LAKE MEAD RAZORBACK SUCKER MONITORING RECOMMENDATIONS

2005-2006 REPORT

PR-977-2

September 2006

Sonic telemetry on Lake Mead.

Trammel netting on Lake Mead.

Larval sampling on Lake Mead.

Submitted to:
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EXECUTIVE SUMMARY

In 1996 the Southern Nevada Water Authority (SNWA) and the Colorado River Commission of Nevada, in cooperation with the Nevada Department of Wildlife (NDOW), initiated a study to develop information about the Lake Mead razorback sucker (*Xyrauchen texanus*) population. BIO-WEST, Inc. (BIO-WEST), under contract with the SNWA, developed the study design and has had primary responsibility for conducting the study. Nevada Department of Wildlife provided equipment, technical support, and field support for the project. Other agencies that joined as cooperators at the beginning of the study included: the U.S. Bureau of Reclamation (Reclamation), which provided funding for equipment, storage facilities, and technical support; the National Park Service (NPS), which provided residence facilities in their campgrounds; and the U.S. Fish and Wildlife Service (USFWS) and Arizona Game and Fish Department (ADGF), both of which assisted with permitting issues.

This document serves as a companion report to the 2005–2006 Annual Lake Mead Razorback Sucker Studies Report (Albrecht et al. 2006). This document was prepared in response to requests by collaborative agencies to provide direction for long-term monitoring efforts of razorback sucker on Lake Mead.

Data obtained during cumulative years of sampling on Lake Mead were used to select the locations, methodologies, and times when the most informative data on razorback sucker population dynamics could be collected to add to the long-term database initiated by BIO-WEST's Lake Mead razorback sucker study. Analyses of the Lake Mead database were performed to provide insights that would help ensure increased sampling efficiency, while maintaining data quality during future monitoring efforts. Given that more than 10 years of data were evaluated during the construction of many portions of this report, coupled with other qualitative and anecdotal observations of Lake Mead razorback sucker obtained during the past decade, the following information should prove useful to various user groups under a wide variety of lake conditions. This companion report and past annual reports indicate that there is a need, as well as utility, in maintaining the long-term Lake Mead razorback sucker database through future monitoring efforts.

Future monitoring should include: continuing to monitor the two populations of razorback sucker at Echo Bay and Las Vegas Bay, aging individual razorback sucker from Lake Mead, monitoring larval fish, and if at all feasible, continuing to investigate and monitor razorback sucker use of the Muddy River/Virgin River inflow area of Lake Mead. We recommend continued sampling activities during February–April for adult, subadult, and juvenile razorback sucker, and March–April for larval fish. These dates appear to be the most effective times for maintaining the long-term database in an efficient manner.

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INTRODUCTION AND OBJECTIVES

A study of razorback sucker (*Xyrauchen texanus*) in Lake Mead was initiated in 1996 and is ongoing. The study has been fairly comprehensive, with sampling for adults, subadults, juveniles, and larvae, and included special, technical studies such as sonic telemetry and aging of captured fish. Various efforts were expended essentially year round. Guidance for the study has come from a group of collaborative agencies. Funding to maintain the extensive and thorough nature of the study may not be available in the future so the involved agencies have requested development of a monitoring plan that outlines the minimal effort needed to continue to track the razorback sucker populations in Lake Mead. We have identified the following objectives as important items to monitor during future efforts:

Objective 1

Track the razorback sucker population trends in Lake Mead, and identify any changes in the relative size and overall health of known spawning populations.

Objective 2

Track annual spawning area use at the known spawning locations in relation to lake elevation, and monitor any continued and successful spawning events.

Objective 3

Continue to ascertain recruitment over time and gather information that elucidates important factors affecting recruitment.

This monitoring report uses information and data obtained throughout the life of the Lake Mead razorback sucker study (October 1996 to June 2006), to develop recommendations for future, continued monitoring efforts pertaining to the above objectives that we deem as important items to continue to track during future years. It is hoped that this report will provide possible direction for long-term monitoring efforts regarding the populations of razorback sucker on Lake Mead.

Data obtained during cumulative years of sampling on Lake Mead were used to generate information regarding the locations, methodologies, and time frames when the most informative data on razorback sucker population dynamics could be collected to maintain the long-term database initiated by BIO-WEST's Lake Mead razorback sucker study. Given that more than 10 years of data were evaluated during the construction of many portions of this report, coupled with other qualitative and anecdotal observations of Lake Mead razorback sucker during the past decade, the following information should prove useful to various user groups under a wide variety of lake conditions.

In general, to achieve the objectives above, monitoring is encouraged at the same locations sampled during the 1996–2006 portions of the study; a description of how we have defined our sampling locations can be found in past annual reports (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b, Holden et al. 2001, Abate et al. 2002, Welker and Holden 2003, Welker and Holden 2004, Albrecht and Holden 2005, Albrecht et al. 2006). Because monitoring should be cost effective and efficient, the two most familiar areas sampled in the past, namely Echo Bay and Las Vegas Bay, should take priority over other areas (Figure 1) and sampling at these areas should be continued on an annual basis. The reason for this prioritization is that Echo Bay and Las Vegas Bay have the longest and most continuous history of data collection than any other areas of Lake Mead, and it has been generally observed that individual razorback sucker can be captured with greater degrees of frequency and reliability, as will be demonstrated below. Additionally, these two study sites are the only areas where juvenile/subadult razorback sucker have been collected, and monitoring should be designed to track and assess recruitment events. Razorback sucker activity has also been observed and studied at the Muddy River/Virgin River inflow area of Lake Mead, the portion of Lake Mead near Fish Island in the northernmost portions of the Overton Arm, and (to a lesser extent) in the Colorado River Inflow region (Figure 1). These locations could also be incorporated into the monitoring design, provided sufficient time, support, etc.

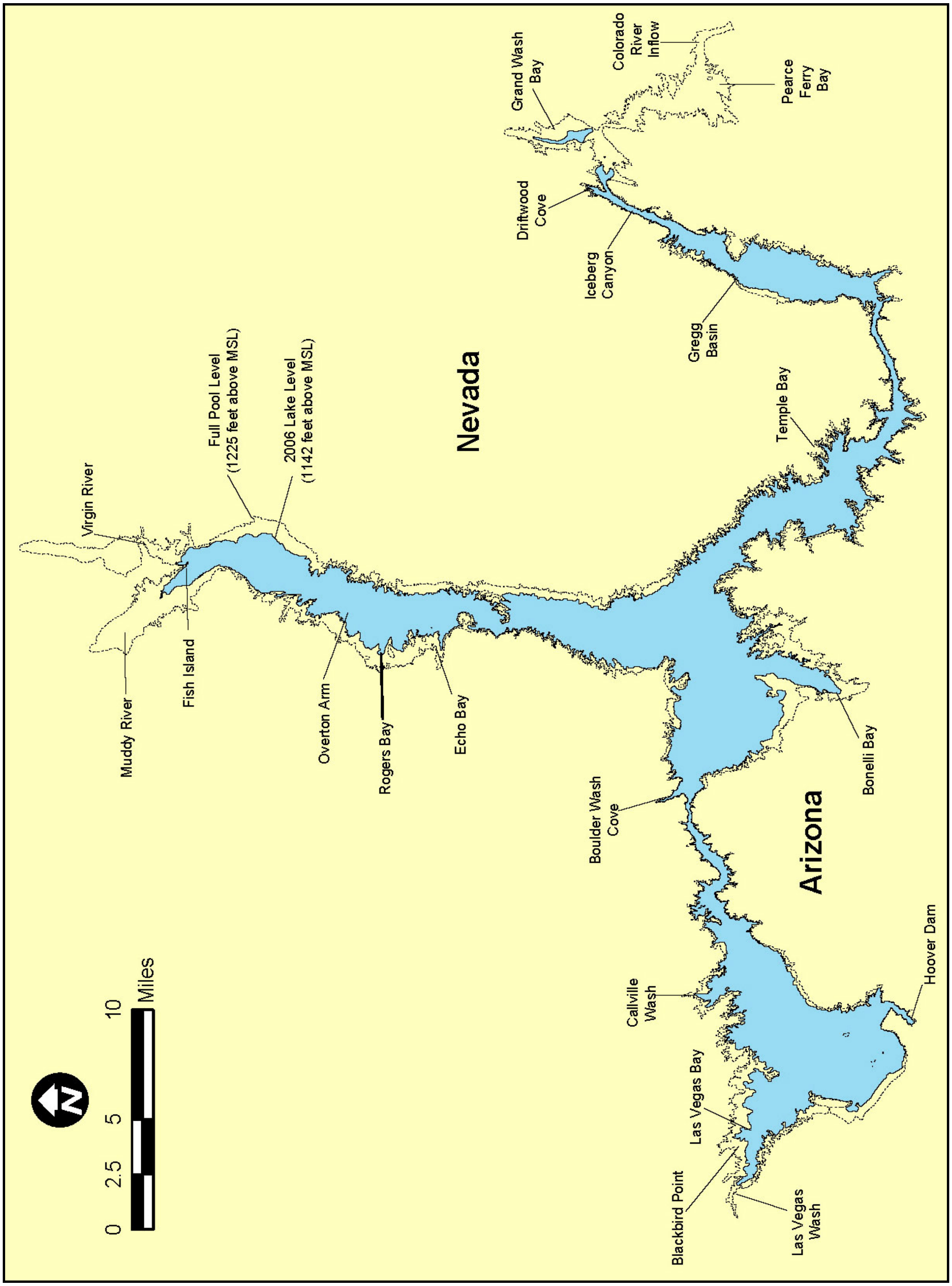

Figure 1. Map of Lake Mead showing general study locations.

Objective 1. Track razorback sucker population trends in Lake Mead, and identify any changes in the relative size and overall health of known spawning populations

How?

Trammel nets have been the primary adult, subadult, and juvenile sampling gear (300 ft long by 6 ft deep with an internal panel of 1 in, 1.5 in, or 2 in mesh and external panels of 12-inch mesh) and this gear is still recommended. Continued use of such nets will allow for continuity between past and future monitoring efforts. Please refer to Albrecht et al. (2006) for a description of specific netting methodologies. When feasible, netting locations at study sites should be selected based on the locations frequented by any active sonic-tagged fish, the location of larval concentrations, and ancillary knowledge of historical spawning areas. As described in greater detail in Albrecht et al. (2006), we recommend netting catch per unit effort (CPUE) as a valid yet cost effective metric to evaluate the relative size and overall population health trends of Lake Mead razorback sucker.

Adult capture data collected from 1992–2006 was evaluated to provide insights about the most productive times and locations to capture adult razorback sucker in Lake Mead. This information is found below. In all instances, effort, when expressed, is representative of one net night. One net night was defined as a single net, set overnight. When shown, error bars indicate one standard error. Although the Lake Mead database contains entries from 1992 to present, in some cases only data from 1996 to present (the duration of BIO-WEST data collection) was used. Data from years before 1996 was obtained and pieced together from other agencies prior to the initiation of our studies. This early data tends to lack associated effort information. Thus, when a given analysis dealt with effort, data utilized may or may not include information collected prior to 1996, or the initiation of BIO-WEST studies. Also, information from the relatively new data collected at the Muddy River/Virgin River inflow area during the 2004–2005 and 2005–2006 study years are provided below in some instances, primarily to serve as baseline information for this recently discovered area.

Where?

Figures 2–4 show the locations of trammel net razorback sucker captures in the primary study areas, as well as a given year's presumptive spawning site location for reference. Figure 2 provides a general overview of locations where razorback sucker have been collected on Lake Mead. In general, trammel netting effort has been most productive near the back of Echo Bay (Figure 3) with captures tending to move down, toward the mouth of Echo Bay, with diminishing lake elevations.

