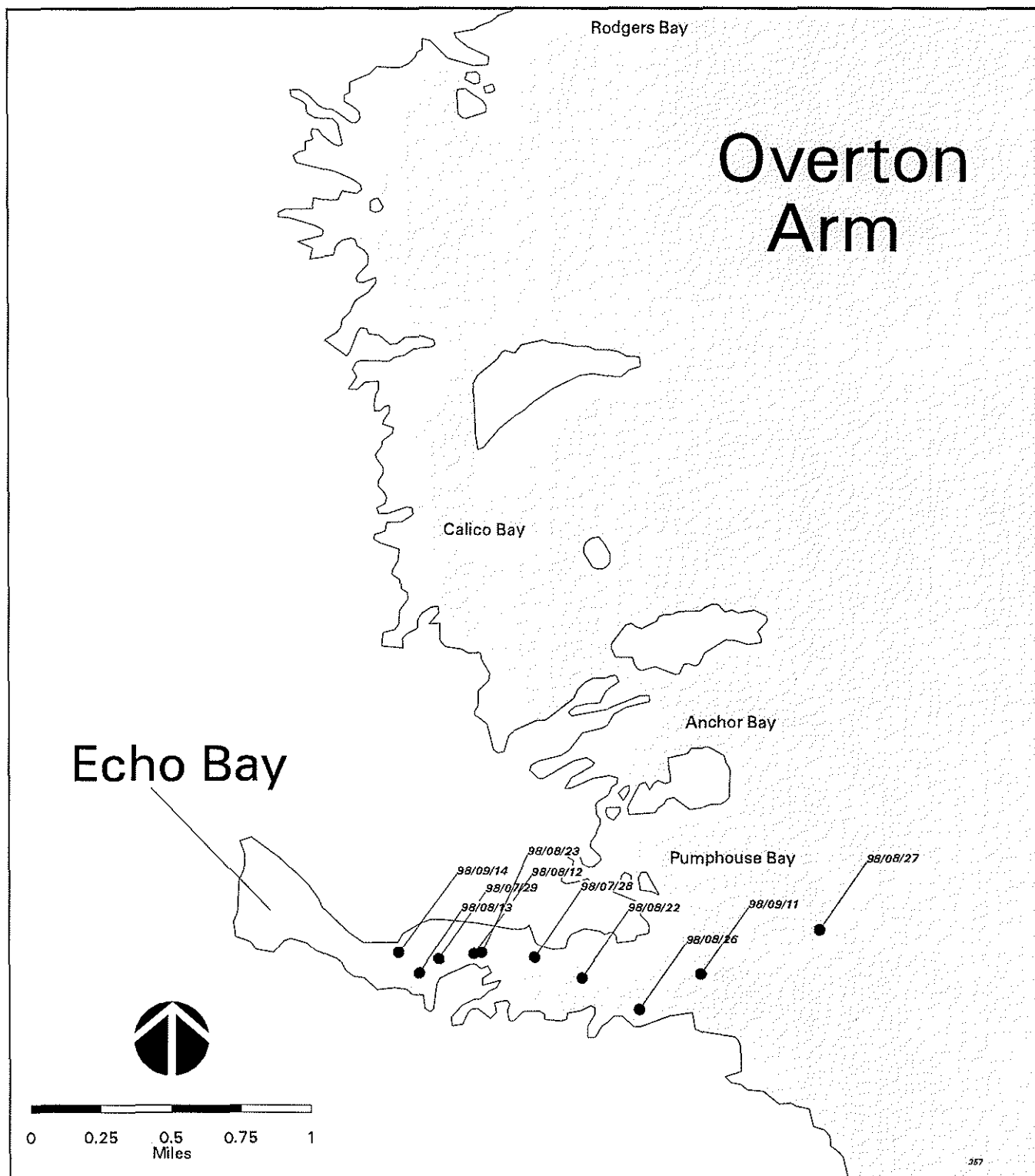


Figure 15. Distribution of fish number: 357.

