



**Razorback Sucker Studies on Lake Mead, Nevada**  
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*The opinions and conclusions expressed in this report are those of the authors, and do not necessarily reflect the views of the Southern Nevada Water Authority, Nevada Division of Wildlife, or other cooperating agencies.*

## EXECUTIVE SUMMARY

Sampling by the Nevada Division of Wildlife (NDOW) during the 1990s suggested that a fairly young population of razorback suckers (*Xyrauchen texanus*) occurred in Lake Mead, distinguishing it from other Lower Colorado River reservoirs where populations of old adults were the norm. In 1996 the Southern Nevada Water Authority (SNWA), in cooperation with the NDOW, initiated a cooperative study of razorback sucker in the lake to learn more about this population. BIO/WEST, Inc. (BIO/WEST), under contract with the SNWA, developed the study design in conjunction with NDOW and SNWA, and had primary responsibility for conducting the study. Other cooperators in the study were the Bureau of Reclamation, the National Park Service, and the Colorado River Commission of Nevada. The study's objectives included determining size, life history characteristics, and spawning locations for the existing population using trammel netting, sonic telemetry, and larval fish collection. Using 1990s mark and recapture information collected by the NDOW, a population estimate of 200 to 250 adult razorback suckers was determined with the program Capture and the Schnabel estimator at the initiation of the field effort. Two primary study sites were used for the field effort, Las Vegas Bay and Echo Bay, where this species has been collected in the 1990s. From October 1996 to June 1997, 61 adult and nearly 5,000 larval razorback sucker were collected. Sonic tags were surgically implanted in 21 adults, and they were tracked on a monthly or more frequent basis.

Spawning aggregations of adults were determined from trammel netting and sonic tracking in both study sites. Large numbers of larvae were collected only at the Echo Bay site, and smaller numbers were collected at Las Vegas Bay. The spawning site at Echo Bay was near the back end of the wash in 10 to 20 feet of water, whereas the Las Vegas Bay spawning site was in 40 to 80 feet of water and mid-point in the bay. Spawning occurred from mid-February to early May, with the height of activity occurring in March and April.

Echo Bay sonic-tagged fish were found as far away as 15 miles to the north near the mouth of the Muddy River. Rogers Bay, about 3 miles north of Echo Bay, was used fairly consistently by several fish. Las Vegas Bay sonic-tagged fish tended to stay within 5 miles of the collection site and used the mouth of Las Vegas Wash extensively.

A new population estimate was run using the program Capture and the Schnabel estimator that included the 61 razorback suckers collected during the first year of this study, resulting in a population estimate of about 50 to 60 adult razorback sucker in the Echo Bay population and about 400 adults in the Las Vegas Bay population. No overlap in distribution between the two populations was seen with either sonic tagging or trammel netting information. Recaptured fish showed about 10 mm annual growth, about three times the growth reported from Lake Mohave or Upper Colorado River riverine razorback sucker populations.

Of the 21 sonic-tagged adults, only 7 remained active and were consistently contacted by field crews through June 1997. Tag expulsion, fish mortality, and fish movement to other parts of the lake may be reasons for this phenomenon, which has been experienced during several other razorback sucker telemetry studies. Lake Mead razorback sucker studies in 1997-98 will proceed with the same general sampling program initiated in 1996, using continued funding from the SNWA.

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## INTRODUCTION

Once fairly common throughout much of the Colorado River Basin (Minckley et al. 1991), the razorback sucker (*Xyrauchen texanus*) is one of four large-river fishes endemic to the basin that is presently considered Endangered by the U.S. Department of the Interior (USFWS 1991). One of the major factors causing the decline of the razorback sucker and the other large-river fishes has been the construction of mainstem dams and the resultant cool tailwaters and reservoir habitats that replaced a warm, riverine environment (Holden and Stalnaker 1975, Joseph et al. 1977, Wick et al. 1982, Minckley et al. 1991). Other factors causing decline of this species include water withdrawal from the system, changes in seasonal flow patterns that have altered habitat conditions, and competition and predation with non-native fishes. Unlike some of the other large-river fishes, razorback sucker has persisted in many of the reservoirs that were constructed in the lower Colorado River Basin since the 1930s. Relatively large populations were reported in Gila River reservoirs by Minckley (1973), and the largest present population occurs in Lake Mohave (Minckley et al. 1991). However, these populations are comprised only of adult fish with little evidence of recruitment. Adult razorback suckers are most evident in these reservoirs from January through April when they congregate in shallow shoreline areas to spawn, and larvae can be very numerous soon after hatching. But recruitment to these populations appears to occur only near the time of reservoir creation, and the population of long-lived adults disappears 40 to 50 years following reservoir creation (Minckley 1983). Predation by sunfish, bass, carp, catfish, and other nonnative species that establish in the reservoirs appears to be the major reason for the lack of razorback sucker recruitment (Minckley et al. 1991).

This trend is presently being played out in Lake Mohave, which was completed in the 1950s, in that an aging population is disappearing (McCarthy and Minckley 1987). As these reservoir populations become older, the razorback suckers tend to look quite old, with numerous incidences of tumors, lesions, and blindness (McCarthy and Minckley 1987). Studies of age and growth on the Lake Mohave population have shown that the old adults show very little, if any, growth (McCarthy and Minckley 1987).

Lake Mead appeared to follow the same trend as other lower Colorado River Basin reservoirs. The reservoir was formed in 1935 when Hoover Dam was closed. Razorback suckers were relatively common in the lake in the 1950s and 1960s and were found generally throughout the lake. Their numbers became noticeably reduced in the 1970s, approximately 40 years after closure of the dam (Minckley 1973, McCall 1980, Minckley et al. 1991, Holden 1994, Sjoberg 1995). From 1980 through 1989, neither the Nevada Division of Wildlife (NDOW) nor the Arizona Game and Fish Department (AGFD) collected razorback sucker from the lake (Sjoberg 1995). This may be in part due to changes in their lake sampling programs, but it was a considerable difference from the 30+ razorback suckers collected during sportfish surveys in the 1970s. These results are not surprising and fit well within the pattern seen in other lower basin reservoirs of razorback suckers dying off 40 years or so following reservoir development.

In 1990 the NDOW received information from local fishing guides that razorback suckers were still found in Lake Mead in two areas (Las Vegas Bay and Echo Bay) where they had been seen since the 1970s. Limited sampling by the NDOW in early April 1990 resulted in the collection of three adults

from an apparent spawning aggregation at Blackbird Point in the Las Vegas Bay portion of Lake Mead (Figure 1) (Sjoberg 1995). The following year no razorback sucker-specific surveys were attempted, but one adult razorback sucker was collected from Bark Bay on the Overton Arm of the lake (Figure 1) during sportfish gill net surveys.

In 1992, the NDOW initiated razorback sucker-specific surveys using trammel nets at both Blackbird Point and Echo Bay in February and March. A total of 25 adult razorback suckers were captured; most were tagged with Passive Integrated Transponder (PIT) tags and released (Table 1). February through April sampling by NDOW in 1993 was expanded to other historic razorback sucker collection sites within Lake Mead, but razorback suckers were caught only at the Blackbird Point and Echo Bay locations. A total of 20 were captured, including five recaptures of 1992 fish (Table 1).

**Table 1. Razorback sucker collections, including recaptures, in Lake Mead from 1990 to 1996 by the Nevada Division of Wildlife.**

| DATE                  | NUMBER CAUGHT | RECAPTURES | RECAPTURE HISTORY | NUMBER MARKED |
|-----------------------|---------------|------------|-------------------|---------------|
| <b>Las Vegas Wash</b> |               |            |                   |               |
| 1990                  | 3             | 0          |                   | 3             |
| 1991                  | 0             | 0          |                   | 0             |
| 1992                  | 12            | 0          |                   | 12            |
| 1993                  | 10            | 2          | 3/10/92 both      | 8             |
| 1994                  | 5             | 0          |                   | 0             |
| 1994 stocking         | -             | -          |                   | 26 stocked    |
| 1995                  | 1             | 0          |                   | 0             |
| 1996 spring           | 3             | 0          |                   | 3             |
| <b>Echo Bay</b>       |               |            |                   |               |
| 1992                  | 13            | 0          |                   | 13            |
| 1993                  | 10            | 3          | 3/18/92 all       | 7             |
| 1994                  | 0             |            |                   | 0             |
| 1995                  | 2             | 0          |                   | 1             |
| 1995 stocking         | -             | -          | -                 | 14 stocked    |
| 1996                  | 2             | 0          |                   | 2             |

In 1994 the Southern Nevada Water Authority (SNWA) funded BIO/WEST, Inc. (BIO/WEST) to assist the NDOW in sampling Lake Mead for razorback sucker (Holden 1994). BIO/WEST provided manpower assistance as well as a boat and other gear for trammel netting activities. Sampling occurred from February through April at Blackbird Point and at other locations throughout the lake using trammel and gill nets and electrofishing. An intensive multi-agency collection effort was made in April in the upper reaches of the lake near Grand Wash. In addition, limited sampling for larval

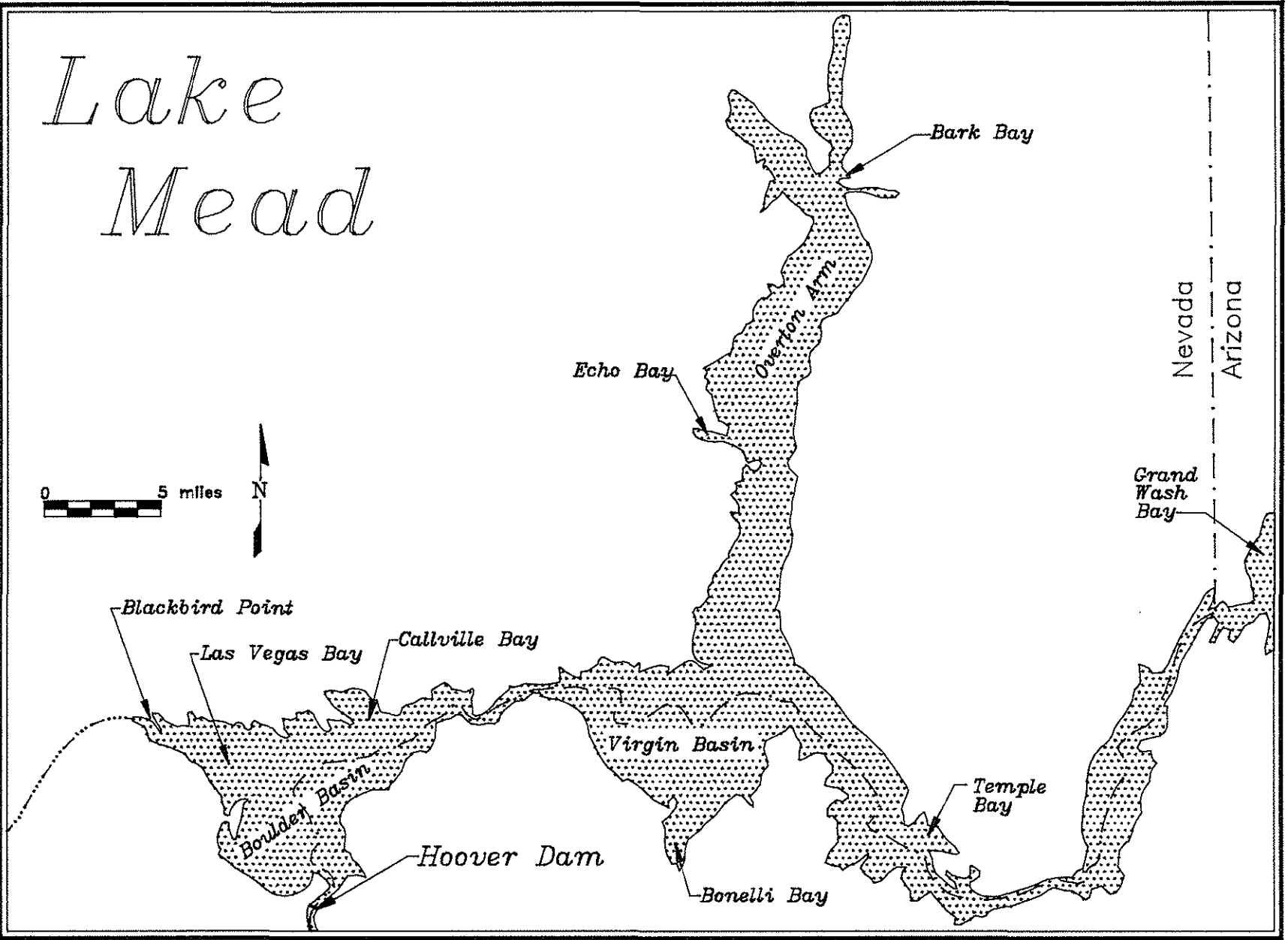


Figure 1. Map of Lake Mead showing general location of study areas.

razorback suckers was also conducted. A total of five adult razorback suckers were collected, all at Blackbird Point or nearby. No other razorback suckers (adult or larvae) were collected in 1994 with the increased effort.

Limited spawning period sampling by Jim Heinrich of the NDOW in the spring of 1995 produced three razorback suckers (two at Echo Bay and one near Blackbird Point), and in 1996 five were collected (two at Echo Bay and three at Blackbird Point) (Table 1). Another NDOW biologist caught two larval razorback sucker in 1995 near Blackbird Point. In addition to the captures of these wild fish, the NDOW also stocked subadult razorback sucker into Lake Mead. A total of 26 razorback suckers were stocked into Las Vegas Bay in 1994, and 13 were stocked into Echo Bay in 1995. All of these stocked fish were PIT-tagged, and they all originated from the Dexter National Fish Hatchery 1984 year-class which were reared at Floyd Lamb State Park in Nevada.

