

Razorback Sucker Studies on Lake Mead, Nevada

1997-1998 ANNUAL REPORT

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EXECUTIVE SUMMARY

During the second year (July 1997-June 1998) of the Lake Mead razorback sucker study, trammel nets remained the primary sampling gear for adult razorback sucker. Larvae were sampled using 12-volt crappie lights and dip nets; hoop and fyke nets and seining continued as juvenile sampling methods. Sonic tagging and telemetry continued to be used to follow adult fish. Most field efforts were again conducted in the Las Vegas Bay and Echo Bay areas, although trammel netting, larval sampling, and telemetry were extended beyond these areas. The Bureau of Reclamation contributed additional financial support to the study, and an objective of looking throughout the lake for other populations was added to the project. Larval sampling was extended into the Gregg Basin in 1998 to help meet this objective.

A total of 137 trammel net nights occurred during the second year of the study, and 45 razorback sucker were collected: 19 in Blackbird Point, 2 in Las Vegas Wash, 20 in Echo Bay and 4 in Rogers Bay. The captures in Las Vegas Wash and Rogers Bay were the result of netting in areas where sonic-tagged adults were found. Perhaps the most important captures during the second study year were four juvenile razorback sucker in Echo Bay. Ranging in size from 318 to 384 millimeters (mm) total length (TL), one fish was caught each month in November, December, January, and February.

The presence of ripe fish, the concentration of fish seen during sonic telemetry, and the numbers collected with trammel netting all confirmed that spawning was most likely taking place at Blackbird Point and the back end of Echo Bay, the same locations noted in the first study year. The spawning period appeared to occur from late February to early May.

Twenty of the 45 razorback sucker collected during the second study year were recaptures. These fish provided additional growth information, which averaged about 22 mm annually at Las Vegas Bay and 11 mm annually at Echo Bay, similar to results from the first study year.

Sonic telemetry showed a seasonal pattern in use of the lake. At Las Vegas Bay, the fish concentrated in the Blackbird Point area during the spawning period, but they moved further out into the bay during the nonspawning period (June-November). At Echo Bay a similar pattern was seen; fish left the Echo Bay spawning area and used Rogers Bay and other points north of Echo Bay in the Overton Arm more regularly.

Larval sampling during spring 1998 resulted in much smaller numbers of larvae at Echo Bay, but more at Las Vegas Bay, than during 1997. These differences were likely due to increased lake depth at Echo Bay that may have spread the larvae more in 1998 and increased effort in Las Vegas Bay. Larvae were also found in several coves some distance from Blackbird Point in 1998 and in the other coves north of Echo Bay. Trammel netting in these areas did not locate adult fish, and it was concluded that these few larvae had originated at either Blackbird Point or Echo Bay. Larval sampling in the Gregg Basin did not find any young razorback sucker.

Two fish were found dead from handling and sonic-tagging stress, and otoliths and fin rays from both were used for aging. A 381-mm TL juvenile was aged at 4 or 5 years, and a 588-mm TL razorback sucker was aged at 7 to 10 years. These aging results, in conjunction with the growth

information and the capture of four juveniles, confirm that recruitment is occurring in the Lake Mead razorback sucker population, and that the population overall appears to be relatively young.

New population estimates using the program CAPTURE indicated that the Echo Bay population is less than 100 fish, and the Las Vegas Bay population is made up of only 170 to 200 fish. These estimates are larger for the Echo Bay area, and lower for the Las Vegas Bay area, than the estimates made in 1997. The reasons for the changes are related to the number of marked versus unmarked fish found at both areas. More unmarked fish were found at Echo Bay in the second year, and more marked fish were found at Las Vegas Bay.

During the July 1998 to June 1999 period, the emphasis will move from the adult fish to younger fish. Emphasis will continue on larval fish, but the effort will be expanded to the entire lake. Emphasis will also be placed on locating juvenile razorback sucker in the Las Vegas Bay and Echo Bay areas. Aging will be conducted on any fish found dead and on any Lake Mead razorback suckers that have recently been collected. A method of using fin rays for aging that will not harm live fish will be investigated.

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INTRODUCTION

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. (BIO/WEST), under contract with the SNWA, developed the study design in conjunction with the NDOW and the SNWA, 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).

An annual report (Holden et al. 1997) summarized the methods and results of the first year of the study (October 1996 to July 1997). Trammel netting was the primary gear used to collect adult razorback suckers, and 21 were surgically implanted with sonic transmitters. Relatively small razorback sucker populations totaling a few hundred fish were identified at Las Vegas Bay and Echo Bay. The fish used the Las Vegas Bay and Echo Bay areas during winter and spring for spawning, but they also moved into other adjacent parts of the lake. The two populations did not intermix. Larval razorback suckers were found at both sites, but they were found in much greater abundance at Echo Bay. Growth rates of recaptured fish indicated that growth of razorback sucker in Lake Mead was considerably higher than in any other known location. This suggested that recruitment may be occurring in Lake Mead.

This report presents findings from the second year of the razorback sucker study conducted on Lake Mead. Information contained in this report was collected from July 1997 through June 1998, although information from the previous year of research (October 1996 through June 1997) has been included where appropriate.

The study was initiated to investigate the population size, habitat use, and life history of razorback sucker in Lake Mead. The primary objectives of the first year of the study were to:

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

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. Due to the timing of the final agreement, larval sampling activities were increased in spring 1998 but not to the level anticipated in future years of the study.

STUDY AREAS

During 1997 to 1998, the majority of study activities occurred in the same locations used in the 1996 to 1997 portion of the study (Holden et al. 1997). Figure 1 shows the general location of the Las Vegas Bay and Echo Bay study sites. New study areas were added for larval sampling, and all large bays in the lake were included in an aerial search for spawning aggregations.

The new study areas sampled for larval razorback sucker were located in Gregg Basin. This basin is located about 3 miles west of Pearce Ferry and was suspected of having a spawning population of razorback sucker as indicated by historic sampling records. The basin is about 4-miles long and 1-mile wide, with the most suitable spawning habitat located along the eastern shore (Figure 1).

Aerial searches for spawning razorback sucker aggregations occurred in all major basins of the lake. These areas included the northwestern shore of Boulder Basin, the southern shores of Virgin Basin and Temple Basin, the east and west shores of Gregg Basin, the northwest shore of Iceberg Canyon, the north shore of Grand Wash Bay, the east and west shores of Overton Arm, and all of the Muddy and Virgin Arms (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 sea level (Figure 2). At the end of the first year of the study the level had risen to 1,200 feet. During the second year of the study, the lake water elevation had risen to 1,211 feet by June 1998. 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. All study activities occurred within the full pool elevation of Lake Mead, which is 1229 feet mean sea level (msl), including those activities noted in this report within the flowing portion of Las Vegas Wash.

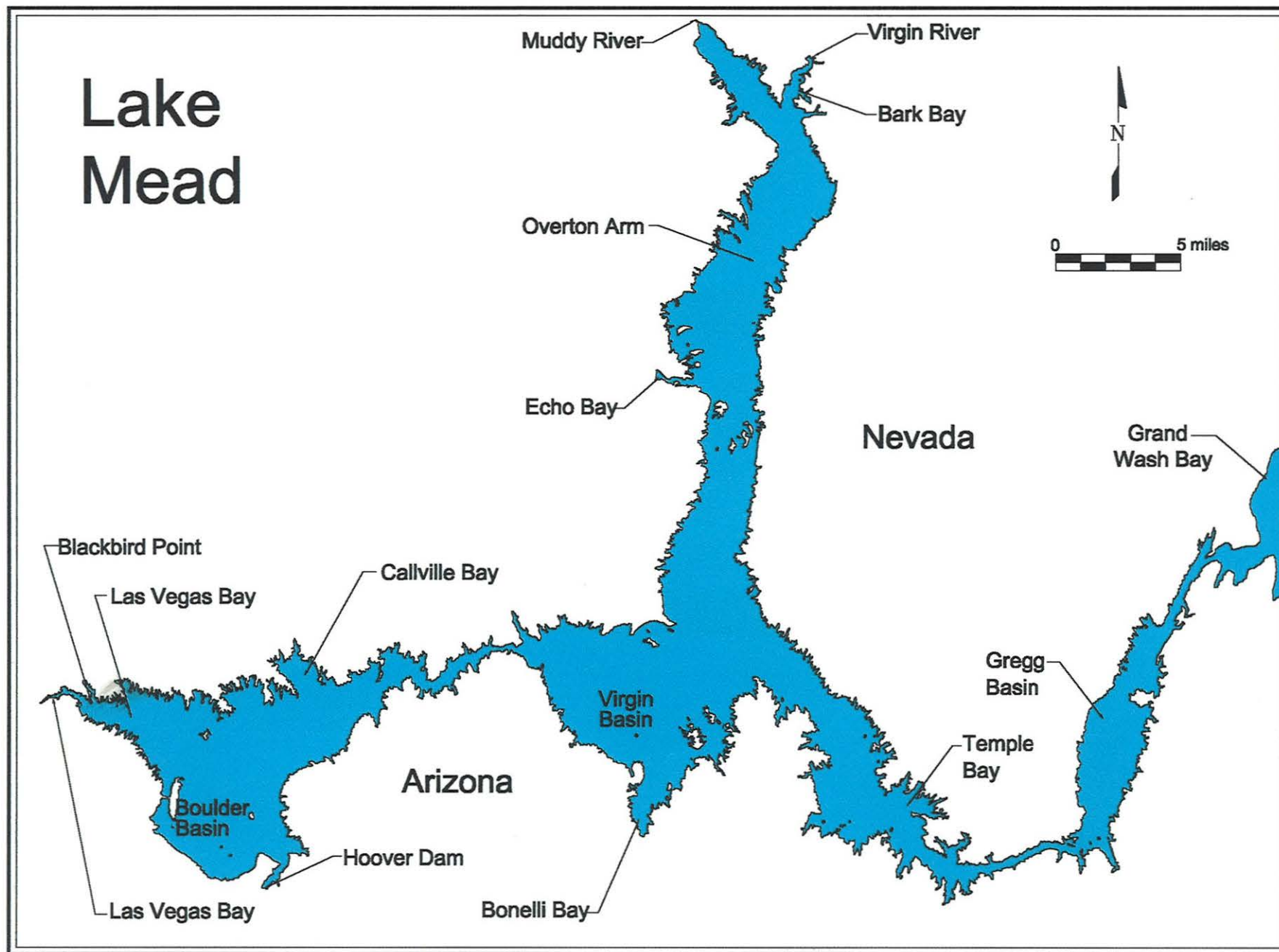


Figure 1. Map of Lake Mead showing general locations of study areas.

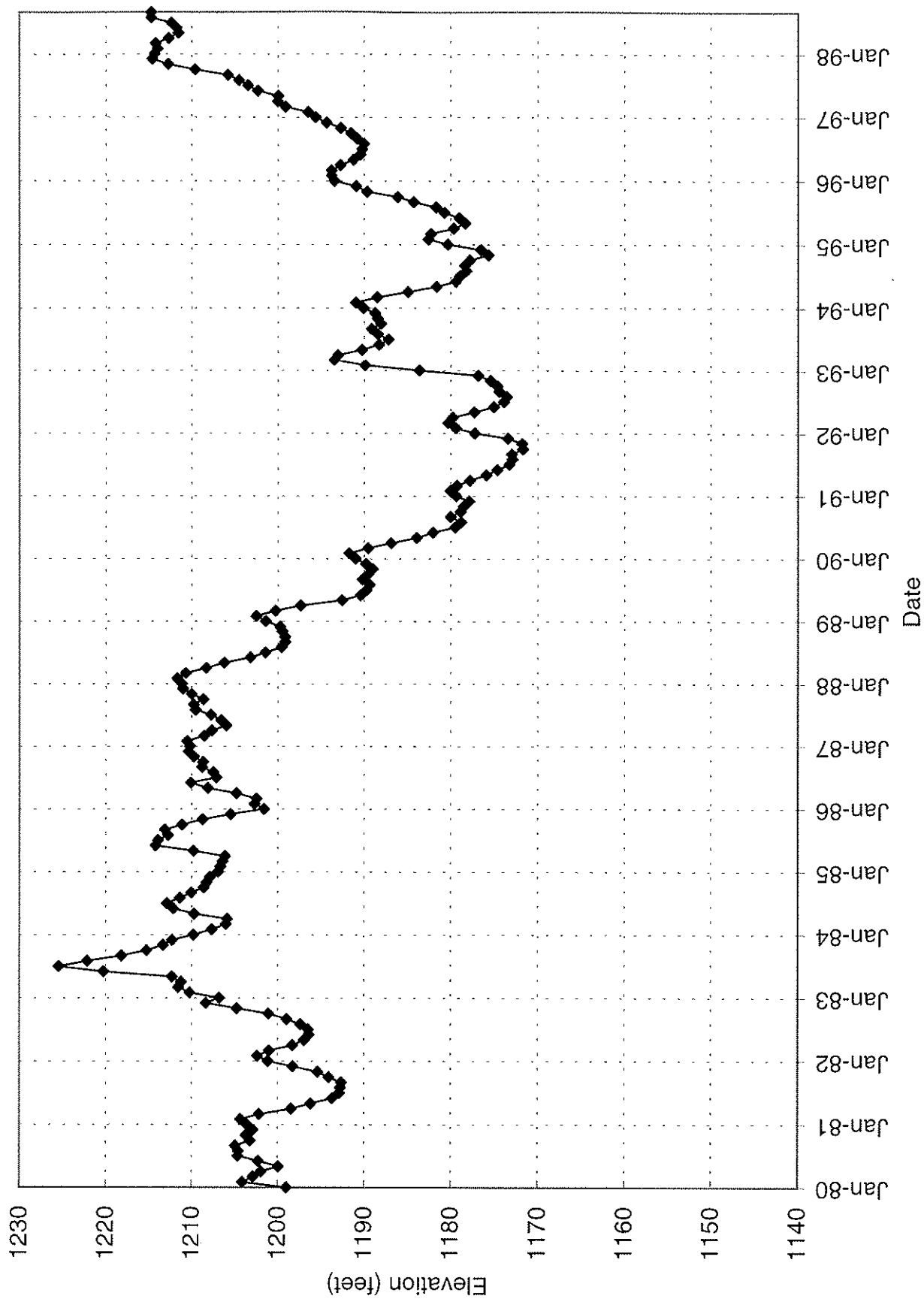


Figure 2. Lake Mead month-end elevations, 1980 to 1998.

METHODS

The same general study techniques were used for the second year of research as were used for the first year (Holden et al. 1997). Trammel nets were the primary technique for collecting adults, and sonic tagging and telemetry was continued as the method to determine habitat use and movement of adults. A Sonotronics Model CT-82-1 (60-day) sonic tag with an air weight of 4 grams (g) (2.6 g water weight) that measured 28-millimeters (mm) long and 8-mm in diameter was used, in addition to the longer-lived and larger tags used in the first year. Larvae were sampled with dip nets and 12-volt crappie lights. Juvenile sampling techniques continued to include the use of minnow traps, seines, and hoop and fyke nets. Limited electrofishing was conducted using a NDOW electrofishing boat equipped with a Coeffelt VVP-15 control unit with 12 inch (in) spherical electrodes. Population estimates continued to be produced using the software program CAPTURE, along with the Schnabel estimator. Locations and timing of sampling continued to vary while searching for the most efficient and effective means of capturing and following razorback sucker in Lake Mead. General methodologies for the continued techniques can be found in Holden et al. (1997).

A new technique used in the second year of the study involved methods to determine the age of fish that had been found dead or were accidentally killed during the course of the study. Structures used to estimate age included otoliths, opercular bones, pectoral fin rays, and scales. Pectoral fin rays were sectioned, sanded, and examined under phase-contrast light microscopy similar to methods used by McCarthy and Minckley (1987). Opercular bones were cleaned of soft tissue and viewed with a dissecting light microscope. Otoliths were sectioned by sanding and polishing, and then viewed under phase-contrast light microscopes. Scales between the dorsal fin and lateral line were removed, cleaned, dried, mounted on glass slides, and viewed with a dissecting light microscope and computer video imaging.

Razorback sucker recovery efforts on Lake Mohave have included helicopter surveys to determine spawning locations. Due to the clarity of the water and the use of fairly shallow spawning areas in Lake Mohave, this method is an effective way to determine the location of spawning aggregations and to actually count spawning fish. An aerial survey was also done in 1995 on Lake Mead, but it had limited results. In 1998 a similar survey was done with BIO/WEST, SNWA, and NDOW personnel using a BOR helicopter. This survey was conducted during the known spawning season by observing likely spawning locations at an altitude of less than 500 feet above ground level.

RESULTS

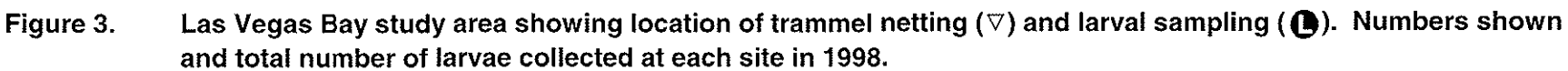
Adult Sampling

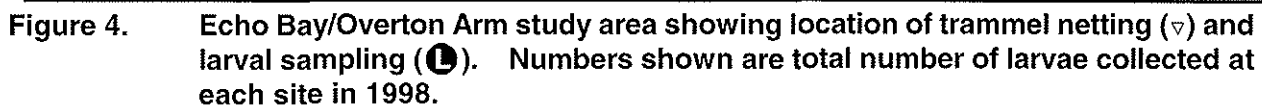
Trammel Netting

Table 1 shows the trammel net effort that was expended from October 1996 to June 1998, and Figures 3 and 4 show the location of trammel net sets in the two primary study areas from July 1997 to June 1998. A total of 134 trammel net nights (one net night is comprised of one overnight net set) was utilized during the first study year, and 137 trammel net nights were used for the second study year. A total of 95 net nights were used in the Las Vegas Bay area, and 39 net nights were used in the Echo Bay/Overton Arm area for the first study year. A total of 62 net nights were used in the Las

Table 1. Trammel netting effort (net nights) on Lake Mead by month from October 1996 to June 1998.

MONTH	LAS VEGAS BAY	ECHO BAY/ OVERTON ARM	TOTAL
1996			
October	6	12	18
November	13	4	17
December	17	0	17
1997			
January	19	4	23
February	13	4	17
March	13	8	21
April	12	4	16
May	2	3	5
June	0	0	0
July	4	8	12
August	3	2	5
September	6	6	12
October	6	6	12
November	6	6	12
December	10	5	15
1998			
January	5	11	16
February	5	5	10
March	7	9	16
April	0	0	0
May	10	13	23
June	0	4	4
Total	157	114	271





Vegas Bay area and 75 net nights were used in the Echo Bay/Overton Arm area during the second study year.

The trammel netting effort during the first year of the study was concentrated in the Blackbird Point area in Las Vegas Wash (Figure 3) and in the back part of Echo Bay (Figure 4). Trammel netting effort during the second year of the study was also concentrated in both of these areas but was extended to the east from Blackbird Point along the north shore of Las Vegas Bay, and north of Echo Bay along the western shore of the Overton Arm. Net locations outside the two primary study sites were selected based on the locations used by sonic-tagged fish.