Figure 2. **Adult trammel net capture locations overview, 1992–2006.**

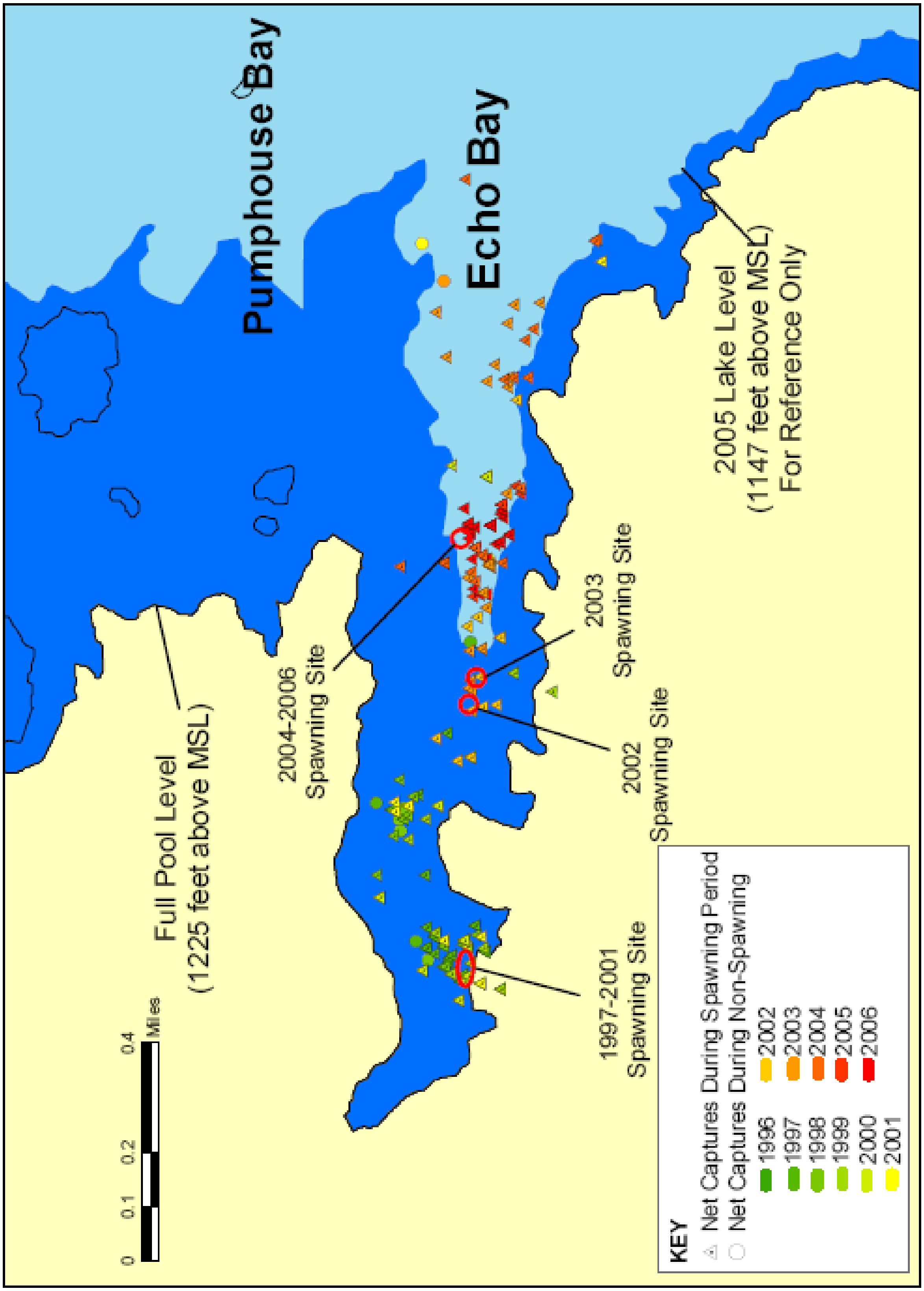

Figure 3. **Adult trammel net capture locations in Echo Bay, 1992–2006.**

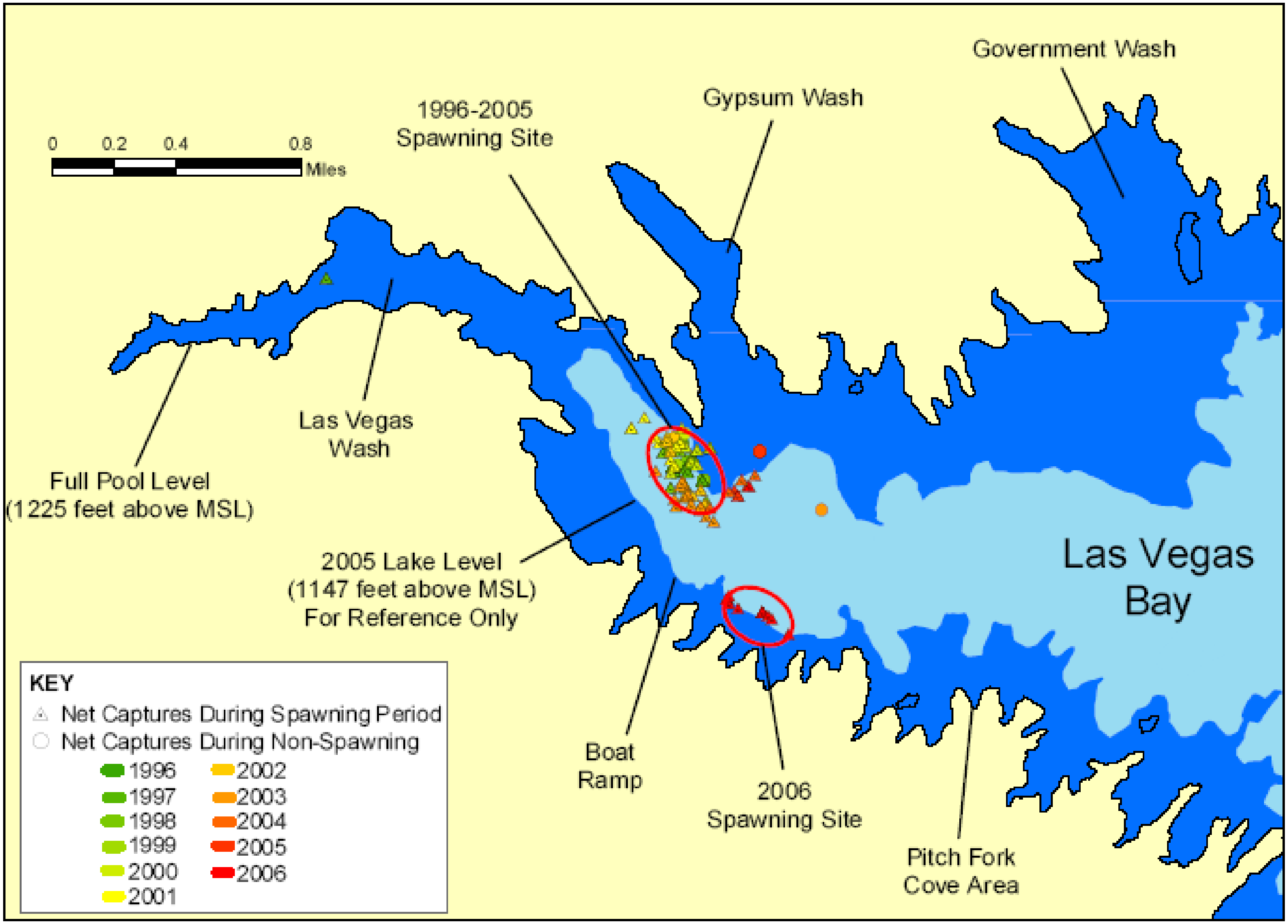

Figure 4. **Adult trammel net capture locations in Las Vegas Bay, 1992–2006.**

Lake elevation may also impact capture locations at Las Vegas Bay, something unknown until last field season (2006) when the historical Blackbird Point Spawning area became desiccated and inaccessible to spawning fish. In response to lowered lake elevations in 2006, the majority of captures were along the western shoreline area of Las Vegas Bay. During all other study years (1996–2005), at higher lake elevations, the most productive capture location was at/near Blackbird Point (Figure 4). In all cases, net sets were largely dictated by the location of sonic-tagged fish when available in each of the sampling areas.

Also provided are the recent trammel netting capture locations of razorback sucker at the Muddy River/Virgin River inflow, which tended to be concentrated around the Fish Island shoreline. In the past, efforts were designed to be flexible, largely dictated by the habitat use and movements of sonic-tagged fish throughout the northern portions of Lake Mead. As such, sampling has occurred even within the lower portions of the Muddy River proper (Figure 5). Hence, sampling locations for adults will change depending on lake elevation, and concentrations of fish may be difficult to find at times.

When?

Figure 6 shows the number of razorback sucker collected via trammel netting monthly from 1992–2006 at each of the study areas. Figure 7 depicts the same information, but in terms of CPUE for data collected from 1996–2006. February appears to be the most productive month for capturing adult fish at Echo Bay, while March appears to the most productive month at Las Vegas Bay. February also appears to be the best month for capturing razorback sucker near the Muddy River/Virgin River inflow area. Therefore, the months of February and March appear to provide the best opportunities for adult captures during future, lake-wide monitoring efforts (Figure 8).

Over the years, CPUE at Echo and Las Vegas Bays have fluctuated (Figure 9). Interestingly, the lowest CPUE values observed coincide with the two seasons when sonic-tagged razorback sucker were absent during the spawning period. The only lack of sonic-tagged individuals has occurred at Las Vegas Bay. Therefore, it is difficult to definitively correlate the presence of sonic-tagged fish with CPUE trends. However, by comparing the relatively low CPUE values of the 2004 and 2005 spawning period (no sonic-tagged fish present) with the CPUE of 2006 (multiple sonic-tagged fish present) in Las Vegas Bay, the utility of sonic-tagged fish presence appears to have helped field crews to appropriately position net sets. During 2004, 2005, and 2006 lake elevations were relatively low and declining (Figure 10). This may have ruled out water level as a possible factor for the dramatic increase in CPUE noted in 2006, leaving presence versus absence of sonic-telemetered fish as the most likely mechanism of change between years. When possible, the use of sonic-telemetered fish could be an effective way to help maintain adult sampling efficiency during future monitoring events. More detail on the utility of sonic telemetry and its methodologies in relation to Lake Mead razorback sucker sampling will be described in the following sections.

Figure 5. Adult trammel net capture locations at the Muddy River/Virgin River inflow area, 2004–2006.

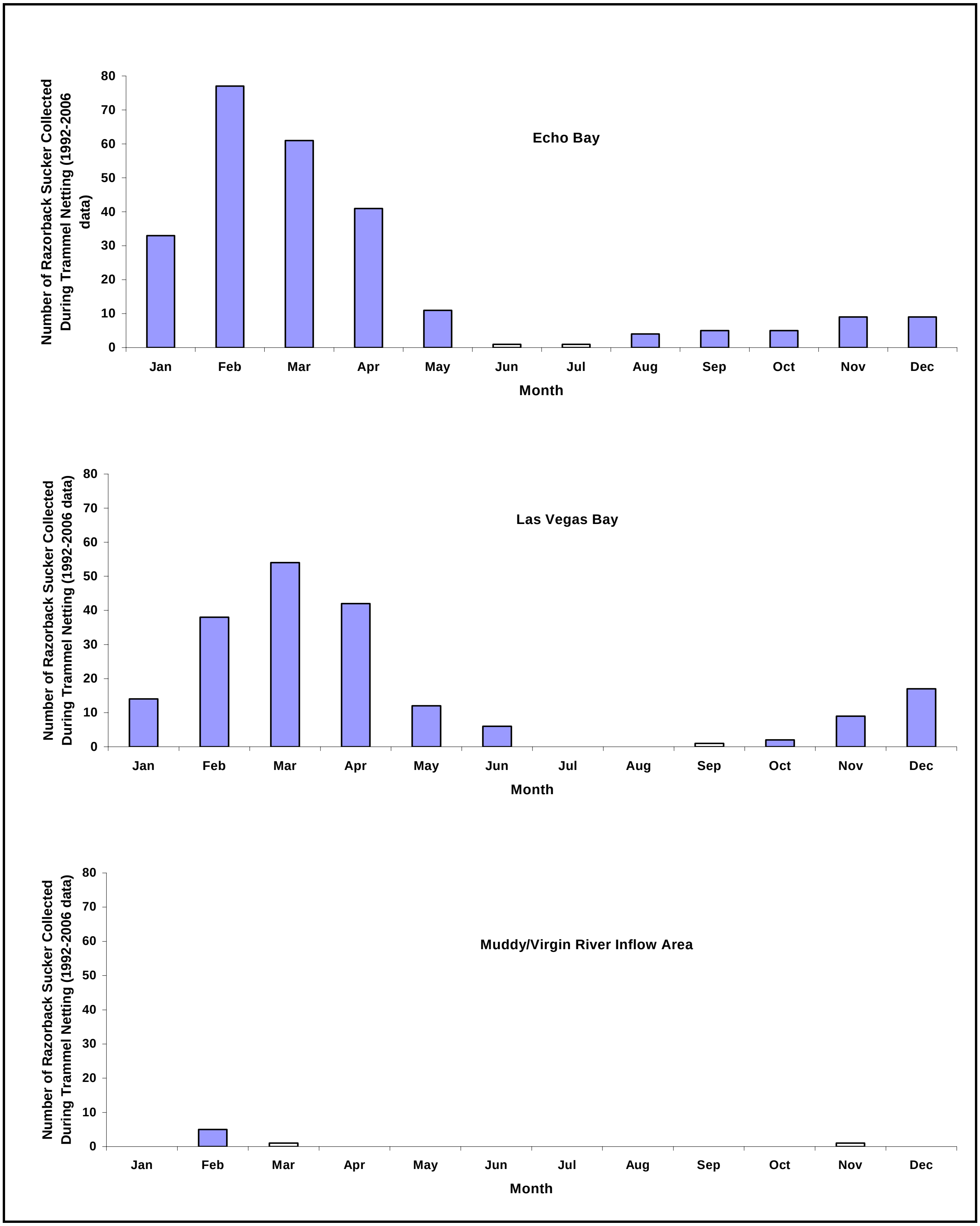

Figure 6. Number of adult razorback sucker collected via trammel netting monthly from 1992–2006.

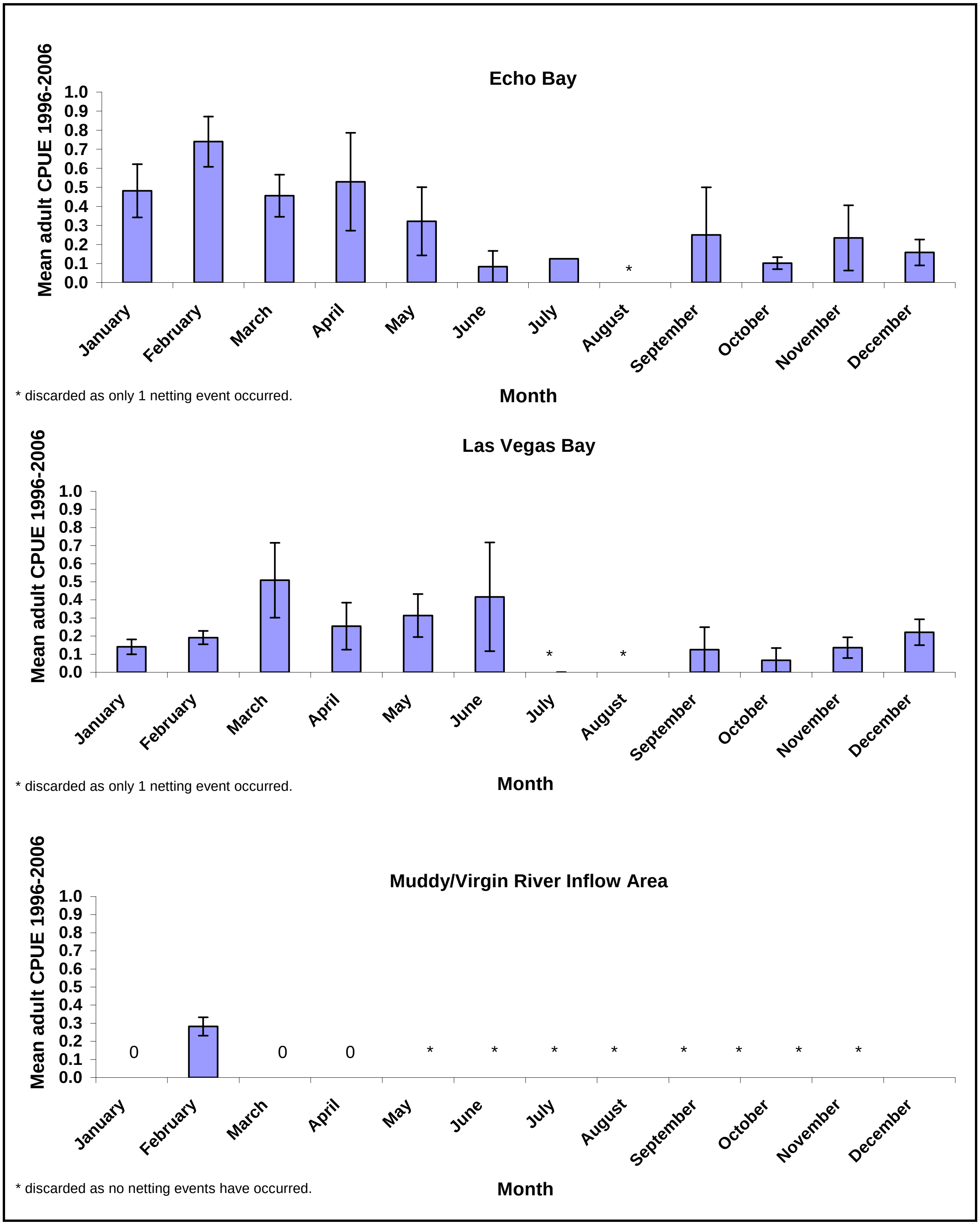

Figure 7. **Mean adult catch per unit effort (CPUE) monthly from 1996–2006 at each study site.**