The NDOW biologists that collected the razorback suckers in Lake Mead during the 1990s were also familiar with the Lake Mohave population and had spent considerable time sampling in Lake Mohave. They noted that the Lake Mead fish appeared much younger than the Lake Mohave fish, since they had a very low incidence of blindness, lesions, tumors, etc., and less overall body scarring (Sjoberg 1995). In addition, one 366 millimeter (mm) total length (TL) razorback sucker was collected in 1994 (Holden 1994), the smallest near-adult razorback sucker that has been collected recently in a lower basin reservoir to our knowledge. These observations suggested the Lake Mead populations found in the 1990s were much younger than the original Lake Mead population that disappeared during the 1970s, and perhaps were also much younger than the Lake Mohave population which originated primarily in the 1950s (McCarthy and Minckley 1987). Lake Mead may be the first reservoir where a relatively young population of razorback sucker persists more than 50 years after the reservoir was formed.

The two present populations of razorback sucker in Lake Mead raise the questions of how and when recruitment took place. Sjoberg (1995) and Holden (1994) have proposed two possible hypotheses. The first hypothesis is that the present population may have come from fish that entered Lake Mead from the Grand Canyon in the 1960s or early 1970s, following closure of Glen Canyon Dam. Glen Canyon Dam was closed in 1963, forming Lake Powell upstream of Lake Mead. As Lake Powell filled, the outflow of Glen Canyon Dam became cooler and cooler, to a point where essentially the entire length of the Colorado River between the dam and Lake Mead has become considerably colder than normal. Pre-dam temperatures ranged from 0-29.5 C, whereas post-dam temperatures vary from 7-11 C. It is possible that this cold water caused the movement of razorback sucker from the Marble and Grand Canyon areas of the Colorado River downstream to Lake Mead. Once in the lake, these fish may have mixed with the existing lake population at that time (1960s or 1970s) and started using spawning sites at Echo Bay and Blackbird Point.

A second hypothesis is that certain conditions in Lake Mead allowed the survival of fish spawned in the lake by the original razorback sucker population. This hypothesis would suggest that razorback suckers that were spawned at Blackbird Point and Echo Bay somehow were able to escape predation and recruited to the adult population. Upon reaching adulthood, these fish continue to return to their hatching site to spawn. Fidelity to spawning areas is common with the known riverine populations of razorback sucker (Tyus and Karp 1990, Modde and Irving 1995). Additional recruitment may

have occurred since the original event, producing a population with several age groups. Fish collected during the 1990s in Lake Mead have shown a range of sizes from 366 mm to 765 mm TL. Although size and age are not directly correlated in razorback sucker (McAda and Wydoski 1980), such a large size spread suggests that perhaps multiple recruitment events have occurred. This hypothesis suggests that conditions for razorback sucker in Lake Mead may occasionally be quite different than those in Lake Mohave or other lower basin reservoirs. While this hypothesis is not supported by data from any other known reservoir situation, it is another possible explanation of the present situation found in Lake Mead.

Collection of razorback sucker in the 1990s has raised many questions about the Lake Mead population. How large is it? Are the Las Vegas Bay and Echo Bay groups separate populations? Does recruitment occur in the lake? How old are the fish in Lake Mead, and are the two groups different in age structure? In 1996 the SNWA, in cooperation with the NDOW, initiated a cooperative study to attempt to answer some of these questions about the Lake Mead razorback sucker population. BIO/WEST, 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 included the Bureau of Reclamation, which provided funding for equipment, storage facilities, and technical support; the National Park Service, which provided residence facilities in their campgrounds; the Colorado River Commission of Nevada; and the U.S. Fish and Wildlife Service (Service). Jim Heinrich of the NDOW provided the primary assistance and input from his agency, and Zane Marshall of the SNWA provided extensive field assistance and logistical support.

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 project are:

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

The study was designed to last a minimum of 3 years in order to provide sufficient time to study the population and to compare and contrast information from several different years. This Annual Report summarizes the results of the study from October 1996 through June 1997.

## METHODS

The intent of the present study was to develop a year-round collection and tagging program for razorback sucker in Lake Mead. Two primary study areas were used, Las Vegas Bay in the vicinity of Blackbird Point, and Echo Bay. Four major study techniques have been utilized in the study and form the basis of the remainder of this report.

## **Adult Sampling**

Trammel nets were the primary adult sampling tool. Most nets used were 300' long by 6' deep and had an internal panel of 2" mesh and external panels of 12" mesh. Some 75' x 6' x 1" x 12" trammel nets were also used, along with one 300' x 6' x 1" x 12" trammel net. Nets were generally set with one end near shore in 5 to 10 feet of water, with the net stretched out into deeper areas. Sampling was generally conducted monthly within each study area, with variable effort between months.

Nets were set in the late afternoon just before sundown and pulled in the morning shortly after sunrise. Each net location was noted using an Eagle AccuNav II Global Positioning System (GPS) unit.

Fish were taken from the nets and live fish were held in large buckets. Razorback suckers were immediately transferred to a large cooler for holding while the remainder of the net was processed. Common carp (*Cyprinus carpio*) were enumerated; and other species were measured for total length (TL) and fork length (FL), weighed, and released at the location of capture. Some channel catfish (*Ictalurus punctatus*) and striped bass (*Morone saxatilis*) were retained by the NDOW for contaminant analysis. Razorback suckers were checked for PIT tags, tagged with PIT tags if they were not recaptures, measured (including standard length (SL)), weighed, and returned to the point of capture unless they were held for sonic tagging. Destron/Fearing Model TX1400 (400 kHz) PIT tags were used, which is consistent with other fishery research in the Colorado River System.

## **Sonic Tagging and Telemetry**

### **Equipment**

Two models of sonic transmitters were used in this investigation, the Sonotronics Model CTT-83-2 (14-month tag) and the Model CTT-83-3 (48-month tag). The 14-month tag had an air weight of 22 grams (g) (6 g water weight) and measured 64 mm long and 16 mm in diameter. The 48 month tag had an air weight of 24g (8 g water weight) and measured 65 mm long by 18 mm in diameter. The tags utilized 75, 76, and 77 kHz. Each tag had its own unique oral code so that individual fish could be distinguished. The 14-month tags were temperature sensitive in that the interval between components of the oral code was slower in cold water and faster in warm water. The tags were individually calibrated for temperature in the laboratory prior to use in the field. The Sonotronics Model USR-5W digital display receiver with DH-2-10 directional hydrophones was used to locate and track implanted razorback sucker. The receiver also provided an interval measurement for determining the temperature of the tag, and, therefore, the depth of the fish.

### **Implant Procedures**

The following surgical protocol was established from procedures developed by Valdez and Nilson (1982), Kaeding et al. (1990), and Valdez and Trinca (1995) for humpback chub; Tyus (1982) for Colorado squawfish; and Valdez and Masslich (1989) for Colorado squawfish and razorback sucker. A transmitter air weight to fish weight of 2 percent or less (Bidgood 1980, Marty and Summerfelt 1990) was used to assure that the tags were not too big for the fish being tagged. Surgical implants were performed on shore. Three people were involved in the surgery: a surgeon, an assistant, and an anesthetist who also monitored respiration of the fish. The surgeon and anesthetist were members

of the BIO/WEST staff and were responsible for insuring that all aspects of the surgical procedure were followed and monitored.

Prior to surgery, each fish was placed in a live well with fresh water. All surgical instruments were cold-sterilized with 90% isopropyl alcohol and allowed to air dry on a disposable sterile cloth. Two 5-gallon buckets were placed above the level of the surgical table, one with anesthetic solution and one with fresh lake water. Each bucket had a 5-foot length of tygon tubing attached to the bottom, allowing the anesthetist to alternately irrigate the gills of the fish with anesthetic or fresh water, according to the reaction of the fish. Just prior to surgery, the fish was anesthetized with Finquel, a brand of tricaine methanesulfonate (MS-222), at a concentration of 100 mg/l for 2 to 4 minutes, or until the fish lost equilibrium in the holding tank but continued moderate opercular movement. During surgery the gills were bathed with anesthetic at 50 mg/l, as needed, and then with fresh water about half way through the surgery to expedite post-surgical recovery.

Fish were removed from the anesthetic bath by the anesthetist and placed on a surgical cradle. A 3- to 4-centimeter (cm) incision was made just lateral to the midline by the surgeon. The incision was generally on the left side anterior to the pelvic girdle and about 1 to 2 cm lateral to the midline of the fish. The sonic transmitter was inserted through the incision and pushed back to rest on the pelvic girdle. The incision was closed with 4 to 6 sutures using 3-0 Maxon absorbable polygluconate monofilament suture with an attached PH 26 curved needle. Fish were allowed to recover in the live well, then released at the point of capture, usually within an hour of surgery.

### **Tracking Procedure**

Sonic-tagged razorback sucker were located and monitored monthly or more frequently depending on the field schedule. Although a grid system was initially planned for locating the fish, it was found that during the winter and spring the fish did not move far from the two primary study areas. Therefore, searches were generally initiated in those areas and then expanded as needed. Also, due to the numerous small coves and bays on Lake Mead, a grid approach did not work well except in the open water areas. Some transmitters were heard up to a 2-mile distance, whereas in the smaller bays and in vegetated areas, transmitters could not be heard, at times, beyond a 100-yard distance. Searches for fish were generally made during daylight hours along shorelines, with listening points every 0.5 mile or less, depending on shoreline configuration and other factors that could affect the ability to hear a signal. Since sonic equipment operates on line-of-site, any obstruction could reduce or block a signal. Once a signal was found, the directional capabilities of the hydrophone, volume of the transmitter, and triangulation were used to pinpoint the location of the fish, which was then noted using the GPS unit. A Hydrolab Model SUR2-SU was used to take temperature profiles of fish locations during summer months so the depth of the temperature-sensitive tags could be determined. During the winter of 1996-97, Lake Mead was a constant 13° C, so temperature profiles were not taken regularly.

### **Larval Sampling**

Larval sampling methods followed those developed by Burke (1995) and other researchers on Lake Mohave. The procedure utilizes the positive phototactic response of larval razorback suckers to capture them. After sundown, a boat was positioned in an area of known or suspected razorback

sucker spawning activity. Two 12-volt "crappie" lights were connected to a battery, placed over each side, and submerged 4 to 10 inches into the water. One or two "netters" were stationed looking down on the area around the lights with long-handled aquarium dip nets. Larval razorback suckers which swam into the lighted area were dip netted out of the water and placed into a holding bucket. The procedure was generally run from 10 to 60 minutes at each location and timed so a catch per unit of time could be calculated. Usually, 4 to 6 sites were sampled each night larval sampling was attempted.

Initially, a variety of sites was sampled for larvae. Once fairly large numbers of larvae were found at Echo Bay, specific sites were visited repeatedly to obtain information related to the timing of larval abundance at each site. Large numbers of larvae were not found at Las Vegas Bay, so the sampling was maintained in the search mode.

Larvae were enumerated as they were placed in the holding buckets and were released at the point of capture when sampling at a site was completed, except for one instance when larvae were maintained by the NDOW for captive rearing. Bureau of Reclamation (Ty Walters and Joe Kahl) and NDOW biologists assisted BIO/WEST personnel with initial identification of young razorback suckers. Due to the early spawning time (February through April), few other larval fish are typically found with larval razorback sucker, so identification was generally not a problem.

In addition to the larval dipping, larval light traps (Southern Concepts, Birmingham, AL) similar to ones used in the Upper Basin for capturing larval razorback suckers (Muth 1995) were also used for a short time in Echo Bay. These traps, which use battery operated lights to attract the larvae, are set in areas for several hours at a time and do not require constant attendance.

## **Juvenile Sampling**

Sampling for juvenile razorback suckers was initiated following the location of relatively large numbers of larvae. Since juvenile razorback suckers have generally not been found in reservoirs (Minckley et al. 1991), standard methods for their sampling have not been developed. Several techniques were employed based on studies of other young native Colorado River fishes, including using minnow traps, seines, fine-mesh gill nets, and hoop and fyke nets. Minnow traps were generally set overnight and remained in place for 2 consecutive nights. They were placed in areas with emergent vegetation and in more open water areas. Seining was conducted in the back of Echo Bay where substrate and vegetation allowed. A 30' x 6' x 0.25" mesh bag seine and a 15' x 6' x 0.125" mesh standard seine were used. Hoop and fyke nets and fine-mesh (0.05 inch) gill nets were set in and around emergent vegetation habitats. Several different sizes of hoop and mesh were utilized on the hoop and fyke nets.

## **Other Methods**

### **Population Estimates**

A population estimate of razorback sucker in Lake Mead was required by the Service prior to sonic tagging. The number of sonic tags that could be implanted was restricted to 10 percent of the population estimate. The computer program CAPTURE (Otis et al. 1978) was used along with the

Schnabel population estimator (Seber 1982) to develop a series of population estimates using the 1990 to 1996 capture/recapture data obtained by the NDOW and BIO/WEST. Dr. Ron Ryel, a population modeling specialist, made the estimates. The model was run again in June 1997 incorporating the information collected during this study.

## SCUBA

SCUBA diving was employed to look for spawning fish in Echo Bay and to search for stationary fish and/or sonic tags. Snorkeling was also employed to look for spawning fish.