At Las Vegas Bay, most of the (1996 to 1998) razorback sucker captures (24 out of 28 during the first study year and 19 out of 21 the second study year) came from net locations that ran into the deep channel just off the end of Blackbird Point. This area was about 20 feet deep on the shoreward side and ended in about 90 feet of water in the channel between Blackbird Point and the Las Vegas Bay Marina. In 1996 and early 1997, most of the razorback sucker were caught at a depth of 30 to 40 feet, but during March and April 1997 and all of 1998, most razorback sucker caught at this location were at a depth of 60 to 80 feet near the end of the 300-foot trammel nets.

The inflow of Las Vegas Wash was the only location within Las Vegas Bay where razorback sucker were captured outside of the Blackbird Point area. Two razorback sucker were captured in this location on December 9, 1997.

During the summer and fall of 1997, several areas in Las Vegas Bay outside Blackbird Point were trammel netted (10 net nights) based on the locations of sonic-tagged fish. Along the northern shore of Las Vegas Bay, these areas included the flowing portion of Las Vegas Wash, the area between Gypsum Wash and Government Wash, the area between Government Wash and Crawdad Cove, the mouth of Boxcar Cove, and the area between Salamander Cove and Roadrunner Cove. None of these netting attempts resulted in captured razorback sucker. These netting efforts demonstrated that even though one or more razorback sucker are known to be in an area, they are difficult to catch with trammel nets. In the spring of 1998, larval razorback sucker were found in Pitch Fork Cove (Figure 3), along the southern shore of Las Vegas Bay. This area was then sampled for 2 nights with trammel nets (7 net nights) in a search for spawning adults, but none were found.

At Echo Bay nets were set about mid-way back into the bay at maximum depths of 30 to 40 feet during 1996. Since sonic-tagged razorback sucker used the back part of the bay, nets in the February through April 1997 period were generally set only in the back part of the bay at maximum depths of 15 to 25 feet. From late 1997 through June 1998, netting was continued in both the back portion of Echo Bay and in the area half-way back. In addition, nets (10 net nights) were set in locations where sonic-tagged razorback sucker were found. These locations included areas in the northern portion of Rodgers Bay and in Pumphouse Bay (Figure 4). A net set in Rogers Bay provided the only razorback sucker that have been caught at a location (in Overton Arm) other than the Echo Bay study area since the study began. Four razorback sucker were captured at this location on August 20, 1997, including one sonic-tagged fish.

Table 2 provides information on the razorback sucker that were caught during the October 1996 to June 1998 time period. A total of 61 razorback sucker were caught within the first study year, 28

Table 2. Location, tagging, and size information related to razorback sucker collected in Lake Mead from October 1996 to June 1998.

Date	Trip No.	Location	Sonic Tag No.	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight (g)	Sex	Ripe ^a
10/23/96	1	Blackbird Point	Not Implanted	1F4B1F5621	No	495	460		1530	U	
10/23/96	1	Blackbird Point	Not Implanted	1F4A173D43	No	588	547		2600	U	
10/24/96	1	Echo Bay	Not Implanted	1F4A30392E	No	704	651	594	9 lb. 0 oz.	F	
10/24/96	1	Echo Bay	Not Implanted	7F7D22242B	Yes	595	555	499	2700	F	
11/18/96	2	Blackbird Point	249	1F483F0D4D	Yes	576	530	485	2130	F?	TU
11/20/96	2	Echo Bay	357	7F7B012325	Yes	591	550	489	2710	F	TU
11/20/96	2	Echo Bay	348	7F7D152A5D	Yes	569	533	471	2270	M	TU
11/20/96	2	Echo Bay	258	7F7D515B6E	No	585	540	479	2871	F	TU
11/20/96	2	Echo Bay	267	7F7D2B330C	Yes	588	545	485	2235	M	TU
11/20/96	2	Echo Bay	285	7F7D165D68	Yes	606	564	502	2604	M	TU
12/18/96	4	Blackbird Point	276	7F7D3B6539	No	713	664	605	9 lb. 15 oz.	F	
12/18/96	4	Blackbird Point	339	7F7D4B7052	No	492	459	410	1637	M	
1/27/97	6	Echo Bay	2255	7F7D4D6F34	No	585	545		2475	M	TU
1/27/97	6	Echo Bay	Not Implanted	7F7D2B2D5F	Yes	590	548		2638	M	TU
1/27/97	6	Echo Bay	Not Implanted	7F7D222A48	Yes	545	510		2055	M	TU
1/27/97	6	Echo Bay	2228	7F7D22351B	Yes	695	645		4245	F	
1/27/97	6	Echo Bay	2246	7F7D4D7777	No	590	550		2610	M	TU
1/28/97	6	Blackbird Point	384	7F7D4A7E47	No	512	483		1603	F	
1/29/97	6	Blackbird Point	2237	7F7D28296B	No	735	695	640	10 lb. 8 oz.	F	
1/29/97	6	Blackbird Point	2264	7F7D4B7C2E	No	560	520	465	2222	M	TU
2/10/97	7	Blackbird Point	294	7F7D4B7A54	No	617	578	525	2375	M	MI
2/25/97	9	Blackbird Point	276R	7F7D3B6539	Yes	713	664		8 lb. 8oz.	F	EG
2/25/97	9	Blackbird Point	Not Implanted	7F7D4D6275	No	502	467	428	1599	M	MI
2/25/97	9	Blackbird Point	Not Implanted	7F7D51716D	No	659	605	550	7 lb. 15 oz.	F	
2/25/97	9	Blackbird Point	Not Implanted	7F7D481D76	No	671	620	560	8 lb. 4 oz.	F	
2/28/97	9	Echo Bay	357R	7F7B012325	Yes	597	550	485	2668	M	
2/28/97	9	Echo Bay	Not Implanted	7F7D1A2B3C	Yes	576	538	481		M	
2/28/97	9	Echo Bay	Not Implanted	1F4A592D11	Yes	681	642	573	3390	F	
2/28/97	9	Echo Bay	Not Implanted	7F7D462104	No	661	620	555	3432	F	
3/8/97	10	Echo Bay	Not Implanted	1F4A157B07	Yes	571	531	467	2434	M	MI
3/10/97	10	Blackbird Point	Not Implanted	7F7D51716D	Yes	659	610	560	3625	F	
3/10/97	10	Blackbird Point	Not Implanted	7F7D4A0478	No	600	552	495	2718	M	MI
3/10/97	10	Blackbird Point	Not Implanted	7F7D51650E	No	565	555	500	2363	M	MI
3/10/97	10	Blackbird Point	Not Implanted	1F7A3E1A0F	No	722	670	610	9 lb. 2 oz.	F	EG
3/10/97	10	Blackbird Point	Not Implanted	7F7D481D76	Yes	670	612	555	7 lb. 12 oz.	F	EG

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

Date	Trip No.	Location	Sonic Tag No.	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight (g)	Sex	Ripe ^a
3/12/97	10	Echo Bay	Not Implanted	201D5F2A3A	No	645	591	525	3095	F	SP
3/12/97	10	Echo Bay	Not Implanted	1F7A26625F	No	560	519	460	2422	M	MI
3/12/97	10	Echo Bay	Not Implanted	7F7D1A2E1A	Yes	584	535	481	2461	M	MI
3/12/97	10	Echo Bay	Not Implanted	1F7A39743A	No	590	538	482	2853	M	MI
3/12/97	10	Echo Bay	357R	7F7B012325	Yes	600	552	496	2649	M	TU
4/5/97	12	Blackbird Point	Not Implanted	203726295A	No	702	648	590	10 lb. 1 oz.	F	
4/5/97	12	Blackbird Point	Not Implanted	1F7B03796A	No	612	563	505	4 lb. 14 oz.	M	TU
4/5/97	12	Blackbird Point	2264 -2nd Time	201D5B1751	No	581	529	475	5 lb. 6 oz.	M	MI
4/17/97	13	Blackbird Point	2525	201D61560C	No	662	605	545	3150	M	MI
4/20/97	13	Echo Bay	3344	1F7B477827	No	573	484	334	1989	M	MI
4/20/97	13	Echo Bay	2273	1F7B0D2435	No	559	516	464	2006	M	MI
4/20/97	13	Echo Bay	2336	201D5B6107	No	632	586	536	3011	F	EG
4/20/97	13	Echo Bay	Not Implanted	1F7A39743A	Yes	582	530	485	2497	M	MI
4/20/97	13	Echo Bay	Not Implanted	1F7B5A503C	No	472	442	387	1194	M	MI
4/20/97	13	Echo Bay	Not Implanted	2037132A6C	No	637	585	542	3142	F	EG
4/20/97	13	Echo Bay	Not Implanted	1F7A721C59	No	582	540	493	2133	M	CO
4/21/97	13	Blackbird Point	Not Implanted	1F7B03796A	Yes	604	555	508	2100	M	MI
4/21/97	13	Blackbird Point	Not Implanted	7F7D4C0651	No	605	558	505	2360	M	MI
4/21/97	13	Blackbird Point	2264R	201D5B1751	Yes	577	525	473	2400	M	MI
4/21/97	13	Blackbird Point	Not Implanted	7F7D3F6F5C	No	552	507	458	2127	M	MI
4/21/97	13	Blackbird Point	Not Implanted	7F7D483714	No	515	474	426	1532	M	MI
4/21/97	13	Blackbird Point	2444	7F7D4D6275	Yes	508	465	419	1330	M	MI
5/19/97	16	Echo Bay	Not Implanted	7F7D301A27	No	499	468		1205	M	SP
5/19/97	16	Echo Bay	Not Implanted	7F7D3B3240	No	667	623	576	3300	F	SP
5/19/97	16	Echo Bay	Not Implanted	1F476B7936	Yes	581	539	481	2178	F	SP
5/19/97	16	Echo Bay	Not Implanted	7F7D1A2B3C	Yes	578	537	480	2166	M	SP
7/16/97	19	Echo Bay	Not Implanted	1F476B7936	Yes	574	536	487	2300	M	
8/20/97	21	Rogers Bay	2246R	7F7D4D7777	Yes	598	560	502	2979	M	
8/20/97	21	Rogers Bay	Not Implanted	1F7B634E35	No ?	725	670		4226	F	
8/20/97	21	Rogers Bay	Not Implanted		?	596	560	500	2641	M	
8/20/97	21	Rogers Bay	Not Implanted		?	598	562	505	2716	U	
10/23/97	23	Echo Bay	Not Implanted	7F7D22341E	Yes	625	575	530	3202	M	TU
11/10/97	24	Blackbird Point	Not Implanted	7F7D3A5B2D	No	621	580	540	7 lbs 4 oz	F	
11/11/97	24	Blackbird Point	Not Implanted	7F7D7D492C	Yes	684	643	565	3695	F	
11/12/97	24	Echo Bay	Not Implanted	7F7D47300C	No	354	327	290	437	I	
12/9/97	25	LVW Inflow	Not Implanted	7F7D4B771D	No	650	615	560	7 lbs 4oz	M	TU

Table 2. Location, tagging, and size information related to razorback sucker collected in Lake Mead from October 1996 to June 1998 (cont.).

Date	Trip No.	Location	Sonic Tag No.	PIT Tag No.	Recap.	TL (mm)	FL (mm)	SL (mm)	Weight (g)	Sex	Ripe ^a
12/9/97	25	LVW Inflow	238	7F7D516462	No	692	645	588	9 lbs 14 oz	F	
12/10/97	25	Echo Bay	365	7F7D2F320A	Yes	595	550	495	2362	M	TU
12/10/97	25	Echo Bay	88	7F7D516F6E	No	318	296	258	305	I	
1/5/98	28	Blackbird Point	347	7F7D467310	No	595	550	495	2559	M	TU
1/5/98	28	Blackbird Point	464	7F7D4A0478	Yes	604	555	500	3047	M	MI
1/15/98	29	Echo Bay	79	7F7D481E44	No	630	588	525	2985	M	MI
1/15/98	29	Echo Bay	555	7F7D302048	No	381	353	310	575	I	
2/10/98	31	Echo Bay	Not Implanted	7F7D4C302B	No	347	321	281	417	I	
2/10/98	31	Echo Bay	Not Implanted	7F7D482104	No	675	632	567	7 lb. 2 oz.	F	
2/10/98	31	Echo Bay	Not Implanted	1F4A157B07	Yes	585	536	488	2550	M	TU
2/12/98	31	Blackbird Point	384R	7F7D4A7E47	Yes	555	520	465	1898	F	
3/9/98	34	Blackbird Point	Not Implanted	1F78022047	No	680	628	581	3559	F	EG
3/9/98	34	Blackbird Point	Not Implanted	1F783F2109	No	662	605	540	2624	M	
3/9/98	34	Blackbird Point	Not Implanted	201D633030	No	564	525	465	1943	F	
3/9/98	34	Blackbird Point	Not Implanted	7F7D4B7A54	Yes	630	581	522	2295	M	MI
3/9/98	34	Blackbird Point	Not Implanted	1F4A46272A	Yes	575	529	481	1935	M	MI
3/9/98	34	Blackbird Point	Not Implanted	1F783D4369	No	578	536	489	2274	M	
3/9/98	34	Blackbird Point	Not Implanted	1F78123225	No	627	574	519	3177	M	MI
3/9/98	34	Blackbird Point	Not Implanted	7F7D4A7E47	Yes	555	523	472	1851	F	
3/9/98	34	Blackbird Point	Not Implanted	7F7D770148	Yes	668	605	557	3192	M	MI
3/11/98	34	Echo Bay	Not Implanted	7F7D222A48	Yes	565	520	476	2094	M	TU
3/11/98	34	Echo Bay	Not Implanted	7F7D4C302B	Yes	351	323	290	411	I	
3/11/98	34	Echo Bay	Not Implanted	7F7D133272	Yes	604	560	510	2779	M	TU
3/11/98	34	Echo Bay	Not Implanted	1F78205673	No	592	553	494	2320	F	EG
3/12/98	34	Echo Bay	Not Implanted	7F7D2B2D5F	Yes	594	553	512	2492	M	MI
3/12/98	34	Echo Bay	Not Implanted	7F7D3B3240	Yes	664	620	560	3648	F	EG
3/12/98	34	Echo Bay	357R	7F7B012325	Yes	606	562	510	2711	M	TU
5/7/98	42	Blackbird Point	247	1F4A40391E	Yes	532	480	430	1620	M	SP
5/7/98	42	Blackbird Point	2444R	7F7D4D6275	Yes	544	500	453	1616	M	
5/7/98	42	Blackbird Point	Not Implanted	1F782C4F6E	No	728	670	620	4608	F	EG
5/7/98	42	Blackbird Point	374	1F7B5E3553	No	588	541	498	1940	M	MI
5/7/98	42	Blackbird Point	283	7F7D483714	Yes	562	515	475	1844	M	SP
5/20/98	44	Echo Bay	274	7F7D222A48	Yes	564	510	462	1876	M	RI
5/20/98	44	Echo Bay	455	7F7D4D5405	No	553	513	460	1833	F	SP
6/3/98	46	Echo Bay	2543	1F78205673	Yes	597	556	510	2175	F	

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

at Las Vegas Bay and 33 at Echo Bay (Holden et al. 1997). Forty-five razorback sucker were caught for the second study year, 20 at Echo Bay, 4 at Rogers Bay, 19 at Blackbird Point, and 2 at the Las Vegas Wash inflow. Razorback sucker were more difficult to catch at Las Vegas Bay than Echo Bay for the first study year, with total catch rates of 0.29/net night and 0.85/net night, respectively, but catch rate was very similar during the second study year (0.34 vs. 0.32, respectively).

Perhaps the most important captures during the second study year were those of four juvenile fish found in Echo Bay. Ranging in size from 318 to 384 mm total length (TL), one fish was caught each month in November, December, January, and February. These captures occurred in the middle portion of Echo Bay that was initially sampled in 1996 but was typically not intensively trammel netted once sonic-tagged adults indicated use of the back end of the bay was most prevalent.

The highest catch rate in any one net for the first year of studies was six razorback sucker at Blackbird Point of Las Vegas Bay on April 21, 1997 (Holden et al. 1997). During the second year of the study, seven razorback sucker were caught in a net set at Blackbird Point on March 9, 1998. Figure 5 shows the monthly catch rate of razorback sucker at both primary study sites for the first and second years of the study. The highest catch rate was during April 1997 at both Las Vegas Bay and Echo Bay for the first study year. The highest catch rates for the second year of the study occurred in August 1997 for Echo Bay/Overton Arm and March 1998 for Las Vegas Bay. The lowest catch rate for the first year of the study was during May 1997 in Las Vegas Bay when no razorback sucker were caught during 2 net nights. The lowest catch rate for the second year of the study was during July, August, September, and October when no razorback sucker were caught at either of the two study locations.

The primary reason for sampling at Blackbird Point and Echo Bay was that past captures suggested razorback sucker spawned at these locations. Evidence of ripeness was observed during the first year of the study starting in November 1997 (Holden et al. 1997). By this time almost all of the males had breeding tubercles on their tails and anal fins (Table 2). Males expressing milt were first collected in February 1997, after which all males were ripe until May. The first running ripe female was collected at Blackbird Point on February 25, 1997, and two other ripe females were captured in March (Table 2). Ripe females were also caught at Echo Bay on April 20, 1997. Spent females were captured in Echo Bay on March 12, 1997, and spent males and females were collected there in May.

During the second year of the study, ripe razorback sucker were caught beginning in late October and continuing through late May. The first male with breeding tubercles was captured October 23, 1997, at Echo Bay, and the first male expressing milt was caught at Blackbird Point January 5, 1998. Female razorback sucker expressing eggs were captured March 9, 1998, at Blackbird Point and on March 11, 1998, at Echo Bay. Spent males were first caught at Blackbird Point May 7, 1998, and females were caught at Echo Bay on May 20, 1998 (Table 2).