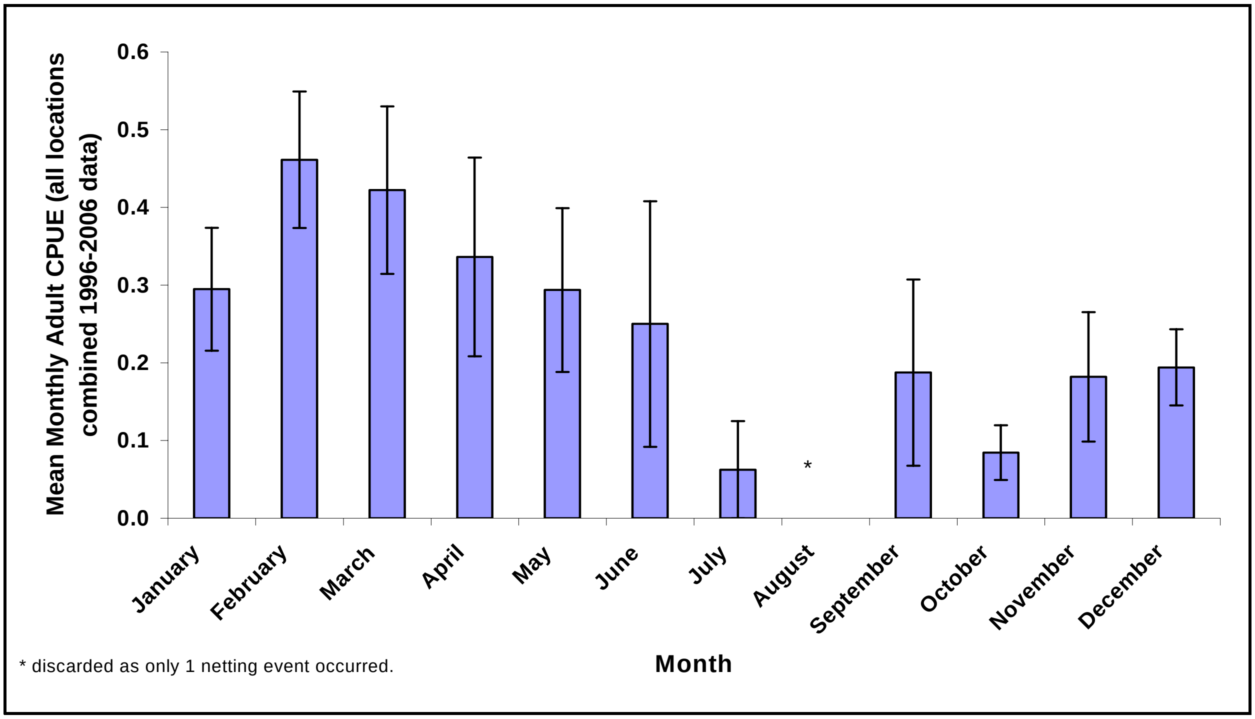

Figure 8. **Mean adult monthly catch per unit effort (CPUE), 1996–2006 (all sites combined).**

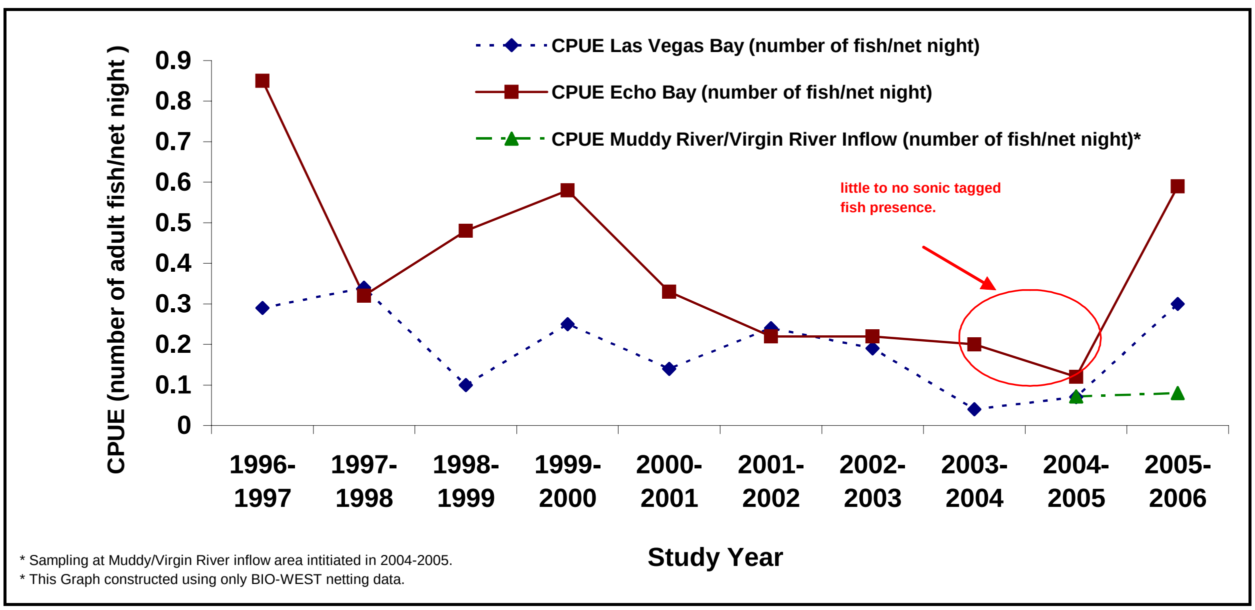

Figure 9. **Annual adult catch per unit effort (CPUE) by study site, 1996–2006.**

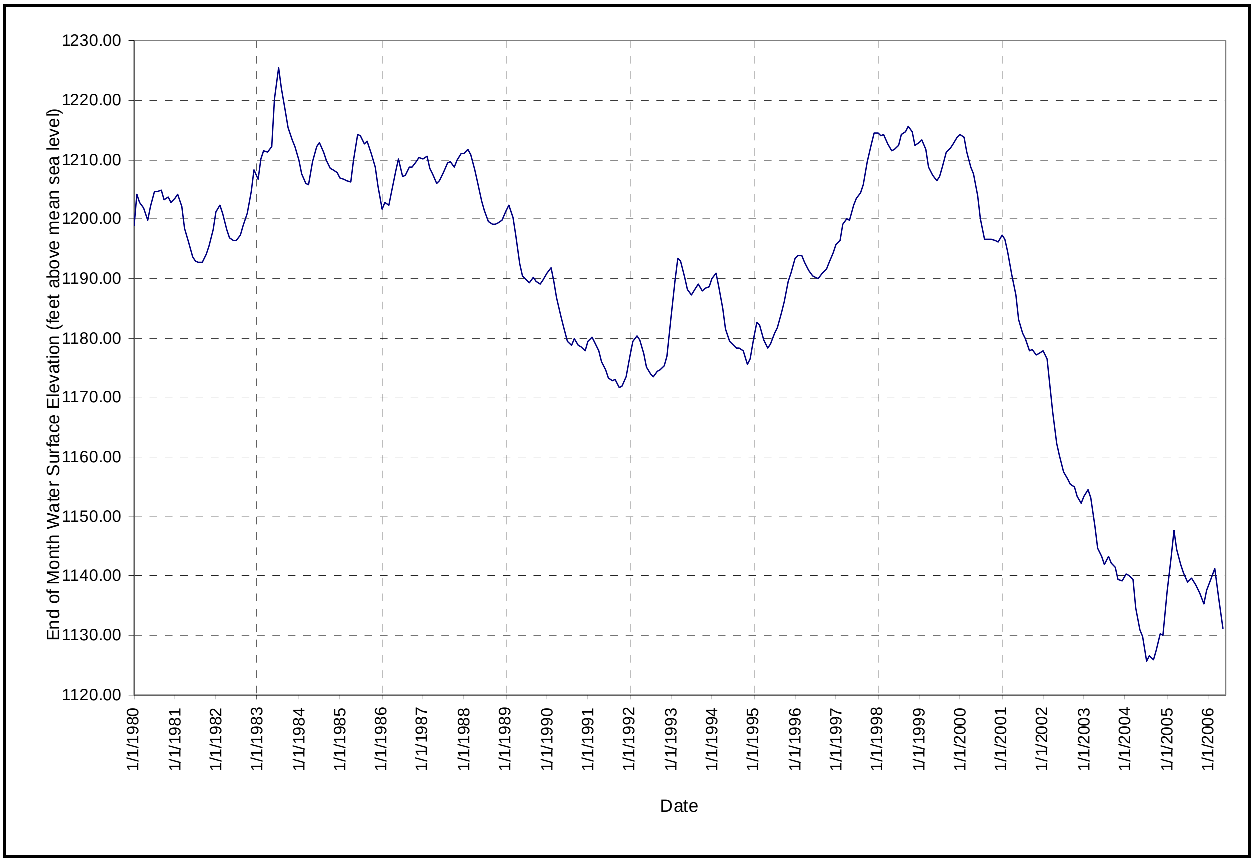

Figure 10. Lake Mead month-end lake elevations, 1980–2006

Objective 2. Track annual spawning area use at the known spawning locations in relation to lake elevation, and monitor any continued and successful spawning events

How?

In addition to the adult trammel netting efforts described in the previous section, larval sampling techniques are key in pinpointing and identifying annual spawning areas. Larval sampling methods on Lake Mead have followed those developed by Burke (1995) and other researchers on Lake Mohave. These methods should be maintained to ensure that Lake Mead razorback sucker populations continue to spawn on an annual basis and to help identify spawning site selection. When possible, the locations of active, sonic-tagged fish should be used to select larval sites. Previous weeks' trammel netting results over the course of a given season may also be helpful in larval sampling site selection. Under fluctuating lake level scenarios, larval sampling sites have typically changed slightly throughout the course of the season. The resulting larval sampling strategy must therefore be a responsive, fluid, and adaptable protocol that will enable flexibility when faced with fluctuating lake elevations. Please refer to Albrecht et al. (2006) for details regarding this technique.

For the purposes of this report, given that larvae are the direct result of annual spawning and are indicative of spawning habitat utilization, larval capture data collected from 1997–2006 were evaluated to provide insights pertaining to the most productive times and locations to capture larval razorback sucker on Lake Mead. In all instances, effort is expressed as catch per minute (CPM). When shown, error bars indicate one standard error. Information from the relatively new data collected at Muddy River/Virgin River inflow area during the 2004–2005 and 2005–2006 study years is provided below in some instances, primarily to serve as baseline information for this relatively understudied location.

Past annual reports provide detailed history and describe the utility and results of sonic telemetry efforts in past study years (e.g., Albrecht et al. 2006). Sonic-tagged fish have proved to be highly useful in determining adult and larval sampling locations and should be incorporated into future monitoring events whenever possible. As mentioned throughout this document, patterning of sonic-telemetered fish habitat use appears to increase netting capture rates and tends to provide an overall increase in sampling efficiency (Figure 9). Anecdotally, the presence of sonic-telemetered fish appears to assist field crews in choosing appropriate netting and larval sampling sites and provides opportunities to find new spawning areas throughout the reservoir. Methodologies for implanting and tracking tagged fish can be found in past annual reports (e.g., Albrecht et al. 2006).

With regard to future spawning site selection, it may be useful to perform an advance evaluation of projected lake level data in conjunction with Figures 2–5 (above), Figures 11–18 (below), and Table 1, to obtain indication of where the given year's spawning site is likely to be (based on historical spawning habitat use patterns). Typically, lake elevation data in past annual reports have been measured in feet above mean sea level (amsl) and obtained from Reclamation's Lower Colorado Regional Office website. This method is perhaps not as reliable or precise as concurrent sonic-telemetered fish habitat utilization patterns, but it may be useful if sonic telemetry is not an option for a particular study location or year. Due to the rather small populations at each of the known spawning sites, and given the overall time investments that netting on Lake Mead requires, the methods described above may increase razorback sucker capture probability and should be pursued prior to the initiation of netting efforts.

Where?

Figures 11–14 show the locations of larval razorback captures in the primary study areas, as well as a given year's presumptive spawning site location for reference. Figure 11 provides a general overview of locations where larval razorback sucker have been collected on Lake Mead. Similar to trammel netting captures, larval sampling effort has been most productive near the back of

Table 1. Spawning site location in comparison to lake elevation information as observed during past spawning periods (January–April lake elevation data used for table construction).

ECHO BAY LAKE ELEVATION RANGE (FT AMSL) DURING SPAWNING SEASON		
Location	**Maximum**	**Minimum**
1996–2001 Spawning Site[a]	1214	1191
2002 Spawning Site	1178	1167
2003 Spawning Site	1154	1148
2004–2006 Spawning Site	1148	1134

LAS VEGAS BAY LAKE ELEVATION RANGE (FT AMSL) DURING SPAWNING SEASON		
Location	**Maximum**	**Minimum**
1996–2005 Spawning Site	1214	1135
2006 Spawning Site	1141	1134

[a] Spawning Sites match with those indicated in map figures for comparative capability.

Echo Bay (Figure 12) with captures tending to move down, toward the mouth of Echo Bay, with diminishing lake elevations.

Lake elevation can also have an impact on larval capture locations at Las Vegas Bay, which was not evident until last field season (2006) when the historical Blackbird Point Spawning area became desiccated and inaccessible to spawning fish. In response to lowered lake elevations in 2006, and associated with a shift in spawning location by adult fish, the majority of larval captures came from along the western shoreline area of Las Vegas Bay. During all other study years, at higher lake elevations, the most productive larval capture locations tended to be at/near Blackbird Point (1996–2005) (Figure 13). In most instances, larval sampling site locations were often times dictated by the location of sonic-tagged fish and previous weeks' netting results if/when available.

Also provided are the recent capture locations of larval razorback sucker at the Muddy River/Virgin River inflow, which tend to be concentrated around the Fish Island shoreline. Perhaps even more so than at Echo and Las Vegas Bays, larval sampling efforts were designed to be flexible in the northern portions of Lake Mead, largely dictated by the habitat use and movements of sonic-tagged fish and previous netting capture locations (Figure 14).

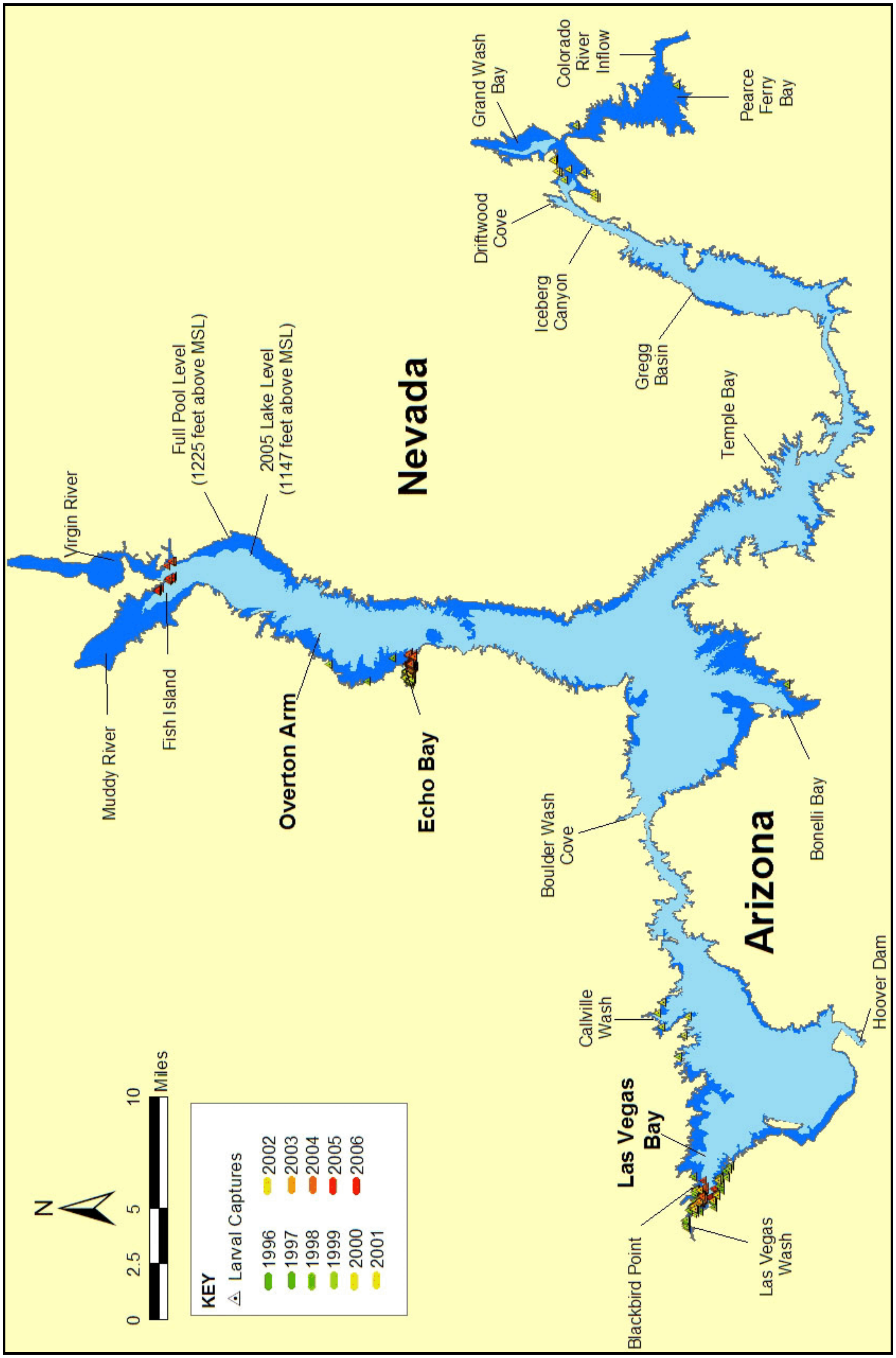

Figure 11. Larval capture locations overview, 1996–2006.