## STUDY AREAS

Figures 2 and 3 show the Las Vegas Bay and Echo Bay study sites in detail. The Las Vegas Bay study area includes the Las Vegas Bay Marina and boat launch area, as well as the inflow area of Las Vegas Wash. Las Vegas Wash is a permanent stream of 200 to 250 cfs comprised of urban runoff, tertiary treated waste water effluent, industrial effluent, and discharge from the Las Vegas Valley shallow aquifer. This inflow makes Las Vegas Bay a very rich system. Blackbird Point, the area of recent razorback sucker spawning activity, is directly across the bay from the marina at the mouth of Gypsum Cove. During the course of the study, the elevation of Lake Mead rose from about 1190 to 1200 feet above sea level. This 10-foot rise created a large area of submerged and emergent riparian and wetland vegetation near the mouth of Las Vegas Wash. Primary plant species were salt cedar (*Tamarisk sp.*), willow (*Salix sp.*), bulrush (*Scirpus sp.*), and cattail (*Typha sp.*). Salt cedar around Blackbird Point was inundated and a small island near Blackbird Point where razorback sucker have been caught in the past was also inundated (Figure 2). Depths of the study area ranged from over 80 feet near the marina and further out into the bay to 5 to 10 feet in the back of the bay.

Echo Bay is located approximately 50 miles by lake or by road from Las Vegas Bay (Figure 1). The Echo Bay study area also includes a marina and boat launch. Echo Wash is dry except during large storm events, so there is no permanent inflow in this portion of the lake. The rising lake level flooded an area of salt cedar at the back of Echo Bay and in all the small embayments and wash mouths around the sides of the bay. Depths of the bay ranged from about 60 to 80 feet near the marina to 5 to 10 feet near the back of the bay.

## RESULTS

### Initial Population Estimate

NDOW razorback sucker collections during the 1990s included some mark/recapture information that allowed for an initial population estimate to be made (Table 1). Because the annual capture effort was markedly different, and recruitment and mortality factors in the population are not well understood, the available data did not fit many standard population estimators. After discussions with the Service and input from a number of population modelers, it was decided that several population estimates would be made using the program CAPTURE (Otis et al. 1978) and the Schnabel estimator (Seber 1982, p. 139, unbiased estimator). Confidence intervals were calculated as suggested by Burnham et al. (1987), and were automatically calculated by CAPTURE. CAPTURE uses both true capture/recapture estimators and removal-type estimators. It was felt that the Lake Mead data did

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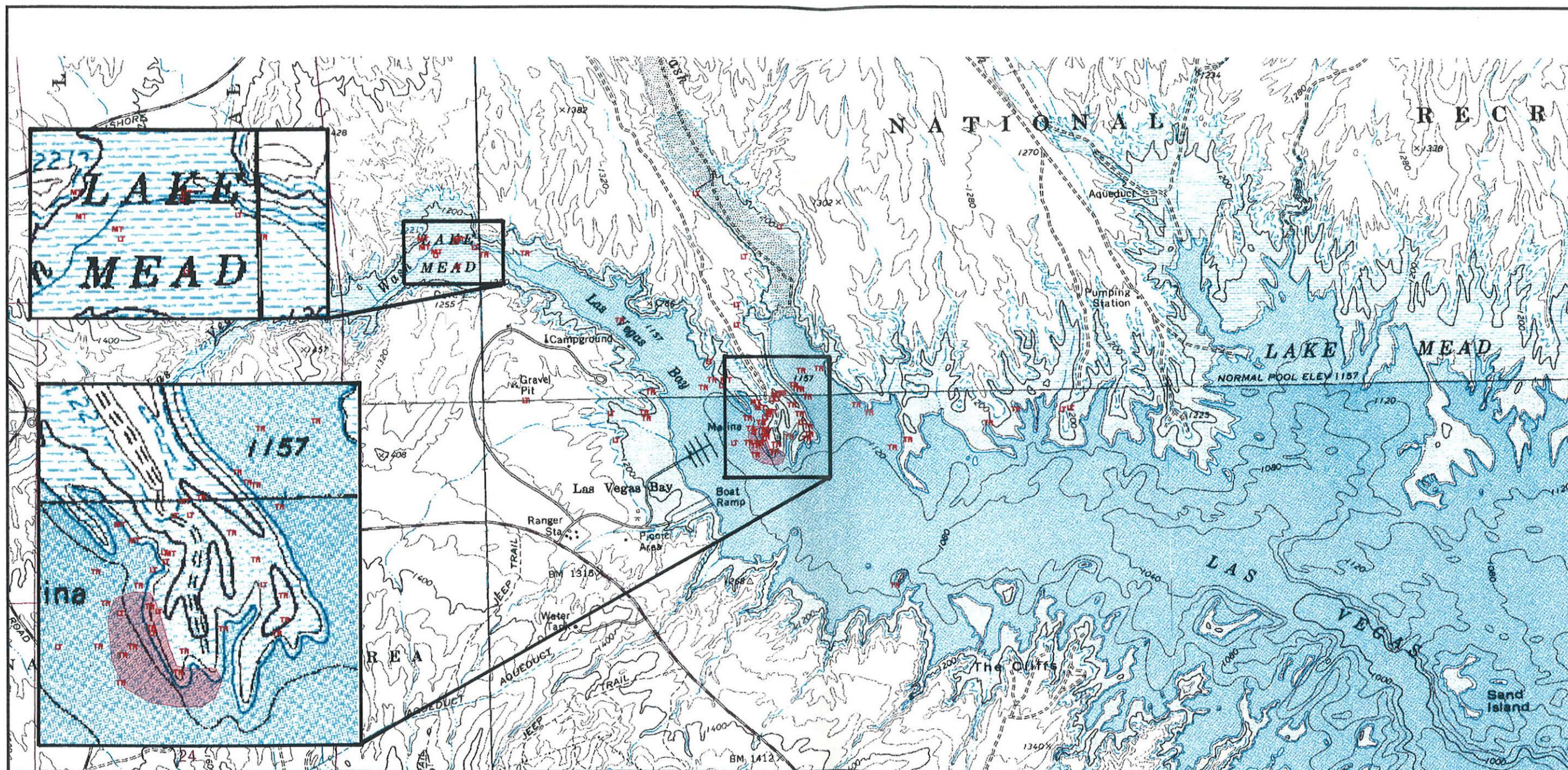


Figure 2. Las Vegas Bay study area with sampling locations by gear type, and suspected spawning areas.

TR Trammel Net Location  
 MT Minnow Trap Location  
 LT Larval Sampling Location

▣ Larval Sampling Site  
 ▨ Spawning Locations

0 2000 4000 6000 8000 10000  
 Feet

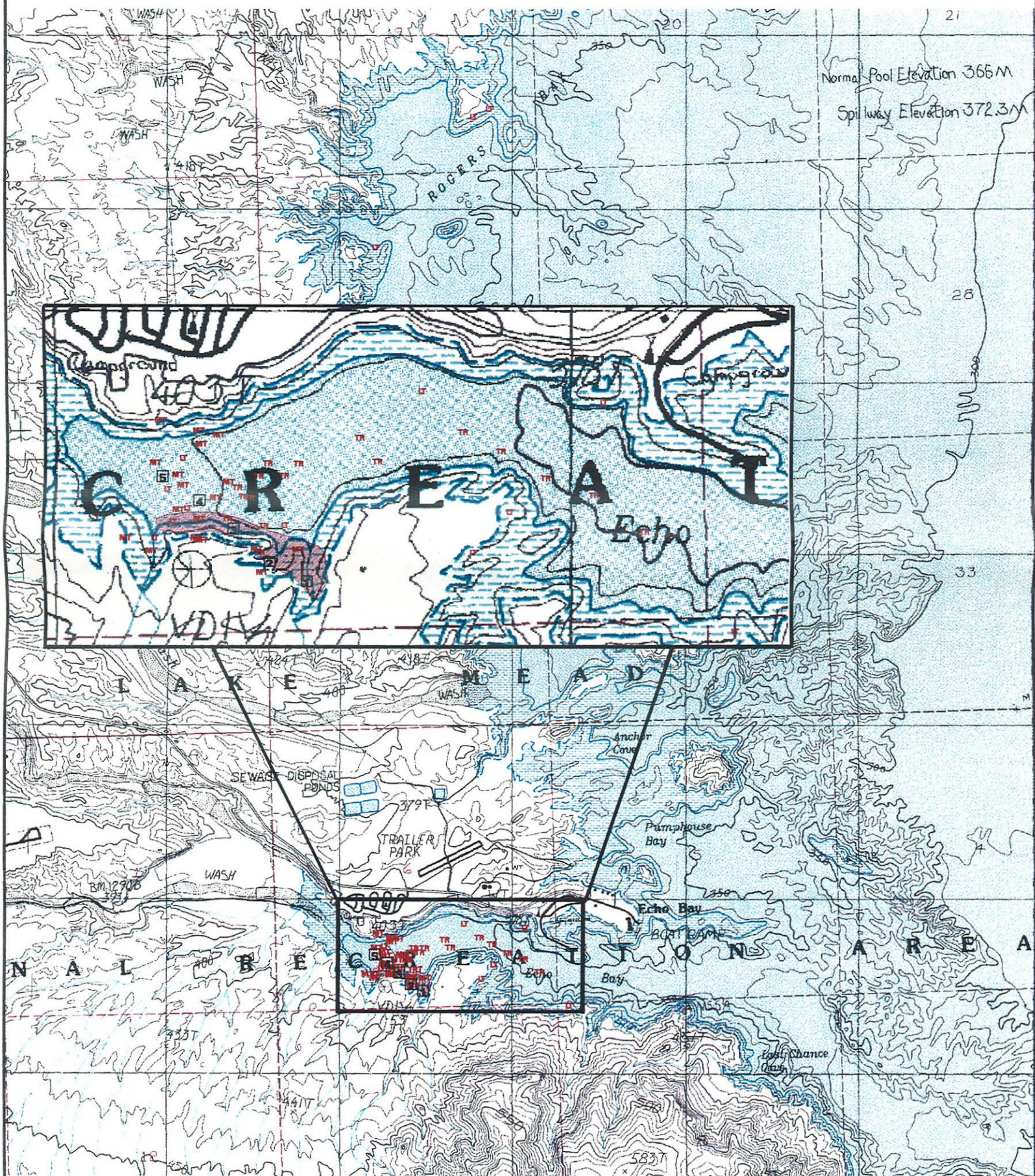


Figure 3. Echo Bay study area with sampling locations by gear type, and suspected spawning areas.

- TR Trammel Net Location
- MT Minnow Trap Location
- LT Larval Sampling Location
- Larval Sampling Site
- Spawning Locations



not fit the removal estimators, so the results of those estimates were not used. Six models run by CAPTURE were used along with the Schnabel estimator, and the results are shown in Table 2.

**Table 2. Population estimates for Lake Mead razorback sucker using data collected by the Nevada Division of Wildlife (NDOW) from 1990 to 1996.**

| ESTIMATOR       | LAS VEGAS BAY |          | ECHO BAY |          | COMBINED |          |
|-----------------|---------------|----------|----------|----------|----------|----------|
|                 | MEAN          | 95% c.i. | MEAN     | 95% c.i. | MEAN     | 95% c.i. |
| Schnabel $M_t$  | 149           | 52-722   | 48       | 27-168   | 194      | 100-487  |
| Model $M_0$     | 191           | 78-578   | 69       | 38-165   | 233      | 132-467  |
| Darroch $M_t$   | 217           | 83-703   | 57       | 34-126   | 223      | 126-458  |
| Chao $M_t$      | 158           | 69-455   | 50       | 32-110   | 196      | 113-396  |
| Chao $M_h$      | 273           | 93-981   | 74       | 38-192   | 273      | 142-603  |
| Chao $M_{th}$   | 247           | 87-878   | 70       | 37-190   | 273      | 143-600  |
| Jackknife $M_h$ | 105           | 79-146   | 57       | 42-86    | 183      | 143-240  |

The population mean and confidence intervals were similar for six of the seven estimators, indicating a mean population size of 150 to 275 razorback suckers at Las Vegas Wash and 50 to 75 razorback suckers at Echo Bay. Confidence intervals were quite large for all estimators, which reflects the nature of the data used for the estimates. The Jackknife estimator may represent an underestimation of the mean as this estimator is known to underestimate population size with sparse data (Chao 1987, 1989). The Service agreed with these results—that a conservative population estimate for the two areas combined was 200 adults—and used this number to permit sonic tagging of up to 10 percent of the population, or 20 individuals.

## **Adult Sampling**

Table 3 shows the trammel net effort that was expended from October 1996 to June 1997, and Figures 2 and 3 show the location of trammel net sets in the two primary study areas. No trammel netting occurred in June. A total of 134 trammel net nights, comprised of one overnight net, were utilized during this time period. A total of 95 net nights were used in the Las Vegas Bay area and 39 net nights were used in the Echo Bay area.