Recapture rates varied between years and study locations. Several fish were caught twice, and several recaptures from previous years were also caught during the first year of the study. Recaptures for the second year of the study increased at both study locations. At Las Vegas Bay, 10 of 21 razorback sucker caught were recaptures, two of which were tagged prior to the initiation of the study. Two of the remaining eight were stocked fish; one was stocked during the study, and one was stocked before the study began. The other six recaptures were all fish that were caught and

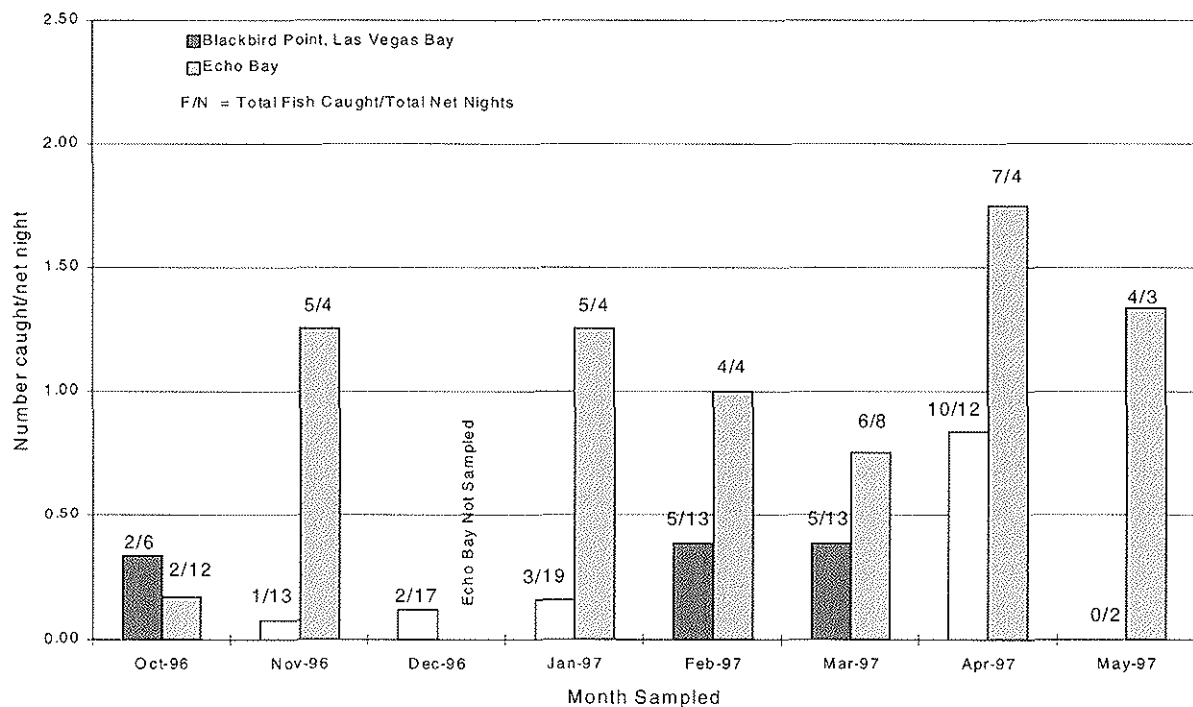
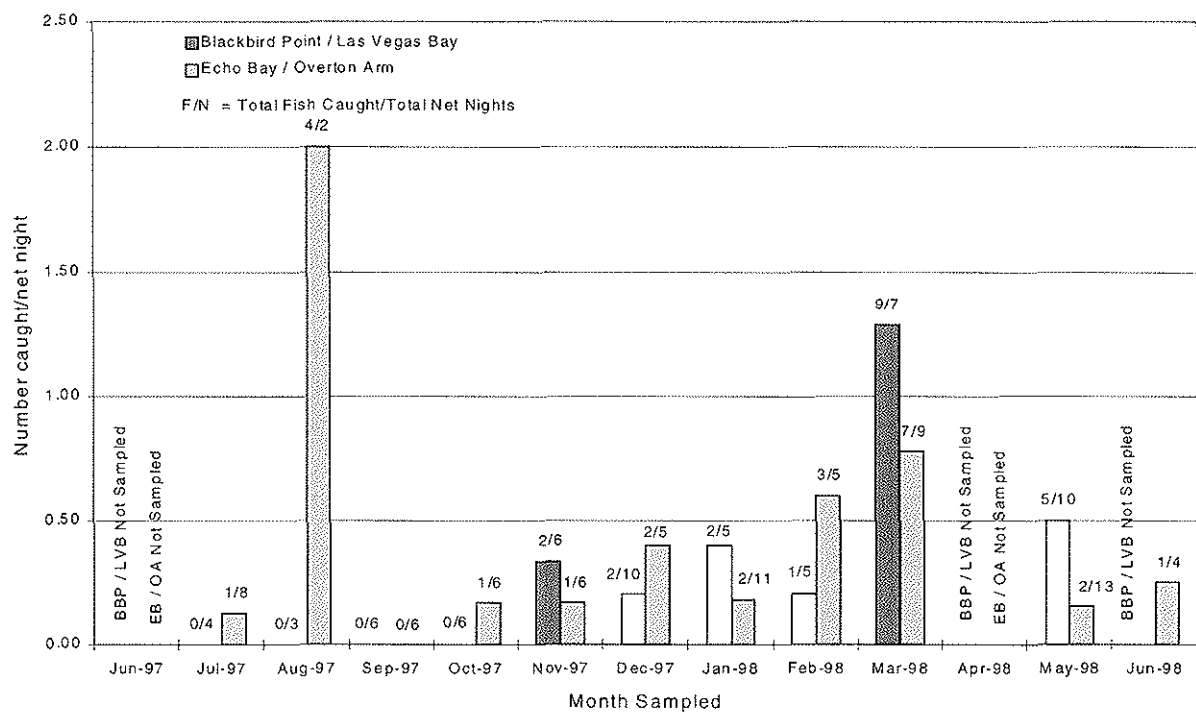


Figure 5. Trammel net catch per unit effort (CPE) for razorback sucker for two study years at two study areas in Lake Mead, Nevada.

Passive Integrated Transponder (PIT)-tagged during this study and later recaptured. The increase in recaptured razorback sucker was minimal at Echo Bay. The second year of the study, 10 of the 17 razorback sucker caught were recaptures. Six of these ten razorback sucker were PIT-tagged prior to the beginning of this study, and the other four were tagged during the course of this study.

Aerial Spawning Surveys

Passive Integrated Transponder (PIT)-tagged during this study and later recaptured. The increase in recaptured razorback sucker was minimal at Echo Bay. The second year of the study, 10 of the 17 razorback sucker caught were recaptures. Six of these ten razorback sucker were PIT-tagged prior to the beginning of this study, and the other four were tagged during the course of this study.

A flight was conducted on March 19, 1998, with a helicopter flying at less than 500 feet above ground level. Conditions for the flight were ideal with no wind, clear sunny skies, no waves, and extremely low turbidity. Searching occurred in the shoreline area between the following coves in the order listed below (Figure 6):

1. From Pumphouse Cove around all of Las Vegas Bay to Swallow Bay, including Las Vegas Wash upstream to Black Butte;
2. Teakettle Bay to East Point, without Danger Bay;
3. Teal Cove to Decision Island;
4. East shore of Overton Arm–Walker Bay to Cottonwood Cove;
5. All of Echo Bay and then north along west shore to Overton Beach;
6. All of Muddy Arm and Virgin River Arm;
7. All of Grand Wash Cove; and
8. All of Gregg Basin on both east and west shorelines—specifically, Devil’s Cove to Gold Cross Bay and Crappie Cove to Smith Bay.

Visual observations occurred from 09:15 to 12:00 and from 13:10 until about 16:00 hours. All areas of the lake that appeared to offer good habitat for razorback sucker spawning were observed. However, the only fish that were spotted were common carp in various areas of the lake. No razorback sucker were seen.

Growth

The 20 razorback sucker that were recaptured during the second year of the study were evaluated for growth. Mean annual growth was determined by calculating the difference in TL between captures and then annualizing the information (Table 3). Since one recapture from Las Vegas Bay was caught

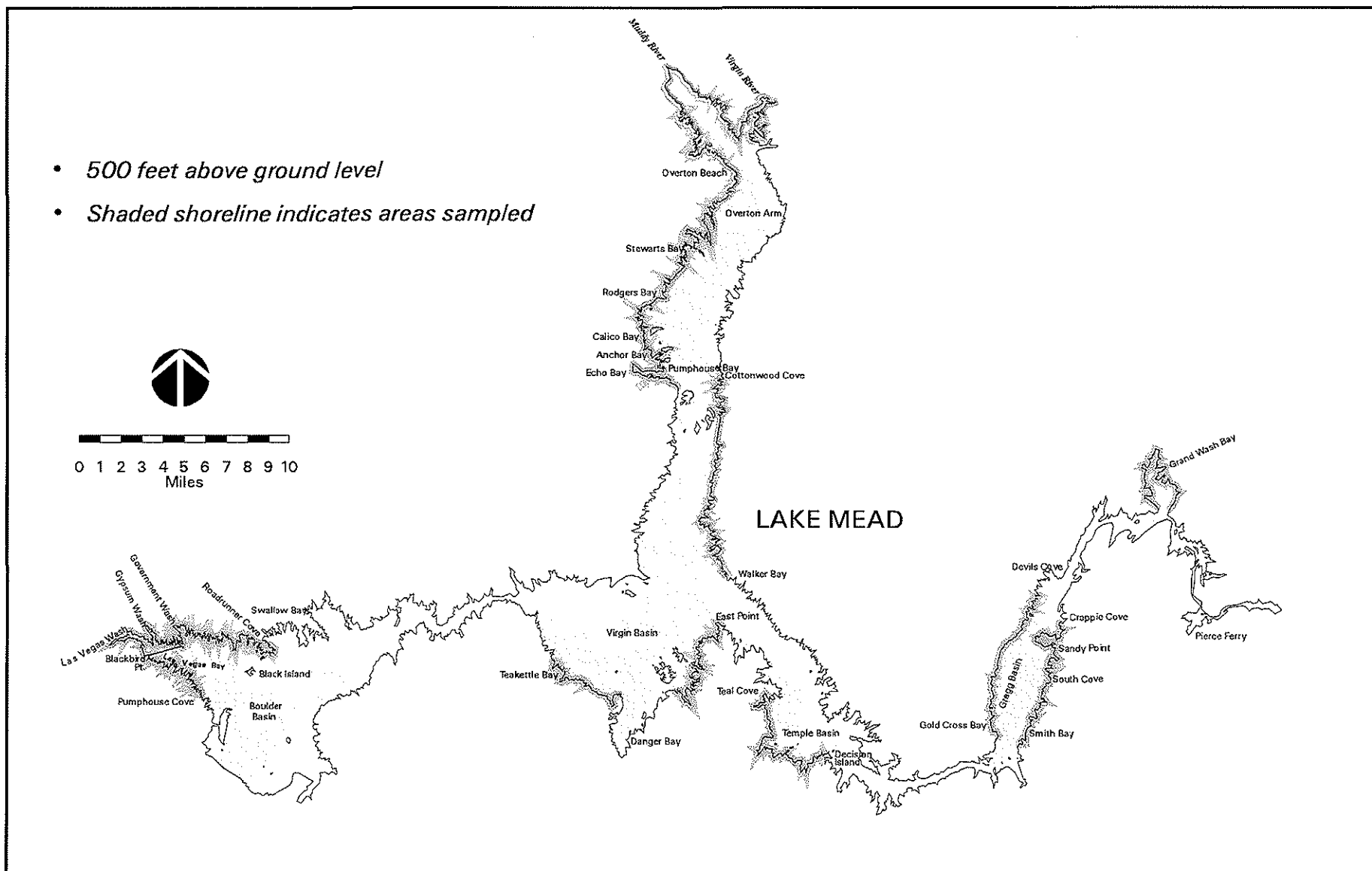


Figure 6. Portions of Lake Mead shoreline surveyed by helicopter for adult razorback sucker on March 19, 1998.

Table 3. Growth of recaptured razorback sucker in Lake Mead from July 1997 to June 1998.

PIT Tag No.	Capture Date	Size TL (mm)	Recapture Date	Size TL (mm)	Total Growth	Days Between Measurements	Growth Per Year (12 mo.)
Las Vegas Bay							
7F7D7D492C	3/22/94	633	11/11/97	684	51	1330	14.00
7F7D4A0478	3/10/97	600	1/5/98	604	4	301	4.85
7F7D4B7A54	2/10/97	617	3/9/98	630	13	392	12.10
1F4A46272A	5/6/94	510	3/9/98	575	65	1403	16.91
7F7D4A7E47	1/28/97	512	3/9/98	555	43	405	38.75
7F7D770148	4/2/93	635	3/9/98	668	33	1802	6.68
1F4A40391E	5/1/97	504	5/7/98	532	28	371	27.55
7F7D4D6275	2/25/97	502	5/7/98	544	42	436	35.16
7F7D483714	4/21/97	515	5/7/98	562	47	381	45.03
Average Growth for One Year							22.34
Echo Bay							
1F476B7936	7/25/95	541	7/16/97	574	33	722	16.68
7F7D4D7777	1/27/97	590	8/20/97	598	8	205	14.24
7F7D22341E	3/18/92	574	10/23/97	625	51	2045	9.10
1F4A157B07	3/5/96	560	2/10/98	585	25	707	12.91
7F7D133272	3/18/92	546	3/11/98	604	58	2184	9.69
7F7D2B2D5F	4/2/93	574	3/12/98	594	20	1805	4.04
7F7D3B3240	5/19/97	667	3/12/98	664	0	297	0.00
7F7B012325	4/2/93	555	3/12/98	606	51	1805	10.31
7F7D222A48	2/26/93	519	5/20/98	564	45	1909	8.60
1F78205673	3/11/98	592	6/3/98	597	5	84	21.73
Average Growth for One Year							10.73

only 1 month after its initial capture, its length change was not considered in this analysis. Mean annual growth, as measured by change in TL, of fish recaptured at Las Vegas Bay from July 1997 to June 1998 was about 22 mm, and ranged from 4.85 to 45.03 mm. Growth was generally highest for smaller fish, which were around 500 mm when first captured. Mean annual growth of fish from Echo Bay was about 11 mm, and growth ranged from 0.00 mm to 21.73 mm. These average growth rates were the same as the average rates seen in the first year of the study (Holden et al. 1997). Stocked fish again showed relatively high growth rates, but several small wild fish had the highest growth rates. Length measurements of live fish are susceptible to error, and growth rates derived from them can be suspect. BIO/WEST's current sample of 32 recaptured razorback sucker, most of which fit the pattern of high growth, provides better assurance that the general pattern of growth is close to that occurring in Lake Mead.

Sonic Tagging and Telemetry

During the first year of the study twenty 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 year of the study, 13 razorback sucker were implanted using two 60-day tags and 11 48-month tags. Similar to the first year of the study, implanting was performed before and after the prime spawning months of February, March, and April. Three sonic-tags were implanted in December 1997, four in January 1998, five in May 1998, and one in June 1998. Six of the tags were implanted in fish that were caught at Las Vegas Bay, and seven of the tags were implanted in fish caught at Echo Bay (Table 2).

During both years of the study, released fish showed a general pattern of moving away from the release point (Blackbird Point or Echo Bay) soon after tagging, but then they returned back to the probable spawning sites in a few weeks. Again, all tagging was conducted during the general spawning period. The second year of the study allowed an evaluation of spawning versus non-spawning period habitat use. Echo Bay sonic-tagged razorback sucker were primarily found close to the spawning areas during the first (November 1996 through April 1997) and second (November 1997 through April 1998) spawning seasons (Figure 7). In the post-spawning period (May through October 1997 and May through June 1998), these razorback sucker were generally found outside of Echo Bay at points along the northwestern shore of Overton Arm, but they were occasionally found back in Echo Bay.

Las Vegas Bay sonic-tagged razorback sucker exhibited similar habitat use patterns as those observed in Echo Bay. This habitat use involved occupying distinctly different areas during the spawning and post-spawning periods. The fish often were found at Blackbird Point and further back into Las Vegas Wash during the first spawning season (November 1996 through April 1997) (Figure 8). During the second spawning season (November 1997 through April 1998), these fish were still found in these areas, but they also moved in and out of the flowing portion of Las Vegas Wash. During the post-spawning period for the first year (May through October 1997) of sonic tracking, Blackbird Point fish were generally found along the northern shore of Las Vegas Bay and occasionally in the flowing and nonflowing portions of Las Vegas Wash. During the beginning of the second post-spawning period, these fish were only occasionally found along the northern shore of Las Vegas Bay, and they were more-commonly found in the flowing and nonflowing portions of

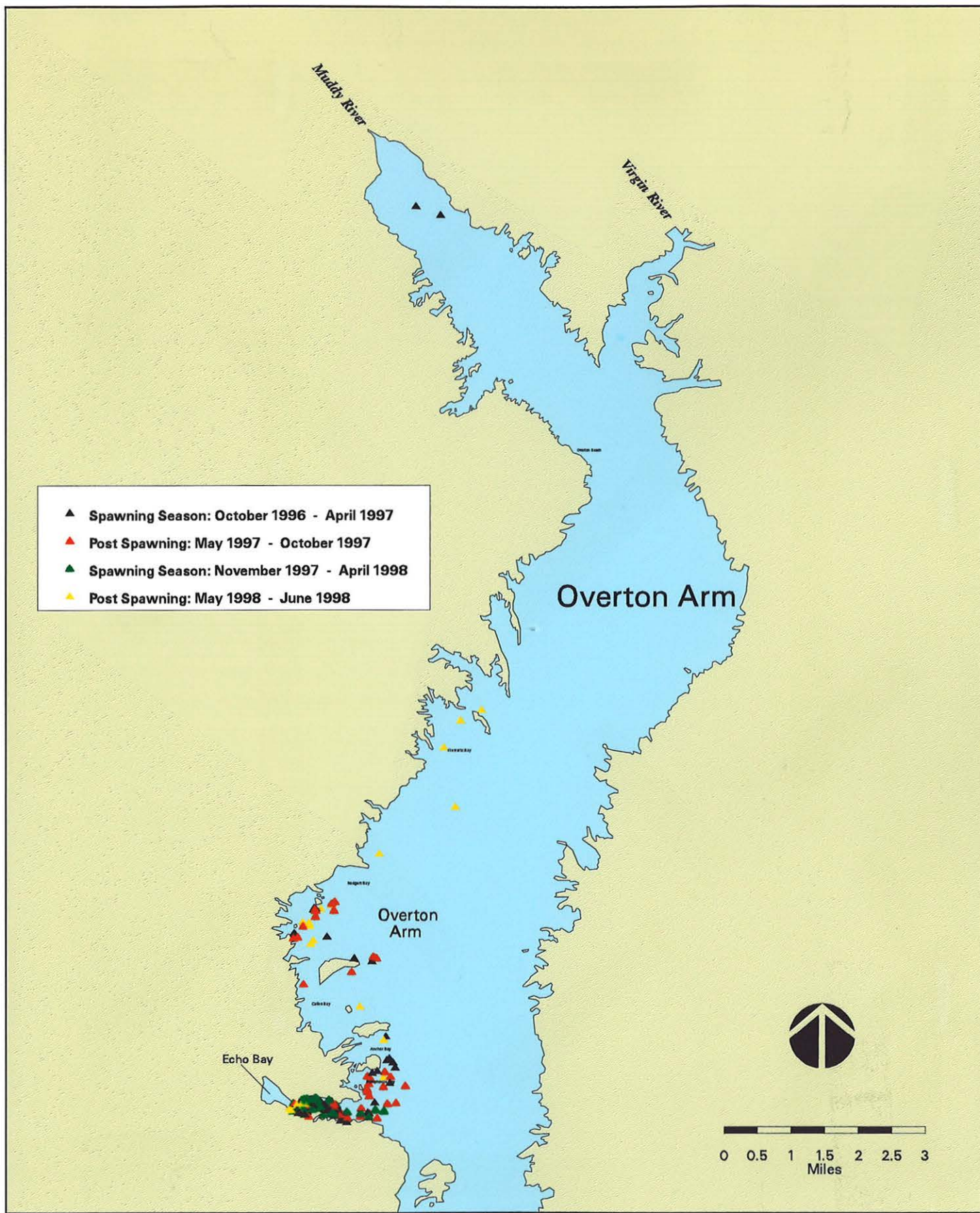


Figure 7. Spawning and post-spawning distributions for sonic-tagged fish, Blackbird Point/Las Vegas Bay.