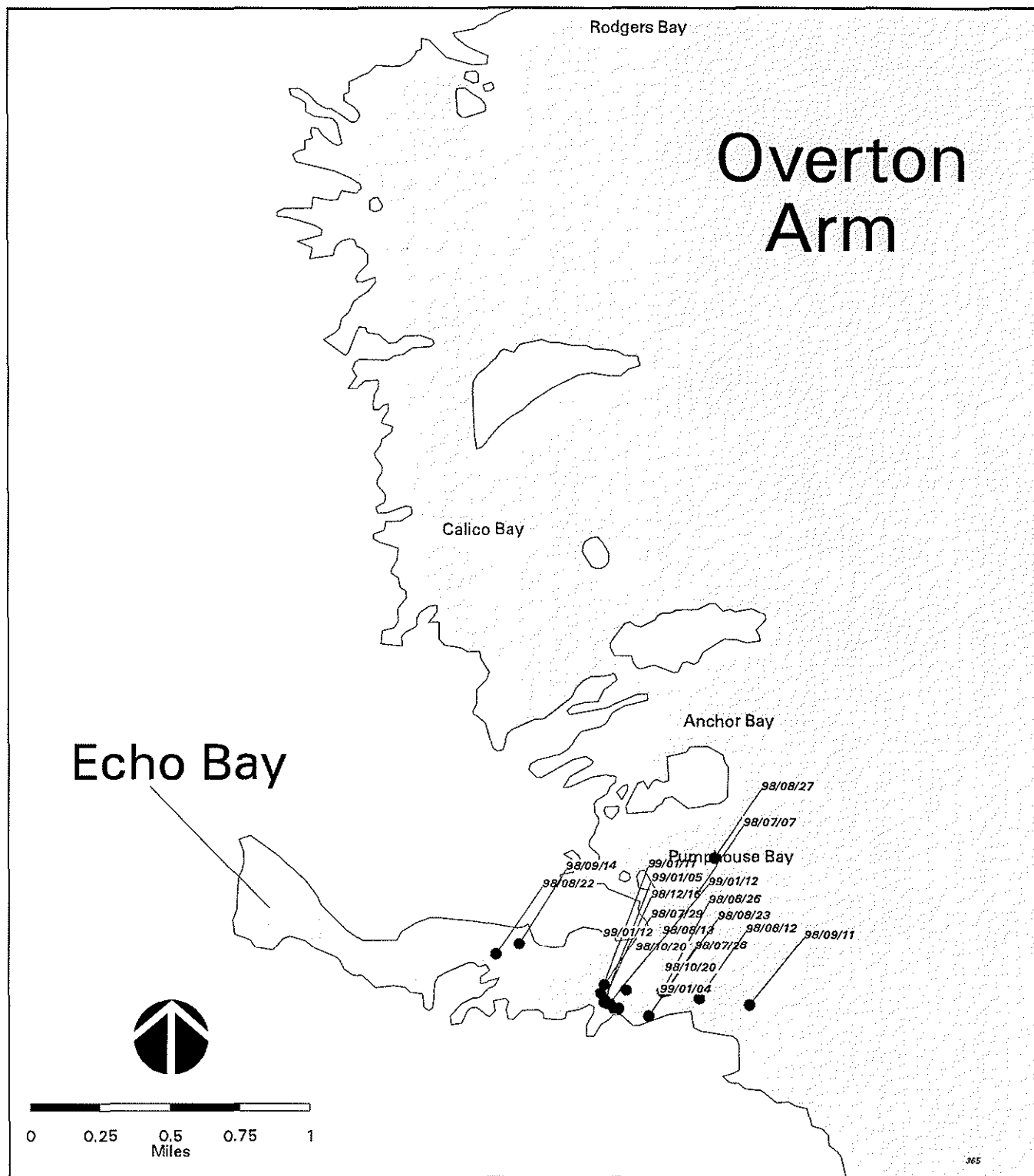


Figure 16. Distribution of fish number: 365.

Tag 455

This 553-mm TL female was implanted with tag 455 (48-month life expectancy) on May 20, 1998, at Echo Bay. Fish 455 was found several times on May 21 at different locations in the back of Echo Bay, and it was then found on June 12, 1998, in the northwest quadrant of Rogers Bay (Figure 17). All subsequent telemetry determined that tag 455 was stationary at this location in approximately 35 feet of water.

Tag 3344

This 573-mm TL male razorback sucker was caught at the Echo Bay spawning site and implanted with tag 3344 (48-month life expectancy) on April 21, 1997. During the first and second study years, this fish was located 55 times in Echo Bay and along the western shore of the Overton Arm. The majority of contacts were made in Echo Bay, and seven locations were recorded from Calico Bay to Stewarts Point. During the third study year, this fish was found in Echo Bay, Pumphouse Bay, Anchor Bay, and Calico Bay (Figure 18). The last contact made with fish 3344 was on January 26, 1999, in Echo Bay. It is not known if the tag became inactive or if something else happened to the fish.

Summary

Sonic telemetry results for the third study year indicate habitat usage by sonic-tagged razorback sucker were similar to results from the previous two study years (Holden et al. 1997, Holden et al. 1999). Sonic-tagged razorback sucker were located relatively close to shore (usually within 200 yards) and in water less than 60 feet deep, similar to the previous two study years. Most fish also were stationary when located, and it was suspected they were on or near the bottom. Video surveillance of the spawning aggregation at Echo Bay confirmed this.

Comparison of the third study year habitat use between the spawning and nonspawning period revealed that different geographical areas of the lake were used at these different times of the year, with some minor overlap. Echo Bay sonic-tagged fish were primarily located close to the spawning area during the November 1998 through April 1999 spawning season (Figure 19). Although no fish were located during May and June 1999, 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).

Las Vegas Bay sonic-tagged razorback sucker exhibited habitat-use patterns similar to those observed in Echo Bay. The fish often were found at Blackbird Point and further back into Las Vegas Bay during the third spawning season, which extended from November 1998 through April 1999 (Figure 20). During the postspawning period for the third study year (May 1999 through October 1999), Blackbird Point fish were located more frequently in the flowing and non-flowing portions of Las Vegas Bay and occasionally along the northern shore of Las Vegas Bay. This pattern is similar to the previous year.

Collectively, the third 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 2 years of the study. These trends include: the fact that sonic-tagged fish from the two study areas did not overlap in distribution during any study year, the 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