The trammel netting effort during the first year of the study was concentrated in the Blackbird Point area in Las Vegas Wash (Figure 2) and in the back part of Echo Bay (Figure 3). Nets were initially placed in areas where the NDOW had the most success in the past and then were modified to locations that sonic-tagged fish were using. At Las Vegas Bay, most of the razorback sucker captures (24 out of 28) came from three net locations off the end of Blackbird Point. This area was about 10 feet deep on the shoreward end and ended in about 80 feet of water in the channel between Blackbird Point and the Las Vegas Bay Marina. Initially, most of the razorback suckers were caught at a depth of 30 to 40 feet, but during March and April most caught at this location were at a depth of 60 to 80 feet near the end of the 300-foot trammel nets. This area is shown as the suspected

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**Table 3. Trammel netting effort (net nights) on Lake Mead by month from October 1996 to June 1997.**

| <b>MONTH</b> | <b>LAS VEGAS<br/>WASH</b> | <b>NET NIGHTS<br/>ECHO BAY</b> | <b>TOTAL</b> |
|--------------|---------------------------|--------------------------------|--------------|
| October      | 6                         | 12                             | 18           |
| November     | 13                        | 4                              | 17           |
| December     | 17                        | 0                              | 17           |
| January      | 19                        | 4                              | 23           |
| February     | 13                        | 4                              | 17           |
| March        | 13                        | 8                              | 21           |
| April        | 12                        | 4                              | 16           |
| May          | 2                         | 3                              | 5            |
| June         | 0                         | 0                              | 0            |
| Total        | 95                        | 39                             | 134          |

spawning location for the Blackbird Point area (Figure 2) and was used during the 1990 to 1996 period by NDOW to capture razorback sucker.

At Echo Bay nets were originally set about mid-way back into the bay at maximum depths of 30 to 40 feet. Since sonic-tagged razorback suckers used the back part of the bay, nets in the February through April period were generally set only in the back part of the bay at maximum depths of 15 to 25 feet.

Table 4 provides information on the razorback suckers that were caught during the October 1996 to June 1997 time period. A total of 61 razorback suckers were caught, 28 at Las Vegas Bay and 33 at Echo Bay. Razorback suckers were more difficult to catch at Las Vegas Bay than Echo Bay, with total catch rates of 0.29/net night and 0.85/net night, respectively. The highest catch rate in any one net was six razorback suckers at Las Vegas Bay on April 21, 1997. Figure 4 shows the monthly catch rate of razorback suckers at both primary study sites. The highest catch rate was during April at both Las Vegas Bay and Echo Bay. The lowest catch rate was during November in Las Vegas Bay when only one razorback sucker was caught during 13 net nights.

As noted above, the primary reason to sample at Blackbird Point and Echo Bay was that past captures suggested razorback suckers spawned at these locations. Starting in November, almost all of the males had breeding tubercles on their tails and anal fins (Table 4). The second smallest fish captured (492 mm SL), caught on December 18, 1996, was the only potential male captured after November that did not have tubercles developed. Males expressing milt were first collected in February, after which all males were ripe until May. The first running ripe female was collected at Blackbird Point on February 25, with two other ripe females being captured in March (Table 4). Ripe

**Table 4. Information on razorback suckers caught at Lake Mead from October 1996 to June 1997.**

| DATE     | LOCATION        | SONIC TAG NO. | PIT TAG NO. | RECAPTURED | TL (mm) | FL (mm) | SL (mm) | WEIGHT (G)  | SEX | RIPE <sup>a</sup> |
|----------|-----------------|---------------|-------------|------------|---------|---------|---------|-------------|-----|-------------------|
| 10/23/96 | Blackbird Point | Not Implanted | 1F4B1F5621  | No         | 495     | 460     |         | 1530        |     |                   |
| 10/23/96 | Blackbird Point | Not Implanted | 1F4A173D43  | No         | 588     | 547     |         | 2600        |     |                   |
| 10/24/96 | Echo Bay        | Not Implanted | 1F4A30392E  | No         | 704     | 651     | 594     | 9lb. 0oz.   | F   |                   |
| 10/24/96 | Echo Bay        | Not Implanted | 7F7D22242B  | Yes        | 595     | 555     | 499     | 2700        | F   |                   |
| 11/18/96 | Blackbird Point | 249           | 1F483F0D4D  | Yes        | 576     | 530     | 485     | 2130        | F   | TU                |
| 11/20/96 | Echo Bay        | 357           | 7F7B012325  | Yes        | 591     | 550     | 489     | 2710        | F   | TU                |
| 11/20/96 | Echo Bay        | 348           | 7F7D152A5D  | Yes        | 569     | 533     | 471     | 2270        | M   | TU                |
| 11/20/96 | Echo Bay        | 258           | 7F7D515B6E  | No         | 585     | 540     | 479     | 2871        | F   | TU                |
| 11/20/96 | Echo Bay        | 267           | 7F7D2B330C  | Yes        | 588     | 545     | 485     | 2235        | M   | TU                |
| 11/20/96 | Echo Bay        | 285           | 7F7D165D68  | Yes        | 606     | 564     | 502     | 2604        | M   | TU                |
| 12/18/96 | Blackbird Point | 276           | 7F7D3B6539  | No         | 713     | 664     | 605     | 9lb. 15oz.  | F   |                   |
| 12/18/96 | Blackbird Point | 339           | 7F7D4B7052  | No         | 492     | 459     | 410     | 1637        | M   |                   |
| 01/27/97 | Echo Bay        | 2255          | 7F7D4D6F34  | No         | 585     | 545     |         | 2475        | M   | TU                |
| 01/27/97 | Echo Bay        | Not Implanted | 7F7D2B2D5F  | Yes        | 590     | 548     |         | 2638        | M   | TU                |
| 01/27/97 | Echo Bay        | Not Implanted | 7F7D222A48  | Yes        | 545     | 510     |         | 2055        | M   | TU                |
| 01/27/97 | Echo Bay        | 2228          | 7F7D22351B  | Yes        | 695     | 645     |         | 4245        | F   |                   |
| 01/27/97 | Echo Bay        | 2246          | 7F7D4D7777  | No         | 590     | 550     |         | 2610        | M   | TU                |
| 01/28/97 | Blackbird Point | 384           | 7F7D4A7E47  | No         | 512     | 383     |         | 1603        | F   |                   |
| 01/29/97 | Blackbird Point | 2237          | 7F7D28296B  | No         | 735     | 695     | 640     | 10lb. 8 oz. | F   |                   |
| 01/29/97 | Blackbird Point | 2264          | 7F7D4B7C2E  | No         | 560     | 520     | 465     | 2222        | M   | TU                |
| 02/10/97 | Blackbird Point | 294           | 7F7D4B7A54  | No         | 617     | 578     | 525     | 2375        | M   | MI                |
| 02/25/97 | Blackbird Point | 276           | 7F7D3B6539  | Yes        | 713     | 664     |         | 8lb. 8oz.   | F   | EG                |
| 02/25/97 | Blackbird Point | Not Implanted | 7F7D4D6275  | No         | 502     | 467     | 428     | 1599        | M   | MI                |
| 02/25/97 | Blackbird Point | Not Implanted | 7F7D51716D  | No         | 659     | 605     | 550     | 7lb. 15oz.  | F   |                   |
| 02/25/97 | Blackbird Point | Not Implanted | 7F7D481D76  | No         | 671     | 620     | 560     | 8lb. 4oz.   | F   |                   |
| 02/28/97 | Echo Bay        | 357           | 7F7B012325  | Yes        | 597     | 550     | 485     | 2668        | M   |                   |
| 02/28/97 | Echo Bay        | Not Implanted | 7F7D1A2B3C  | Yes        | 576     | 538     | 481     |             | M   |                   |
| 02/28/97 | Echo Bay        | Not Implanted | 1F4A592D11  | Yes        | 681     | 642     | 573     | 3390        | F   |                   |
| 02/28/97 | Echo Bay        | Not Implanted | 7F7D462104  | No         | 661     | 620     | 555     | 3432        | F   |                   |
| 03/08/97 | Echo Bay        | Not Implanted | 1F4A157B07  | Yes        | 571     | 531     | 467     | 2434        | M   | MI                |
| 03/10/97 | Blackbird Point | Not Implanted | 7F7D51716D  | Yes        | 659     | 610     | 560     | 3625        | F   |                   |
| 03/10/97 | Blackbird Point | Not Implanted | 7F7D4A0478  | No         | 664     | 552     | 495     | 2718        | M   | MI                |
| 03/10/97 | Blackbird Point | Not Implanted | 7F7D51650E  | No         | 565     | 555     | 500     | 2363        | M   | MI                |
| 03/10/97 | Blackbird Point | Not Implanted | 1F7A3E1A0F  | No         | 722     | 670     | 610     | 9lb. 2oz.   | F   | EG                |
| 03/10/97 | Blackbird Point | Not Implanted | 7F7D481D76  | Yes        | 670     | 612     | 555     | 7lb. 12oz.  | F   | EG                |
| 03/12/97 | Echo Bay        | Not Implanted | 201D5F2A3A  | No         | 645     | 591     | 525     | 3095        | F   | SP                |
| 03/12/97 | Echo Bay        | Not Implanted | 1F7A26625F  | No         | 560     | 519     | 460     | 2422        | M   | MI                |
| 03/12/97 | Echo Bay        | Not Implanted | 7F7D1A2E1A  | Yes        | 584     | 535     | 481     | 2461        | M   | MI                |
| 03/12/97 | Echo Bay        | Not Implanted | 1F7A39743A  | No         | 590     | 538     | 482     | 2853        | M   | MI                |

**Table 4. Information on razorback suckers caught at Lake Mead from October 1996 to June 1997 (cont.).**

| DATE     | LOCATION        | SONIC TAG NO. | PIT TAG NO. | RECAPTURED | TL (mm) | FL (mm) | SL (mm) | WEIGHT (G) | SEX | RIPE <sup>a</sup> |
|----------|-----------------|---------------|-------------|------------|---------|---------|---------|------------|-----|-------------------|
| 03/12/97 | Echo Bay        | 357           | 7F7B012325  | Yes        | 600     | 552     | 496     | 2649       | M   | TU                |
| 04/05/97 | Blackbird Point | Not Implanted | 203726295A  | No         | 702     | 648     | 590     | 10lb. 1oz. | F   |                   |
| 04/05/97 | Blackbird Point | Not Implanted | 1F7B03796A  | No         | 612     | 563     | 505     | 4lb. 14oz. | M   | TU                |
| 04/05/97 | Blackbird Point | 2264-2nd Time | 201D5B1751  | No         | 581     | 529     | 475     | 5lb. 6oz.  | M   | MI                |
| 04/17/97 | Blackbird Point | 2525          | 201D61560C  | No         | 662     | 605     | 545     | 3150       | M   | MI                |
| 04/20/97 | Echo Bay        | 3344          | 1F7B477827  | No         | 573     | 484     | 334     | 1989       | M   | MI                |
| 04/20/97 | Echo Bay        | 2273          | 1F7B0D2435  | No         | 559     | 516     | 464     | 2006       | M   | MI                |
| 04/20/97 | Echo Bay        | 2336          | 201D5B6107  | No         | 632     | 586     | 536     | 3011       | F   | EG                |
| 04/20/97 | Echo Bay        | Not Implanted | 1F7A39743A  | Yes        | 582     | 530     | 485     | 2497       | M   | MI                |
| 04/20/97 | Echo Bay        | Not Implanted | 1F7B5A503C  | No         | 472     | 442     | 387     | 1194       | M   | MI                |
| 04/20/97 | Echo Bay        | Not Implanted | 2037132A6C  | No         | 637     | 585     | 542     | 3142       | F   | EG                |
| 04/20/97 | Echo Bay        | Not Implanted | 1F7A721C59  | No         | 582     | 540     | 493     | 2133       | M   |                   |
| 04/21/97 | Blackbird Point | Not Implanted | 1F7B03796A  | Yes        | 604     | 555     | 508     | 2100       | M   | MI                |
| 04/21/97 | Blackbird Point | Not Implanted | 7F7D4C0651  | No         | 605     | 558     | 505     | 2360       | M   | MI                |
| 04/21/97 | Blackbird Point | 2264          | 201D5B1751  | Yes        | 577     | 525     | 473     | 2400       | M   | MI                |
| 04/21/97 | Blackbird Point | Not Implanted | 7F7D3F6F5C  | No         | 552     | 507     | 458     | 2127       | M   | MI                |
| 04/21/97 | Blackbird Point | Not Implanted | 7F7D483714  | No         | 515     | 474     | 426     | 1532       | M   | MI                |
| 04/21/97 | Blackbird Point | 2444          | 7F7D4D6275  | Yes        | 508     | 465     | 419     | 1330       | M   | MI                |
| 05/19/97 | Echo Bay        | Not Implanted | 7F7D301A27  | No         | 499     | 468     |         | 1205       | M   | SP                |
| 05/19/97 | Echo Bay        | Not Implanted | 7F7D3B3240  | No         | 667     | 623     | 576     | 3300       | F   | SP                |
| 05/19/97 | Echo Bay        | Not Implanted | 1F476B7936  | Yes        | 581     | 539     | 481     | 2178       | F   | SP                |
| 05/19/97 | Echo Bay        | Not Implanted | 7F7D1A2B3C  | Yes        | 578     | 537     | 480     | 2166       | M   | SP                |

<sup>a</sup>TU = tubercles present  
MI = expressing milt  
EG = expressing eggs  
SP = spawned out