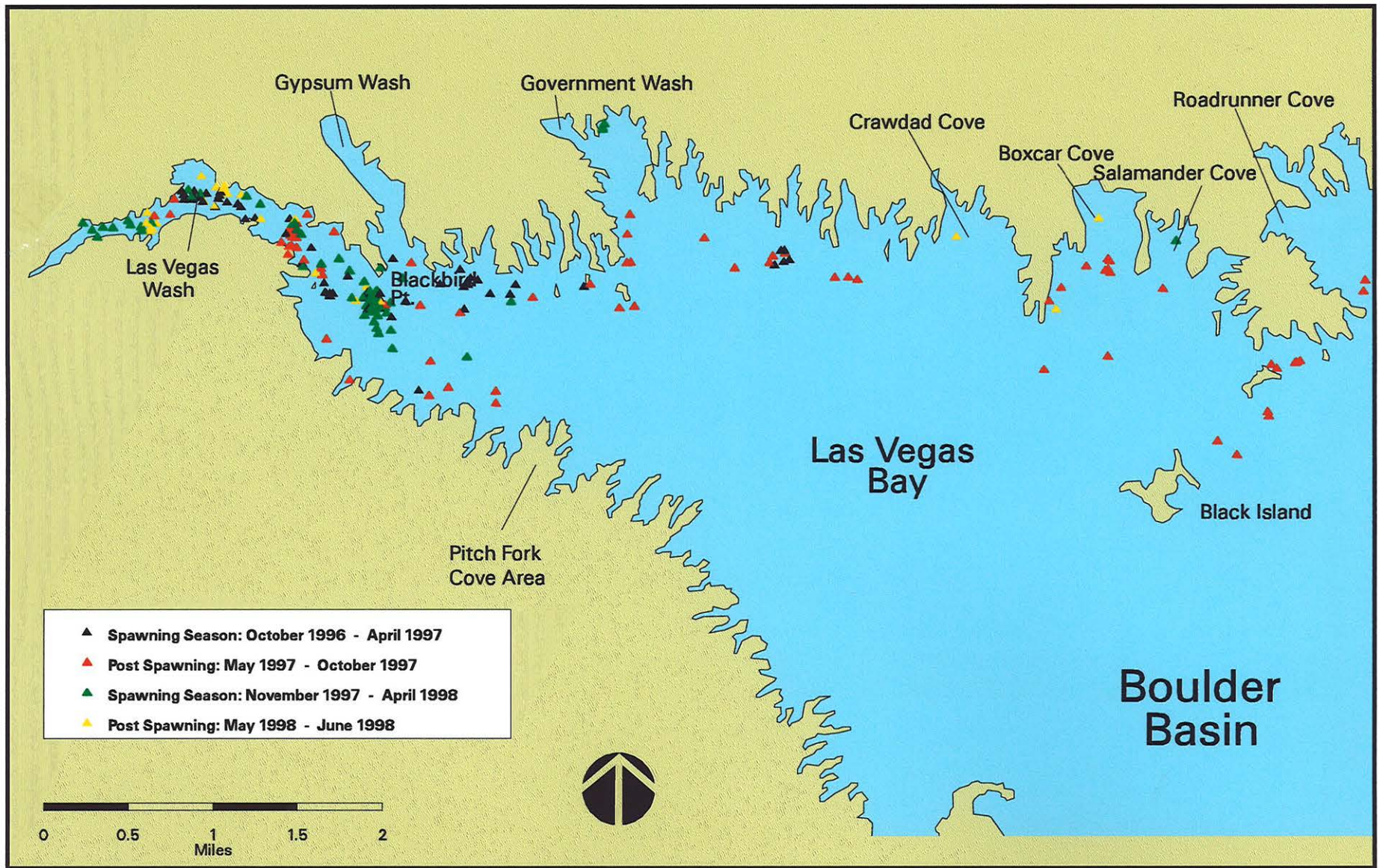


Figure 8. Spawning and post-spawning distributions for sonic-tagged fish, Echo Bay/Overton Arm.

Las Vegas Wash. All locations of sonic tagged fish were within the full pool elevation of Lake Mead (1,229 feet msl) including all Las Vegas Wash locations. Telemetry results for individual sonic-tagged fish for both Echo Bay and Blackbird Point are discussed below.

Las Vegas Wash

Tag 238

Tag 238 was implanted on December 9, 1997, into a 692-mm TL female captured at the inflow area of Las Vegas Wash. This fish was not located through June 1998.

Tag 247

Tag 247 was implanted May 7, 1998, into a 532-mm TL male captured at Blackbird Point. This fish was found May 12, 13, and 16 in the northern, nonflowing portion of Las Vegas Wash. It was not located during the month of June.

Tag 276

This fish was a large female (713-mm TL) that was sonic-tagged and released at Blackbird Point on December 19, 1996, and was then tracked over a range of about 4 miles during the next 6 months (Figure 9). Once released, fish 276 was found 1 day later 0.5 mile to the south, across Las Vegas Bay. Three days later, on December 3, it was located 1 mile to the northeast on the north shore of Las Vegas Bay, 0.5 mile west of Government Wash. Tracking on January 6 to 8, 1997, located fish 276 at the inflow area of Las Vegas Wash. Also in this area on January 6 to 8 was fish 339. Tracking conducted between February 11 and March 6, 1997, located this fish at Blackbird Point. Fish in this same area on February 11 included 294 and 2,237. Fish 276 was found again on March 17, 1997, close to the inflow of Las Vegas Wash. One month later (April 17, 1997), fish 276 was found 0.75 mile to the east of Government Wash, for a total distance traveled of about 3.5 miles. Fish 276 was found in a cove close to the center of Las Vegas Wash on May 1 and then found 1,000 feet southeast of the boat docks of Las Vegas Bay Marina on June 9, 1997.

During the second year of this study, fish 276 was found as far east as Black Island but was most frequently found in the Blackbird Point area. On August 3, 1997, this fish was found about 0.5 mile east of Government Wash (Figure 9). On August 22 and 23, 1997, this fish was found in a cove about 1 mile north of Black Island. On September 19, 1997, fish 276 was found in Roadrunner Cove. One month later, on October 17, this fish was found back in the middle of the nonflowing portion of Las Vegas Wash. This fish remained in the Las Vegas Wash/Blackbird Point area from mid October through the time the last contact was made on March 10, 1998.

Tag 283

Tag 283 was implanted May 7, 1998, into a 562-mm TL male at Blackbird Point (Figure 10). On May 12 and 13, this fish was located in flowing portion of Las Vegas Wash, and on May 16 it was near Blackbird Point. This fish was then found 4 miles to the east in Boxcar Cove on May 19. The last (May 27, 1998) known location for fish 283 was in the flowing portion of Las Vegas Wash in the same general location in which it was found in early May.

Tag 294

Tag 294 was implanted February 11, 1997, into a 617-mm TL male at Blackbird Point (Figure 11). This fish was located over the next 3 months in three general locations including Blackbird Point,

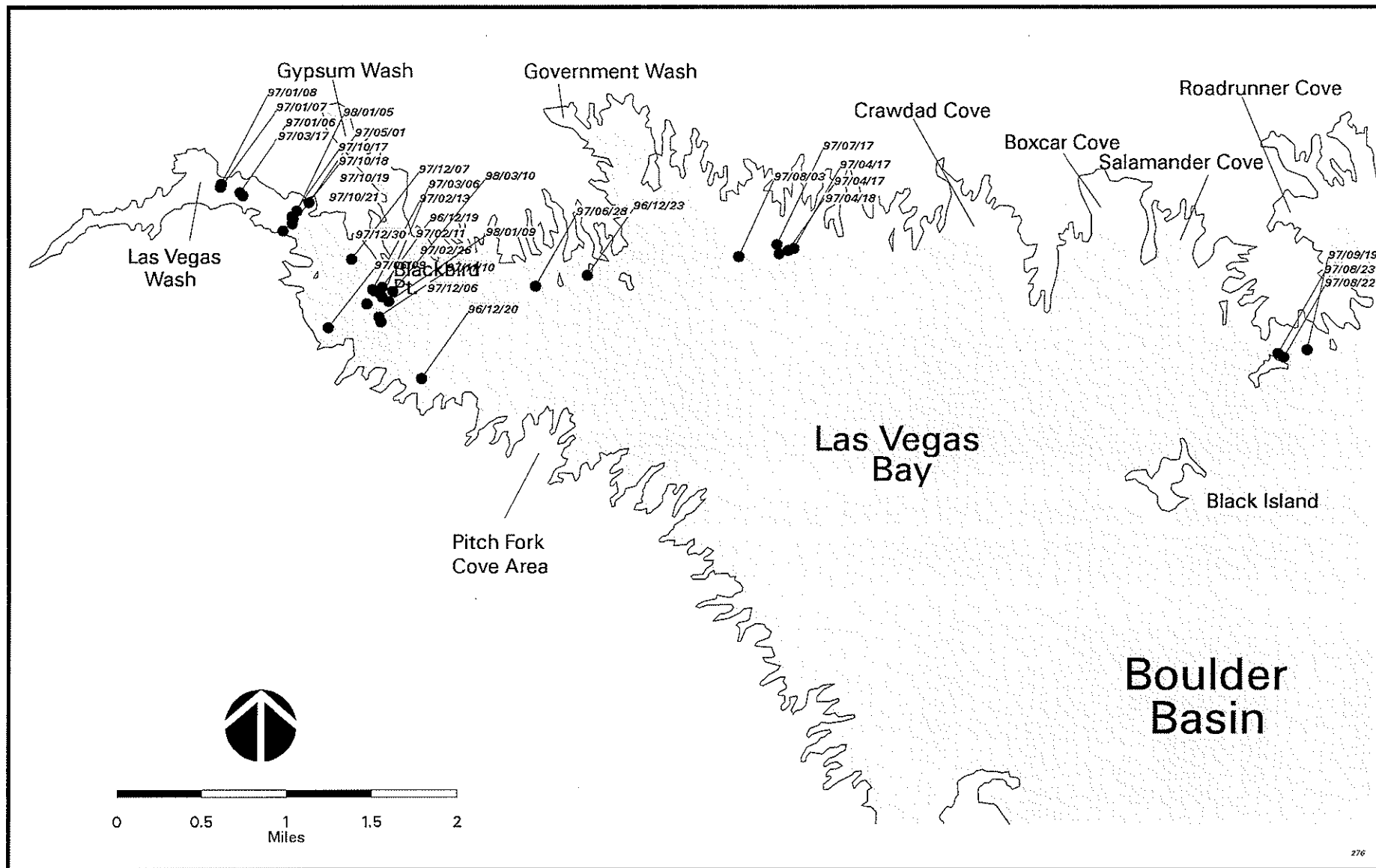


Figure 9. Distribution of fish number: 276.

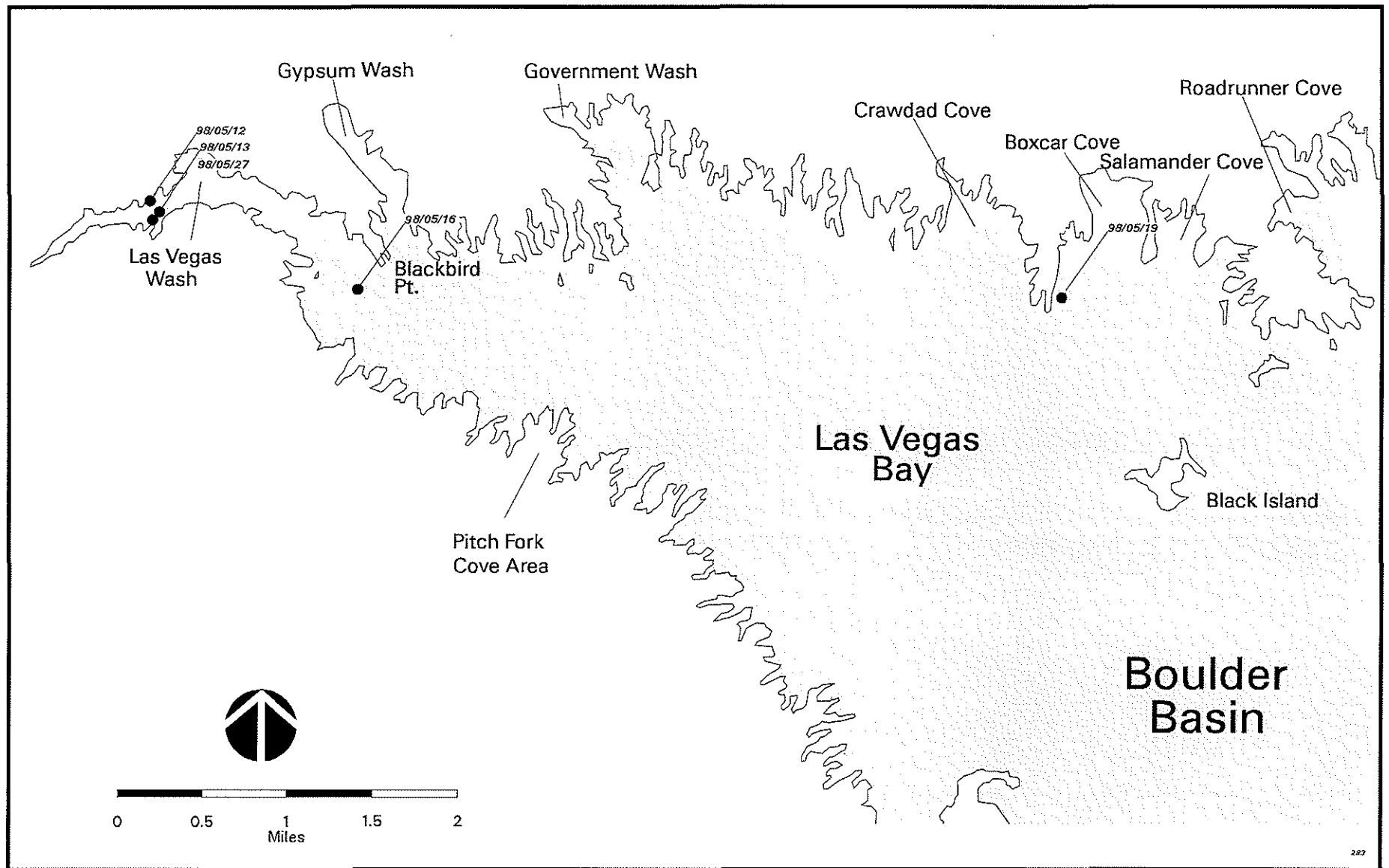


Figure 10. Distribution of fish number: 283.

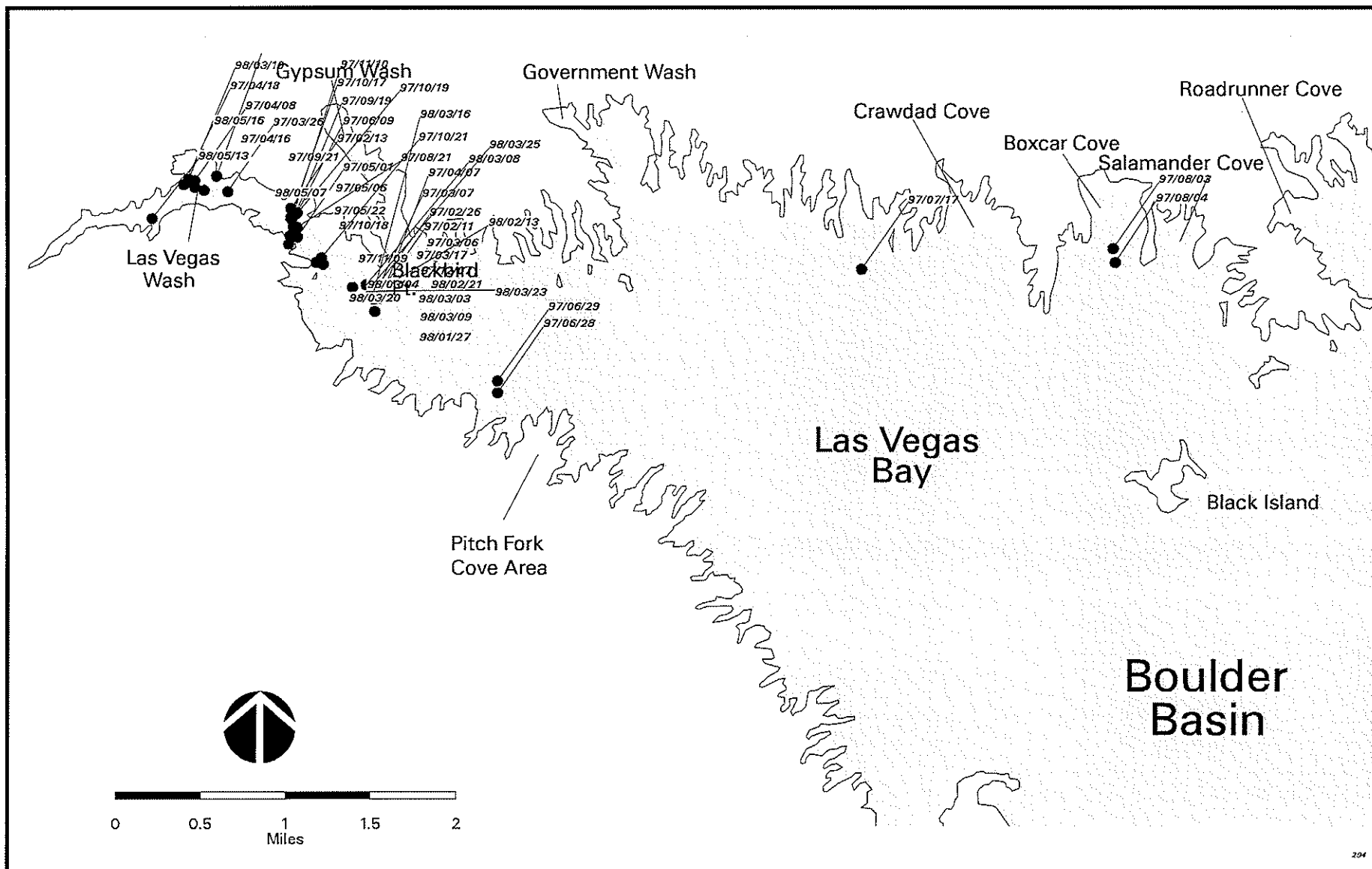


Figure 11. Distribution of fish number: 294

the central portion of Las Vegas Wash (0.5 mile north of Blackbird Point), and the inflow area of Las Vegas Wash. Fish 294 was found at the center of Las Vegas Wash 2 days after implantation. From February 26 through March 17, fish 294 was found at Blackbird Point. On March 26, it was located at the inflow area of Las Vegas Wash and was subsequently found in this general area on April 8, 16, and 18, 1997. On tracking days in May and June, fish 294 was consistently found in the center of Las Vegas Wash. At one location in this area (along the west side of the wash), fish 294 did not appear to move for tracking dates May 1, 6, and 22. On June 6, this fish had finally moved and was found on the opposite side of the wash.

During the second year of this study, fish 294 occupied some of the same general locations as it had during the previous year, including: Blackbird Point, the central area of the non-flowing portion of Las Vegas Wash, and the inflow area of Las Vegas Wash (Figure 10). On July 17, 1997, this fish was found about 1 mile east of Government Wash. During early August 1997, this fish was found about 2.75 miles east of Government Wash in Boxcar Cove. Contacts were made with this fish within the months of August, September, October, November, and December 1997 and February, March, April, and May 1998 at Blackbird Point the non-flowing and flowing areas of Las Vegas Wash.