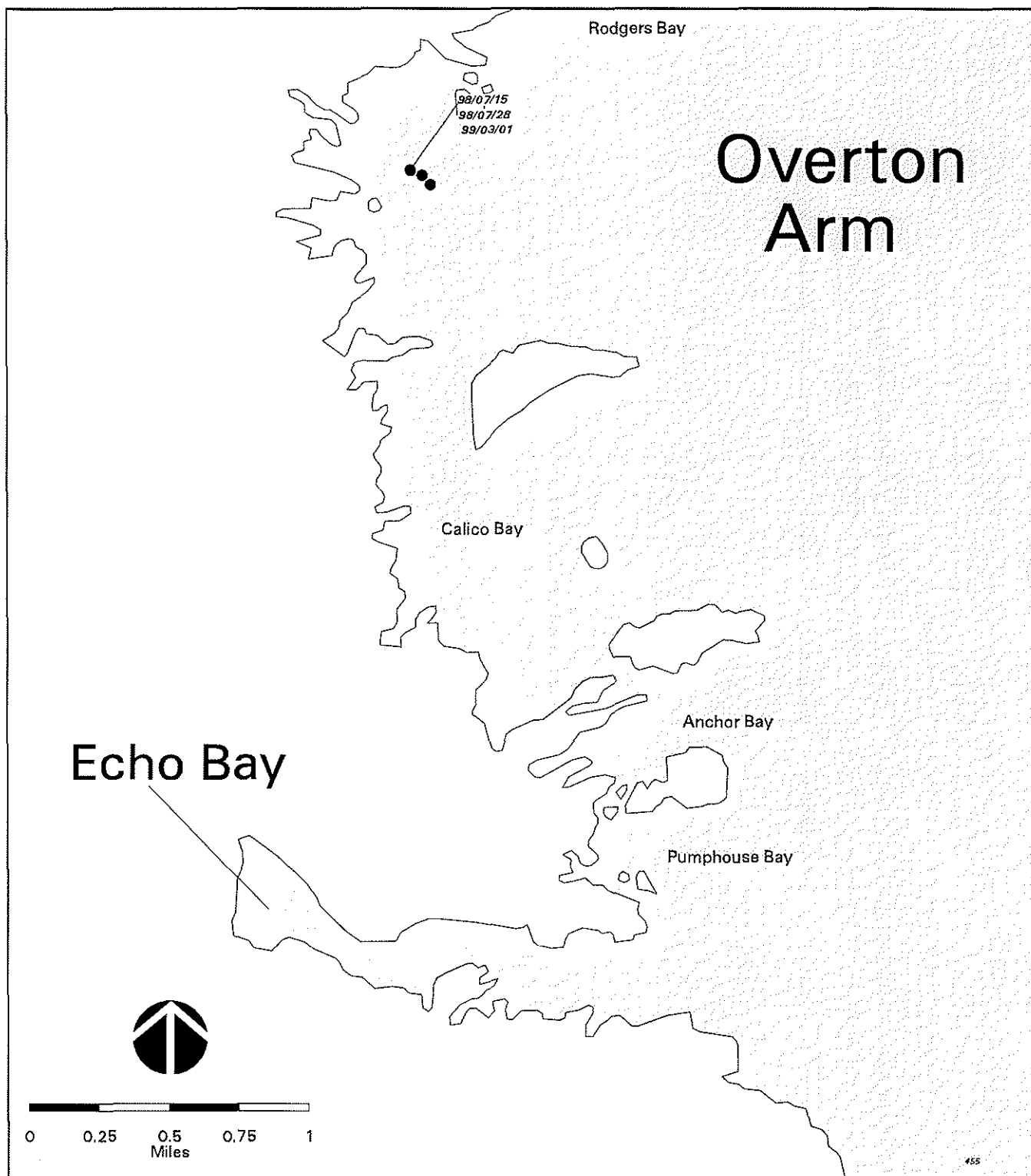


Figure 17. Distribution of fish number: 455.

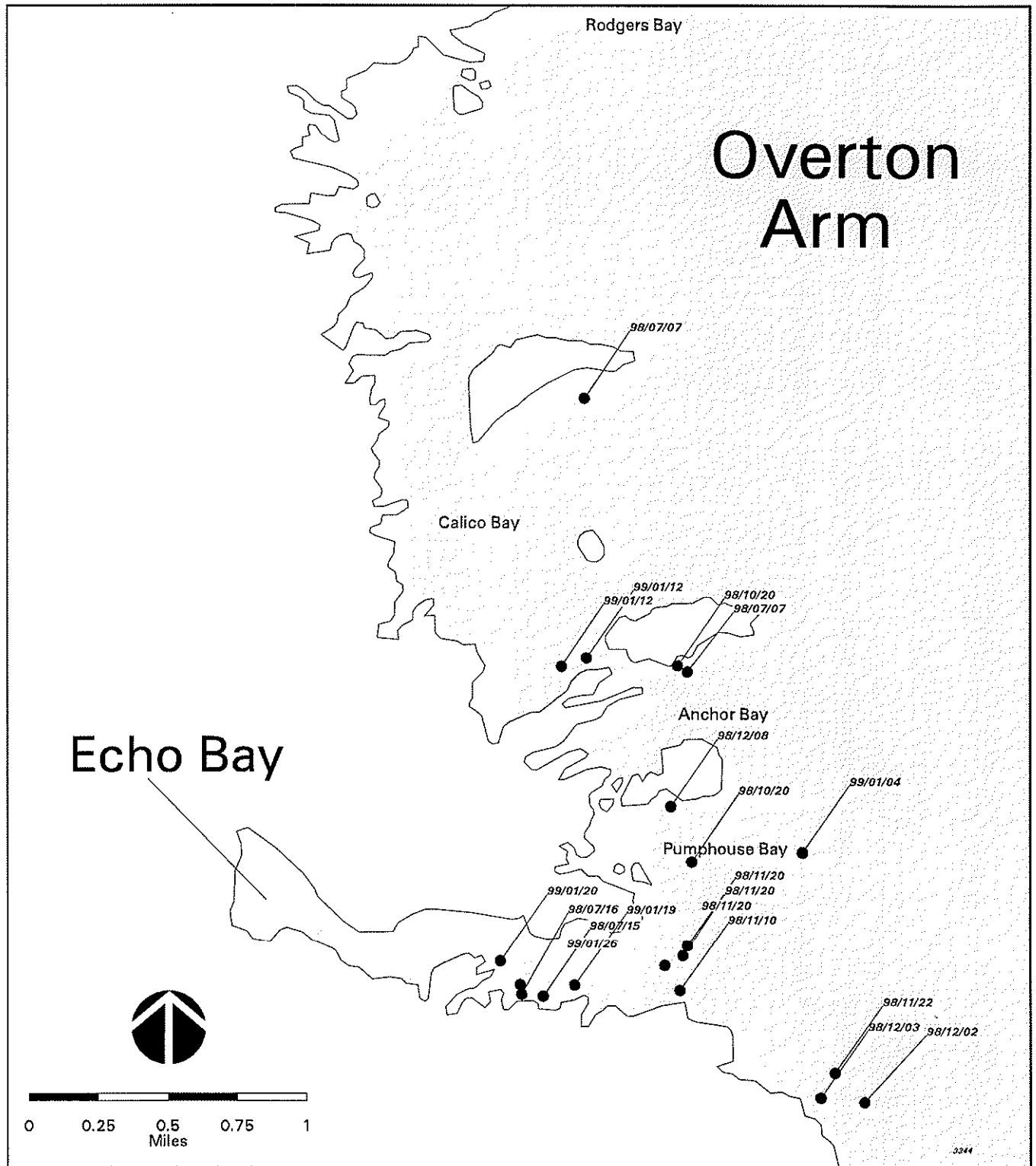


Figure 18. Distribution of fish number: 3344.