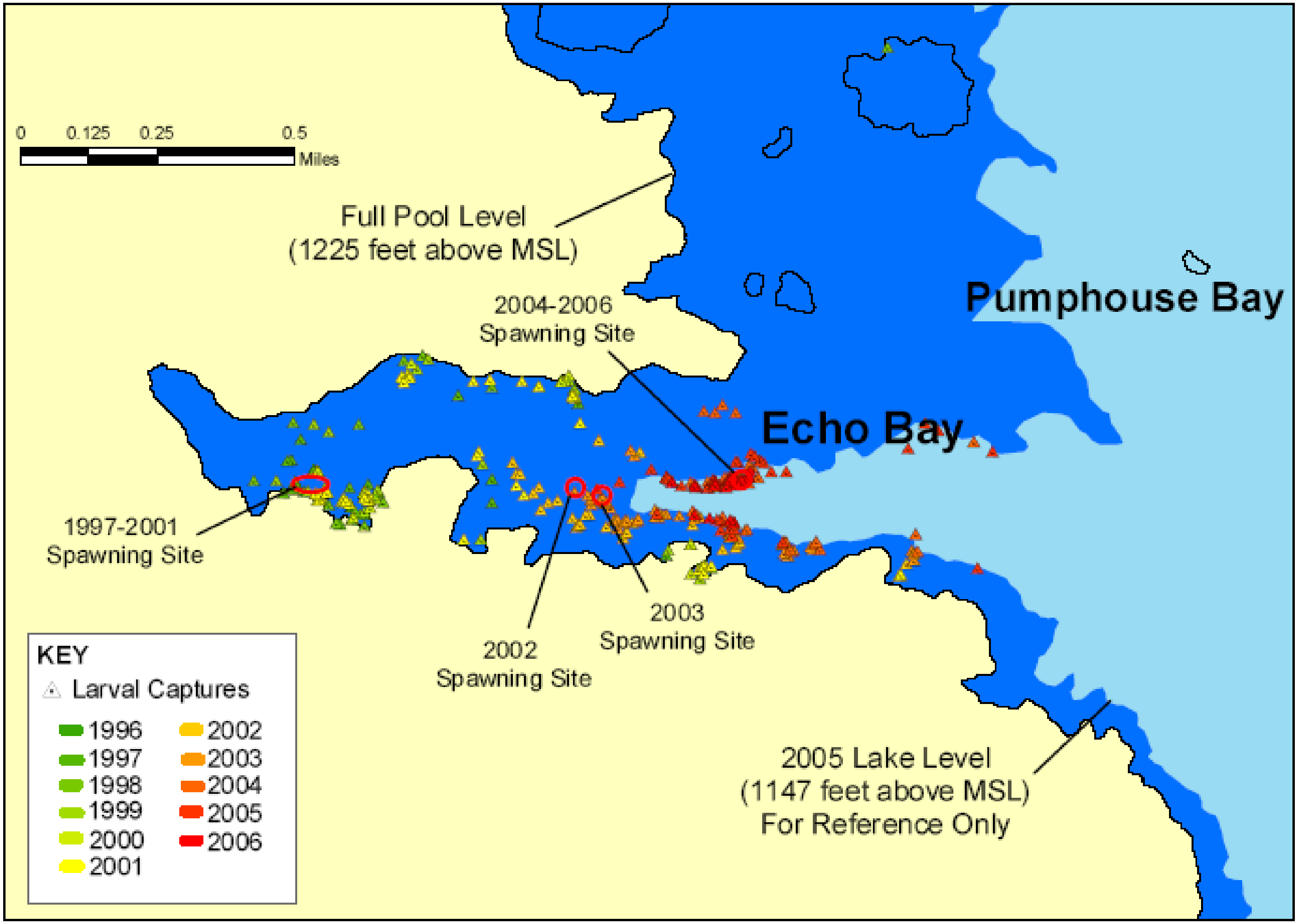

Figure 12. **Larval capture locations in Echo Bay, 1996–2006.**

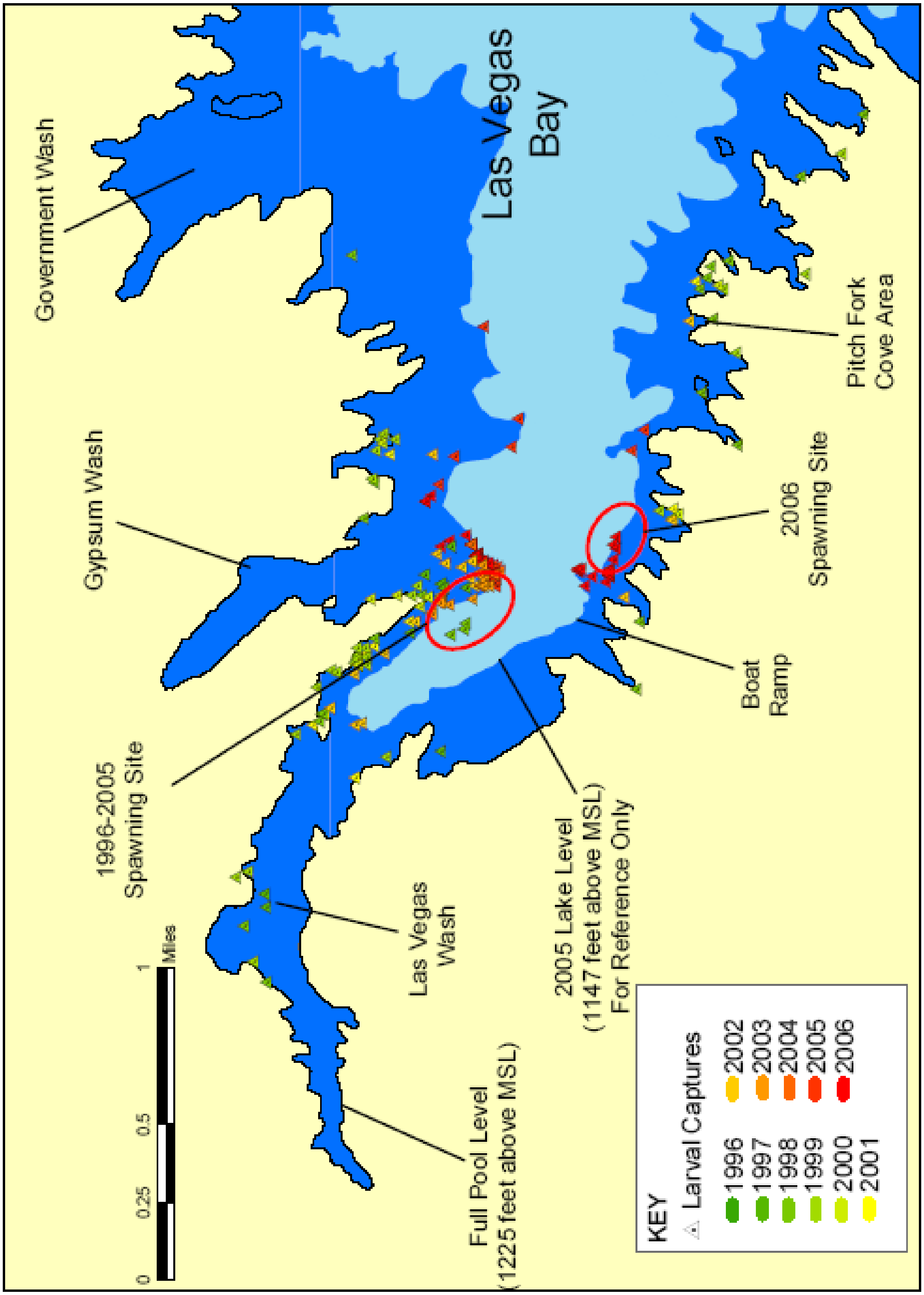

Figure 13. Larval capture locations in Las Vegas Bay, 1996–2006.

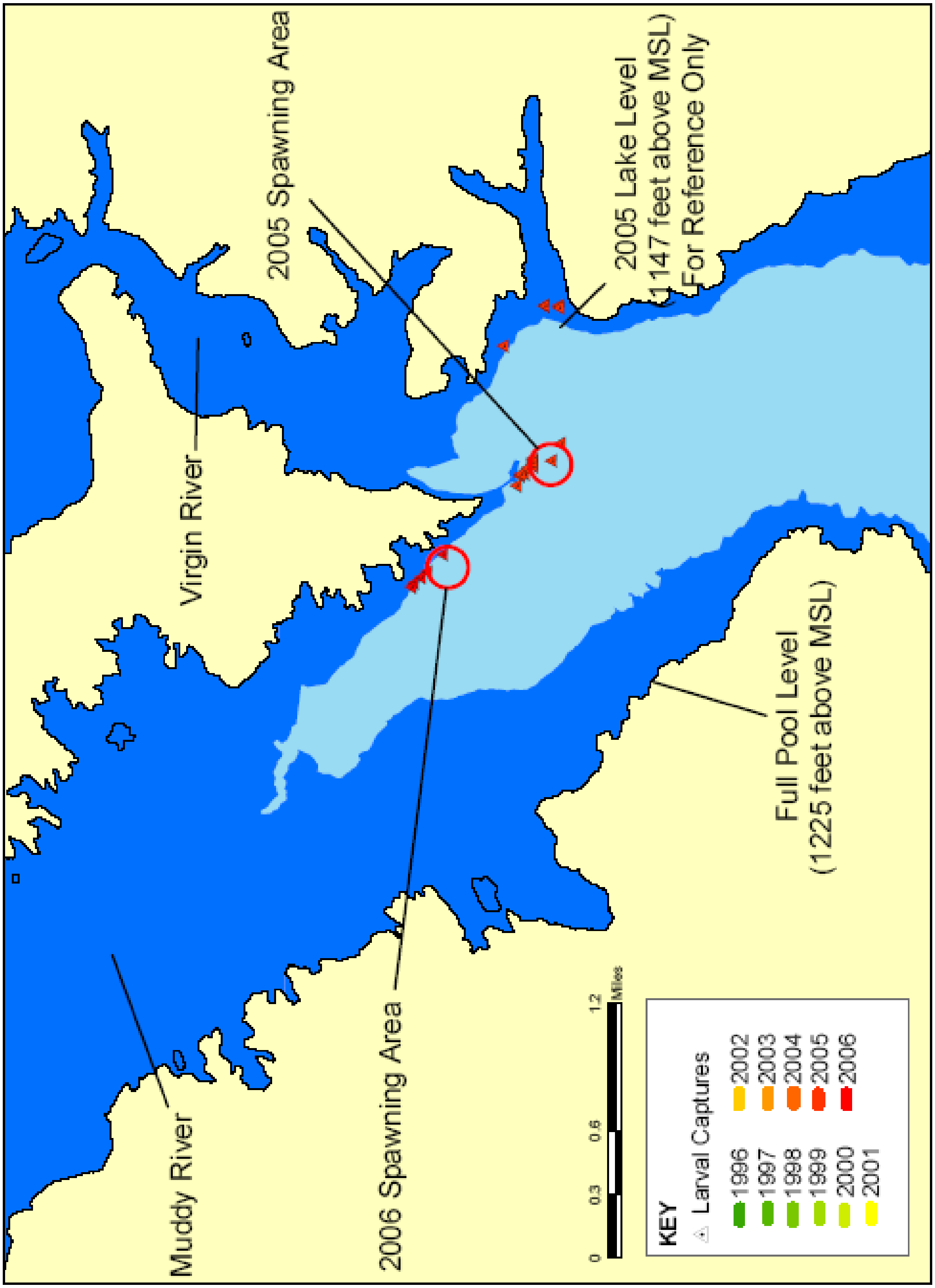

Figure 14. Larval capture locations in the Muddy River/Virgin River inflow area, 2005–2006.

Based on the above information, coupled with the overall continuity of larval data collected to date, larval sampling at Echo Bay and Las Vegas Bay should be continued during future monitoring events. If at all possible, larval sampling is recommended at the Muddy River/Virgin River inflow area.

In addition to the larval capture information presented above, Figure 15 shows an overview of lake-wide, sonic-telemetered fish habitat utilization from 1996–2006. Figure 16 depicts sonic telemetered fish habitat use of Echo Bay in greater detail. Figures 17 and 18 provide similar detail for sonic-telemetered fish utilization of Las Vegas Bay and the Muddy River/Virgin River inflow areas, respectively. It is hoped that the history of habitat and location usage by sonic-telemetered fish during past study years, depicted in Figures 15–18, will enable field crews to be more effective in locating sonic-telemetered fish during future monitoring efforts, facilitate in the location of annual spawning sites, and enable findings of new areas of importance to Lake Mead razorback sucker during future years.

When?

Figure 19 shows monthly larval CPUE information for lake-wide larval data collected from 1997–2006. In general, it is apparent that March and April appear to be the best times to capture larval razorback sucker in Lake Mead. Figure 20 shows that overall, larval CPM is highest at Echo Bay, intermediate at Las Vegas Bay, and lowest at the Muddy River/Virgin River inflow area. Figure 21 presents information from Figures 19–20, but simultaneously. As in accordance with the netting efforts described above, conducting larval sampling during March and April appears to fit well with regards to the timing of other monitoring actions.

If more precision is desired in selecting times for future larval razorback sucker monitoring, lake surface temperature data may be a tool for increasing the effectiveness and efficiency of larval production monitoring during future years. For example, our data from the past decade indicate that, regardless of location, larval razorback sucker CPM appears to become elevated when Lake Mead surface temperatures reach approximately 50 degrees Fahrenheit. Larval CPM peaks when lake surface temperatures reach the mid to upper 50s to mid to upper 60s (Figure 22). In order to achieve efficiency, future monitoring designs could evaluate any available lake surface temperature information in order to more effectively time future larval sampling events, thereby maximizing use of available resources.