Tag 347

This 595-mm TL male razorback sucker was implanted and released at Blackbird Point on January 5, 1998. Four days after tagging, this fish was located 300 feet off of the south shore and was moving north. On January 27, 1998, this tag was stationary; it did not move from its location in the northern portion of Government Wash.

Tag 374

This 588-mm TL male razorback sucker was implanted and released at Blackbird Point on May 7, 1998. On May 12, it was located in the non-flowing portion of Las Vegas Wash heading upstream. On May 13, 1998, this fish was found dead; it was floating in an area of inundated tamarisk.

Tag 384

This 512-mm TL female razorback sucker was implanted and released at Blackbird Point on January 30, 1997 (Figure 12). Within a few hours of release it had moved east across the mouth of Gypsum Bay. On February 10 and 13, 1997, it was still in the same general area (just east of Gypsum Wash). During the next 2 months, eight locations in the back of Las Vegas Wash were determined for this fish. On May 1, 1997, fish 384 was found 3.5 miles to the east, near the northern shore of Las Vegas Bay.

During the second year of this study, fish 384 was found in an area extending east over 6 miles from the flowing portion of Las Vegas Wash to Boxcar Cove. During July, August, and September, six contacts were made with this fish in the area between Government Wash and Salamander Cove. On September 20, 1997 this fish was found 0.5 mile west of Gypsum Wash. On September 21 it moved to the south side of the bay and was about 0.5 mile east of the Las Vegas Bay Marina. On October 18 and 19, fish 384 was located in the Government Wash area and on November 10 it was located in the cove between Boxcar and Salamander Cove. During December 16, 1997, through March 4, 1998, this fish was found in the flowing portion of Las Vegas Wash. On March 9, 1998, fish 384

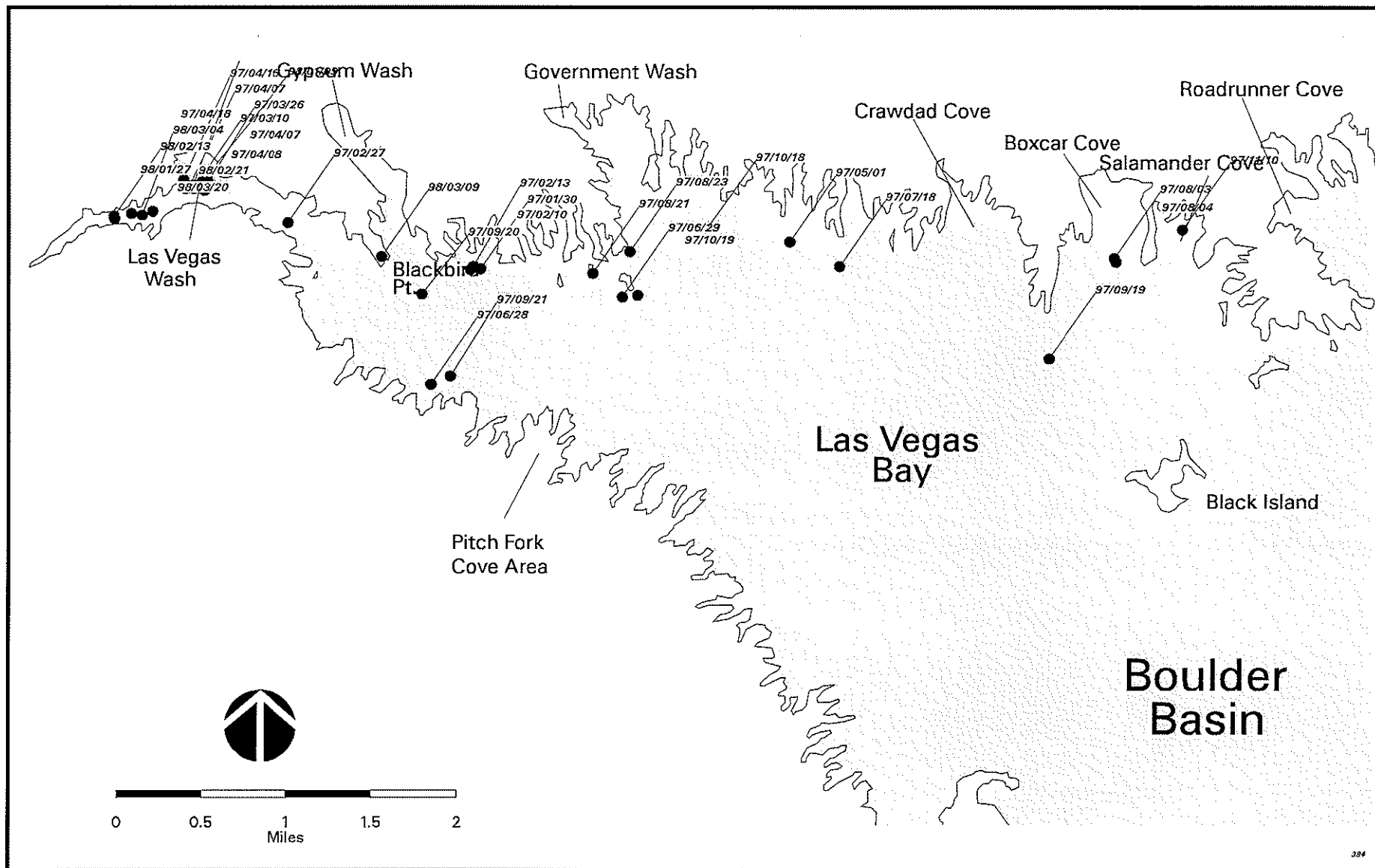


Figure 12. Distribution of fish number: 384.

was located in the Blackbird Point area. It was located back in the flowing portion of Las Vegas Wash on March 20, 1998. Fish 304 was not located in April, May, or June 1998.

Tag 464

This 604-mm TL male razorback sucker was implanted and released at Blackbird Point on January 5, 1998. Fish 464 was 0.5 mile north of Blackbird Point on January 9, 1998 (Figure 13). This fish was not found again until March 9 and 10 when it was located at Blackbird Point. This fish was last contacted at Boxcar and Crawdad Coves on May 19 and May 27, 1998, respectively.

Tag 2237

Tag 2237 was implanted into a 735-mm TL female that was caught and released at Blackbird Point on January 30, 1997. This fish was found later in the day 0.5 mile to the east along the north shore of Las Vegas Bay. Ten days later it was located less than 0.125 mile east of Las Vegas Bay Marina. Subsequent tracking on February 11 and 13 located this fish in the same general area. On February 26, this fish was located by sonic tracking and visually observed with SCUBA equipment. The fish appeared to be in good condition. On February 27, 1997, it was found about 2,000 feet to the east of the previous day's location, and on March 17 it had moved another 0.5 mile east near Government Wash. Fish 2237 was not located again even though extensive monitoring occurred in the Las Vegas Bay area.

Tag 2264

Tag 2264 was implanted into two different razorback sucker. A 560-mm TL male was caught, implanted with tag 2264, and released at Blackbird Point on January 30, 1997. Later that day this fish was located 0.5 mile further up Las Vegas Bay, closer to the inlet of the wash. February tracking for fish 2264 located it along the north shore of Las Vegas Bay, 0.5 mile east of Government Wash. The tag did not move again from this location until it was recovered with SCUBA on February 26, 1997. On April 6, 1997, this tag was implanted into a 581-mm TL male fish caught at Blackbird Point. This fish was found along the first point east of Blackbird Point on April 7 and 8 (Figure 14). On April 16 and 18, this fish was found off the west side of Blackbird Point; on May 1 it was back in the area where the tag had been recovered on February 26. On June 9, 1997, this fish was located on the western side of Blackbird Point.

Thirty-one points of contact were made with fish 2264 during the second year of the study. During mid summer this fish was generally found along the north shore of Las Vegas Bay, east of Government Wash. On July 17 and 18, 1997, it was 1 mile east of Boxcar Cove, and on August 3 and 4 it was located at Boxcar Cove. On August 23 and 24 this fish was located between Roadrunner Cove and Black Island. Then from October 18, 1997, through May 16, 1998 this fish was found at Blackbird Point in Las Vegas Wash.

Tag 2444

This 508-mm TL male razorback sucker was implanted on April 22, 1997, at Blackbird Point (Figure 15). Fish 2444 displayed similar affinity to the same three general locations as fish 294. On May 1, fish 2444 was found in the Las Vegas Wash channel above the lake, the only fish to actually be found moving up into the channel during the first year of the study. Tracking on May 6 located this fish at the central area of Las Vegas Wash along the western shore; on May 22 it was back at the inflow area of Las Vegas Wash. On June 9, 1997, fish 2444 was at the central area of Las Vegas Wash along the western shore.

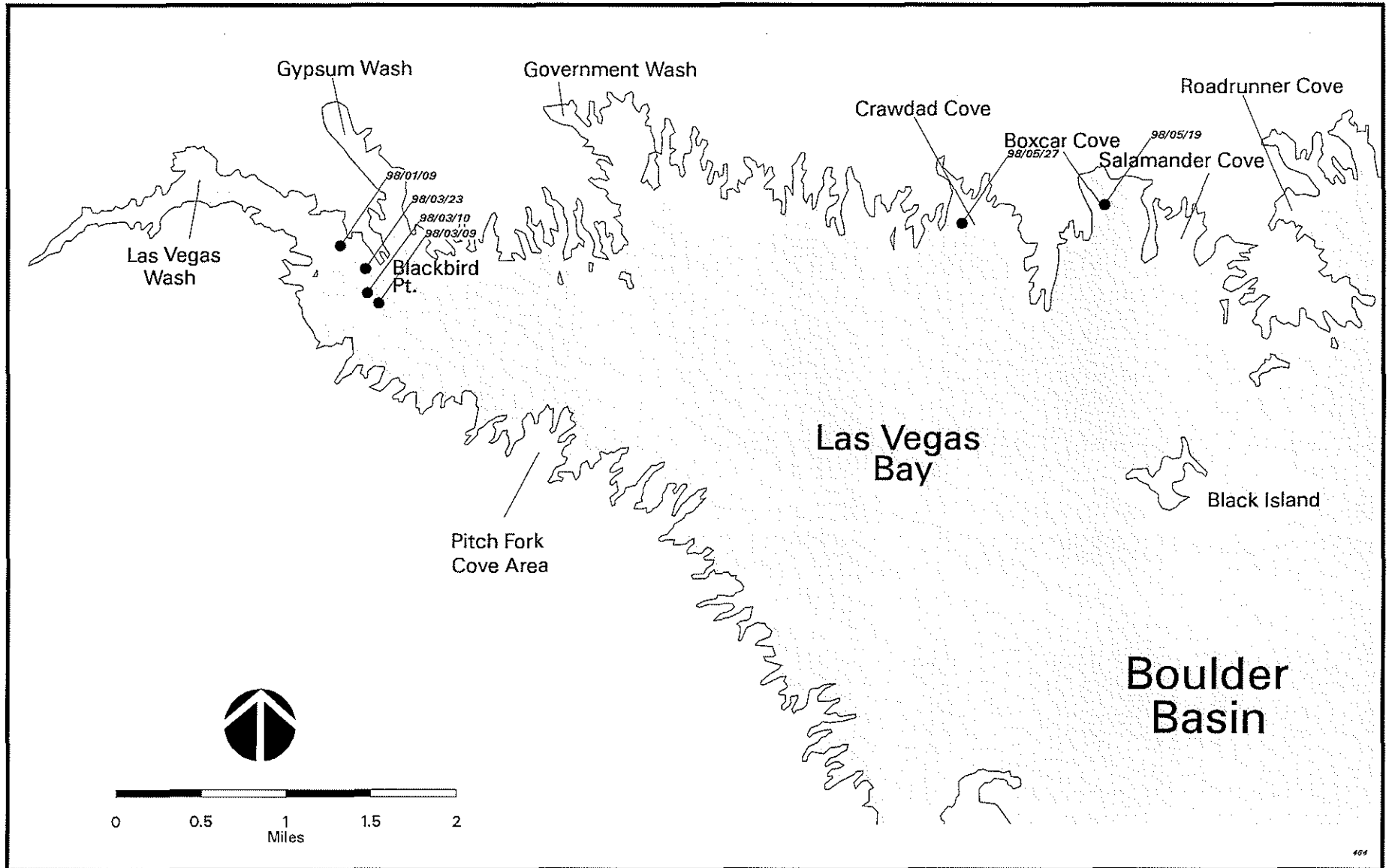


Figure 13. Distribution of fish number: 464.

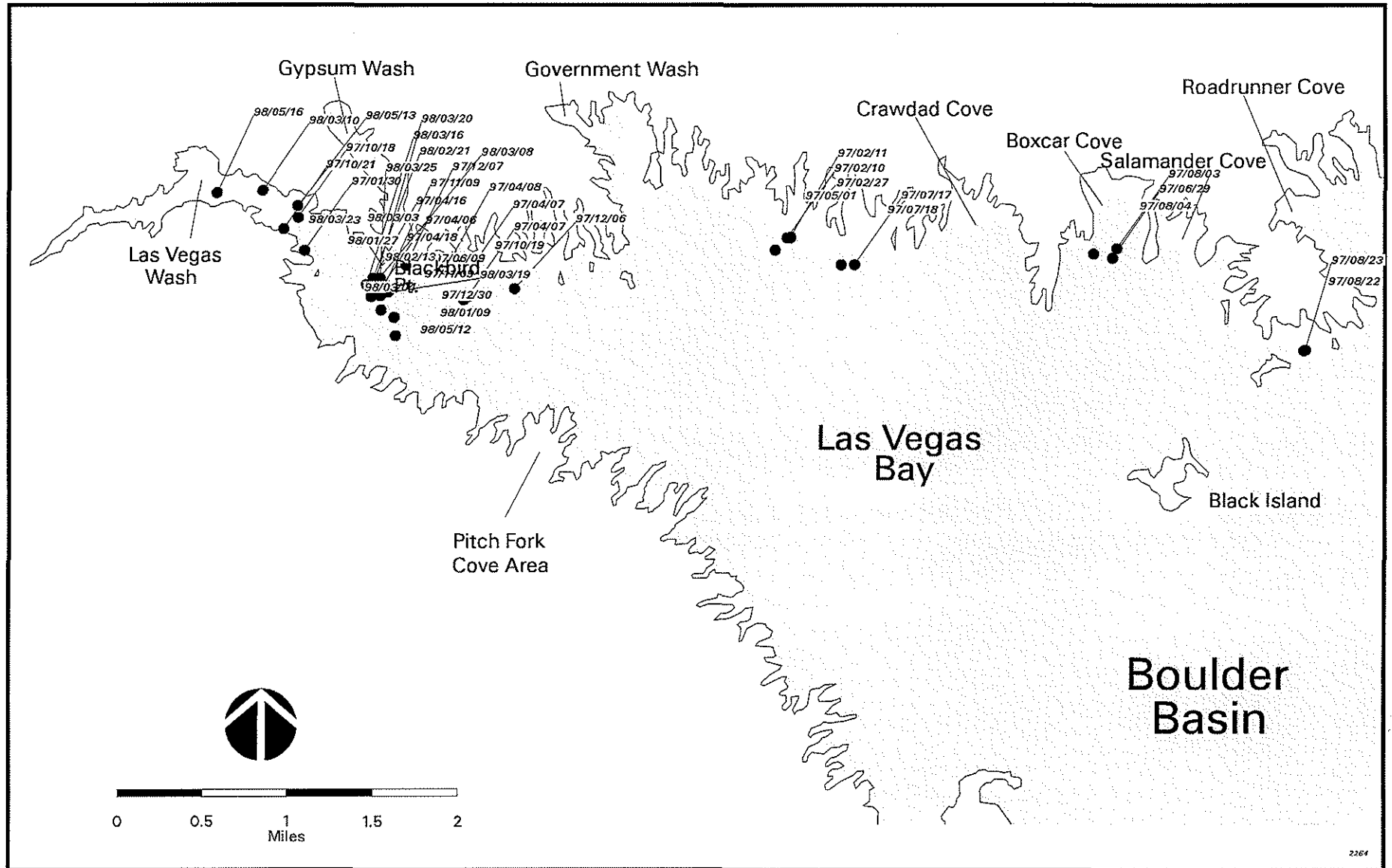


Figure 14. Distribution of fish number: 2264.

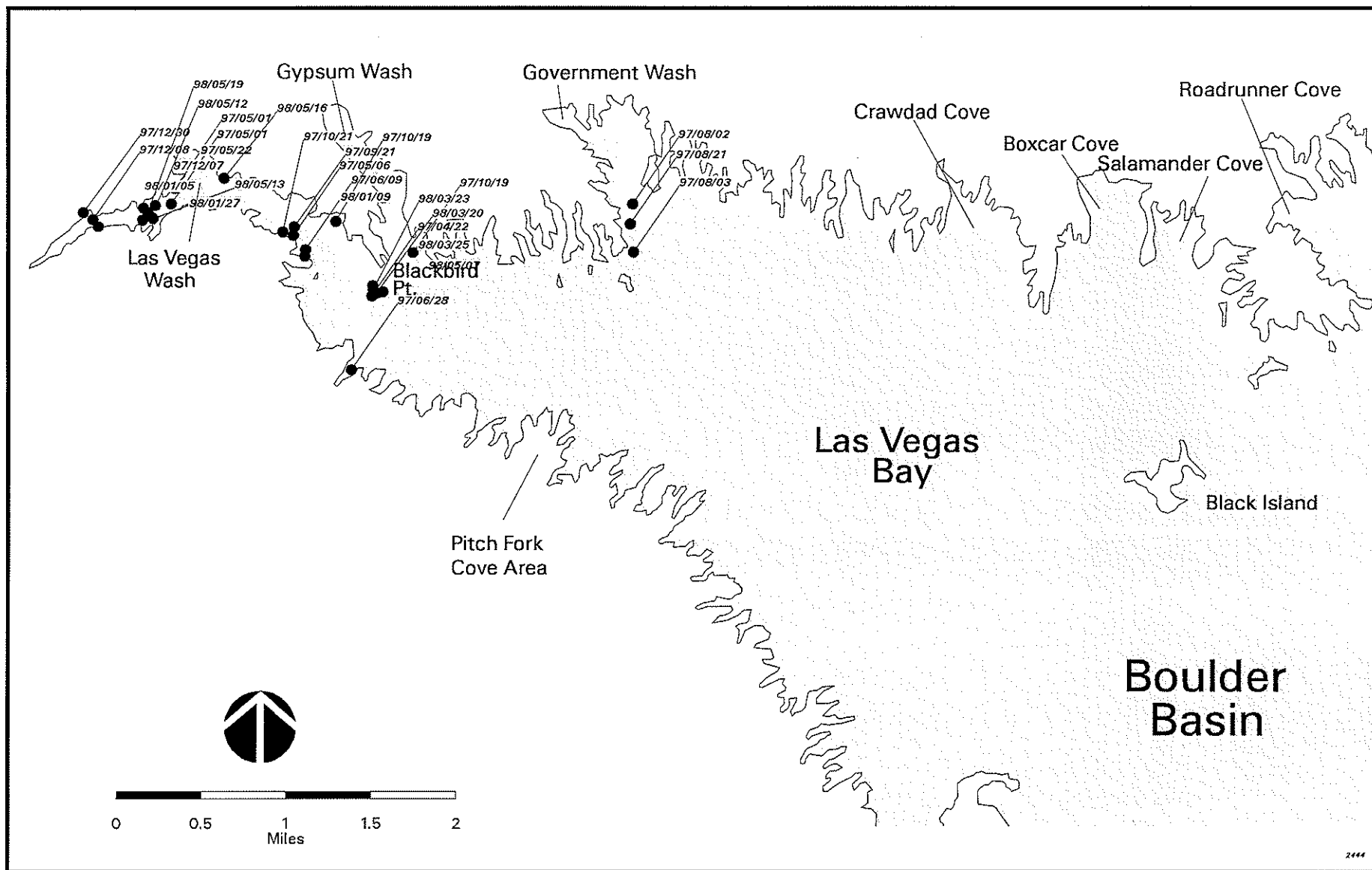


Figure 15. Distribution of fish number: 2444.