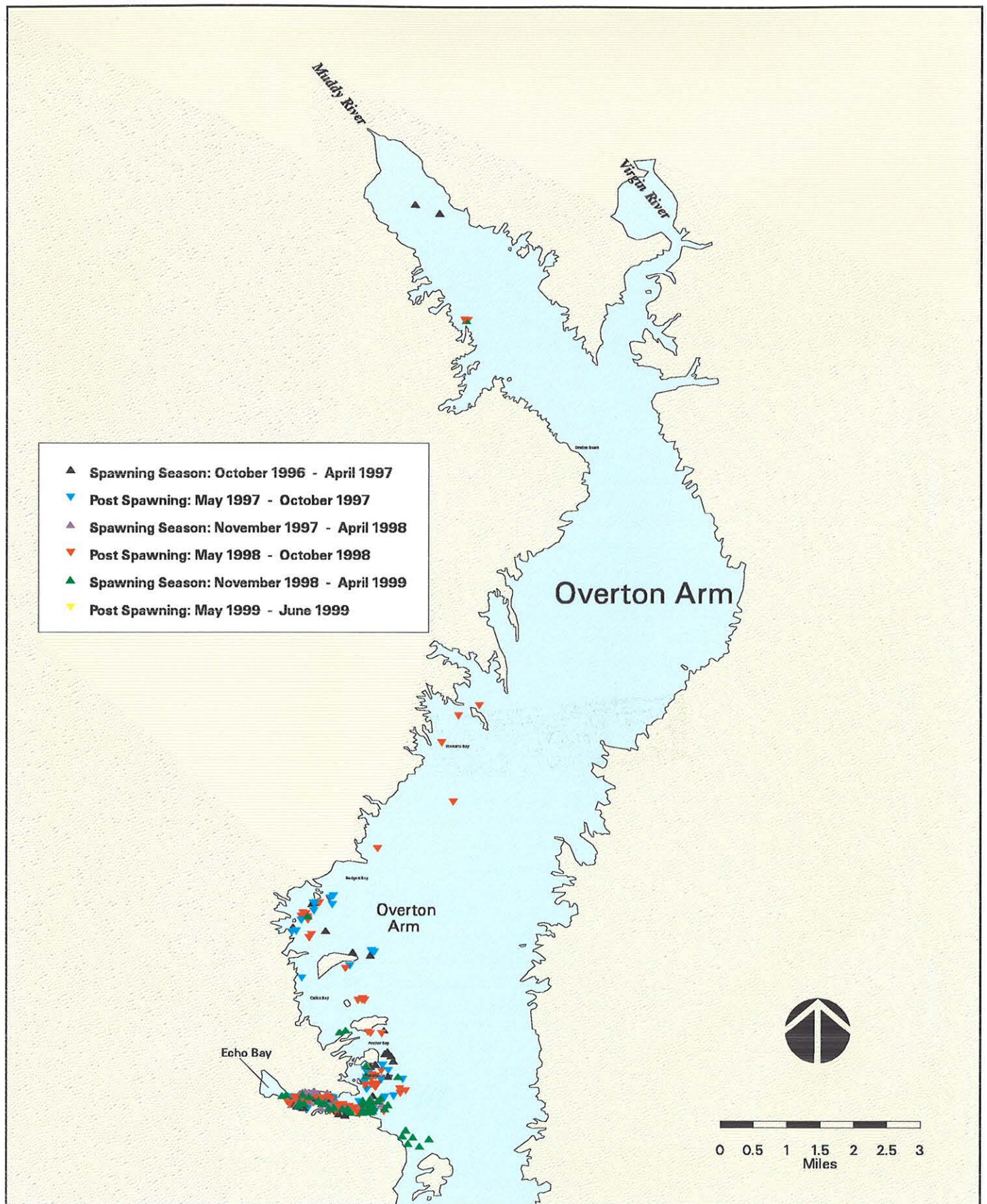


Figure 19. Spawning and postspawning distributions for sonic-tagged fish, Echo Bay/Overton Arm.

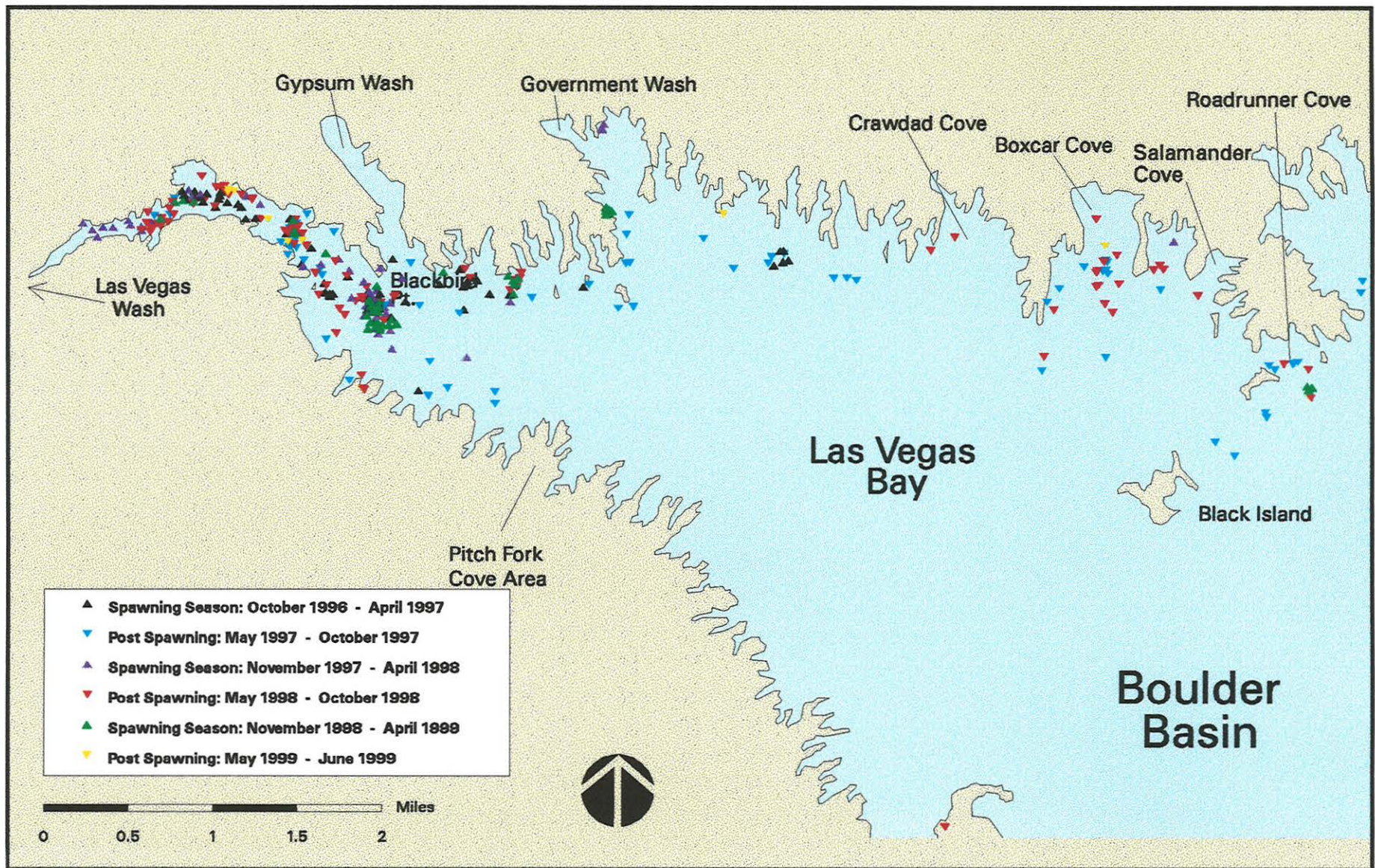


Figure 20. Spawning and postspawning distributions for sonic-tagged fish, Blackbird Point/Las Vegas Bay.

nonspawning season (Holden et al. 1997, Holden et al. 1999). One observation that the third study-year data reveals is that the flowing and non-flowing portions of Las Vegas Bay had high usage by sonic-tagged razorback sucker (Figure 20). Six of the eight sonic-tagged razorback sucker tracked during 1998-1999 were found in the flowing portion of the bay or very close to the end of the flowing portion. Most important is the concentration of usage during the spring spawning season. Spawning season telemetry from each of the three study years shows frequent usage of the area of the bay where the flowing portion terminates. This is the only area in the lake aside from Echo Bay and Blackbird Point where there was a concentration of usage by sonic-tagged razorback sucker during the spawning season.