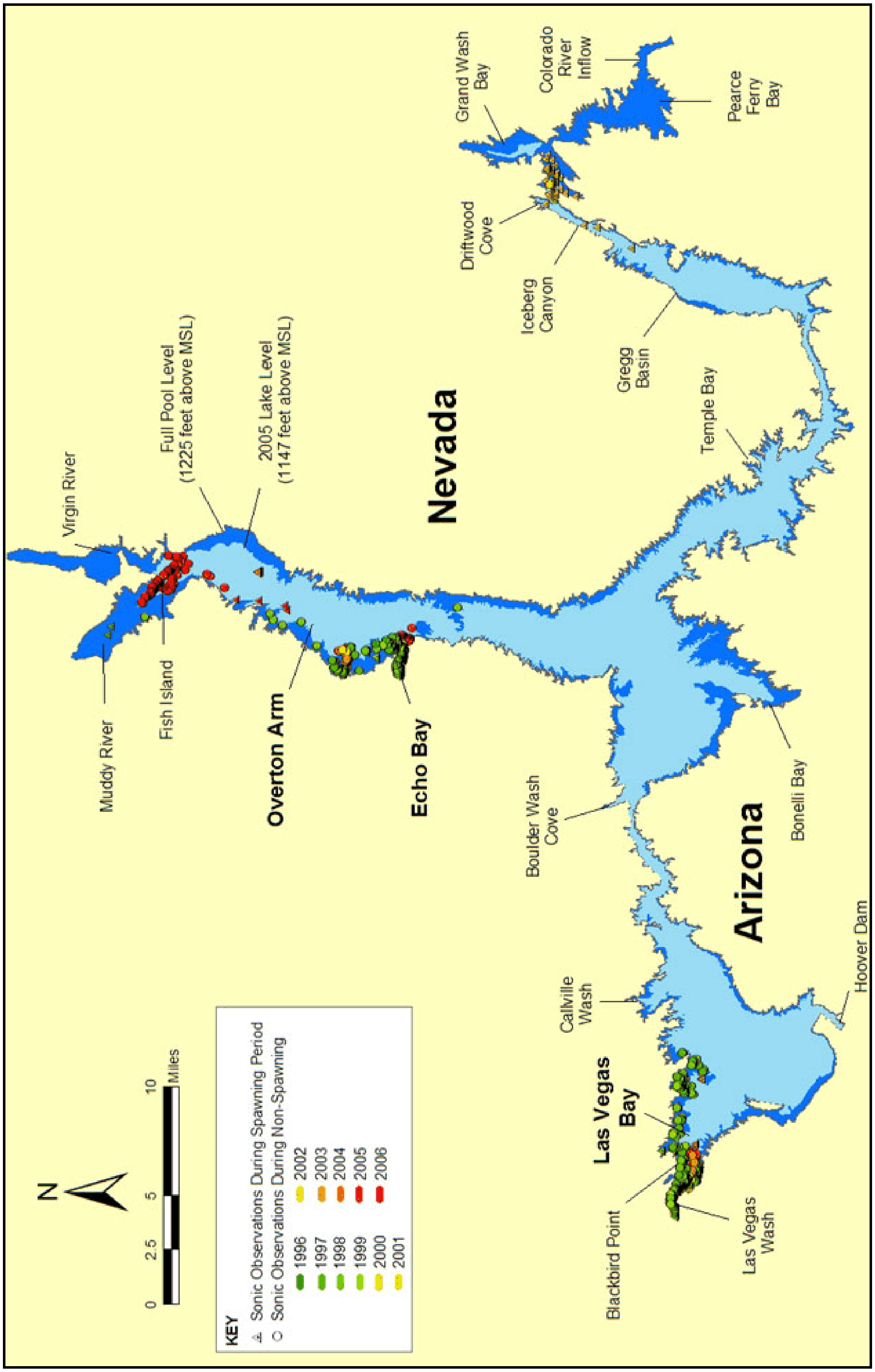

Figure 15. Sonic-tagged fish contact locations during studies on Lake Mead.

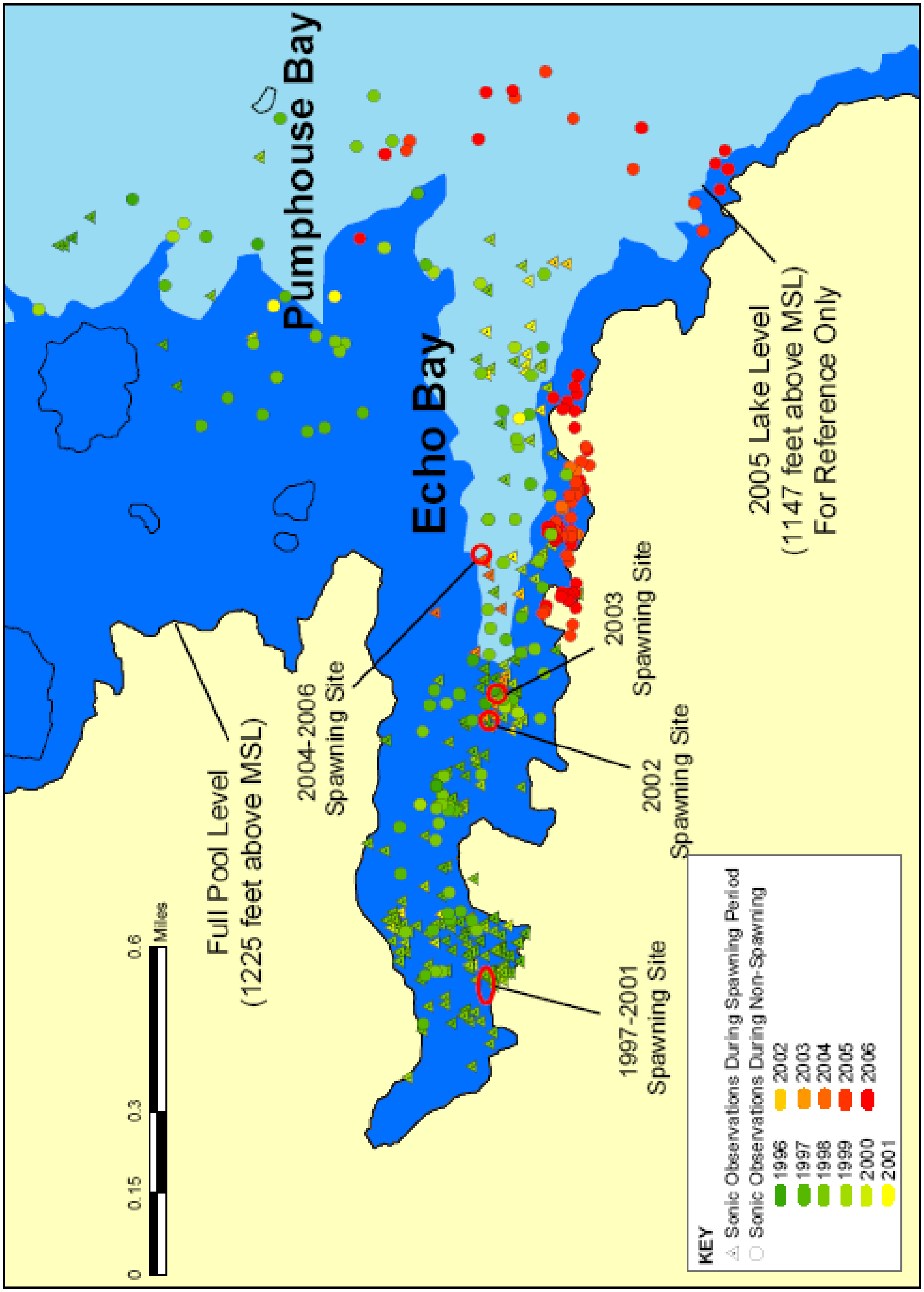

Figure 16. Sonic-tagged fish contact locations in the Echo Bay area, 1996–2006.

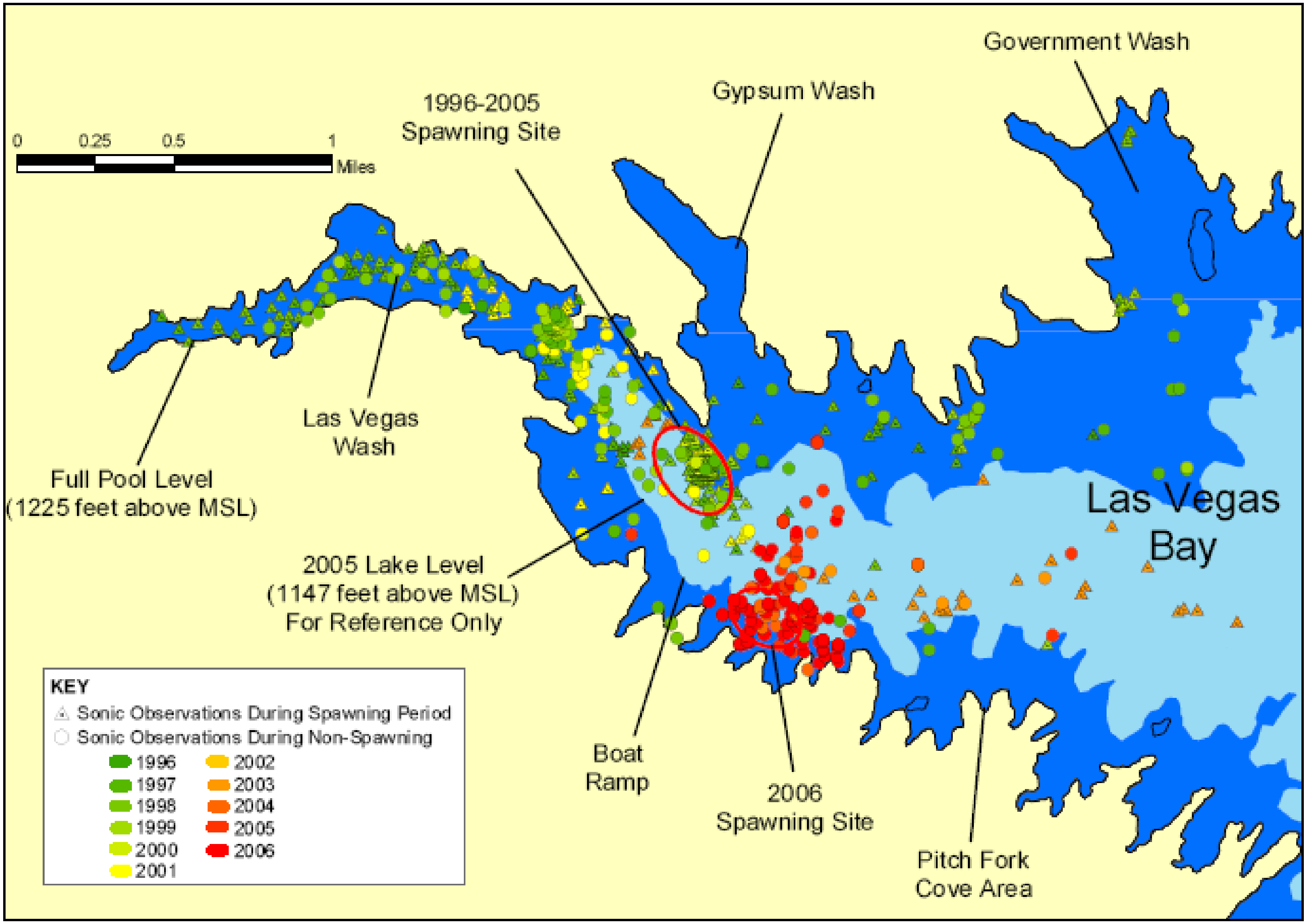

Figure 17. Sonic-tagged fish contact locations in Las Vegas Bay, 1996–2006.

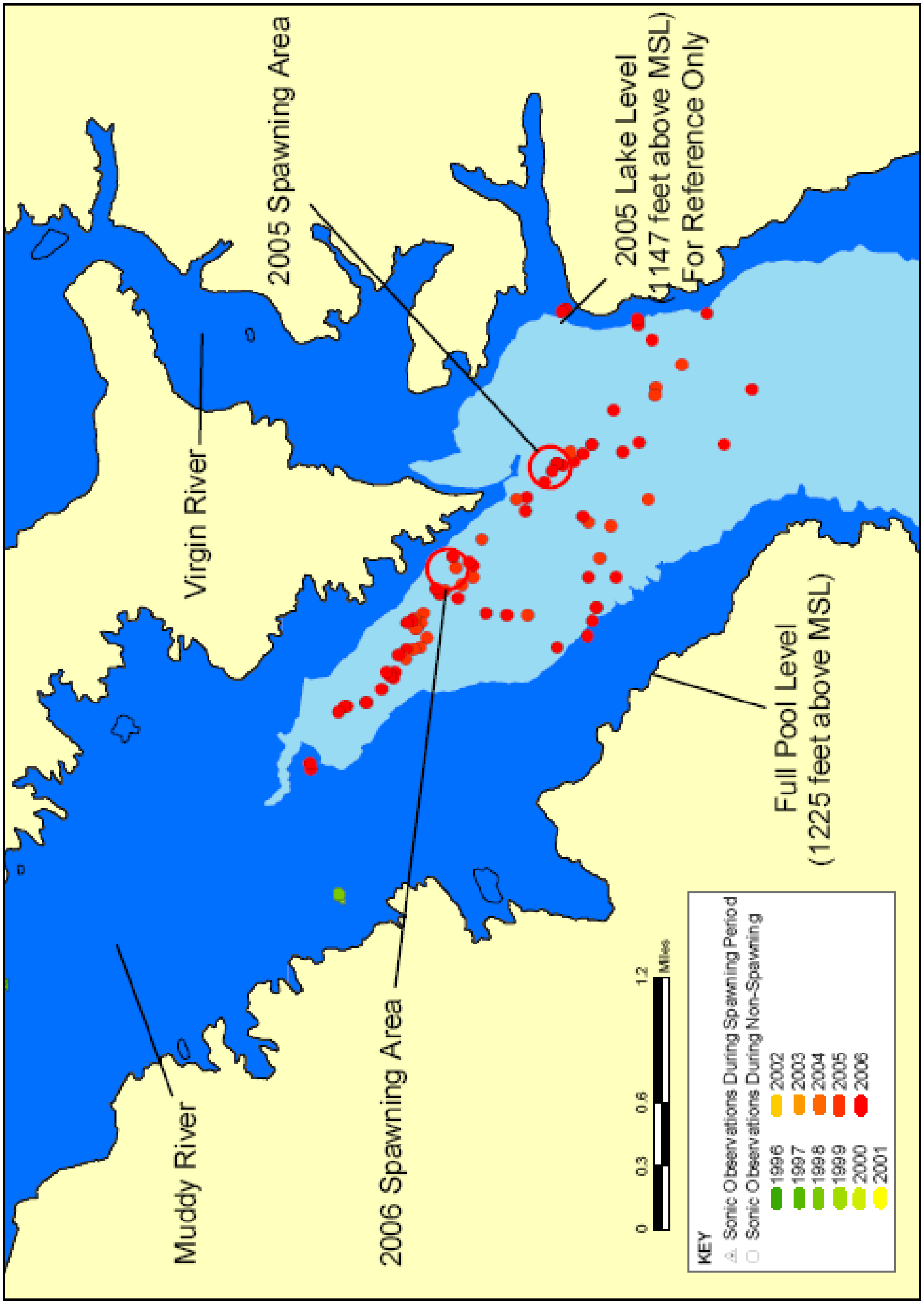

Figure 18. Sonic-tagged fish contact locations at the Muddy River/Virgin River inflow area, 2004–2006.