During the second year of this study, fish 2444 moved from the Government Wash area in August to Las Vegas Wash on September 21, 1997 (Figure 15). This fish remained in that area through October 21 and was then located in the flowing portion of Las Vegas Wash on December 7 and 8, 1997, and January 5, 1998. On January 9 it was located in nonflowing portion of Las Vegas Wash, and it was not located again until March. On March 20, 23, and 25, fish 2444 was located at Blackbird Point. It was not found during April and was next located on May 7 at Blackbird Point. On May 13 and 16, 1998, it was found in the nonflowing portion of Las Vegas Wash; on May 19 it had moved to the furthest upstream location in the flowing portion of Las Vegas Wash.

Tag 2525

This 662-mm TL male razorback sucker was implanted on April 18, 1997, at Blackbird Point. On May 1, 1997, this fish was found in the middle of Las Vegas Bay, 0.5 mile east of its release site (Figure 16). This fish could not be found during subsequent tracking in May or June 1997.

During the second year of this study, fish 2525 was located between Boxcar Cove and Swallow Bay on dates between August 3 and October 19, 1997 (Figure 16). On November 9, 10 and December 7 and 16 this fish was located in the nonflowing portion Las Vegas Wash. On January 5, 1998, it was found in the flowing portion of Las Vegas Wash. Then, from January 9 to March 9, 1998, this fish was found near Blackbird Point.

Echo Bay

Tag 79

This 630-mm TL male razorback sucker was implanted on January 15, 1998. All contacts with this fish were made either at Rogers Bay or at Echo Bay (Figure 17). After sonic-tagging, this fish was repeatedly found in Echo Bay through April 2, 1998. After the spawning period (on May 15, 21, 22, and 29, 1998) this fish was found at Rogers Bay.

Tag 88

This 318-mm TL juvenile razorback sucker was caught in Echo Bay, implanted with a 60-day tag, and released on December 10, 1997. This fish was next found on December 31, 1997, in a cove on the north shore of Echo Bay in about 15 feet of water. Because of disturbance from telemetry activities and the shallow depth, it was thought that the fish would have moved since the tag location did not change, SCUBA was used to recover this tag on January 6, 1998. No evidence was found of the implanted juvenile.

Tag 274

This 564-mm TL male razorback sucker was caught in Echo Bay and implanted on May 20, 1998. This fish exhibited a response to implanting that was similar to that exhibited by fish during the previous study year; its subsequent locations on May 21 and 22 showed movement to the north, away from the implant location (Figure 18). This fish had moved about 5 miles north in two days. This tag was found on May 29, 1998, in Calico Bay; it has remained in this location since that time.

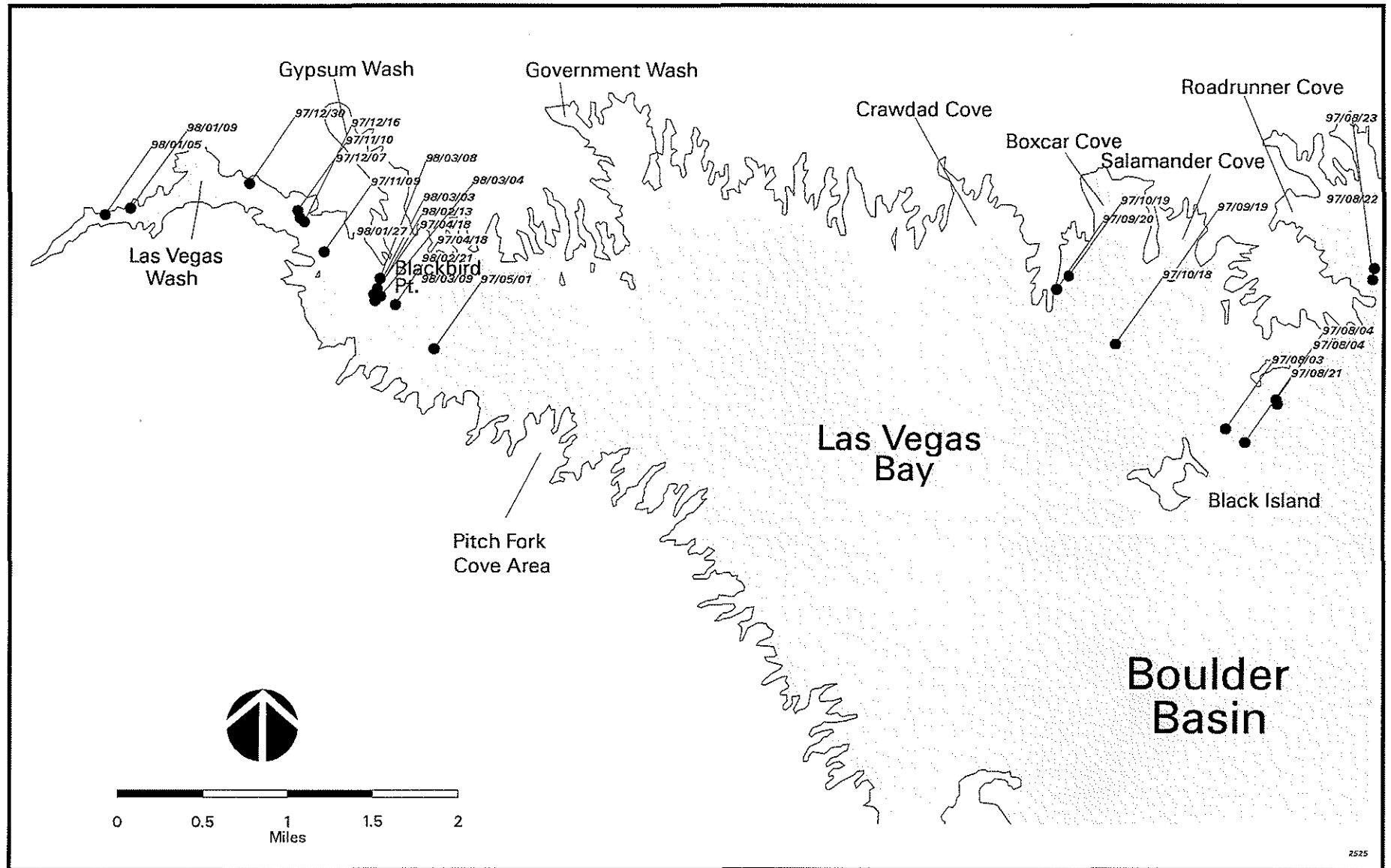


Figure 16. Distribution of fish number: 2525.

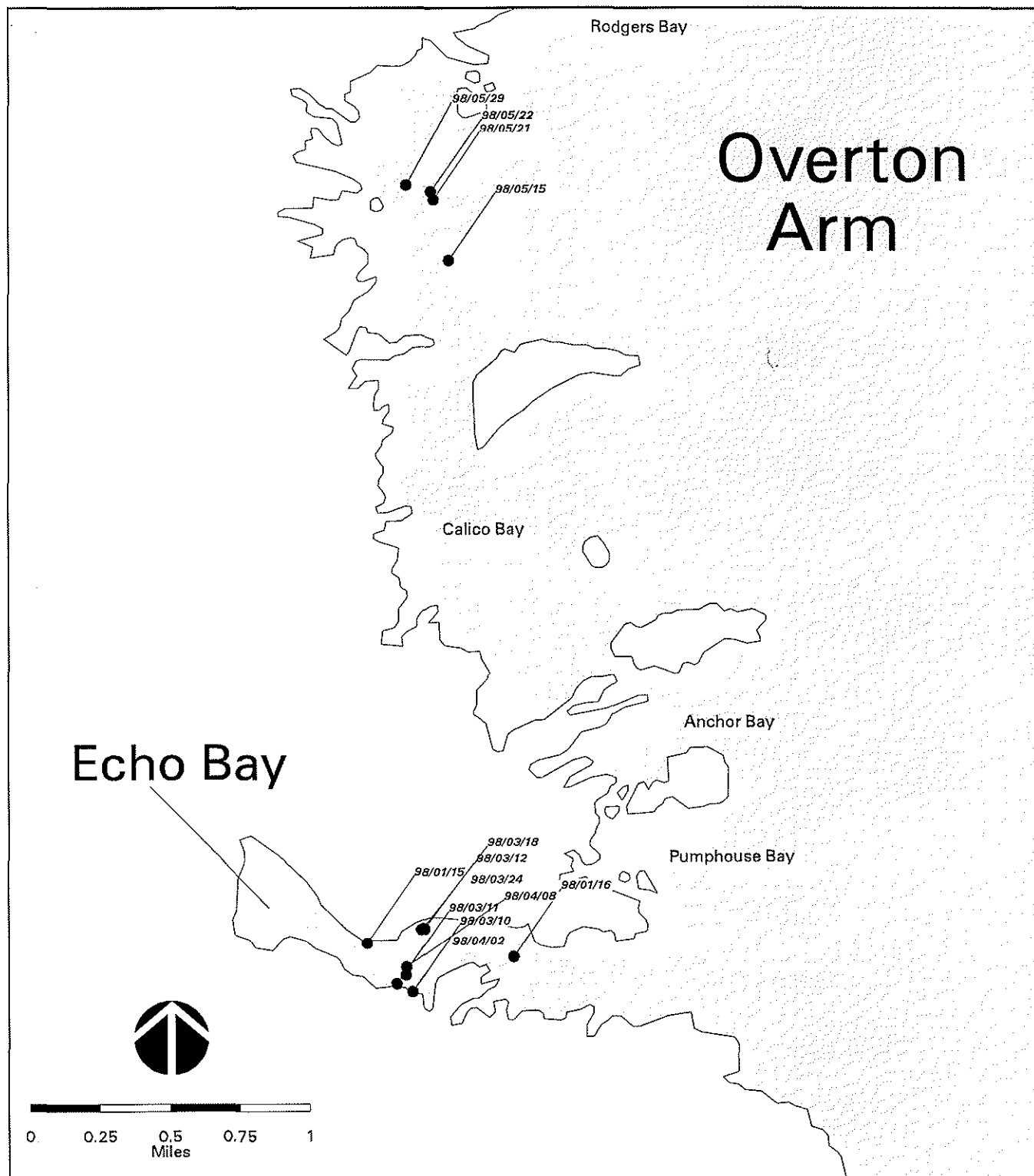


Figure 17. Distribution of fish number: 79.

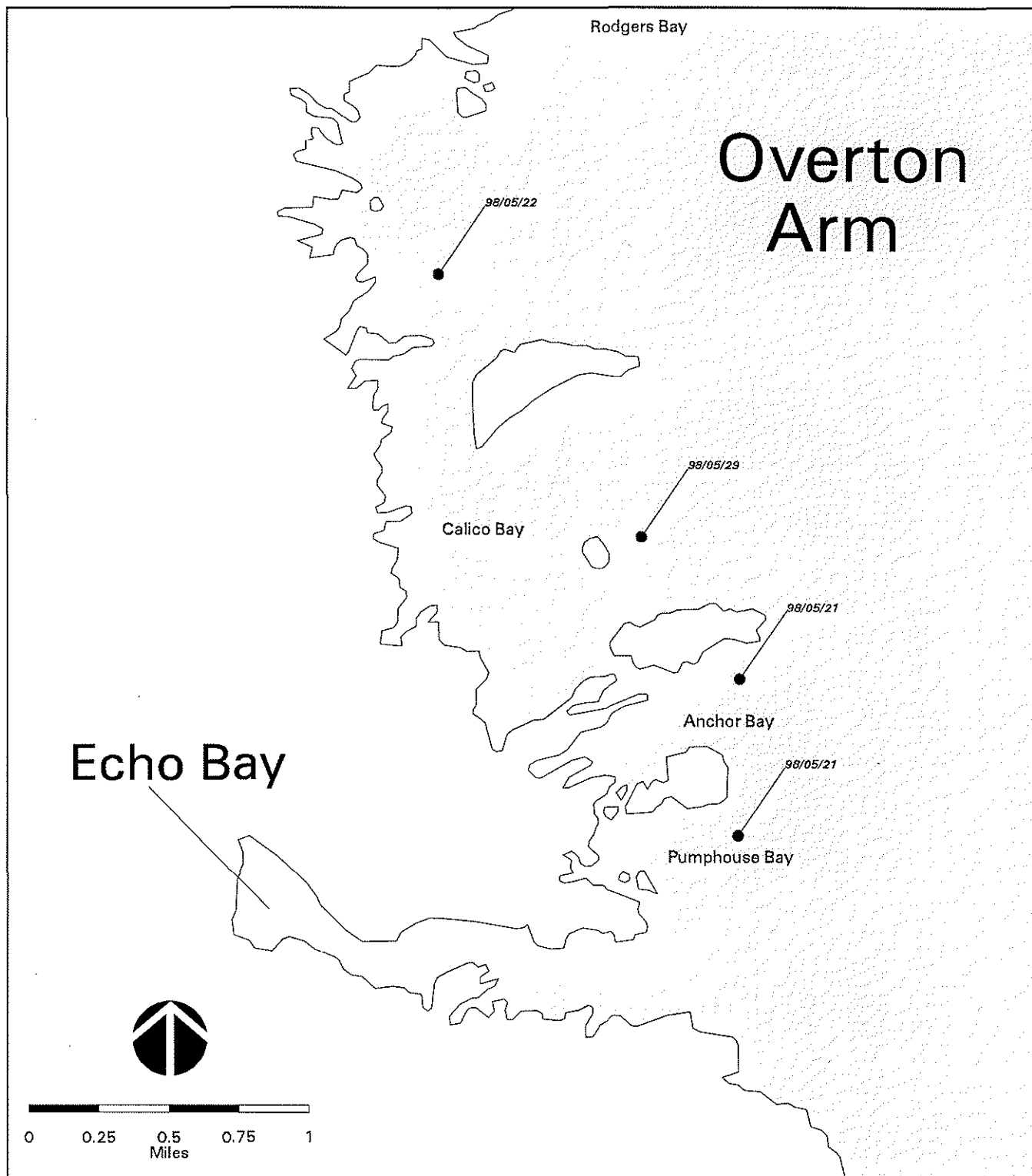


Figure 18. Distribution of fish number: 274.

Tag 357

This 591-mm TL female was one of five fish caught at Echo Bay and implanted on November 11, 1996 (Figure 19). Although this fish was implanted with a 14-month sonic tag, it was still providing locations in July 1998. Subsequently, it has been the most active fish of the study. Fish 357 was located at the south end of Rogers Bay on December 4, 1996. All subsequent positions for this fish were in Echo Bay during the spawning season. Specifically, this fish was on or near the spawning area until April 21, 1997, as is shown by the dense cluster of dots at the back of Echo Bay on Figure 22. Other sonic-tagged razorback sucker in the spawning location during the same time included fish 2255 on January 28; fish 2246, 2228, and 2255 on February 11; fish 2246 on March 8; and fish 3344 on April 21, 1997. Between April 21 and June 10, fish 357 was not located. On June 10 and 11, 1997, this fish was once again located in the center of Echo Bay.

Locations determined for fish 357 during the second season of the study were very similar to those of the past year (Figure 19). This fish was primarily found in Anchor Bay and Pumphouse Bay during July and August 1997. During September and October 1997, this fish was found in Echo Bay most of the time. On one occasion fish 357 moved from the mouth of Echo Bay on October 22, 1997, to Pumphouse Bay on October 23 and 25. On October 27 it was found in the back, western portion of Echo Bay. Fish 357 remained in Echo Bay and near the spawning area from late October 1997 through April 8, 1998. Similar to what occurred in late spring 1997, this fish was not found in May or June 1998. However, this fish was relocated in July 1998 in Echo Bay.

Tag 365

This 595-mm TL male razorback sucker was implanted on December 10, 1997. This fish was contacted in Echo Bay from the implant date through April 30, 1998 (Figure 20). On May 15 to 22, 1998, fish 365 was located in Rogers Bay. This fish was next located in Echo Bay on May 29 and 30. On June 6, 1998, it was again found in Rogers Bay.

Tag 455

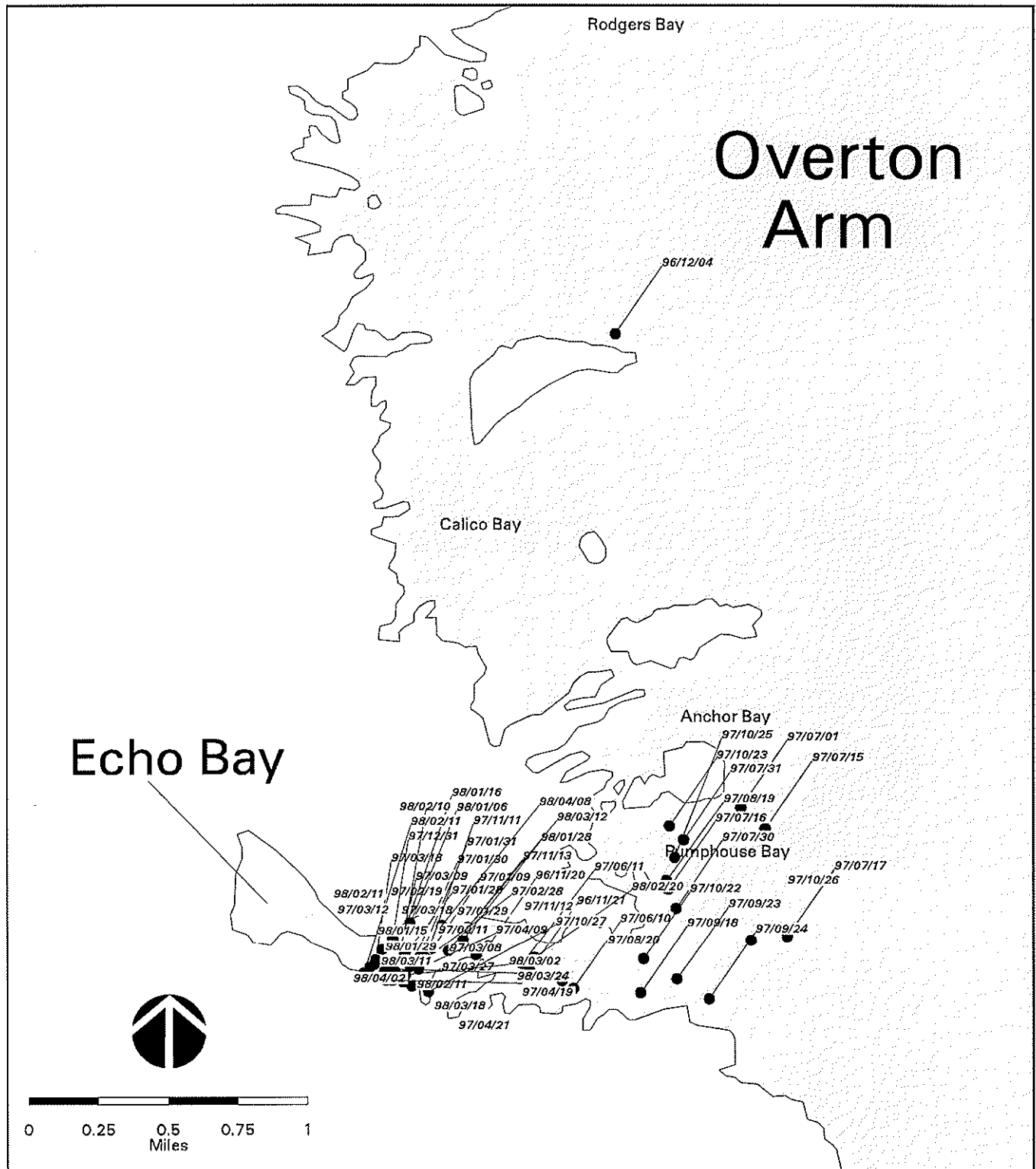
This 553-mm TL female was tagged on May 20, 1998, at Echo Bay. It was found several times on May 21 at different locations in the back of Echo Bay. This fish was not found again through June 1998.