Larval Sampling

Echo Bay and Las Vegas Bay

Sampling for razorback sucker larvae was initiated in late February 1999, and larvae were first collected on March 4, 1999, around the Blackbird Point area of Las Vegas Bay, and on March 12 at Echo Bay. The last larvae was collected on May 18, 1999, at Echo Bay (Tables 4 and 5). An attempt was made in 1999 to sample six standardized monitoring sites every week at each location, but a combination of weather conditions and personnel availability did not allow that goal to be achieved. High winds and rain made the spring of 1999 a difficult time to sample on Lake Mead. This resulted in only some of the standardized sites being sampled during some weeks. Tables 4 and 5 show the general locations sampled in 1999, as well as the number collected and the catch-per-minute (CPM). The total number of razorback sucker larvae collected within Las Vegas Bay (Table 4) was slightly lower in 1999 than 1998 (145 and 159, respectively), although the CPM was similar (0.10 and 0.09, respectively). Larvae were collected at all three of the general sites set up for standardized sampling (Blackbird Point, east of Gypsum Wash, and Pitch Fork Cove). Collections in the Las Vegas Bay sites appeared to peak around the end of March, but a few larvae were found throughout the sampling period (Table 4).

The number of larvae collected at Echo Bay was reduced considerably from previous years. During 1999, less than half the number of 1998 larvae was collected (95 vs. 197). The CPM of 0.08 at Echo Bay was also lower than in 1998 (CPM of 0.19). This continues a downward trend for razorback sucker larvae collected over the past 3 years in Echo Bay. Larvae in Echo Bay were collected in two different time periods, early March (a few) and mid April. A similar pattern was evident in collections outside the standardized sites (Table 5).

Similar to larval sampling results in previous years, razorback sucker larvae were collected in locations somewhat removed from confirmed or presumptive spawning sites. At Las Vegas Bay, larvae were collected up to 1.5 miles from the presumed spawning site at Blackbird Point. Thirty-five larvae were collected around the Pitch Fork Cove area over five different nights, 21 larvae were collected near the flowing portion of Las Vegas Bay on one night, and 18 larvae were collected just East of Gypsum Wash over the course of the sampling (Figure 21). No larvae were found in any of the other areas sampled, which were coves on the north and south shores of Las Vegas Bay (Table 4).

Table 4. Number of razorback sucker larvae collected at Las Vegas Bay during 1999.

DATE	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM
	Blackbird Point Area			Pitch Fork Cove Area			East of Gypsum Wash			Other		
2/23/99	45	0	0.00	30	0	0.00	15	0	0.00			
3/04/99	45	6	0.13	15	0	0.00	15	1	0.07			
3/08/99	45	1	0.02	15	0	0.00				15 (North shore)	0	0
3/09/99	15	0	0.00	15	0	0.00				15 (Government Wash)	0	0
3/09/99										30 (Saddle Island)	0	0
3/15/99	35	3	0.09				15	1	0.07			
3/16/99	15	6	0.40	15	0	0.00	15	0	0.00			
3/19/99	45	3	0.07									
3/21/99	60	4	0.07	34	0	0.00	15	0	0.00	45 (Wash Inflow)	4	0.09
3/22/99				15	1	0.07				30 (Government Wash)	0	0
3/22/99										45 (Wash Inflow)	1	0.02
3/22/99										15 (Salamander)	0	0
3/22/99										15 (Boxcar)	0	0
3/22/99										45 (Crawdad)	0	0
3/22/99										15 (Saddle Island)	0	0
3/30/99	30	33	1.1							15 (Wash Inflow)	21	1.4
4/07/99	30	7	0.23	30	2	0.07	15	5	0.33			
4/19/99	45	9	0.2	30	12	0.4	15	9	0.6			
4/21/99	45	1	0.02	15	0	0						
4/22/99				60	20	0.33	30	1	0.03			
4/25/99	45	2	0.04				15	1	0.07	15 (Wash inflow)	0	0
4/27/99	40	2	0.05									
5/06/99	45	3	0.07	15	0	0	15	0	0			
5/10/99	45	0	0	15	0	0	15	0	0	15 (South shore of Las Vegas Bay)	0	0
5/17/99	30	0	0	30	0	0				30 (Wash Inflow)	0	0
Totals	660	80	0.12	334	35	0.10	180	18	0.1	345	26	0.08

Table 5. Number of razorback sucker larvae collected at Echo Bay during 1999.

DATE	MINUTES SAMPLED	LARVAE COLLECTED	CPM	MINUTES SAMPLED	LARVAE COLLECTED	CPM
	Echo Bay Standard Sites			Echo Bay Other Sites		
2/25/99	45	0	0.00			
3/01/99	90	0	0.00			
3/10/99	75	0	0.00	15 (South shore)	0	0.00
3/12/99	45	4	0.09	15 (North shore)	1	0.07
3/17/99	45	0	0.00			
3/18/99	45	0	0.00	15 (Southwest corner of bay)	0	0.00
3/23/99	90	0	0.00			
3/25/99	45	0	0.00	15 (West shore of bay)	0	0.00
4/01/99	75	0	0.00			
4/06/99	90	7	0.08			
4/20/99	90	35	0.39			
4/21/99				30 (South shore, East of site 1)	4	0.13
4/21/99				15 (North shore below upper campground)	5	0.33
4/21/99				15 (Southwest end of bay)	20	1.33
4/21/99				15 (North shore West of site 4)	2	0.13
4/21/99				15 (South shore near mouth of bay)	0	0.00
4/28/99	15	0	0.00			
5/18/99	60	1	0.02	15 (North shore West of site 4)	0	0.00
5/18/99				15 (Northwest end of bay)	0	0.00
5/19/99	60	0	0.00	15 (South shore between sites 1 and 2)	0	0.00
5/19/99				15 (West end of bay)	0	0.00
Total	870	47	0.05	210	32	0.15

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.