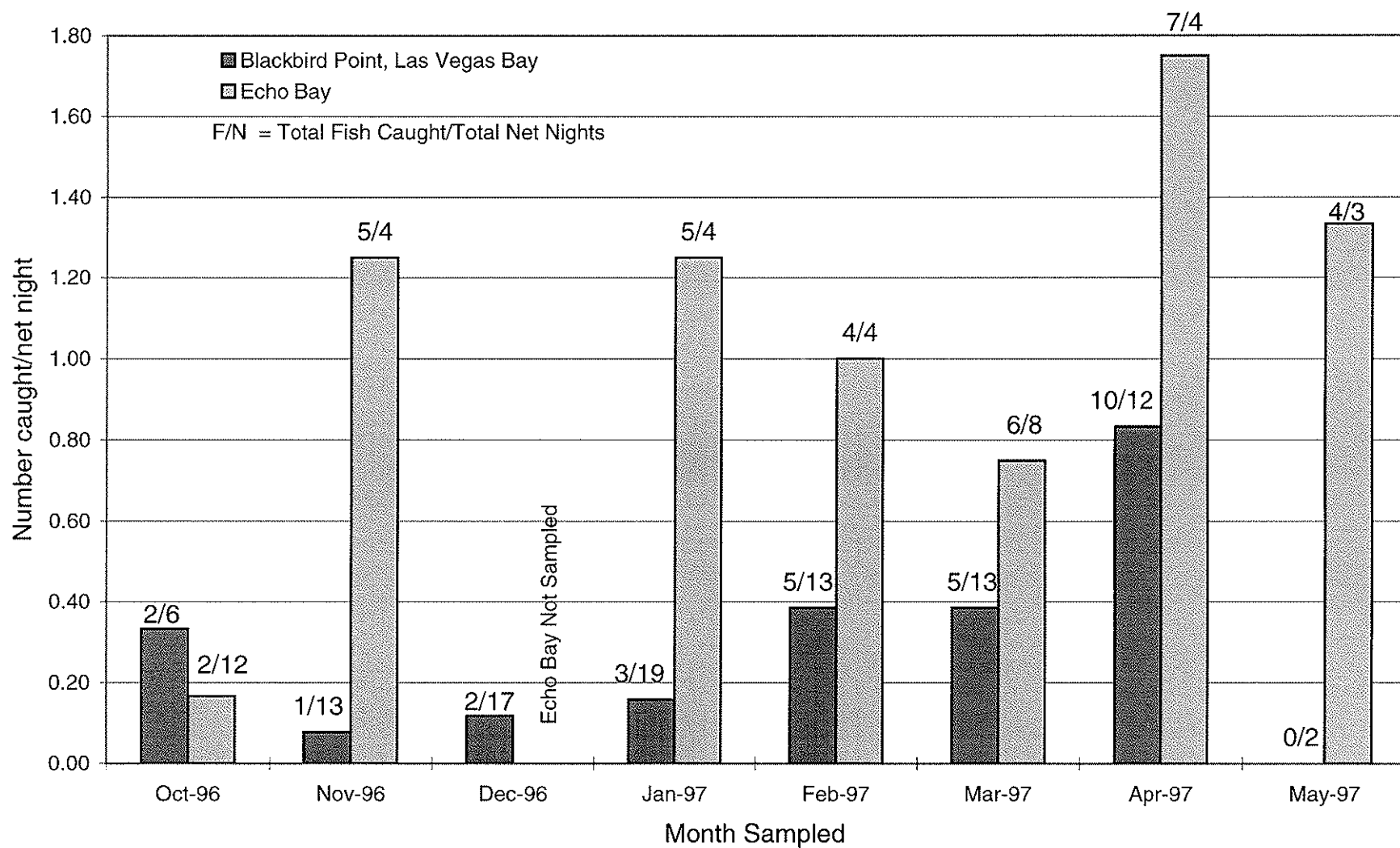


**Figure 4.** Trammel net catch per unit effort (CPE) of razorback sucker at two study areas in Lake Mead, Nevada, for October 1996 through May 1997.

females were also caught at Echo Bay on April 20. Spent females were captured in Echo Bay on March 12 and spent males and females were collected there in May.

Most of the razorback suckers collected were in good health with few deformities or abnormalities. Three fish were blind in one eye or had lacerations or other characteristics that suggested they were fairly old fish. Most of the fish collected after February showed signs of spawning, such as worn fins and loss of sheen and color in the peduncle and tail.

Several fish were caught twice, and several recaptures from previous years were also caught (Table 5). In Las Vegas Bay, 7 of the 28 razorback suckers caught were recaptures, but only one had been tagged prior to the initiation of this study. That particular fish was stocked in May of 1994 by the NDOW in Las Vegas Bay. The other six recaptures were all fish that were caught and PIT-tagged during this study, and then recaptured again. Recaptured razorback suckers from Echo Bay were more numerous than those from Las Vegas Bay. Seventeen of the 33 total razorback sucker captures were recaptures, and several of those fish were recaptured more than once. All 17 of the recaptures had been originally PIT-tagged prior to the present study, and one (captured in May) was part of a group of 14 razorback suckers stocked in Echo Bay in 1995 by the NDOW.

Table 6 shows the growth that occurred with the recaptured razorback suckers based on changes in TL. The two fish that showed the greatest annual growth, about 20 mm per year (IF483F0D4D and 1F7D6B7936), were both fish that were stocked into Lake Mead by the NDOW in 1994 and 1995, respectively. One fish from Echo Bay only grew 1 mm in the past year. Two fish showed total growth of 75 mm over periods of around 4 to 5 years. Annual growth varied from 1.1 mm to 22.4 mm TL, with an average growth of about 9.6 mm for the 11 wild (unstocked) fish recaptured. Total length measurements, as with any measurements of live fish, have some error associated with them. Therefore, individual growth calculations may be somewhat suspect, but the combination of 13 fish provides better assurance that the general pattern of growth is close to what is occurring in Lake Mead. These data suggest that Lake Mead razorback suckers are growing at an average rate of about 10 mm per year, and that the recently stocked fish appear to be growing at about twice that rate.

## **Sonic Tagging and Telemetry**

Twenty sonic tags were used to tag 21 adult razorback suckers, including 16 14-month tags and 4 48-month tags. Table 4 provides information on the fish that were implanted. One tag (2264) was used to tag two different fish. As discussed below, the first fish apparently expelled the tag, and it was found by SCUBA diving and subsequently used to implant another fish.

None of the four razorback suckers captured in October 1996 were implanted, since the population estimate for the Federal Collecting Permit had not been completed. In November, all six razorback suckers collected were implanted, as were both razorback suckers collected in December. Six more fish were implanted in January, and one more in February, before implanting was postponed until near the end of the spawning period. This was done to avoid adversely affecting spawning fish, and in the anticipation that new fish would enter the spawning areas near the end of the spawning period. The final six fish were implanted in late April (Table 4).

**Table 5. Capture/recapture information for razorback sucker in Lake Mead, October 1996 to May 1997.**

| DATE                 | NUMBER CAUGHT | RECAPTURES | RECAPTURE HISTORY                                    | NUMBER MARKED | MARKED AT LARGE |
|----------------------|---------------|------------|------------------------------------------------------|---------------|-----------------|
| <b>LAS VEGAS BAY</b> |               |            |                                                      |               |                 |
| <u>1996</u>          |               |            |                                                      |               |                 |
| October              | 2             | 0          |                                                      | 2             | 52              |
| November             | 1             | 1          | 5/6/94 stocked <sup>a</sup>                          | 0             | 54              |
| December             | 2             | 0          |                                                      | 2             | 54              |
| <u>1997</u>          |               |            |                                                      |               |                 |
| January              | 3             | 0          |                                                      | 3             | 56              |
| February             | 5             | 1          | 12/18/96                                             | 4             | 59              |
| March                | 5             | 2          | 2/25/97 both <sup>b</sup>                            | 3             | 63              |
| April                | 10            | 3          | 4/5/97 (2), 2/25/97                                  | 7             | 66              |
| May stocking         |               | -          |                                                      | 5 stocked     | 73              |
| <b>ECHO BAY</b>      |               |            |                                                      |               |                 |
| <u>1996</u>          |               |            |                                                      |               |                 |
| October              | 2             | 1          | 3/18/92                                              | 1             | 37              |
| November             | 5             | 4          | 4/2/93, 3/18/92 (2),<br>Tag not located <sup>c</sup> | 1             | 38              |
| December             | NS            |            |                                                      |               | 39              |
| <u>1997</u>          |               |            |                                                      |               |                 |
| January              | 5             | 3          | 4/2/93, 2/26/93 (2)                                  | 2             | 39              |
| February             | 4             | 3          | 4/2/93 & 11/20/96, <sup>d</sup><br>2/26/93, 3/5/96   | 1             | 41              |
| March                | 6             | 3          | 3/5/96, 3/18/92, 4/2/93 &<br>11/20/96 & 2/28/97      | 3             | 42              |
| April                | 7             | 1          | 3/12/97                                              | 6             | 45              |
| May                  | 4             | 2          | 7/25/95 stocked, 2/26/93<br>& 2/28/97                | 2             | 51              |

<sup>a</sup>The recaptured razorback sucker was originally PIT-tagged on May 6, 1994 and was part of a group stocked by the NDOW on that day.

<sup>b</sup>Both recaptured fish were originally PIT-tagged on February 25, 1997.

<sup>c</sup>Although a captured razorback sucker had an existing PIT tag, the number of the tag could not be found in records of past captures of razorback suckers from Lake Mead.

<sup>d</sup>The & sign indicates a recaptured fish had been captured more than once, in this case it had been originally captured and tagged on April 3, 1993, was recaptured on November 20, 1996, and then recaptured again in February 1997.

**Table 6. Growth of recaptured razorback suckers in Lake Mead.**

| PIT TAG #            | CAPTURE DATE | SIZE TL (mm) | RECAPTURE DATE | SIZE TL (mm) | TOTAL GROWTH | GROWTH PER YEAR (12 mo.) |
|----------------------|--------------|--------------|----------------|--------------|--------------|--------------------------|
| <b>Las Vegas Bay</b> |              |              |                |              |              |                          |
| 1F483F0D4D           | 05/26/94     | 525          | 11/18/96       | 576          | 56           | 22.40                    |
| <b>Echo Bay</b>      |              |              |                |              |              |                          |
| 7F7D22242B           | 03/18/92     | 554          | 10/24/96       | 595          | 41           | 8.90                     |
| 7F7B012325           | 04/02/93     | 555          | 11/20/96       | 591          | 36           | 10.60                    |
| 7F7D152A5D           | 03/18/92     | 523          | 11/20/96       | 569          | 46           | 10.00                    |
| 7F7D165D68           | 03/18/92     | 531          | 11/20/96       | 606          | 75           | 15.60                    |
| 7F7D2B2D5F           | 04/02/93     | 574          | 01/27/97       | 590          | 16           | 4.30                     |
| 7F7D222A48           | 02/26/93     | 519          | 01/27/97       | 545          | 26           | 6.70                     |
| 7F7D22351B           | 02/26/93     | 620          | 01/27/97       | 695          | 75           | 19.20                    |
| 7F7D1A2B3C           | 02/26/93     | 540          | 02/28/97       | 576          | 36           | 9.00                     |
| 1F4A592D11           | 03/05/96     | 680          | 02/28/97       | 681          | 1            | 1.10                     |
| 1F4A157B07           | 03/05/96     | 560          | 03/08/97       | 571          | 11           | 11.00                    |
| 7F7D1A2E1A           | 03/18/92     | 536          | 03/12/97       | 584          | 48           | 9.60                     |
| 1F476B7936           | 07/25/95     | 541          | 05/19/97       | 578          | 37           | 20.60                    |

A general movement pattern was seen prior to spawning (November to February) where newly-tagged fish would move away from Blackbird Point or Echo Bay soon after tagging, but would then generally come back to the probable spawning sites. At Las Vegas Bay, these fish often were found near the mouth of Las Vegas Wash for a period of time after tagging. At Echo Bay, the fish often left the bay and either disappeared for some time, or were then found from 1 to 10 miles north of Echo Bay in other bays, primarily in Rogers Bay. The following accounts detail the activities of each fish tagged.

### **Las Vegas Wash**

#### **Tag 249**

This fish was a 576 mm TL female implanted and released at Blackbird Point (BBP) on November 19, 1996. This fish was originally stocked in Las Vegas Bay in 1994 by the NDOW. After being released at the point of capture, this fish was found November 22 and 24, 1996, in shallow, turbid water with inundated vegetation in the inflow area of Las Vegas Wash. On December 2, 1996, fish 249 was found just north of Las Vegas Bay Marina (LVBM) against the shore and appeared to be moving southeast towards Las Vegas Bay. This fish had moved approximately 450 feet southeast towards LVBM on December 3, 1996, and the tag has not moved from that location since December 3. The tag is located in 55 to 60 feet of water about 100 feet from boats moored in the marina.

**Tag 276**

This fish was a large female (713 mm TL) that was sonic-tagged and released at BBP on December 19, 1996, and was then tracked over a range of approximately 4 miles during the next 6 months (Figure 5). Once released, fish 276 was found a 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 BBP. Fish in this same area on February 11 included 294 and 2237. 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 LVBM on June 9, 1997.