Tag 555

This 381-mm TL razorback sucker was implanted with a 60-day tag on January 15, 1998. It was heavily scarred from the trammel net, and following surgery it was held in a live cage to make sure it would survive prior to release. It was found dead in the holding pen on January 22, 1998.

Tag 2246

This fish was a 590-mm TL male razorback sucker caught in the center of Echo Bay, implanted with a sonic tag, and released on January 28, 1997 (Figure 21). Fish 2246 was found in Echo Bay during February and March, and it was at the Echo Bay spawning location on February 11 and March 8. The largest distance traveled from point of release by any fish in this study occurred when fish 2246 was located in the northwest corner of Muddy Bay on April 20, a movement of about 15 miles. This fish was found again 10 days later (on April 30) in Muddy Bay, 0.5-mile southwest of its first location. Fish 2246 was next located in Echo Bay on June 10, 1997. On June 11 this fish was found just west of Pumphouse Bay.



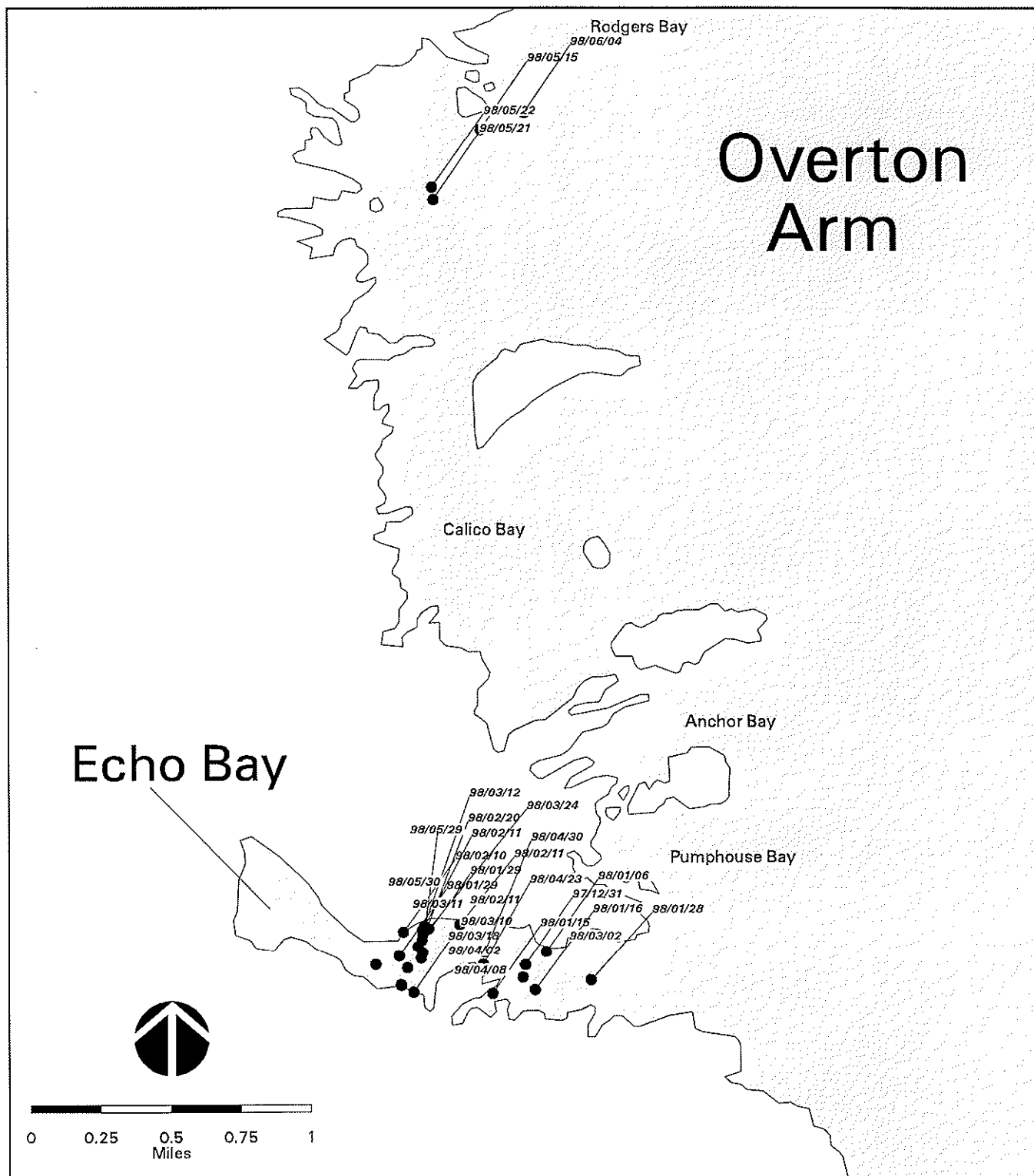
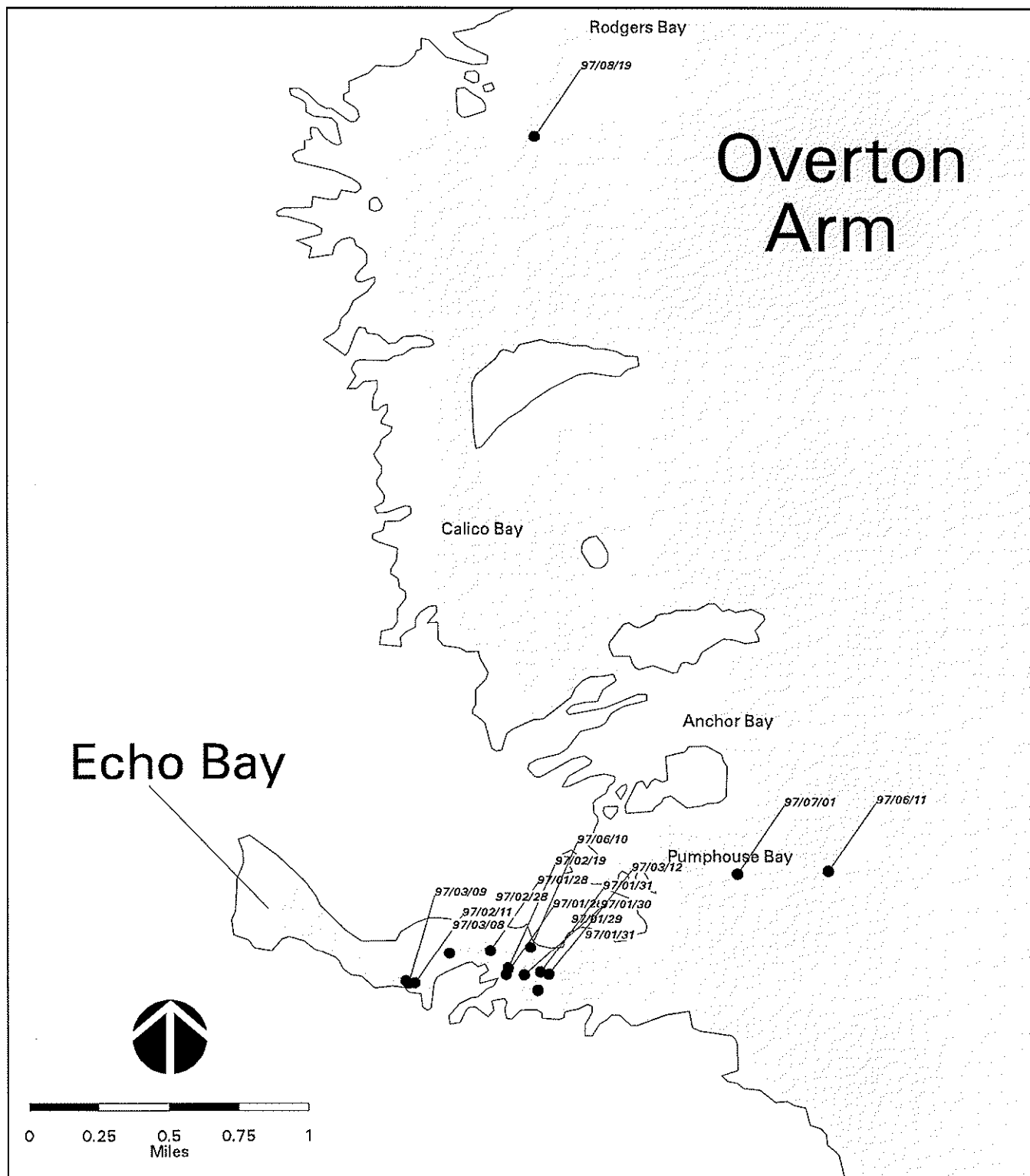


Figure 20. Distribution of fish number: 365.



During the second year of the study, this fish was found on July 1, 1997, at the center of Pumphouse Bay, and on August 19, 1997, at the center of Rogers Bay (Figure 21). This fish was not found after August 19.

Tag 2273

This 559-mm TL male was caught in Echo Bay and sonic-tagged on April 21, 1997. Fish 2273 was caught at the spawning site and was located again in this area on April 30 and May 7. This fish was also found on May 20, 1997, at the southern point that comprises Rogers Bay. During the second year of the study this tag remained stationary at its May 20 location in Rogers Bay.

Tag 2336

This 632-mm TL gravid female razorback sucker was caught in Echo Bay and sonic-tagged on April 21, 1997. Fish 2336 was located in the back of Echo Bay later in the day on April 21, and again on April 30. This fish was also found on May 20 along the western shore of Rogers Bay, and it was in the same location on June 11. During the second year of this study, tag 2336 remained stationary at its June 11 location in Rogers Bay.

Tag 2543

This 597-mm TL female was caught in Echo Bay and sonic-tagged on June 3, 1998. On June 4 this fish was found in Echo Bay. On July 7, 1998, this tag was located about 2 miles northwest of Overton Beach Marina in the Muddy Arm. This tag was sitting in 48 feet of water and had not moved since it was located in the Muddy Arm.

Tag 3344

This 573-mm TL male razorback sucker was caught at the Echo Bay spawning site and sonic-tagged on April 21, 1997. Fish 3344 was located in the spawning site on April 30 and May 7, as were fish 2273 and 2336 (Figure 22). Fish 3344 was found again on June 10 and 11, 1997, in the center of Echo Bay.

During the second year of this study, this fish was very active, ranging from Stewarts Point in the north portion of the Overton Arm south to Echo Bay (Figure 22). Fish 3344 was again found in Echo Bay July 1 and 2, 1997. On July 16 and 17 this fish was found in Rogers Bay. It was not located during August and was then found in Echo Bay on September 18, 1997. Following this date, this fish was continuously found in Echo Bay (except for October 26 and 27 when it was located in Calico Bay) through May 29, 1998. Fish 3344 was found in Stewarts Bay and Rogers Bay on June 4, 1998.

Summary

In general, most of the fish located with sonic-tagging and tracking equipment were relatively close to shore (usually within 200 yards) and in water less than 60-feet deep. Most fish also were stationary when located, and it was suspected they were on or near the bottom. The temperature sensing tags provided little additional information on depth of the fish during the winter because of the constant lake temperature. During the summer, fish above or within the thermocline could be readily distinguished from those below the thermocline. None of the sonic observations suggested the fish were more than a few feet from the bottom. Fish 2237, the only tagged fish that was actually observed during the study, was on the bottom when it was observed with SCUBA (Holden et al. 1997).

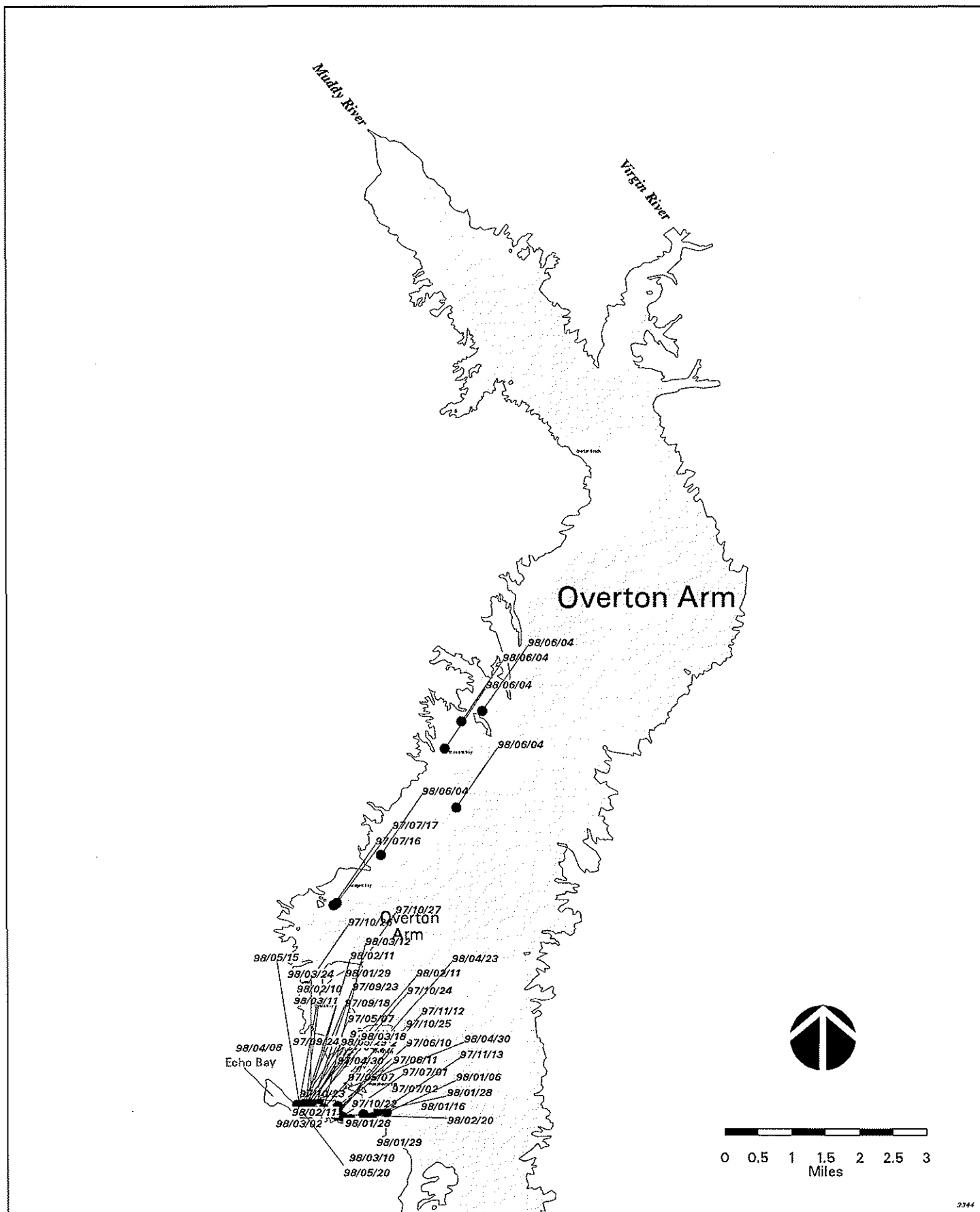


Figure 22. Distribution of fish number: 3344.

In addition, sonic-tagged fish from the two study areas did not overlap in distribution. Las Vegas Bay fish were only located in the Las Vegas Bay/Boulder Basin, and the Echo Bay fish were only located in the Overton Arm from Echo Bay north to near the mouth of Muddy River.

Three (247, 283, and 464) of the six sonic tags implanted in fish at Las Vegas Bay during the second study year were still active in May 1998. Two of the six tags became stationary after implantation. Tag 347 was found in the back of Government Wash and did not move from where it was first located. Tag 374 was found in Las Vegas Wash floating dead on the surface. Tag 238 was not found after release.

The five tags (276, 294, 384, 2264, and 2444) that were still active in Las Vegas Bay at the end of the first study year were still active through the beginning of 1998. One tag (2525) that was not found in May or June of 1997 reappeared and was found several different times at the end of 1997 and the beginning of 1998. Tag 2237 was not found after March 1997 during the first study year and was not found at all during the second study year.

Two of the seven sonic tags (79 and 365) implanted in fish at Echo Bay during the second study year were still active in May/June 1998. Tags 274 and 2543 became stationary after implantation, and tag 88 was recovered with no sign of the implanted fish. The fish tag 555 was implanted into was recovered dead from the holding pen it was placed in. Tag 455 was only found the day after it was implanted.

Two of the three tags (357 and 3344) active at the end of first study year were still active at the end of the second study year. The third tag (2246) was not found after August 1997, and tags 2273 and 2336 remained stationary at their May 1997 locations.

Larval Sampling

Las Vegas Bay Area

Areas sampled by Holden et al. (1997) were again sampled regularly during the 1998 spawning season. Primary sampling was in the vicinity of Blackbird Point, the suspected spawning area, with other sampling near the outflow of Las Vegas Wash and in nearby coves. Additional sites sampled in 1998 were located around the Pitch Fork Cove area on the south shore of Las Vegas Bay and in Salamander Cove on the north shore of Las Vegas Bay near the mouth of the bay (Figure 3).

Razorback sucker larvae were first collected on March 19, 1998, at Blackbird Point in Las Vegas Bay, and the last one was collected on May 5, 1998, in the Pitch Fork Cove area (Table 4). Similar numbers of larvae (82) were collected in the Blackbird Point area, for a catch-per-minute CPM of 0.08, and in the Pitch Fork Cove area (75), for a CPM of 0.13. As shown in Figure 3, some of the larvae in the Blackbird Point area were actually found near mid channel of the bay. These fish were found near a tire breakwater for the Las Vegas Bay Marina in about 80 feet of water. No larvae were found in Salamander Cove. The number of larvae collected in Las Vegas Bay was considerably higher in 1998 than 1997 (159 vs. 25, respectively).

Table 4. Number of razorback sucker larvae collected at four areas in Las Vegas Bay during 1998.