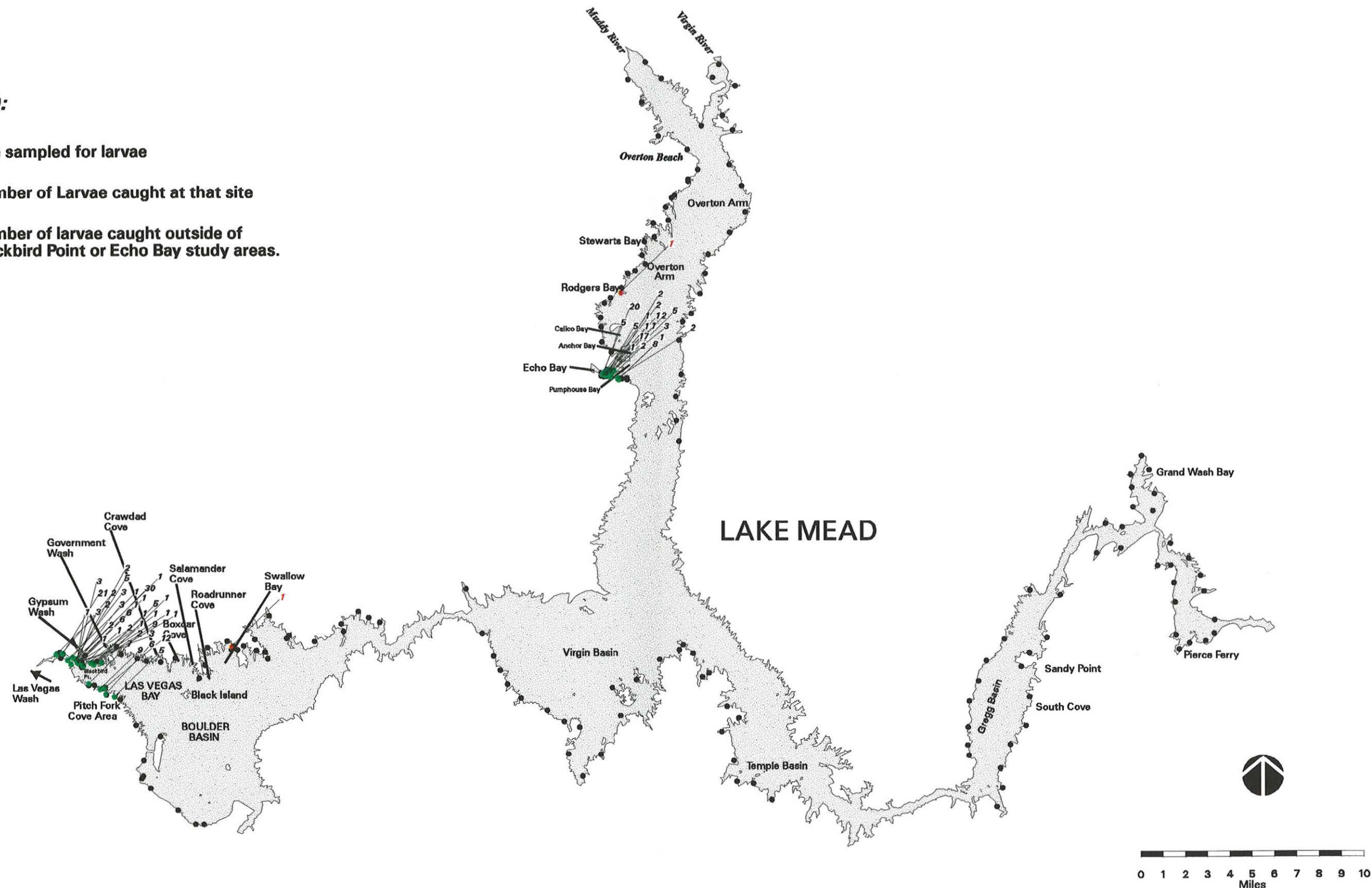


Figure 21. Lake Mead study area showing locations where larval razorback sucker were sampled for and found, spring 1999.

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 (3/21/99 and 3/22/99), 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.

The area near the confluence of Las Vegas Wash was sampled five times from late March to mid-May (Table 4). Larval razorback sucker were collected during three of the five visits, all at the end of March. The collection of 21 larvae in this area on one night (March 30, 1999) had a CPM of 1.4, the highest CPM for any site for the year (Table 4). The next highest CPM was 1.1 at Blackbird Point on the same night. Because of the high number of larvae collected near the Las Vegas Wash inflow, drift net sampling was attempted in the flowing section of the bay on April 26, 1999. The sampling did not produce any larval fish primarily because of deep mud conditions that made placement of a drift net problematic, and large amounts of debris that filled the net.

Lakewide

Lakewide larval sampling was conducted in all major bays and basins of the lake during March, April, and May 1999 (Figure 21). Prior to larval sampling, 220 sample sites were identified on the lake using the 1.0 mile criteria (see the Methods section for more detail). As mentioned above, high winds, rain, and large waves throughout spring 1999 made sampling difficult. Rain tended to obscure surface visibility and large waves created turbidity that made locating subsurface larvae impossible. Despite these conditions, a total of 155 sites were sampled. 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. A single larval razorback sucker was found at two of the 155 sites sampled. One of these sites was located at the northwest portion of Swallow Bay, which is approximately 8 miles east of Blackbird Point. This larval fish was captured on March 13, 1999, at a water temperature of 61 F, in approximately 6 feet of water, during stormy weather conditions and 2- to 3-foot waves. No additional larval razorback sucker were found when sampling was intensified in this area the following night.

The other new site where a larval razorback sucker was located was at the north end of Rogers Bay, which is approximately 5 miles north of Echo Bay along the western shore of Overton Arm. This larval fish was found March 11, 1999 at a water temperature of 59 F, in approximately 3 feet of water, during stormy weather conditions and 2- to 3-foot waves. Sampling during the same evening, in either direction at 0.5 mile increments along the shore, did not result in collection of any additional larval razorback sucker.

Juvenile Sampling

Table 6 shows sampling efforts specifically targeting juvenile razorback sucker. No juvenile razorback sucker were collected during the period covered by this report (July 1998 through June 1999). Gill nets were set in Echo Bay in the area where juveniles were captured by trammel nets during the previous year (Holden et al. 1999). Fyke nets were set in relatively shallow water (up to 4 feet) near shore, usually in association with submerged vegetation.

Table 6. Sampling effort for juvenile razorback sucker in Lake Mead at each site by gear type, July 1998 through June 1999.