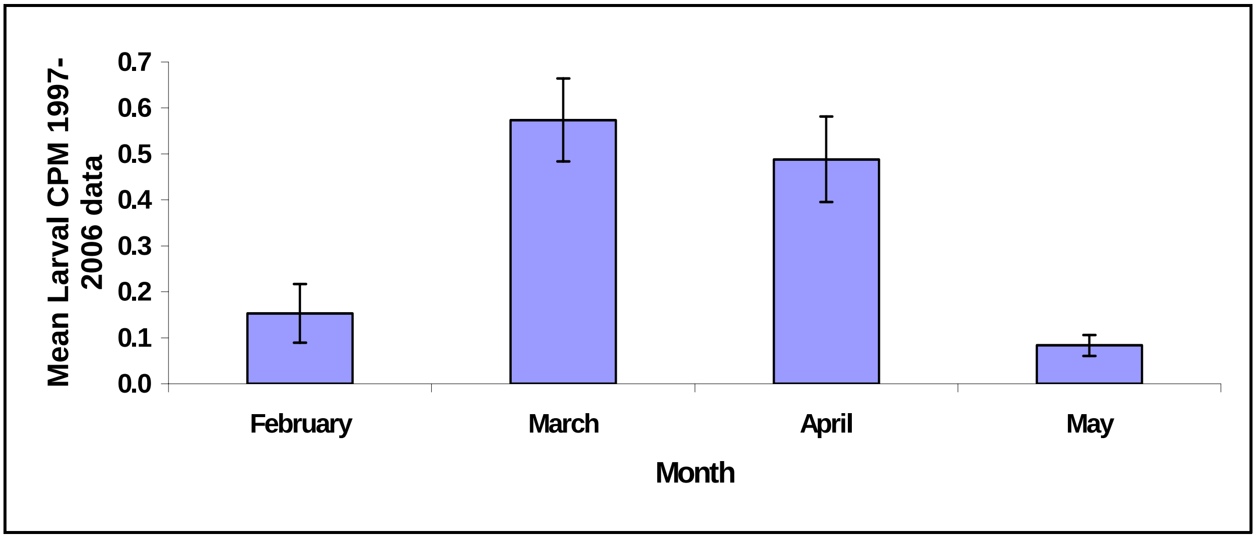

Figure 19. Mean monthly larval catch per minute (CPM) from all study sites, 1997–2006.

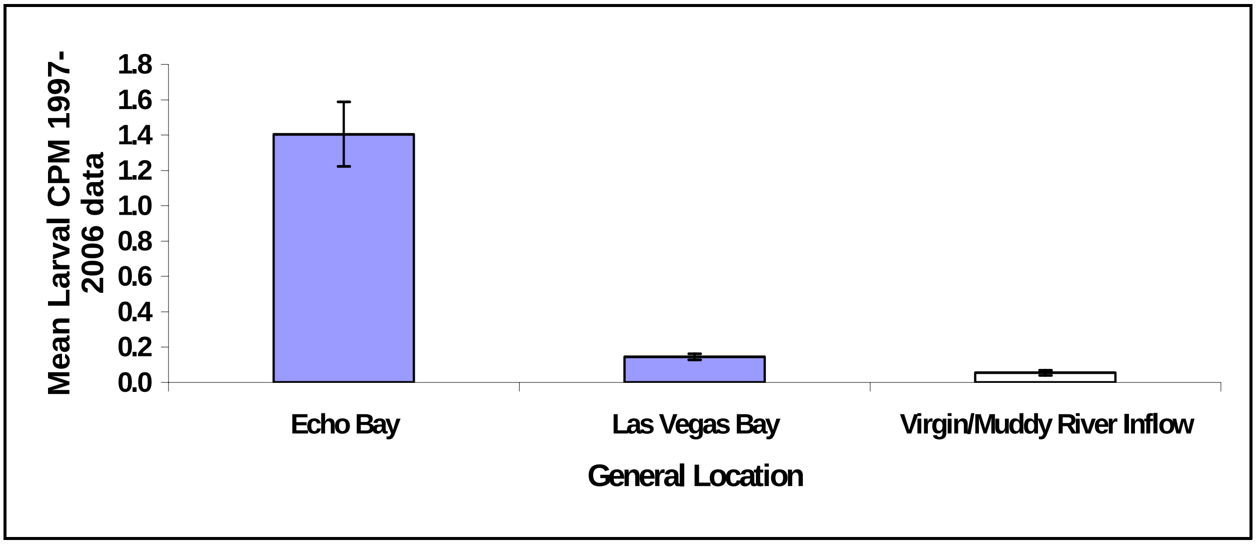

Figure 20. Mean larval catch per minute (CPM) by study site (all months), 1997–2006.

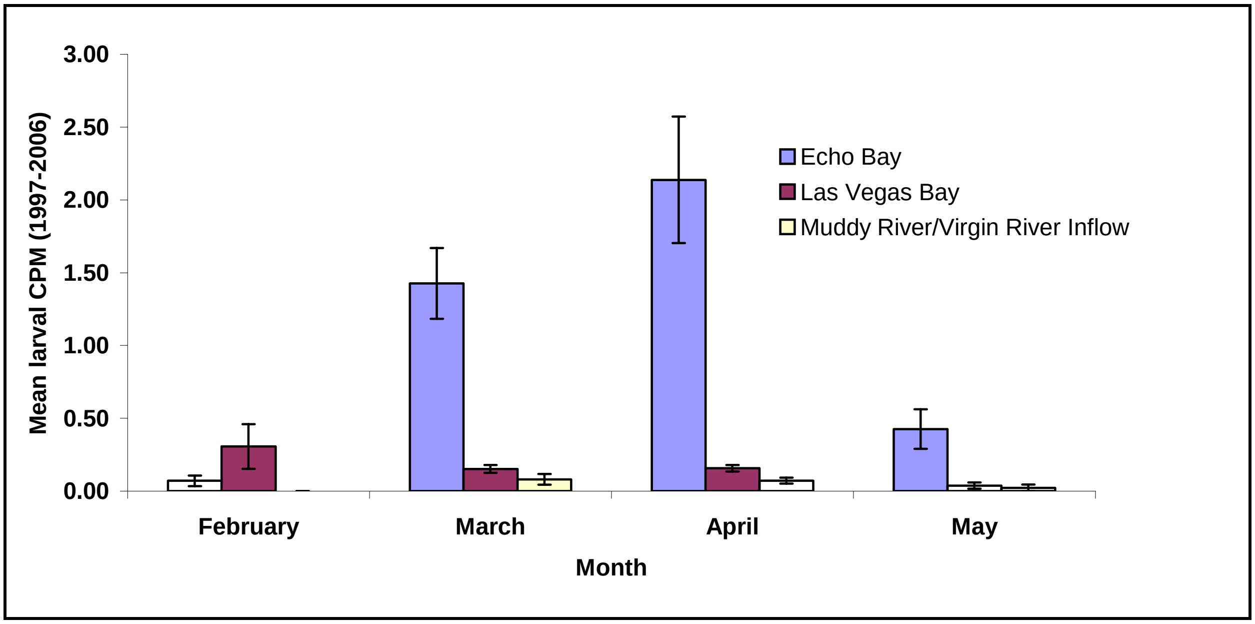

Figure 21. **Mean larval catch per minute (CPM) by month and study site, 1997–2006.**

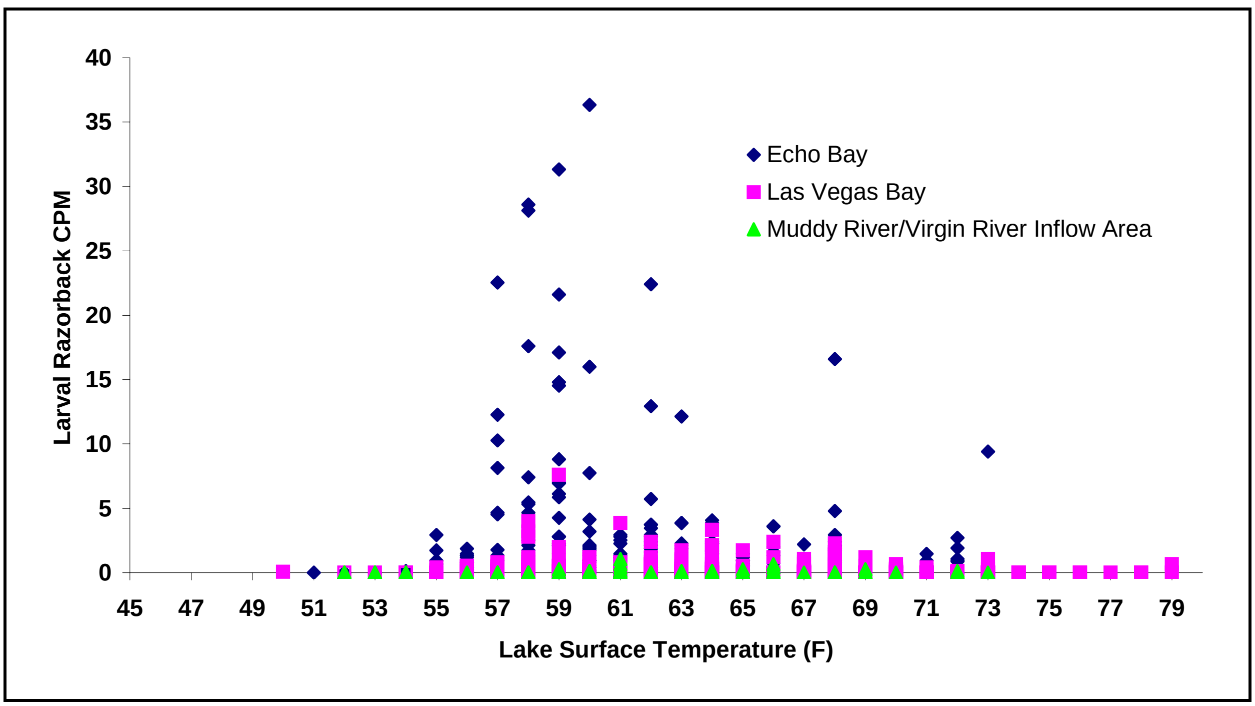

Figure 22. **Larval catch per minute (CPM) and temperature association; data from 1997–2006. Only data with both CPM value and temperature value was included. Only data from 2005–2006 was used for the Muddy River/Virgin River inflow.**

Objective 3. Continue to ascertain recruitment over time and gather information that elucidates important factors affecting recruitment

How?

The trammel netting techniques (in combination with sonic telemetry) outlined previously have been the most effective way to collect wild adult, juvenile and subadult razorback sucker. In the past we have experimented with various capture methodologies in hopes of increasing early life stage captures, such as the use of minnow traps, seines, fine-mesh gill nets, electrofishing, hoop nets, and fyke nets with little to no success (Holden et al. 1997, Holden et al. 2000a, Holden et al. 2000b, Holden et al. 2001, Abate et al. 2002, Welker and Holden 2003). Therefore, we recommend standard trammel netting, as described previously, to capture young fish. Further, we recommend that wild (unmarked) fish captured via trammel netting be subjected to age determination (adults, subadults, and juveniles). While juvenile and subadult fish collections provide direct evidence of recent recruitment, and any capture of this unique life stage is highly desirable, age determination can help to ascertain recruitment events of not only young fish, but can help to identify when adult individuals were spawned. This can help to better understand the underlying factors driving recruitment events on Lake Mead.

During the 2005–2006 study year, razorback sucker were documented to have successfully recruited through 2002. Although we would expect to begin capturing limited numbers of fish recruited during 2003–2006 (and for recruitment to continue) obtaining and analyzing wild razorback sucker age information should be continued under any future monitoring scenario. This would increase understanding of past recruitment events, facilitate a greater understanding of factors affecting recruitment on Lake Mead, and enable continued tracking of future recruitment to the population, all of which will enable managers to make informed decisions regarding the preservation of Lake Mead razorback sucker. Over past years of razorback sucker research on Lake Mead, methodologies for obtaining and analyzing fin ray sections have evolved by trial and error. Current refined and recommended methodologies for non lethally obtaining razorback sucker fin ray age information are provided in Albrecht et al. (2006).

Table 2 shows the results of aging efforts for the 91 fish aged though 2006. Figure 23 shows the number of razorback recruits per year plotted against Lake Mead elevations from January 1935 to June 2006. All of the aged fish were spawned between 1974 and 2002, with the exception of one fish that was spawned around 1966. Table 2 and Figure 23 indicates evidence of recruitment nearly every year, with some low level of recruitment occurring even during diminished lake levels. Pulses in recruitment can be observed during high lake elevations from 1978–1989 with another, apparently strong razorback cohort originating during the 1997–1999 period. Continued aging of wild individuals though future monitoring efforts will allow for assessments of recruitment beyond 2002 because fish that may have recruited during 2003–2006 and in future years will increase in size and become more susceptible to trammel net capture.

Table 2. Ages determined from razorback sucker pectoral fin ray sections collected from Lake Mead.

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
	LAS VEGAS BAY		
05/10/1998	588	10[b]	1987
12/14/1999	539	13	1986
12/14/1999	606	17+	1979–1982
12/14/1999	705	19+	1977–1980
01/08/2000	650	18+	1978–1981
02/27/2000	628	17+	1979–1982
01/09/2001	378	6	1994
02/07/2001	543	11	1989
02/22/2001	585	13	1987
12/01/2001	576	8–10	1991–1993
12/01/2001	694	22	1979
12/01/2001	553	10	1991
02/02/2002	639	16	1985
03/25/2002	650	22	1979
03/25/2002	578	10–11	1990–1991
03/25/2002	583	22–24	1977–1979
03/25/2002	545	20[c]	1982
03/25/2002	576	20	1982
05/07/2002	641	15	1986
06/07/2002	407	6	1995
06/07/2002	619	20[c]	1982
06/07/2002	642	20[c]	1982
12/03/2002	354	4	1998
12/06/2002	400	4	1998
12/06/2002	376	4	1998
12/19/2002	395	4	1998
01/07/2003	665	16	1986
01/22/2003	494	4	1998
02/05/2003	385	4	1998
02/18/2003	443	5	1997
03/04/2003	635	19	1983
03/20/2003	420	4	1998
04/08/2003	638	21[c]	1982
04/17/2003	618	10	1992
04/22/2003	650	20–22	1980–1982
05/04/2003	415	3+[b]	1999
03/03/2004[d]	370	5	1998
02/22/2005	529	6	1998
02/22/2005	546	6	1998

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
03/29/2005	656	16	1989
01/26/2006	740	15	1991
02/21/2006	621	23	1983
03/23/2006	461	5	2001
03/23/2006	718	16	1990
03/31/2006	635	7	1999
03/31/2006	605	6	2000
04/04/2006	629	6	2000
04/25/2006	452	4	2002
04/25/2006	463	4	2002
	ECHO BAY		
01/22/1998	381	5	1993
01/09/2000	527	13	1987
01/09/2000	550	13	1987
01/09/2000	553	13	1987
01/09/2000	599	12–14	1986–1988
01/27/2000	557	13	1986
01/27/2000	710	19+	1979–1981
02/09/2001	641	13	1988
02/24/2001	577	18+	1980–1982
02/24/2001	570	8	1992
02/24/2001	576	15	1986
02/24/2001	553	18	1983
12/18/2001	672	13	1988
02/27/2002	610	18–20	1982–1984
03/26/2002	623	16	1986
04/02/2002	617	35+	1966–1968
04/17/2002	583	20[c]	1982
05/02/2002	568	18–19	1983–1984
11/18/2002	551	13	1989
12/04/2002	705	26	1976
01/21/2003	591	16	1986
02/03/2003	655	27–29	1974
02/03/2003	580	13	1989
04/02/2003	639	19–20	1982
04/02/2003	580	23–25	1978
04/23/2003	584	10	1992
05/06/2003	507	9+	1993
05/06/2003	594	20	1982
12/18/2003	522	20	1982
01/14/2004	683	14	1989

DATE COLLECTED	TOTAL LENGTH (mm[a])	AGE	PRESUMPTIVE YEAR SPAWNED
02/18/2004	613	10	1993
03/17/2004	616	19	1983
03/17/2004	666	17	1985
03/17/2004	618	9	1994
04/06/2004	755	17	1985
03/02/2005	608	15	1990
03/02/2005	624	8	1996
01/10/2006	630	12	1994
02/01/2006	705	16	1990
02/16/2006	601	22	1984
	FISH ISLAND		
02/23/2005	608	6	1998
02/22/2006	687	33[d]	1973

[a] mm = Millimeters.
[b] Fish stocked from Echo Bay larval fish captured in 1999 and raised at Nevada Department of Wildlife Lake Mead Fish Hatchery.
[c] Fish stocked from Floyd Lamb State Park ponds (1982 Dexter National Fish Hatchery cohort placed in Floyd Lamb State Park ponds in 1984).
[d] Fish was aged at 33 years of age, +/- 2 years.