Date	Blackbird Point Area			Las Vegas Wash Area			Pitch Fork Cove Area			Salamander Cove Area		
	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM
3/03/98	50	0	0	NS ^a			NS			NS		
3/08/98	45	0	0	NS			NS			NS		
3/09/98	69	0	0	NS			NS			NS		
3/16/98	90	0	0	NS			NS			NS		
3/19/98	125	1	0.01	NS			NS			NS		
3/22/98	85	2	0.02	NS			NS			NS		
3/31/98	120	61	0.51	NS			NS			NS		
4/09/98	90	8	0.09	30	1	0.03	NS			NS		
4/10/98	NS			NS			NS			50	0	0
4/18/98	NS			NS			180	8	0.04	NS		
4/21/98	25	0	0	NS			95	54	0.57	NS		
4/24/98	30	4	0.13	62	1	0.02	50	2	0.04	NS		
4/27/98	NS			NS			180	10	0.06	NS		
4/28/98	180	6	0.03	NS			NS			NS		
5/05/98	120	0	0	NS			60	1	0.02	NS		
Total	1029	82	0.08	92	2	0.02	565	75	0.13	50	0	0

^aNS = not sampled

Echo Bay Area

Sampling for razorback sucker larvae was initiated on February 20, 1998. This was the approximate time period sampling was started the previous year (Holden et al. 1997). Sonic-tagged adult razorback sucker had congregated in known spawning areas by this time; however, no obvious redds were observed. A shoreline walk around Echo Bay on March 2 revealed an area in a cove off the south shore that appeared to have been cleaned of silt and sand. This cove was used for spawning in 1997 (Holden et al. 1997), and sonic-tagged adults were again gathering in and around it.

Sites that larvae were routinely sampled and collected at during the 1997 spawning season (Holden et al. 1997) were sampled during 1998. Additional sites were sampled during 1998 in an effort to find other potential spawning locations, and they included sites in Rogers Bay, Calico Bay, and the Anchor/Pumphouse Cove area. Sampling sites are shown on Figure 4. Sampling continued almost weekly through May 15, 1998.

The first razorback sucker larvae were collected at Echo Bay on March 11, 1998, and the last larvae was collected on April 30, 1998, at the Calico Bay site (Table 5). Numbers of larvae collected at Echo Bay were substantially less than found in 1997. During 1997, over 5,000 larvae were collected for a CPM of 3.95, whereas in 1998 only 197 larvae were collected for a CPM of 0.19. No larvae were collected at Rogers Bay, while Anchor Cove and Calico Bay produced one larval razorback sucker each. The total number of larvae collected in the Echo Bay area was substantially less in 1998 compared with 1997 (about 200 versus 5,000, respectively).

Gregg Basin

Sampling for larval razorback sucker at Gregg Basin was conducted March 14 to 16, 1998. Sampling was conducted for 30 minutes at 18 locations. All sampling locations were established along the eastern shore of the basin in areas that appeared to have the best spawning habitat. However, after sampling about 8 miles of the eastern shoreline, no razorback sucker larvae were collected.

Juvenile Sampling

Sampling for juvenile razorback sucker was again conducted on a limited basis. Gear availability was the limiting factor in effectively sampling for juvenile fish. Techniques used in 1998 for juvenile sampling were similar to those used by Holden et al. (1997), with the addition of electrofishing. Table 6 shows effort expended by gear type. No juvenile razorback sucker were collected using minnow traps, hoop nets, gill nets, or electrofishing. However, four presumptive juveniles were captured in trammel nets during adult sampling in Echo Bay. Total lengths of these fish ranged from 318-mm to 381-mm. Most other fish (TL ranging from 555-mm to 692-mm) collected by trammel netting during this time period were in spawning condition, while these four juveniles showed no signs of sexual maturity.

Table 5. Number of razorback sucker larvae collected at four areas in the Overton Arm during 1998.

Date	Echo Bay Area			Rogers Bay Area			Anchor Cove/ Area			Calico Bay		
	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM	Minutes sampled	Larvae collected	CPM
2/20/98	95	0	0	NS			NS			NS		
3/01/98	50	0	0	NS ^a			NS			NS		
3/02/98	48	0	0	NS			NS			NS		
3/10/98	100	0	0	NS			NS			NS		
3/11/98	100	1	0.01	NS			NS			NS		
3/17/98	120	31	0.26	NS			NS			NS		
3/18/98	100	32	0.32	NS			NS			NS		
4/01/98	90	35	0.39	NS			NS			NS		
4/02/98	60	39	0.65	55	0	0	NS			NS		
4/08/98	120	59	0.49	NS			NS			NS		
4/22/98	121	0	0	NS			NS			NS		
4/29/98	NS			NS			150	1	0.01	30	0	0
4/30/98	NS			NS			NS			180	1	0.01
5/15/98	90	0	0	NS			NS			NS		
Total	1094	197	0.19	55	0	0	150	1	0.01	210	1	0.005

^aNS = not sampled

Table 6. Sampling effort for juvenile razorback sucker in Lake Mead at each site by gear type, July 1997 through June 1998.

Gear Type	Effort	
	Echo Bay	Las Vegas Bay
Electrofishing		
30-60 Hz Pulsed Direct Current	130 minutes	
Gill Net		
100' x 4', experimental, mesh ^a		10.5 net hours
Hoop/Fyke Nets		
3' fyke, 0.125" mesh	2 net nights	
2' hoop, 0.25" mesh	4 net nights	
Minnow Traps		
0.125" nylon mesh	36 trap nights	18 trap nights

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

Age Estimation of Razorback Sucker

One otolith was recovered from the 381-mm TL juvenile (Tag 555) that died in a holding pen in Echo Bay on January 22, 1998. It was difficult to read, with annular marks not clearly defined. However, four to five potential annuli were identified. Pectoral fin ray sections from the same fish revealed four fairly distinct annuli and one to two potential annular marks. Otoliths from the 588-mm TL adult male found in Las Vegas Bay (Tag 374) revealed seven fairly distinct annular marks and three to four additional marks that were potential annuli. Pectoral fin ray sections also revealed seven to ten potential annular marks. Opercular bones from both fish were difficult to read, but presumptive annuli tended to support age estimates from otoliths and fin ray sections. Scales from razorback sucker inhabiting Lower Colorado River Basin reservoirs have typically not shown distinct annular marks, and the fish aged during this study followed that pattern.

New Population Estimate

Sampling from July 1997 to June 1998 provided an additional 45 razorback sucker captures, including several recaptures, to use in a new population estimate. Since neither the capture data nor the sonic tracking information suggested there was mixing between the Las Vegas Bay and Echo Bay populations of razorback sucker (for either the first or second years of the study), separate population estimates were made for each location. Capture data from 1990 to 1995 had been assimilated and used in the initial population estimate conducted in 1996. A second population estimate was made for the first annual report (Holden et al. 1997) using all the data from the 1990s. Stocked fish, including the recaptured stocked fish, were not used in the population estimates. That

same protocol was used to make the second-year population estimate. In addition, a new population estimate was also calculated with data that were collected only during BIO/WEST research in 1996, 1997, and 1998. This second estimate, of only the last two years of data, was completed since sampling during this period has been relatively systematic, more so than sampling conducted previously.

Table 7 shows the results of the population modeling using the Schnabel model and six different models from the program CAPTURE. The capture of an increased number of marked fish at Las Vegas Wash decreased the population estimate in that area from 300 to 400 individuals to 170 to 200 individuals (estimated using all data). The population estimate using only BIO/WEST sampling data further reduces the estimate to about 80 to 90 individuals since most of the recaptures at this site were fish originally tagged by BIO/WEST during the past 2 years. The capture of more untagged fish in the second year at Echo Bay caused the population estimate there to increase from 50 to 60 individuals to about 80 to 90 individuals (estimated using all data). The population estimate using BIO/WEST sampling data only does not change this estimate.

DISCUSSION

Data collected during the second year of the Lake Mead razorback sucker study have expanded on the information that was collected during the first year, and they have provided new information for several aspects of razorback sucker life history in Lake Mead. The spawning areas that were identified at Echo Bay and Blackbird Point during the first year of the study were also used during the second year. Larval light trapping, trammel netting, and sonic telemetry results indicated that adult razorback sucker used these two areas for spawning and subsequently produced larval razorback sucker in spring 1998. Identification of other spawning areas in the lake was attempted using these same methods, as well as aerial observation via helicopter. Effort varied among sampling gear type. Light trapping performed in Echo Bay and Rodgers Bay found larvae concentrated in the back portion of Echo Bay concurrent with the previous year. Larval sampling conducted in the outer portion of Echo Bay and along the western shore of Overton Arm north of Echo Bay did not identify any specific spawning areas; however, one larvae was found in Anchor Bay and one was found in between Calico Bay and Rogers Bay (Figure 3). These larvae were probably spawned at the Echo Bay site and then drifted into the areas where they were sampled. However, it is possible that the Calico Bay larval razorback sucker was spawned in this area considering several sonic-tagged razorback sucker were tracked in this area. In addition, four adult razorback sucker were netted in July 1997 at the northern portion of Rogers Bay (about 1.5 miles north of the location where the larval fish was found).

Larval sampling conducted in Las Vegas Bay at locations other than Blackbird Point had mixed results. Larval sampling conducted at the inflow area of Las Vegas Wash, points along the northern shore of Las Vegas Bay between Blackbird Point and Government Wash, and at the Pitch Fork Cove area was successful in finding larval fish (Figure 2). As with the Echo Bay area, it is likely that the larval razorback sucker found at these areas are a result of drift from wave and wind action. Because a relatively high concentration of larvae was only found in the Pitch Fork Cove area, it is probably the only area of the three where a potential spawning area might exist. However, because no sonic-tagged fish were found in this area over the last 2 years of tracking and no adults were found during

Table 7. Comparison of first study year population estimates for Lake Mead razorback sucker using data collected October 1990 through June 1997 with new estimates using additional data collected during the second study year from July 1997 through June 1998.

	FIRST YEAR LAS VEGAS BAY ALL DATA		SECOND YEAR LAS VEGAS BAY ALL DATA		SECOND YEAR- 10/1996 - 6/1998 DATA LAS VEGAS BAY		FIRST YEAR ECHO BAY ALL DATA		SECOND YEAR ECHO BAY ALL DATA		SECOND YEAR 10/1996 - 6/1998 DATA ECHO BAY	
ESTIMATOR	MEAN	95% c.i.	MEAN	95% c.i.			MEAN	95% c.i.	MEAN	95% c.i.		
Schnabel M_t	282	106-1014	173	110-322	86	50-209	52	41-109	71	57-120	86	57-171
Model M_o	399	165-1114	214	137-370	97	60-189	62	48-92	81	66-109	92	65-151
Darroch M_t	342	155-862	211	136-364	94	59-178	57	46-82	79	65-105	89	63-144
Chao M_t	286	133-727	172	114-297	78	51-149	50	42-72	80	64-119	81	58-139
Chao M_h	452	177-1325	197	125-354	96	58-199	59	46-94	87	67-134	94	63-171
Chao M_{th}	398	158-1181	204	133-348	92	57-180	57	45-87	85	66-129	90	63-151
Jackknife M_h	167	133-216	189	143-262	91	68-130	62	50-86	92	73-128	93	71-134

trammel netting efforts, it is likely that the larvae sampled in this area drifted from the Blackbird Point area.

Aerial surveys used in March 1998 to locate new concentrations of spawning adults found none. This method has been used on Lake Mohave with success, and it has generally revealed spawning aggregations during the razorback sucker spawning season. Conditions were near perfect on Lake Mead for the flight which resulted in many common carp identifications. Razorback sucker were not sighted during the flight at the two previously identified spawning locations. This method of locating new aggregations may not be very dependable in Lake Mead.

Overall, numbers of larvae collected at Las Vegas Bay and Echo Bay were substantially different from the previous year. Number of larvae at Echo Bay decreased from about 5,000 the first year to about 200 the second year. Reasons for this decrease may include variability in sampling conditions and differences in lake level between the first and second study years. Larval sampling on Lake Mohave has shown that wind direction can cause great night-to-night differences in larval sampling success (M. Burell 1998, NDOW, pers. comm.). Wind blowing toward the shore in an area where spawning has occurred helps to congregate larval razorback sucker and may help to produce as many as 1,000 to 2,000 larvae per night of sampling. Results in the same area with wind blowing in an off-shore direction have been reported as a magnitude of order less. This same phenomenon probably had a similar effect on the larval sampling results in the Echo Bay area.

The increase in lake level probably also contributed to the decreased number of larvae found during the second year of sampling. Lake level increased an average of 15 feet between the 1997 and 1998 spawning season. This increase caused the cove at Echo Bay, in which the concentrated number of larvae were found in 1997, to nearly double in size. This increase, coupled with variable wind direction during sampling, could partially explain the lower numbers of larvae found in 1998 at Echo Bay.

The Las Vegas Bay larval sampling results for the 1998 spawning year increased in total from 25 larvae found in 1997 to about 160 found in 1998. Number of larvae collected in the Blackbird Point area increased from 25 in 1997 to 82 in 1998. Large numbers of larvae (73) were also collected at the Pitch Fork Cove area (Figure 3). The larvae collected in this area were likely fish that drifted from the Blackbird Point spawning area.

The spawning period for razorback sucker in Lake Mead was determined from captured ripe adults, movement patterns of sonic-tagged fish, and collection of larvae. The spawning period for 1998 was similar to the period observed in 1997. Spawning was probably initiated at Echo Bay in 1998 at the beginning of March and lasted through mid to late April, but spawning significantly tapered at the beginning of April. In comparison, the spawning period at Echo Bay in 1997 ran from about late February through the beginning of May, with considerable tapering at the beginning of April. The 1998 spawning period at Las Vegas Bay began in mid March and lasted through the beginning of May. In comparison, the spawning period for 1997 in Las Vegas Bay began in mid to late March and lasted through mid April.

Trammel netting during the second study year resulted in a sizeable reduction of total razorback sucker (45) captured compared with the first study year (71). Sampling effort was relatively equal between the two study years, totaling 134 net nights for the first sampling year and 137 net nights for the second sampling year. Differences in catch rate between the first and second study years (#/net night) were most noticeable at Echo Bay decreasing from a CPE of 0.85 to a CPE of 0.32. Change in catch rate between study years for Las Vegas Bay was minimal, increasing slightly from 0.29 to 0.34. Differences in the overall catch rate between years may partially be a result of the time of year sampling was conducted for each study year. For example, seven razorback sucker were captured in April 1997 in Echo Bay in 4 net nights, but no sampling occurred in April 1998. More effort at the Echo Bay study area was also directed at other coves in 1998, and effort continued during summer and fall months. All of these factors may help lead to a lower catch rate.

Sonic telemetry and trammel netting data have shown that the largest concentrations of razorback sucker occurred during the spawning season. These fish were usually closer to shore and more active during this time, allowing for higher catch rates. During the first spawning season sampled, netting was conducted during all spawning season months (February through May). Forty-one fish were netted, and 17 of those were caught during the month of April. Total number of fish netted during the second spawning season sampled decreased to 27. However, trammel netting was not performed in April 1998 in order to reduce stress on spawning adults.

The razorback sucker population estimate conducted after the first study year, using data from 1990 through 1997, resulted in estimates of about 400 individuals at Las Vegas Bay and 50 to 60 individuals at Echo Bay with high confidence intervals estimated for both populations. The additional capture data obtained for the second study year were incorporated into two new populations estimates. The estimate calculated with data from 1990 through 1998 determined means of 170 to 200 individuals at Las Vegas Bay and 70 to 80 individuals at Echo Bay. (The confidence intervals decreased and thereby provided a more precise estimate.) The calculations with just the data from BIO/WEST sampling changed the estimate to 90 to 100 individuals at Las Vegas Bay and 80 to 90 individuals at Echo Bay. The changes between these estimates from year to year represent changes in accuracy and not actual increases or decreases in population number.

All captured razorback sucker for both the first and second study years were similar in condition to the "young-looking" suckers that were caught previously by the NDOW. These suckers had healthy fins and almost no incidences of lesions, tumors, blindness, or parasites. The four juveniles that were captured between December 1997 and March 1998 further indicate that razorback sucker in Lake Mead are a young population.

Aging performed on a juvenile and an adult razorback sucker further confirms that the Lake Mead population is young and has limited recruitment. The juvenile razorback sucker (381-mm TL) was estimated at 4 to 5 years old, and the adult (588-mm TL) was estimated at 7 to 10 years old.

Growth of Lake Mead adults as measured during the first and second study years continues to rank as the highest recorded for any wild population where growth has been determined. McCarthy and Minckley (1987) analyzed Lake Mohave adult growth from otolith data and suggested that growth was a few mm per year. This was recently reconfirmed by analysis of growth by Pacey and Marsh (1998). McAda and Wydoski (1980) and Tyus (1987) indicated growth estimates from the Green

River population of razorback sucker based on mark/recaptured fish was 2 to 3 mm per year. Growth rates for the first 2 years were similar at each study site, and Echo Bay razorback sucker had a lower rate (11 mm per year) compared with the Las Vegas Bay fish (22 mm per year). Faster growth at Las Vegas Bay may be due to higher food levels, especially zooplankton, caused by higher nutrient levels because of the inflow of Las Vegas Wash.

Second study-year sonic-telemetry results indicated that razorback sucker continued to frequent the high-use areas identified during the first year of the study including: Echo Bay, the northwestern shore of Overton Arm, Blackbird Point, Las Vegas Wash, and the northern shore of Las Vegas Bay. However, during the spawning season razorback sucker were often found in the flowing portion of Las Vegas Wash (below full pool elevation). The 13 additional fish implanted during the second year of the study had about the same implant success as the original 21 razorback sucker that were implanted during the first year of the study. This involved about a 50 percent inactivity rate, indicating that either the implanted fish died and the tag sank to the bottom or the fish expelled the tag and recovered from the resulting open wound. However, although trammel netting in Lake Mead has yielded sonic-tagged razorback sucker on four recaptures, it has not resulted in capture of sonic-implanted razorback sucker that had shed their tags. Similar studies conducted on other populations of razorback sucker have shown that either of the two scenarios is possible and that a 50 percent inactivity rate is fairly common (Burdick and Bonar 1997, Ryden 1997). Ryden (1997) implanted radio tags in 74 juvenile and subadult razorback sucker from 1994 to 1996 and had 42 (57%) become inactive either in holding ponds or after stocking in the San Juan River.

Sonic-tagged razorback sucker have provided invaluable information to this project, including location of spawning areas and seasonal habitat-use data. However, from the number of sonic tags that were recovered or have become stationary, it is clear that continuing to implant more razorback sucker with sonic tags using the current methods would have a negative effect on the populations at Echo Bay and Las Vegas Wash. For this reason, sonic-tags will only be implanted in fish that are caught in other areas of the lake. If more implants are needed at Las Vegas Bay or Echo Bay, noninvasive methods (external attachment) will be used to ensure the survival of the tagged fish.

RECOMMENDATIONS FOR THE THIRD YEAR OF STUDY

The same general research objectives pursued during the first 2 years of the study will be focused on for the third year of the study. These include:

1. Continuation of monthly trammel netting at Echo Bay and Las Vegas Bay to determine the population size of 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 net and initiate sonic tag implants and telemetry if new concentrations of razorback sucker are found; and
5. Sampling for juvenile suckers at the Echo Bay and Blackbird Point/Las Vegas Bay study sites.

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