Gear type	EFFORT	
	Echo Bay	Las Vegas Bay
Fyke Nets		
3'x4'x15', 3/8" mesh	44 net nights	16 net nights
Gill Net		
100' x 4', experimental mesh ^a	13 net hours	0 net hours

^a mesh size starts at 0.5" and increases to 2.0"

Although no razorback sucker were captured in fyke nets, this gear proved effective at collecting smaller sizes of nonnative fish species. The species composition and abundance of nonnative fish in fyke net samples is relevant in terms of demonstrating the predation pressures facing larval and early juvenile razorback sucker. Table 7 shows the species composition of fyke net samples from Lake Mead. Of the 946 fish captured in fyke nets, all were nonnatives. Young green sunfish (*Lepomis cyanellus*) and largemouth bass (*Micropterus salmoides*), believed to be among the primary predators on young razorback sucker, comprised the overwhelming majority of the samples (67 and 27 percent, respectively).

Table 7. Species composition of fyke net samples from Lake Mead, Nevada.

SPECIES	AGE CLASS	NUMBER	PERCENT OF TOTAL ^a
black crappie	YOY	15	2
bluegill	adult	22	2
	juvenile	4	1 <
common carp	adult	1	1 <
green sunfish	adult	12	1
	juvenile	517	55
	YOY	116	12
gizzard shad	juvenile	5	1 <
	YOY	1	1 <
largemouth bass	adult	3	1 <
	juvenile	225	24
	YOY	25	3

^a n = 946

Aging Razorback Sucker

Age estimation performed during the 1998-1999 sampling period was done on otoliths and fin rays from razorback sucker carcasses recovered from Lake Mead (Holden et al. 1999). No carcasses were recovered from the lake during the period covered by this report. However, non-lethal aging techniques continued to be refined with the goal of attempting to age more of the razorback sucker population in Lake Mead. Based on the 1997-1998 aging effort (Holden et al. 1999), fin rays appeared to show accurate ages, and had the potential to be a relatively easy method for aging that would not harm the fish. In order to evaluate possible harmful effects, portions of fin rays and entire fin rays were surgically removed from eight anesthetized age-2 razorback sucker that were being reared by NDOW in Boulder City, Nevada. These were fish that had been collected from Echo Bay in 1997 as larvae (Holden et al. 1997). Four fish were allowed to recover in fresh water and then returned to rearing tanks for monitoring, while the other four were sacrificed for aging using otoliths and fin rays. There was little to no bleeding from clipped fins, and no mortalities. The loss of fin rays had no apparent impact on the ability of fish to maintain position in the water or on swimming ability immediately after surgery. Since damaged (clipped or removed) fin rays will regenerate over time, removing fin rays from live razorback sucker should have no long-term negative impacts to the fish. Aging of the pectoral fin rays from the razorback sucker described above demonstrated that the first 3 to 4 rays provided readable annuli and were consistent with the known age of these fish. (Note: observations of the fish in September 1999 indicated fin rays were regenerating and some were fully regenerated.)

DISCUSSION

Data collected during the third year of the Lake Mead razorback sucker study have expanded on, and continued to confirm, many of the observations made during the first 2 years of the study. Sonic telemetry, trammel netting, and video surveillance continue 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 around these areas during the spawning season. In addition to these areas, sonic-tagged razorback sucker were also concentrated at the inflow area of Las Vegas Wash during the 1997, 1998, and 1999 spawning seasons.

Sonic-telemetry results determined that areas adjacent to Echo Bay and Blackbird Point continue to provide important habitat both during the spawning and, more importantly, post spawning seasons. However, the minimal number of postspawning contacts made it difficult to discern the prominent patterns that were evident with past years' data. The shortage of postspawning contacts made at Echo Bay and Las Vegas Bay during 1999 was probably more a function of low numbers of implanted razorback sucker than lack of tag activity (Figure 19, Figure 20). Because of the expiration and stationary status of implanted sonic tags, there were three active fish at Las Vegas Bay and two active fish at Echo Bay at the end of the third study year.

Trammel netting catch-per-effort (CPE) of razorback sucker increased at Echo Bay and decreased at Las Vegas Bay for the third study year. At Echo Bay/Overton Arm, CPE for the first, second, and third study years was 0.85, 0.32, and 0.48, respectively. At Las Vegas Bay, CPE for the first, second, and third study years were 0.29, 0.34, and 0.10, respectively. The primary reasons for the decline in catch observed at Las Vegas Bay were the timing and location at which some of the sampling

occurred. Sampling did not occur at Echo Bay or Las Vegas Bay during the months when trammel netting was most successful (March, April, May) during prior years. This was done in order to reduce interference with spawning activities. Also, about one third of the nets set at the Las Vegas Bay study site were set in areas where no razorback sucker has been previously collected, such as in Swallow Bay. Typically, sampling in new areas has resulted in a low or zero catch of razorback sucker.

The loss of sonic-tagged fish 365 suggested that trammel netting can stress razorback sucker and cause mortality. This fish was tagged on December 10, 1997, in Echo Bay and appeared to exhibit normal behavior, moving between Echo Bay and Pumphouse Cove for nearly a year before being recaptured by trammel net. It subsequently stopped moving less than a month later, and likely died soon after being recaptured. The history of this fish suggests that it survived sonic tagging well, and either died or shed its tag after being stressed in trammel nets. This is one of the reasons that trammel netting and sonic telemetry has been de-emphasized in the study.

Several sonic tags became stationary during the third year. Tag 238, which had been missing since implanted in a fish in December 1997, was found stationary in the back of Government Bay in December 1998. It is likely this tag was shed, or the fish died and the tag came out, soon after tagging. Tags 283, 2264, 2525, and 365 moved around for over a year before becoming stationary. In the past, tags have typically been found to be stationary within a month or two following surgery (Holden et al.1999). To have fish remain healthy for so long and then have the tag become stationary, was unusual. Tag 3344 also moved around for over a year before it disappeared, but this was likely due to tag failure.

Video surveillance at Echo Bay was extremely successful in documenting the location and usage of and spawning activity at this site. This method provided an efficient way to observe spawning razorback sucker at close range, without interfering with the spawning process. Although turbidity was too high at Las Vegas Bay for this method to be effective, lower fall, winter, and early spring turbidities may allow for more-effective use in the coming year.

Larval sampling in 1999 was hampered by poor weather. High winds and storms seemed to coincide with most of the sampling efforts and may have contributed to lower catch rates. But, numbers of larvae at Echo Bay appear to be definitely lower than those seen in 1997. Although one spawning aggregation of adults was caught on video in March 1999, no other spawning sites could be located at that time. The capture of larvae in Echo Bay (Table 5) suggests that spawning occurred there in March, and then a larger amount of spawning occurred again later in April when the underwater video was not used. It is not known if lower numbers of captured larvae reflect lower numbers of spawners, lower survival of eggs and larvae, or more-dispersed larvae because of wind and other weather conditions.