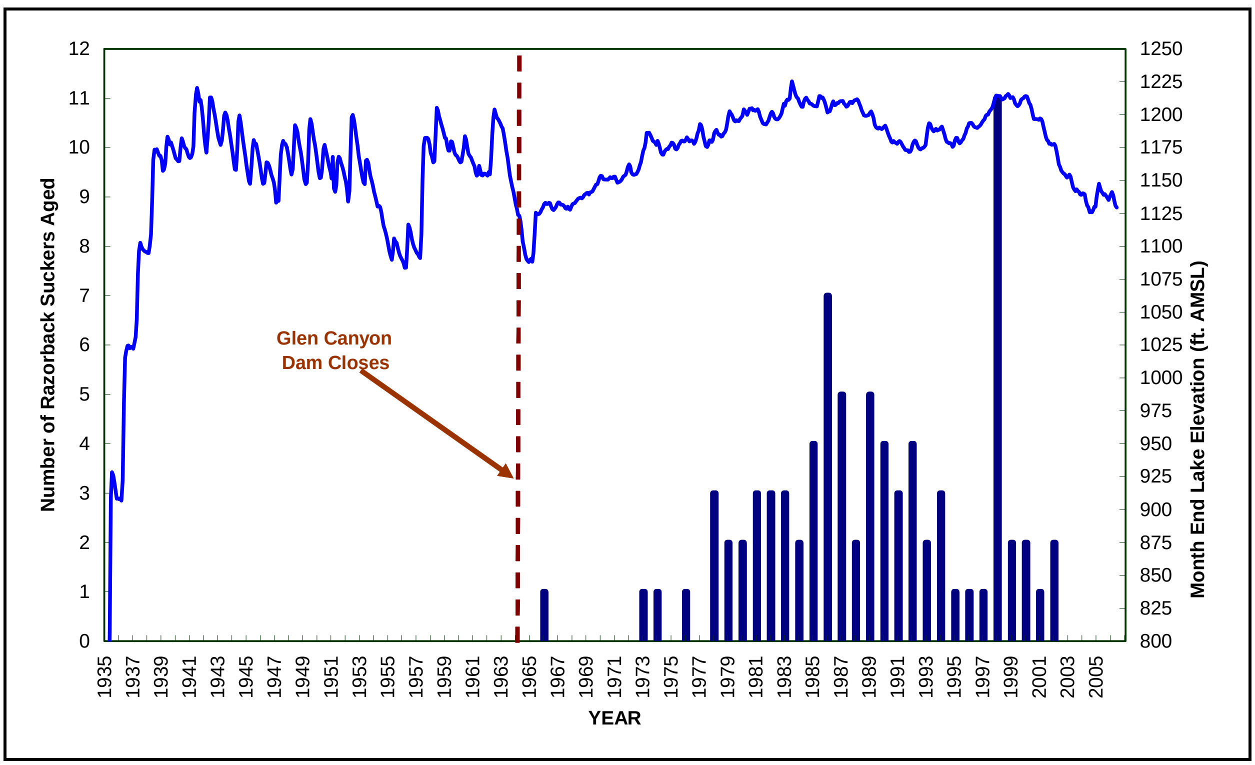

Figure 23. **Lake Mead hydrograph from January 1935 to June 2006 with the number of aged razorback sucker that were spawned each year.**

It should also be noted that, over the years, juvenile fish younger than four years of age have not been readily susceptible to capture gear. As such, future monitoring events will inherently sample for young fish that were spawned approximately 4 years prior to the given sampling season, thereby resulting in a potential 4-year delay between the actual date of spawn and capture date. This further stresses the need for continued, long-term monitoring efforts and the incorporation of aging techniques to ascertain recruitment patterns over time (Table 2, Figure 23).

In addition to adult capture information provided earlier in this report, juvenile and subadult capture data collected from 1996–2006 were evaluated to provide insights pertaining to the times and locations most conducive to capturing juvenile/subadult razorback sucker on Lake Mead. The results of this effort are provided below. In all instances, effort, when expressed, is representative of one net night. One net night was defined as a single net, set overnight. No error bars are shown due to the relatively sparse juvenile/subadult data obtained during the past decade. To insure that only known, validated juvenile and subadult data were utilized in this analysis, only data collected during the BIO-WEST study years was included for the following analyses.

Where?

In all instances, juvenile and subadult razorback sucker have been collected during standard adult trammel netting efforts and the only known captures of this rare life stage have occurred in Echo and Las Vegas Bays. As such, please refer to Figures 2–4, which depict the locations of trammel net razorback sucker captures for all netted fish in the primary study areas, as well as the presumptive annual spawning site locations.

Most juvenile and subadult captures have occurred at or near a given year’s spawning area, which is likely an artifact of increased netting efforts at those locations. Provided the overall rarity of this life stage, it appears that the most appropriate monitoring strategy would be to continue the historical trammel netting efforts at presumptive spawning sites. Such a strategy should provide the best opportunity to monitor not only adult fish, but also provides a chance to simultaneously capture subadults and juveniles.

When?

Figure 24 shows the total number of juvenile/subadult razorback sucker collected via trammel netting from 1996–2006 at each of the study areas, and concisely demonstrates the apparent importance of Las Vegas Bay to Lake Mead razorback sucker recruitment. Figure 25 depicts the total number of juvenile/subadult razorback sucker collected by month and by location. Figure 26 shows the similar information, but instead is expressed in CPUE for data collected from 1996–2006. In general, there is some degree of consensus between the figures: November though March all appear to be fairly similar in terms of capturing juvenile and subadult fish at Echo Bay. Although interesting, this does not provide much direction for monitoring efforts to

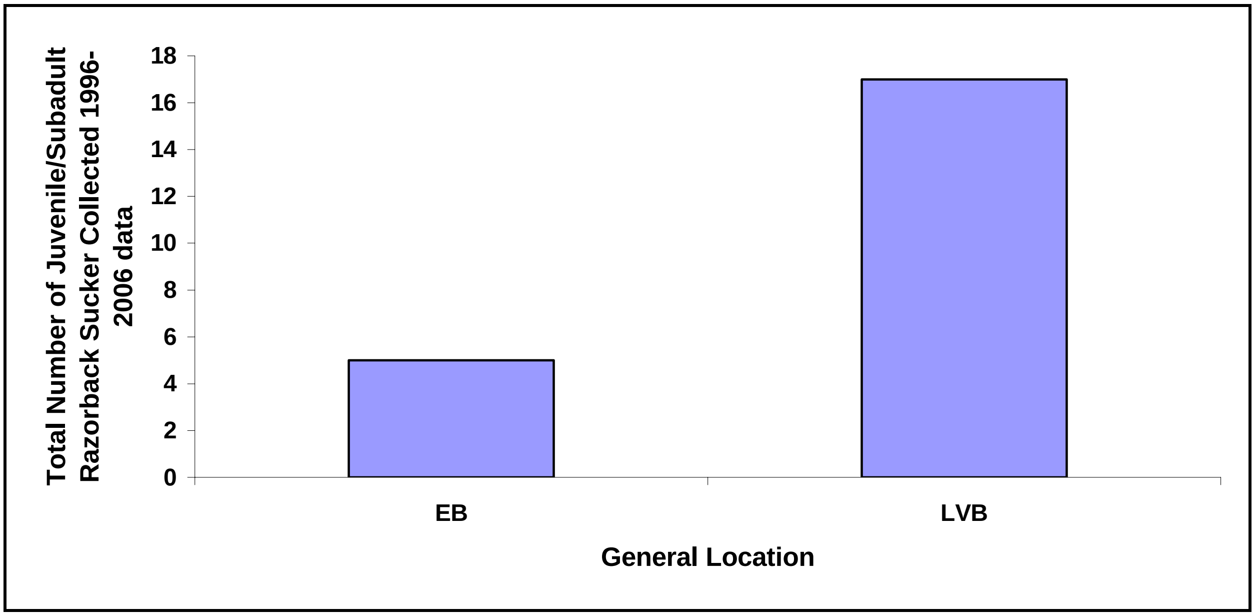

Figure 24. **Total number of juvenile/subadults collected by location (1996–2006 data).**

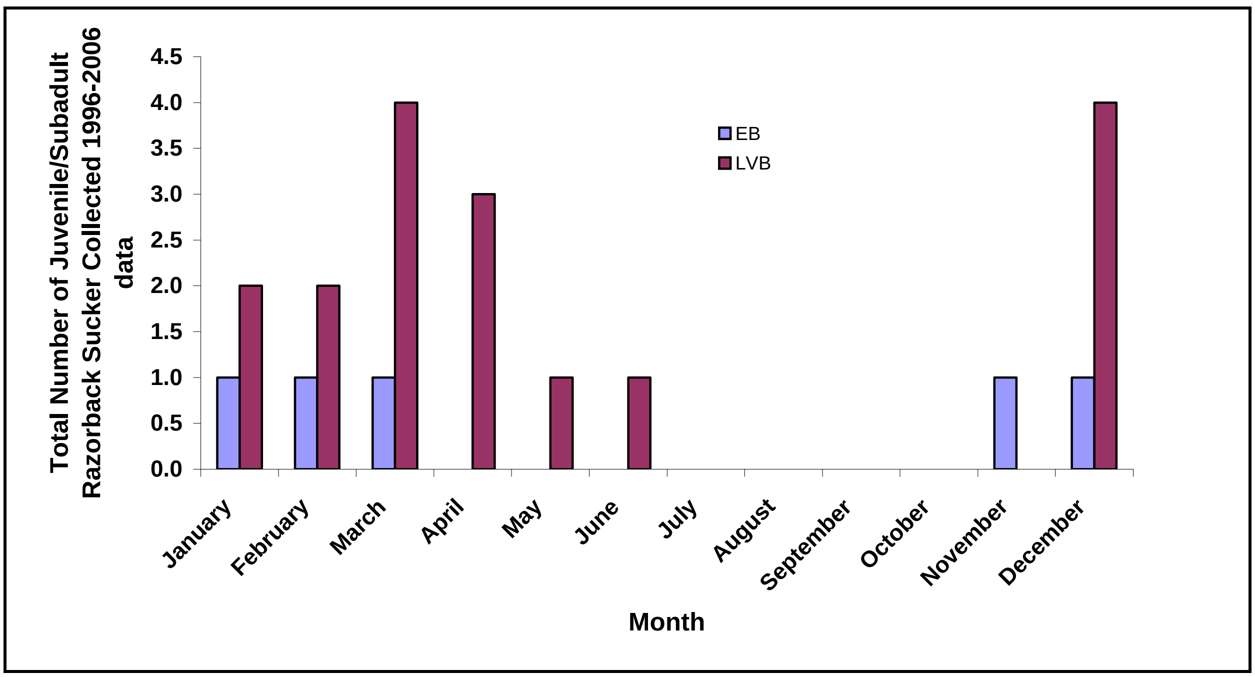

Figure 25. **Total number of juvenile/subadults collected by month (1996–2006 data).**

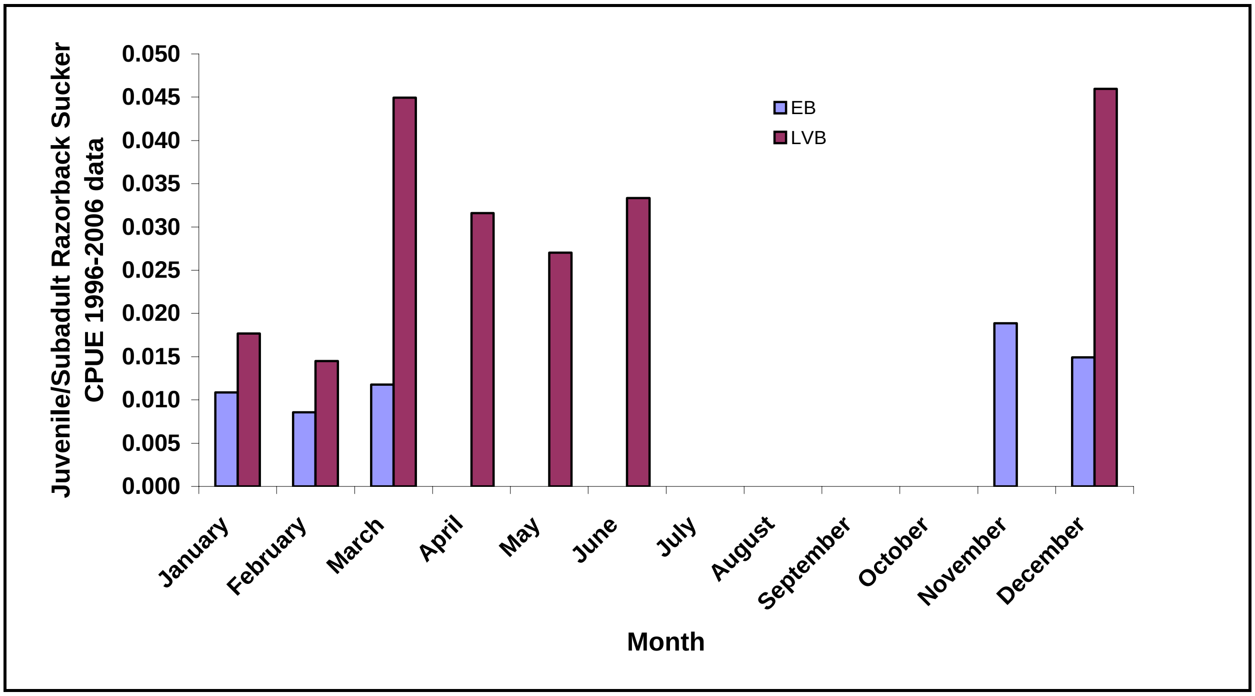

Figure 26. Juvenile/subadult catch per unit effort (CPUE); data from 1996–2006.

be specifically tailored to capturing early life stage fish at Echo Bay. At Las Vegas Bay, March–June and December appear to be the best months for juvenile/subadult razorback sucker capture. Unfortunately, this is also a fairly wide time frame and is not overly useful for monitoring purposes, particularly if resources are reduced.