**Tag 339**

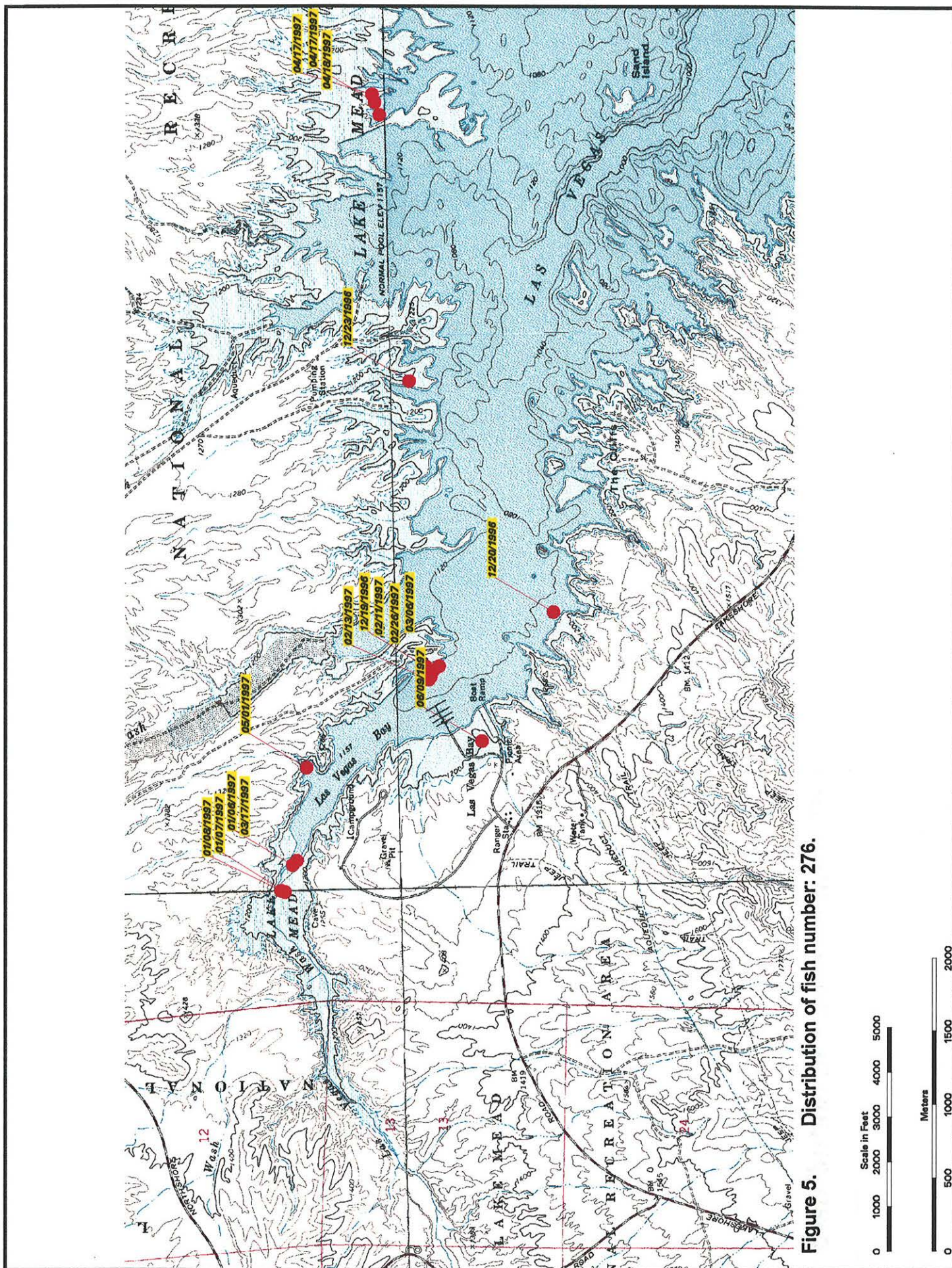
This 492 mm TL male razorback sucker was caught and released with sonic tag 339 implanted on December 19, 1996, at BBP. The following day it was located in the center of Las Vegas Wash, 0.5 mile from the release point. The remaining contacts with this fish occurred at the inflow area of Las Vegas Wash on January 6, 8, 10, and 30, 1997. The last contact with this fish indicated there may have been a malfunction with the tag because it could barely be heard when tracking was conducted directly over the tag in less than 15 feet of water.

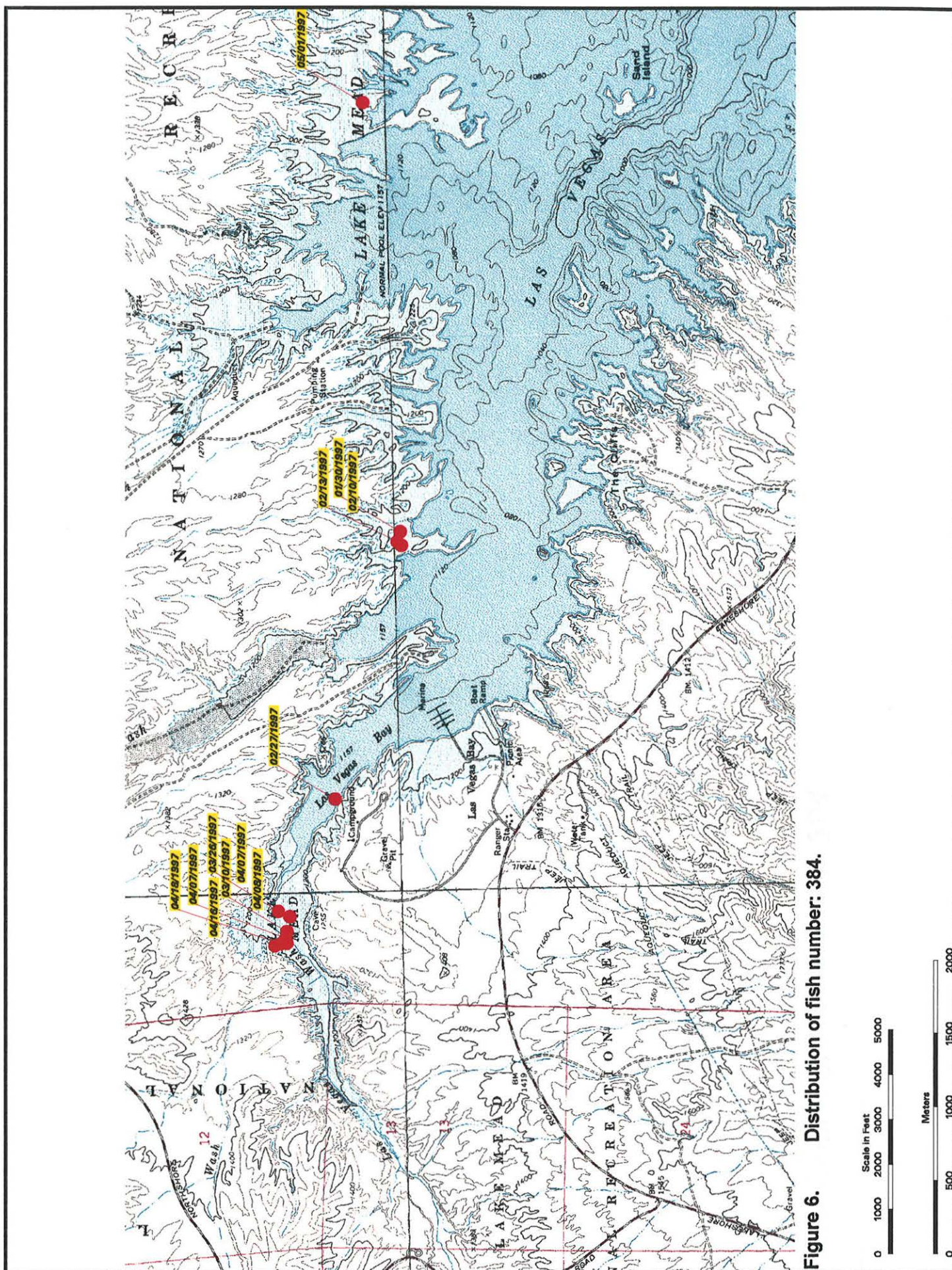
**Tag 384**

This 512 mm TL female razorback sucker was implanted and released at BBP on January 30, 1997 (Figure 6). Within a few hours of release it 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 were determined for this fish in the back of Las Vegas Wash. On May 1, 1997, fish 384 was found 3.5 miles to the east, near the northern shore of Las Vegas Bay. It was not found during tracking in June.

**Tag 2237**

Tag 2237 was implanted into a 735 mm TL female that was caught and released at BBP on January 30, 1997 (Figure 7). 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 LVBM. 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 approximately 2000 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 (Figure 7). Fish 2237 was not located again even though extensive monitoring occurred in the Las Vegas Bay area.





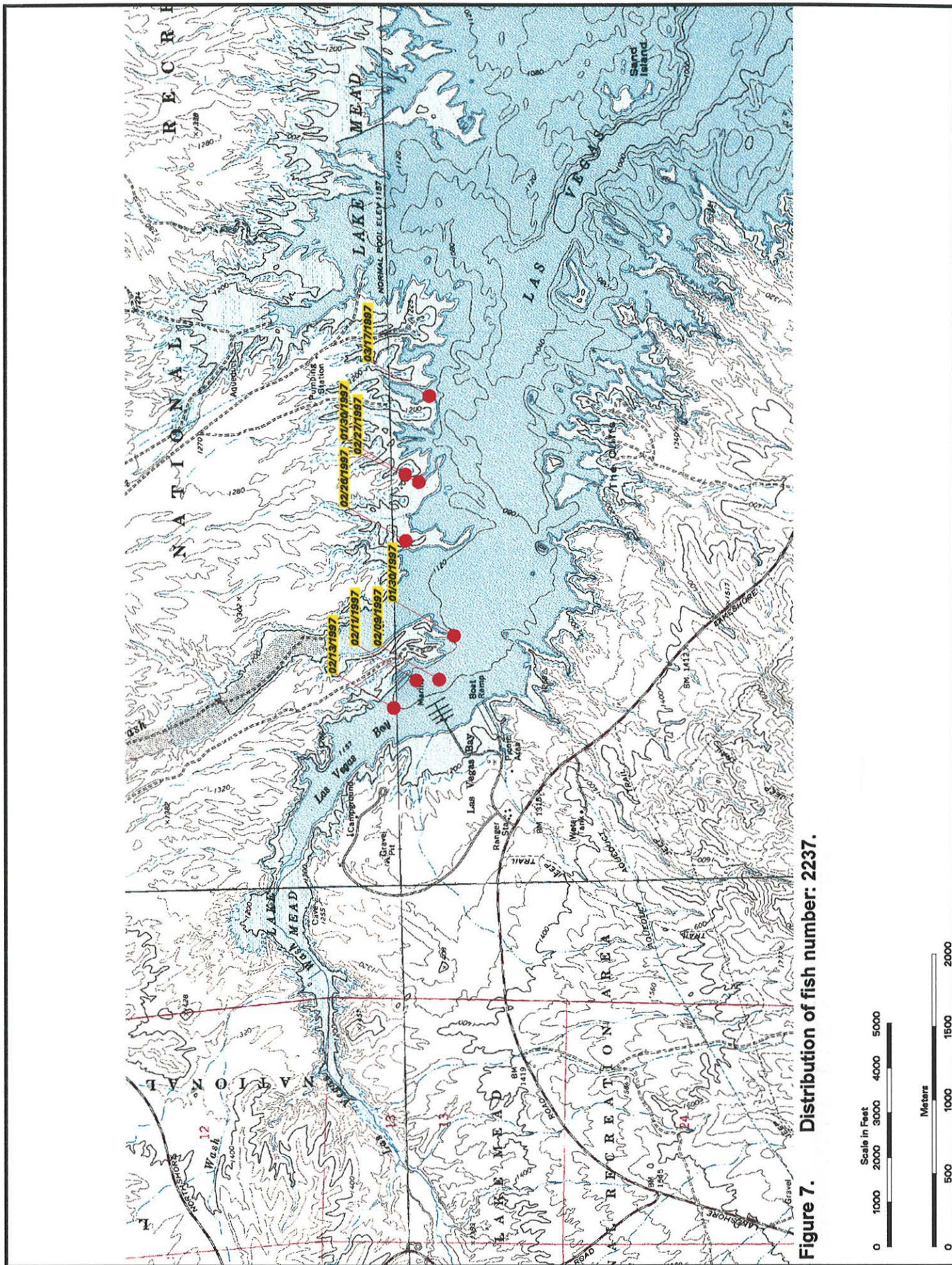


Figure 7. Distribution of fish number: 2237.

#### **Tag 2264**

Tag 2264 was implanted into two different razorback suckers. A 560 mm TL male was caught, implanted with tag 2264, and released at BBP 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 BBP. This fish was found along the first point east of BBP on April 7 and 8 (Figure 8). On April 16 and 18, this fish was found off the west side of BBP; 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 BBP.

#### **Tag 294**

Tag 294 was implanted February 11, 1997, into a 617 mm TL male at BBP (Figure 9). This fish was located over the next 3 months in three general locations including BBP, the central portion of Las Vegas Wash (0.5 mile north of BBP), 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 BBP. 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.

#### **Tag 2525**

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

#### **Tag 2444**

This 508 mm TL male razorback sucker was implanted on April 22, 1997 at BBP (Figure 10). Fish 2444 displayed similar affinity to the 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. 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.

### **Echo Bay**

#### **Tag 357**

This 591 mm TL female is one of five fish caught at Echo Bay and implanted on November 11, 1996 (Figure 11). 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 11. Other sonic-tagged razorback sucker in the spawning location during the same time included fish 2255 on January 28; tags 2246, 2228, and 2255 on February 11; tag 2246 on March 8; and tag 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.