The sonic tracking information from 1998 and 1999 suggests that the flowing portion of Las Vegas Bay, and even Las Vegas Wash, was used by razorback sucker, especially during the spawning period. Six of the eight sonic- tracked adults used this area in 1998-1999, and many others used it in earlier study years. The collection of relatively large numbers of larvae on one night, at the bottom edge of the flowing portion, suggests that spawning could have occurred in that section of the bay or even up in the wash. The one attempt at larval drift netting was unsuccessful because of

mud and debris in the wash. Conditions at the confluence of the wash changed dramatically after mid-1998, before which it was possible to access the wash and motor upstream nearly a quarter mile. Large flows in the wash and resultant erosion, as well as changes in lake level, caused a large mud flat to develop at the lake interface and thereby blocked access by boat. Hence, sampling was not conducted during the past year in portions of the wash that at one time were accessible. When the wash was accessible, several adult sonic-tagged razorback sucker were found using it. Since the wash became inaccessible, it was not possible to determine how far up the wash the razorback sucker were moving. Because of uncertainties about razorback sucker use of the wash, it is proposed that the wash be more-intensively studied in 2000 to ascertain usage by adults and whether larvae are drifting down the wash or are moving up the non-flowing portion of the bay from Blackbird Point by wind action.

The third year of the Lake Mead razorback sucker study included expanded efforts in sampling for juvenile fish and searching for populations other than those identified at Echo Bay and Las Vegas Bay. New fyke nets were used to sample areas of submerged vegetation in and around known spawning areas at Blackbird Point and Echo Bay. As with previous years' juvenile sampling, no razorback sucker juveniles were caught in fyke nets. Unlike the 1997-1998 sampling period when four juvenile razorback sucker were caught in trammel nets, no juveniles were collected using that gear type either.

The search for new populations of razorback sucker in Lake Mead has produced some encouraging results but has yet to definitively locate a new concentration of razorback sucker. With the lake-wide larval razorback sucker sampling effort that was started during the third study year, about 75 percent of the preselected sampling sites, or 75 percent of the lake, was sampled. At two of these sites (Rogers Bay and Swallow Bay) one larval razorback sucker was collected. However, no other larval razorback sucker were collected anywhere near these sites. It is interesting to note that both of these larval razorback sucker were captured during stormy weather conditions with high winds and waves. It is possible that these conditions helped to concentrate larvae against the shore where they were caught and may also have contributed to long distance movements from the known spawning areas.

The Rogers Bay site had adult razorback sucker activity in the past. July 1997 trammel netting in this area collected four razorback sucker in one net (Holden et al. 1999). Several sonic-tagged razorback sucker have been located in the area also. If spawning were occurring in the Rogers Bay area, larger concentrations of larvae would have been expected to be captured. Likewise, if the larval razorback sucker that was found in Rogers Bay drifted into this area from Echo Bay, it is not clear why razorback sucker were not found in areas between these two locations.

The other new larval razorback sucker site—Swallow Bay in Boulder Basin—did not have other larval razorback sucker captured nearby either. Pitch Fork Cove, the location closest to Swallow Bay where larval razorback sucker were captured, is approximately 6 to 7 miles to the west. Similar to the situation at Rogers Bay, no larval razorback sucker were captured in between the sites at Swallow Bay and Pitch Fork Cove.

The aerial survey conducted in March 1999 had good sampling conditions but did not locate any new concentrations of razorback sucker. This is the same result as was found with the aerial survey conducted during March 1998. Thus far, this method has not been useful for locating new concentrations of razorback sucker in Lake Mead.

Growth of recaptured razorback sucker was lower than in previous years; however, it still was far higher than growth recorded for other wild razorback sucker populations. Mean annual growth for recaptured fish at Echo Bay was 7.0 mm, compared with 10.73 mm the previous sampling year, and compared with about 2 mm per year for Lake Mohave (Pacey and Marsh 1998) and the Green River (McAda and Wydoski 1980, Tyus 1987). Lower numbers of fish recaptured because of less trammel netting, and capture of older, slower-growing individuals, likely contributed to different growth numbers in 1998-1999. Only two fish were recaptured from Las Vegas Bay, and they had such a wide variance in growth (161.6 versus 16.8 mm), that a mean was not calculated. The high growth rate came from a fish stocked in 1996 and was an average of two year's growth. Las Vegas Bay fish continue to show greater growth rates than Echo Bay fish, likely because of higher food production in Las Vegas Bay.

Although no dead razorback sucker were recovered from Lake Mead during this year's sampling, aging efforts continued. Captive-reared razorback sucker held by the NDOW have been used to compare ages read from otoliths and fin ray segments in order to validate pectoral fin ray sections as a method of accurately aging fish collected from Lake Mead. Data are preliminary at this point; however, in samples examined to date, ages from otoliths agree with ages read from pectoral fin ray sections. Live fish that had fin rays clipped at the base while anesthetized showed no excessive bleeding or apparent adverse effects. This methodology has been summarized into a sampling plan that will be used to determine age of razorback sucker captured from Echo Bay and Blackbird Point. This methodology must first be approved by the USFWS and is currently under review.

RECOMMENDATIONS FOR THE FOURTH YEAR OF STUDY

The same general research objectives pursued during the first 3 years of the study will be continued for the fourth year of the study, with the addition of increased emphasis on aging the razorback sucker population, studying Las Vegas Wash and adjacent portions of the bay, and incorporating more video surveillance. Objectives include:

1. Continuation of focused trammel netting 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 new razorback sucker population concentrations in new portions of the lake 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. This will involve removing a small section of the second and third rays near the base, putting a small rectangular hole in the fin that will heal up in a relatively short time. The fin ray sections will be dried and then sectioned, mounted, and sanded so they can be read with a phase-contrast microscope;
6. Sample for adults and larvae in the flowing portion of Las Vegas Bay and in Las Vegas Wash. This will involve adding a boat to the project that can access the wash. Trammel netting and perhaps electrofishing will be conducted monthly in Las Vegas Wash, starting in December 1999. Light trapping and drift netting will be accomplished weekly from February 15 to May 15, 2000. Sonic tagging and tracking of adults collected in Las Vegas Wash may also be included in the study if permission from the USFWS is obtained for use of external tagging techniques; and
7. Use of video surveillance to monitor spawning activities at Echo Bay and Las Vegas Bay on a weekly basis and also to attempt to locate new concentrations of razorback sucker.

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