Figure 27 further illustrates the difficulty of identifying appropriate, efficient sampling dates for juvenile and subadult razorback sucker. By plotting the total number of juveniles/subadults collected during past study years against the number of net nights associated with the same study year, a slight positive correlation between the number of nets set versus the number of juvenile/subadults collected can be observed. In other words, the more netting that is accomplished, the more that early life stage fish tend to be captured. Figure 27 also indicates that the minimum number of nets that have been known to collect even a single juvenile/subadult fish equates to 96 net sets between the two study areas. This number, 96, should not be viewed as a threshold or guarantee for collection of juvenile/subadults; rather, it is simply the minimum number of net sets that in the past have allowed for the capture of juvenile/subadults. For example, during the 2005 spawning season 104 nets were set without a single juvenile or subadult collected. Figure 28 was constructed to demonstrate the capture probability associated with encountering a juvenile or subadult fish during past study years. In this case, capture probability was defined as the total number of juvenile/subadult razorback sucker collected during a given study year and site, divided by the total number of nets set in a study area over the course of a particular year. In general, the probability of encountering even a single juvenile/subadult ranges from 0 to approximately 7%, and there appears to be no logical pattern

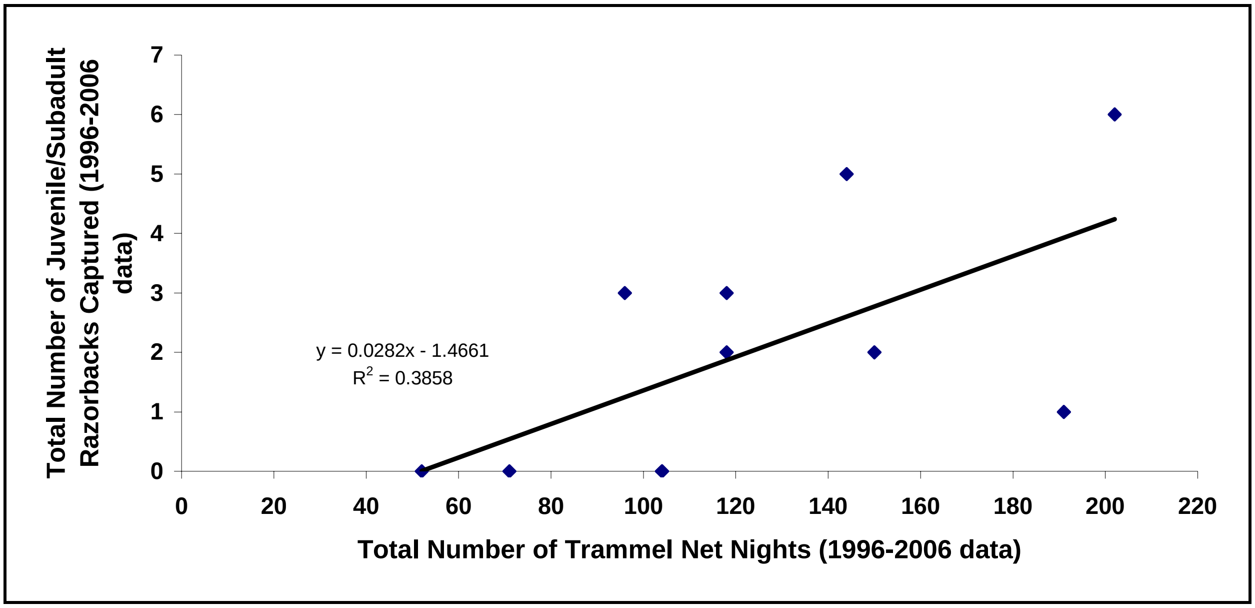

Figure 27. **Relationship between trammel netting effort vs. the number of juveniles/subadults collected on a annual basis; 1996–2006 data.**

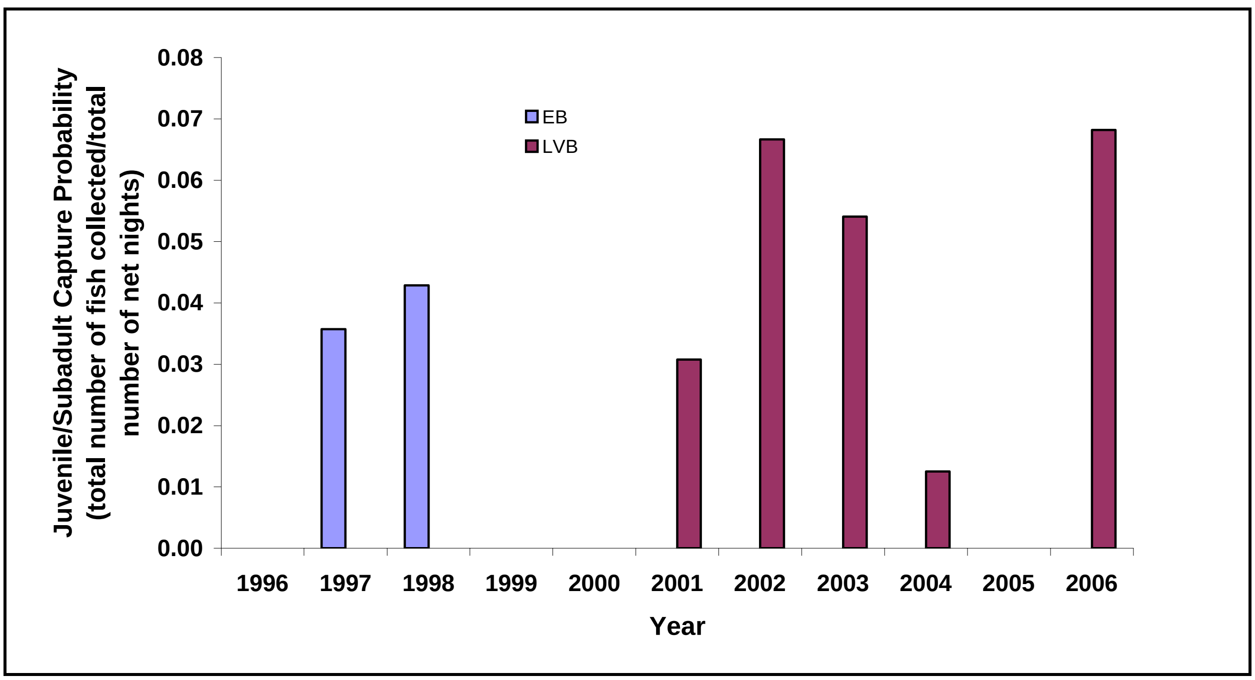

Figure 28. **Capture probability (number of fish per number of net nights) of all juvenile/subadults by year.**

to successful collections. The probability averaged lake wide, provided slightly more than a 1 in 100 chance of detecting even a single juvenile/subadult fish.

In summary, given the spurious results regarding juvenile/subadult razorback sucker capture success (particularly regarding the best month for capturing fish in this life stage) the only solid conclusion is that the more netting included in a future monitoring plan, the greater the chances of documenting recruitment in the form of juvenile or subadult fish. However, a sampling strategy that provides approximately 50 net nights at each study location will increase the likelihood of encountering even one of the relatively rare, newly recruited young fish. Taking into account that the months of February through April tend to provide the most productive sampling times for adult fish, while still rating high in terms of juvenile and subadult fish captures, it may be wise to focus annual monitoring efforts during those months. Monitoring commencing in February and ending in April provides approximately 12 weeks of sampling, which in turn necessitates that a little more than 4 net nights would need to be accumulated at each study location on a weekly basis. This is entirely feasible in terms of crew effort, provided sufficient resources.

As previously stated, habitat use patterns elucidated by sonic-telemetered fish (when available) appear to increase netting efficiency. An example of this was witnessed during the most recent spawning period (2006) when habitat use patterns of five sonic-tagged razorback sucker facilitated net positioning, resulting in the capture of three subadult fish in Las Vegas Bay. This success can be compared to the 2005 spawning period in Las Vegas Bay, when sonic-tagged fish were absent and no juvenile/subadult fish were captured.

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Information collected during future years on Lake Mead would undoubtedly serve to expand knowledge on age, growth, habitat use, recruitment patterns, and spawning behavior of razorback sucker both in Lake Mead, and possibly throughout the Colorado River Basin. In addition, information regarding maturity, stocked and wild fish behavior and interactions, population abundance, and razorback sucker response to fluctuating lake elevations could be facilitated and improved provided that continued monitoring occurs. If possible, a combination of sonic telemetry, trammel netting combined with fin ray aging, and larval collection at Echo and Las Vegas Bays should be effective in describing the future population dynamics of Lake Mead razorback sucker. This combination of methodologies has helped to identify continued razorback sucker spawning in the relatively new Muddy River/Virgin River inflow area of Lake Mead and confirmed the importance of river inflow areas to Lake Mead razorback sucker spawning aggregates. The continuation of data collection of the type obtained to date, especially annual razorback sucker aging data coupled with larval production and spawning habitat selection information, should help to ascertain continued spawning, identify recruitment events, and provide an overall synopsis of the state of Lake Mead razorback sucker populations.

As highlighted throughout this report, the use of sonic-telemetered fish has produced remarkable findings and has been invaluable in locating new spawning habitat utilization throughout Lake Mead. Sonic-tagged fish have helped in confirming and pinpointing annual spawning at known locations. This information would have been difficult to obtain without the experimentation and subsequent monitoring of tagged fish. Maintaining sonic tagged razorback sucker in the system would certainly help to provide answers to a multitude of questions regarding population intermixing and habitat usage throughout the lake. Sonic telemetry could serve particularly well as a monitoring tool because it facilitates relatively rapid, efficient, and precise sampling site selection. Sonic telemetry would also provide the potential to locate any new/unknown spawning sites, or other areas of importance to Lake Mead razorback sucker during future years.

As indicated above and in Albrecht et al. (2006) a key research/monitoring priority should be to continue to follow the selection of spawning sites by the Echo and Las Vegas Bay populations. Additionally, when feasible, continued efforts in the northernmost portions of Lake Mead near the Muddy River/Virgin River inflow areas could provide interesting findings about the dynamics of the population in this area and its relationship to the Echo Bay population. Currently, results in the northernmost portions of the lake are somewhat preliminary as multiple questions remain unanswered concerning this new spawning area. For example, although limited evidence may suggest that the Muddy River/Virgin River population interacts at some level with the Echo Bay population (Albrecht et al. 2006), we have yet to capture a wild fish (with or without PIT-tag) from Echo Bay at the Muddy River/Virgin River inflow. Therefore, a multitude of questions remain unanswered regarding the interaction of fish in this portion of Lake Mead. These include: To what degree is the razorback sucker population at the Muddy River/Virgin River area independent? Is this new spawning aggregate simply reflective of an extension of habitat usage by the Echo Bay population? Is the Muddy River/Virgin River area used every year, or only at diminished lake elevations? Does spawning occur in this area on an annual basis? Do the razorback sucker that utilize the Muddy River/Virgin River area follow similar patterns of recruitment documented for the Echo Bay and Las Vegas Bay fish? What is the size of the Muddy River/Virgin River area population? These questions and a multitude of others highlight the need to continue sampling efforts in this new and relatively understudied area of Lake Mead, and also demonstrate the utility of continued sampling at the more familiar study sites, Echo Bay and Las Vegas Bay.

Since the early years of our research on Lake Mead, fin ray aging data and back-calculation techniques have indicated that recruitment of razorback sucker on Lake Mead has occurred nearly every year. Known numbers of fish recruited to the population range from a single, individual recruit per year (typically spawned during low water years) to more than 10 individual recruits per year (generally associated with relatively high water years). Recruitment has been documented to have occurred as recently as 2002 (Albrecht et al. 2006). The continued presence of wild recruitment makes the Lake Mead razorback sucker population an anomaly in terms of razorback sucker persistence throughout the Colorado River drainage, especially since Lake Mead supports a similar composition and density of nonnative fish as other locations where natural recruitment does not occur (Holden et al. 2005). As time passes and monitoring efforts continue, we would expect to begin capturing a low number of individuals spawned during 2003, 2004, 2005, and even 2006. If/when the lake rises in future years, we would also expect to see another pulse in recruitment. Only through continued efforts on Lake Mead can we ascertain if in fact recruitment events continue, and perhaps begin to understand if we can promote conditions amenable to recruitment elsewhere in the Colorado River Basin.

Lake Mead razorback sucker monitoring will become particularly important given that a large number of razorback sucker from Lake Mead may soon be repatriated, providing a unique opportunity to expand knowledge about Lake Mead populations and provide potential findings that may become important for future native fish recovery efforts throughout the Colorado River. Annual monitoring provides the best opportunity to assess potential effects, impacts, and/or successes related to potential future repatriation/stocking events. Future annual monitoring will provide a mechanism to quantitatively explore potential responses that repatriation efforts may create in terms of natural recruitment of razorback sucker on Lake Mead. Annual monitoring also provides the only mechanism currently available to consistently and dependably track other unforseen and currently unknown biotic or abiotic stressors to the Lake Mead razorback sucker population. Such information could be key in identifying and facilitating sound and justifiable management actions in the future.

In conclusion, we recommend continuing to monitor adult and larval razorback sucker from the two populations at Echo Bay and Las Vegas Bay, continuing to age individual razorback sucker from Lake Mead, and, if feasible, continuing to investigate and monitor adult and larval razorback sucker use of the Muddy River/Virgin River inflow area of Lake Mead. In relation to the aforementioned sites, we analyzed data collected from the early 1990s through 2006 from the current Lake Mead razorback sucker database to ascertain when, where, and how information regarding the individual life history stages could be most effectively obtained and continually maintained on an annual basis at these locations. A condensed summary of the major recommendations stemming from this effort are outlined below. In all cases, readers are encouraged to refer to the associated portions of this document and to familiarize themselves with annual reports from past study years, so as to ensure continuity of future data collection efforts and to provide further understanding of historical findings pertaining to Lake Mead razorback sucker (Holden et al. 1997, Holden et al. 1999, Holden et al. 2000a, Holden et al. 2000b, Holden et al. 2001, Abate et al. 2002, Welker and Holden 2003, Welker and Holden 2004, Albrecht and Holden 2005, Albrecht et al. 2006).

Recommended Adult/Subadult/Juvenile Razorback Sucker Monitoring

- Frequency: Monitoring is recommended on an annual basis.
- Method: Trammel netting as outlined above and in past annual reports.
- Locations: Echo Bay, Las Vegas Bay, and, if/when possible, the Muddy River/Virgin River inflow area.

- Dates to Sample: February, March, and April (a 12-week period is recommended).

- Other: Continuation of standard fish processing, PIT-tagging, and age determination techniques are recommended. If/when feasible, use of sonic-tagged fish would prove useful for selecting sampling sites, increasing field crew efficiency, and providing an opportunity for new/undocumented knowledge to be obtained regarding habitat use patterns throughout Lake Mead.

Recommended Larval Razorback Sucker Monitoring

- Frequency: Monitoring is recommended on an annual basis.

- Method: Nighttime larval techniques provided above and in past annual reports.

- Locations: Echo Bay, Las Vegas Bay, and if/when possible the Muddy River/Virgin River inflow Area.

- Dates to Sample: March and April (an 8-week period is recommended).

- Other: If/when feasible, use of sonic-tagged fish would prove useful for selecting sampling sites and to increase field crew efficiency and to provide opportunity for new/undocumented knowledge to be obtained regarding spawning throughout Lake Mead.

Recommended Monitoring of Sonic-Telemetered Fish

- Frequency: If at all possible, monitoring is recommended on a weekly basis during adult, subadult, juvenile, and larval sampling periods (dates provided above and preferably prior to the initiation of other sampling techniques). Telemetry is recommended monthly during other times of the year (non-spawning period) in order to reduce tagged fish location loss.

- Method: Sonic telemetry implantation and tracking techniques provided in this document and in greater detail in past annual reports.

- Locations: As needed and dictated by previous contact locations.

ACKNOWLEDGMENTS

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