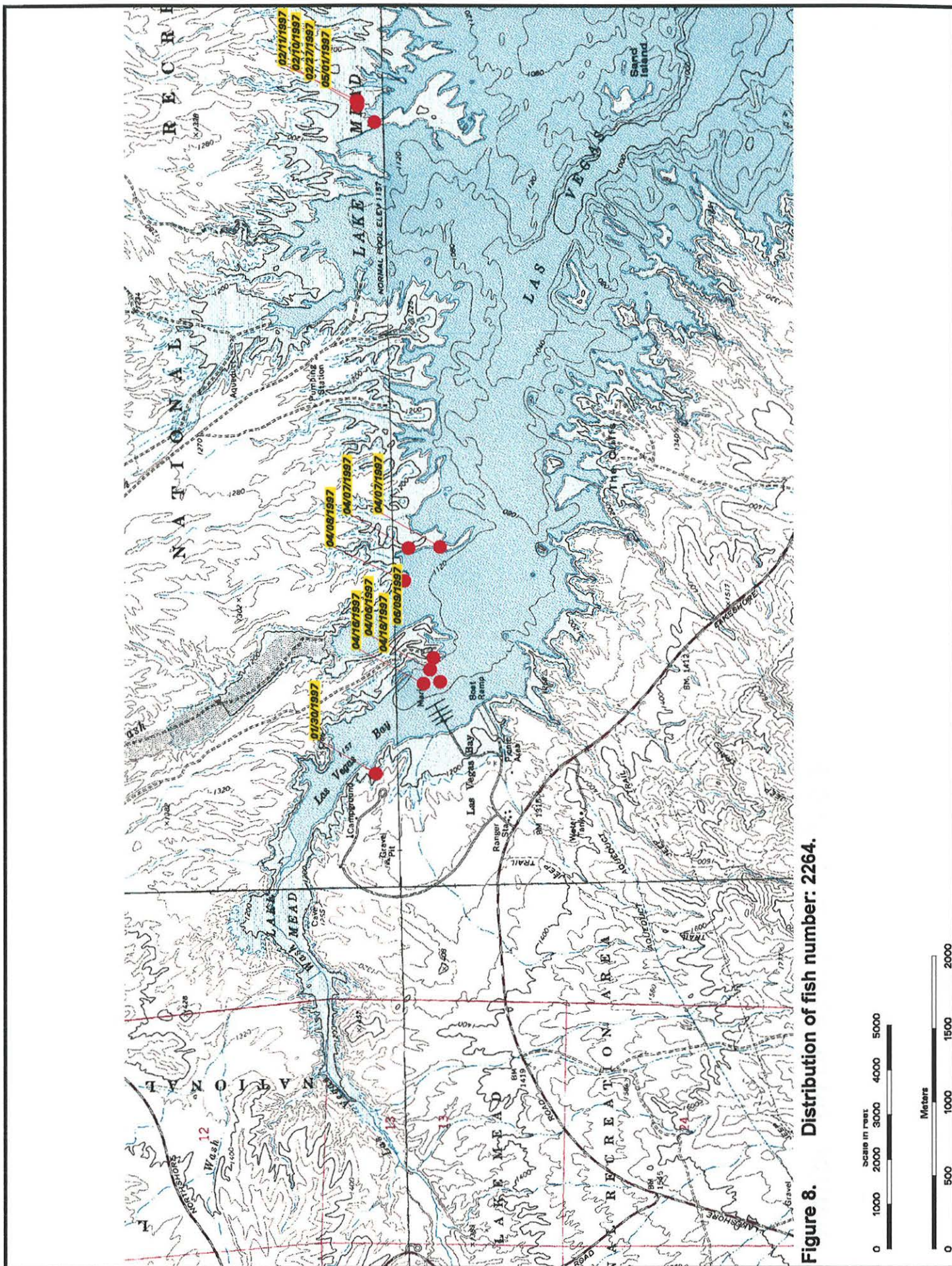
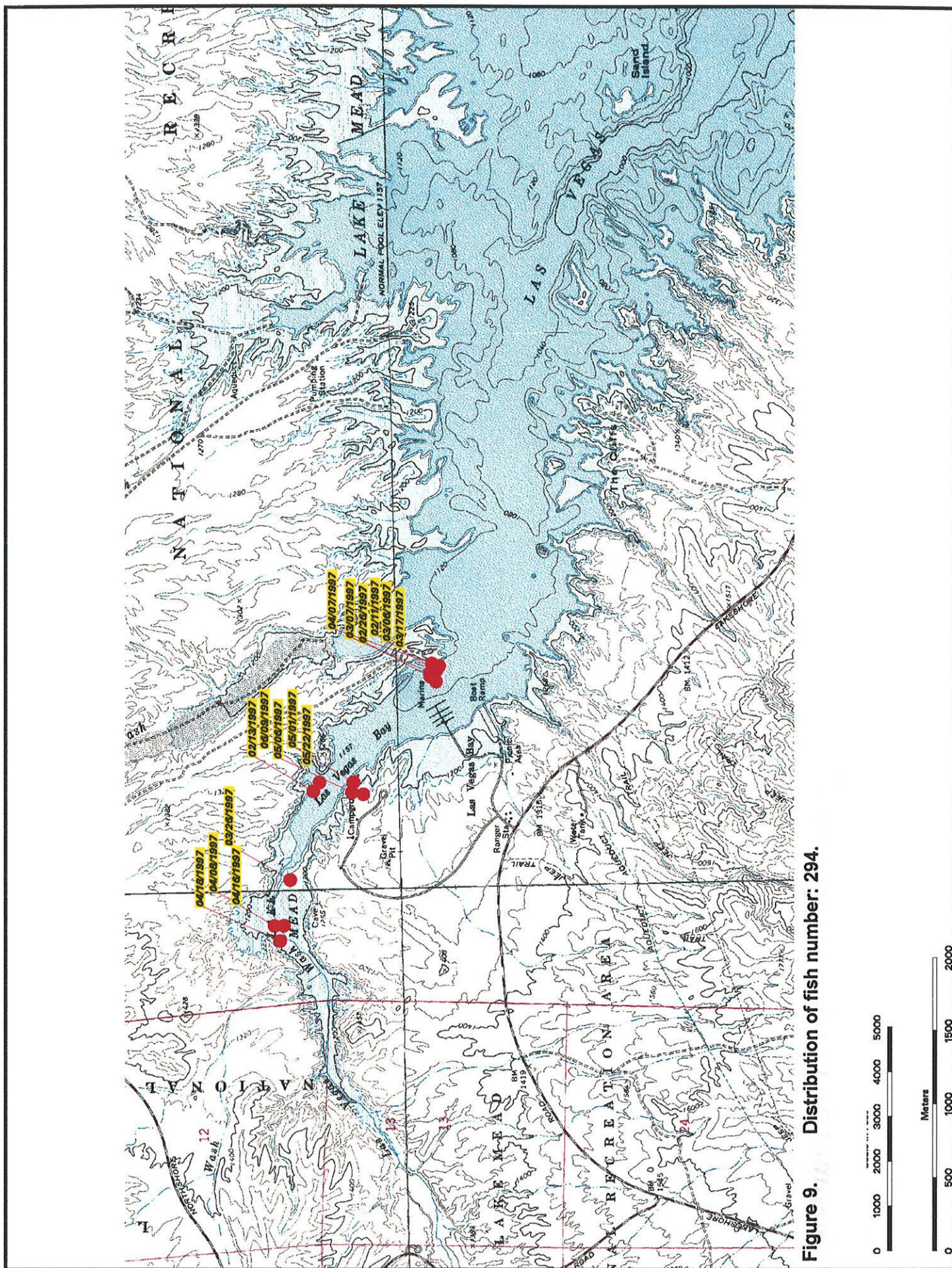
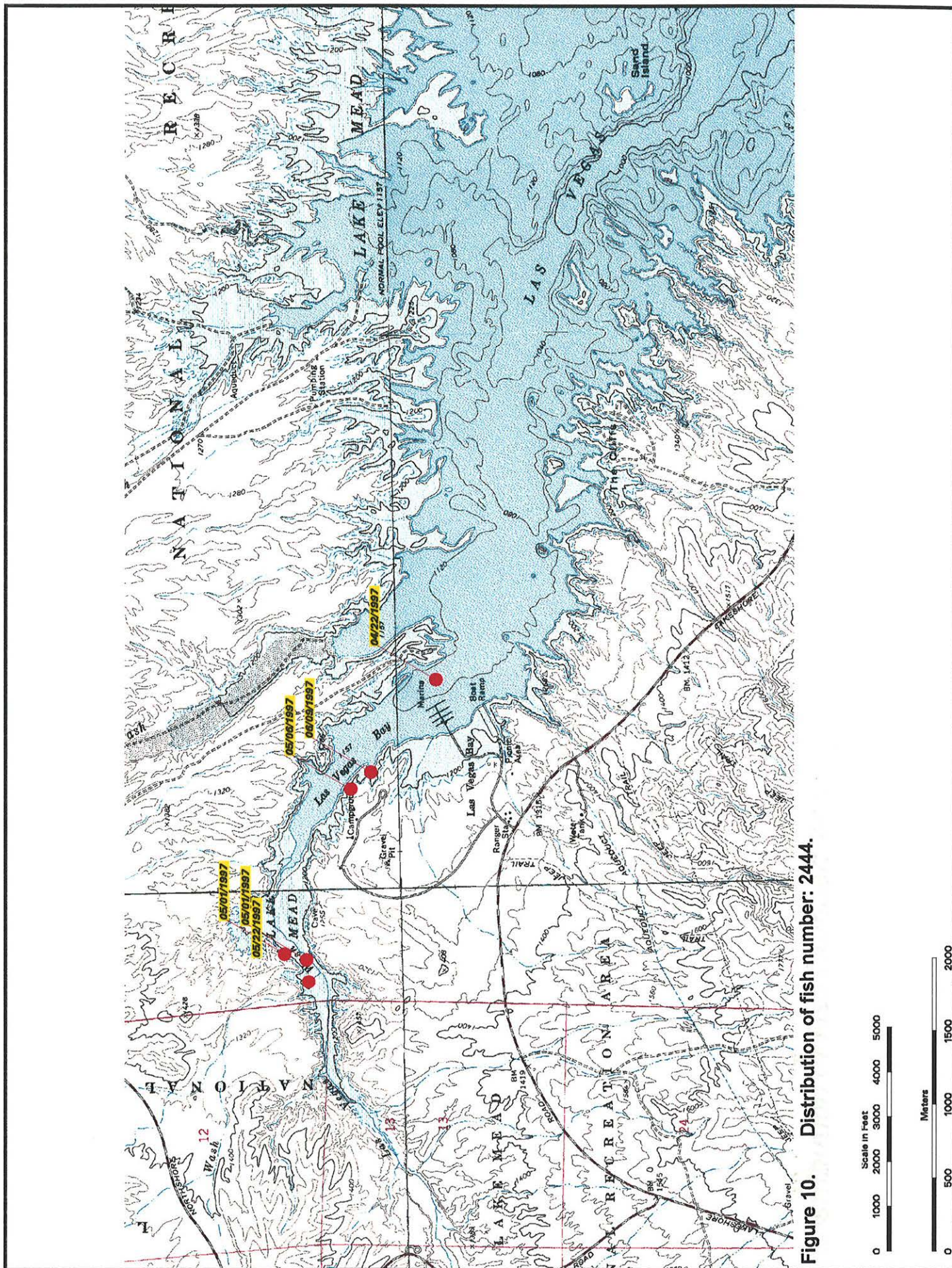


Figure 8. Distribution of fish number: 2264.





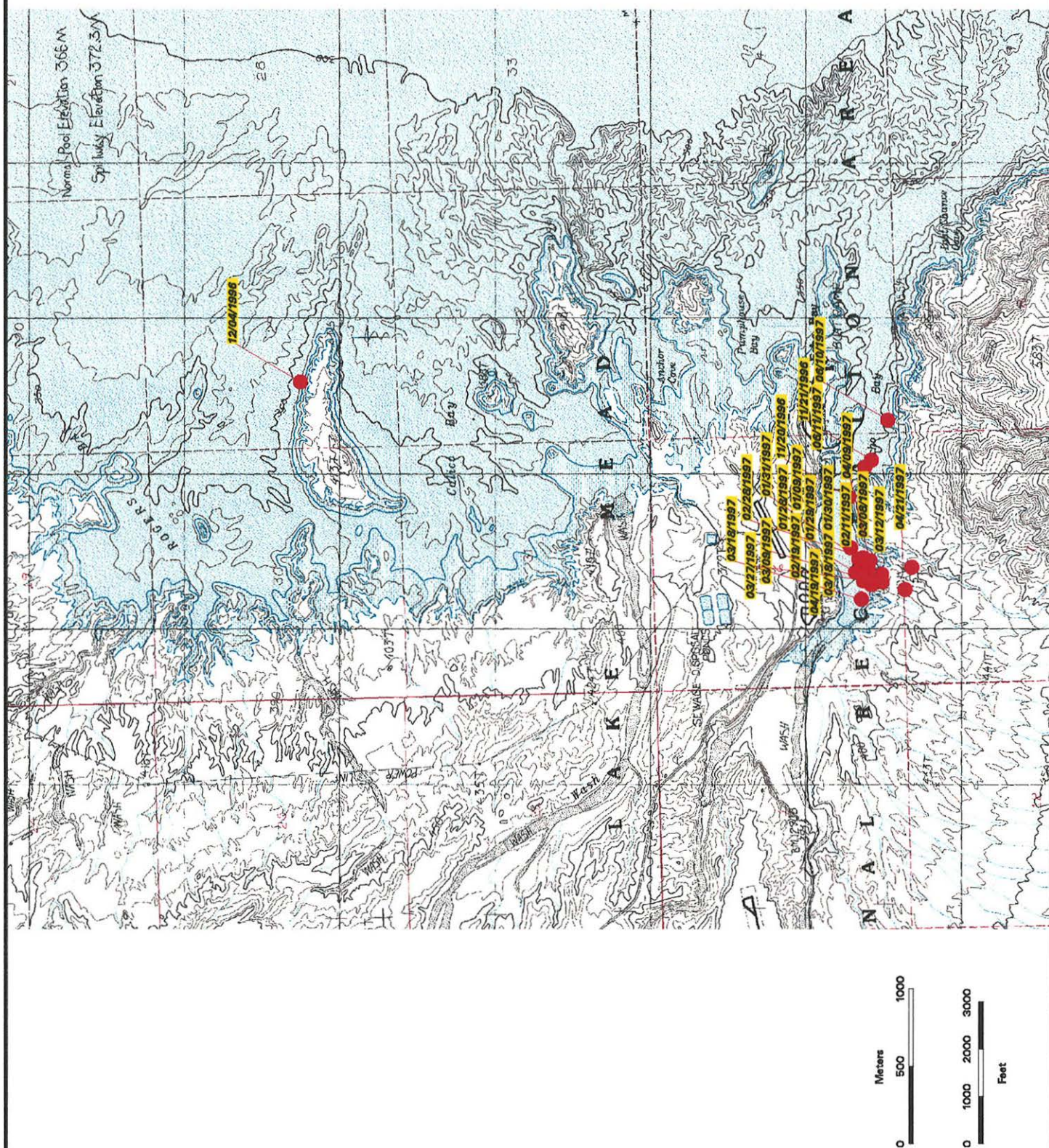


Figure 11. Distribution of fish number: 357.

**Tag 348**

This 569 mm TL male fish was implanted on November 20, 1996. On November 23 it was located 2.5 miles north at the southern end of Rogers Bay. On November 24 and 25 the fish was moving around in the area east of the point separating Anchor Cove and Pumphouse Bay. From December onward, the tag has remained stationary in this location in about 155 to 160 feet of water.

**Tag 258**

This 585 mm TL female was tagged on November 20, 1996, at Echo Bay. It was found on November 21 in the general area of its release. On November 23, the fish was located at the opening of Echo Bay and was moving north. In approximately 2 hours it had moved about 1 mile north. This was the last contact made with this fish.

**Tag 267**

This 588 mm TL male razorback sucker was caught, tagged, and released at the center of Echo Bay on November 20, 1996. On the following day, it was found at a location approximately 0.25 miles to the southeast. On November 23, this fish was located in the center of Rogers Bay; however, it had returned the following day, crossing 3.5 miles back to Echo Bay. This tag was again located in an area at the center of Echo Bay under a moored houseboat in 55 feet of water in early December. It has remained stationary since that time. Two attempts to locate the tag with SCUBA were not successful.

**Tag 285**

This 606 mm TL male was caught, implanted, and released just west of center in Echo Bay. Fish 285 did not move from its release site, which was in about 20 feet of water. Attempts to locate the tag with SCUBA were unsuccessful. The tag is apparently lying in a loose gravel-cobble slope near a cliff.

**Tag 2255**

This 585 mm TL male was caught and tagged at Echo Bay on January 28, 1997 (Figure 12). Fish 2255 moved to the back of Echo Bay later that day and then was found back at the release site on January 31. From the release site, this fish traveled to the opening of Echo Bay; it then was found on February 11, 19, and 28, 1997, back in the center of Echo Bay. Fish 2255 was found in the general spawning area on March 8, 1997, and was later located in the center of Echo Bay on March 9 and 18. On March 27, this fish was found moving in Pumphouse Bay. Tag 2255 was located in Rogers Bay on April 19. The tag had not moved from that site when checked in early June.

**Tag 2228**

This 695 mm TL female has a movement pattern similar to fish 2255 (Figure 12). It was caught in Echo Bay and tagged on January 28, 1997. On January 30 and 31, this fish was found along the south shore close to the release area. Fish 2228 was later found in the general vicinity of the spawning location at Echo Bay. This tag was located again on April 19, 1997, in Rogers Bay, and had not moved from that site in early June.



**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 13). Fish 2246 was found in Echo Bay during February and March and 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.

**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 fish 2336. Fish 3344 was found again on June 10 and 11 in the center of Echo Bay.

**Tag 2273**

This 559 mm TL male was caught in Echo Bay and sonic-tagged on April 21, 1997 (Figure 14). 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 at the southern point that comprises Rogers Bay, but it was not located in June.

**Tag 2336**

This 632 mm TL gravid female razorback sucker was caught in Echo Bay and sonic-tagged on April 21, 1997 (Figure 15). 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.

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 due to the constant temperature of the lake. 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.

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

Figures 2 and 3 show probable spawning areas at Blackbird Point and Echo Bay that were derived from sonic tagged fish, as well as trammel netting data. Other relatively heavily used locations in the lake include the inflow area of Las Vegas Wash, a couple of small bays just east of Government Wash, and Rogers Bay north of Echo Bay.

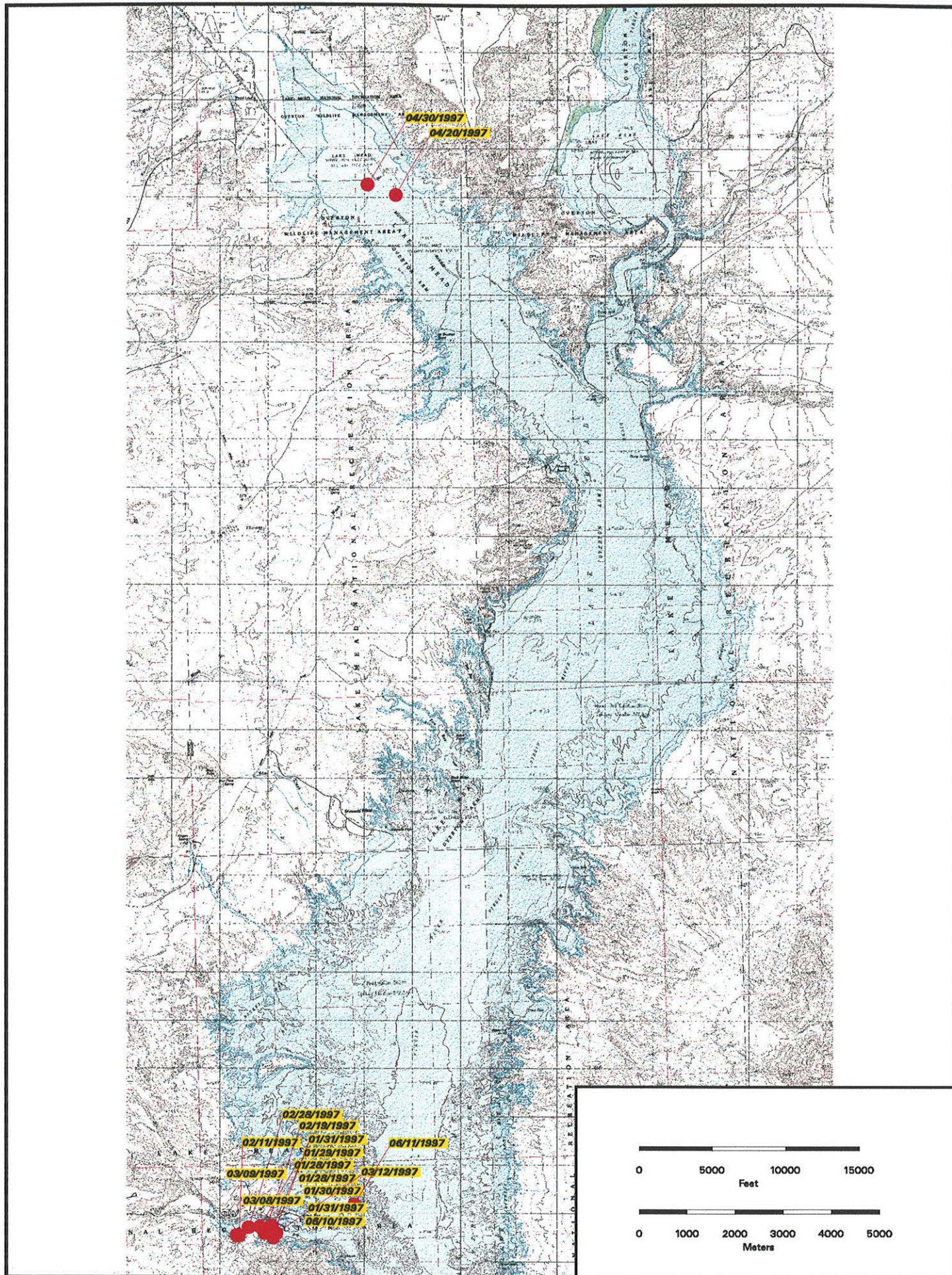


**Figure 13. Distribution of fish number: 2246.**





Of the 10 razorback suckers tagged at Las Vegas Wash, four were still active in June 1997 (276, 2264, 294, and 2444). Four other tagged fish have not been relocated for some time. Tag 339 was followed for 6 weeks and then disappeared. The last time the tag was located, the signal was getting weak, possibly indicating a faulty battery or other problem with the tag itself. Tags 2525, 2237, and 384 all disappeared 1 to 2 months after implantation and release.

Two tags, 249 and 2264, stopped moving within about 2 weeks of implantation. Tag 2264 was located with SCUBA about 1 month after it was implanted and was later used in another fish. Tag 249 is in an area where water clarity prohibits effective searching with SCUBA and has remained at that location since December 3, 1996.

Of the 11 fish tagged at Echo Bay, only three (357, 2246, and 3344) were still active in June 1997. Two others (285 and 2273) had not been located during tracking in June. Six have stopped moving but can be located. The six that stopped moving generally stopped within 2 weeks of implantation, similar to the occurrences at Las Vegas Bay, although some tags (2255, 2225) were actively moving for nearly 2 months before they stopped. In March, SCUBA was used to attempt to locate tags 285 and 267 which stopped moving in December, but the tags could not be found. No evidence of a carcass was found at either location, but several months had passed since the tag stopped moving, and the carcass likely would have been obliterated. SCUBA was also attempted in June 1997 on some of the tags now stationary in Rogers Bay, but water clarity was too poor to effectively search for the tags.

Three sonic-tagged fish were recaptured, providing an opportunity to observe the sutures and incisions. The fish with tag 357 at Las Vegas Bay was recaptured twice 3 to 4 months after release, and the sutures, except for one missing suture, appeared in good shape and the incision was healing well. Fish 276 was recaptured about 2 months after release; its sutures were intact and the incision was healing well. This female was actually expressing eggs when it was recaptured. The fish with tag 2246 was recaptured 3 months after release, and again the sutures and incision appeared fine.

## **Larval Sampling**

### **Echo Bay**

Larval sampling was initiated in Echo Bay on February 18, 1997, after sonic-tagged adults appeared to exhibit spawning aggregations and several apparent redds had been seen on February 12, 1997. Larval sampling continued from that time until late May at almost weekly intervals. Five fairly specific sites were used for most of the larval sampling (Figure 3). These sites were within the general area that appeared to be used for spawning as determined from sonic-tagged adults, from observations of adults made from surrounding cliffs, and from observations of adults made while snorkeling.

Site 1 and Site 2 were two small coves along the southern shore of the back part of Echo Bay. Site 1 was a shallow (3 to 15 feet deep at the 1199.1 foot lake elevation) cove measuring about 50 feet wide and 60 feet long, with sparse submerged tamarisk at the end of the cove and loose conglomerate cliffs intermixed with loose gravel/cobble-covered slopes on the sides. Substrate in the cove was

primarily silt-covered gravel/cobble with clean, freshly deposited gravel and cobble at the bases of the conglomerate cliffs. The open end of the cove had little submerged vegetation. Little wave action was observed in the cove due to its protection by steep banks on three sides.

Site 2 had essentially the same substrate and shore characteristics as Site 1 but was slightly deeper (6 to 20 feet deep at the 1199.1 foot lake elevation) and had sparse tamarisk throughout the cove. Sonic and visual observations of adult razorback suckers were made in both Site 1 and Site 2.

Site 3 was located along a 50-foot high cliff that comprises the shore in the southwest corner of Echo Bay and was selected as a larval sampling site because sonic-tagged fish were found at this area during the spawning period. The cliff is made of the same conglomerate that surrounds Sites 1 and 2, and therefore has similar substrate composition. The bottom was primarily silt-covered gravel and cobble with newly deposited gravel and cobble directly below the loose conglomerate cliffs. Sparse tamarisk covers portions of the bottom at this site. Depths range from 6 to 12 feet at the 1199.1 foot lake elevation.

Sites 4 and 5 were located at the end of Echo Bay (Figure 3). Site 4 was located over an area where potential razorback sucker redds were located on February 12, 1997. This site was primarily open water surrounded by tamarisk at sparse and medium densities. The substrate consisted of silt-covered gravel that was cleared in 3-foot circles in the areas resembling redds. Sampling was conducted over depths that ranged from 3 to 6 feet. Site 5 was located at the inflow area of Echo Wash. This site was chosen for larval sampling because its physical characteristics were similar to those of Site 4, and it, therefore, may have provided a good location for spawning. Substrate in this area was silt-covered gravel with a small amount of cobble protruding. The open "wash" area was bordered on both sides by dense tamarisk stands. Sampling was conducted at the edge of the dense stand of tamarisk on the south side of the open area in 3 to 6 feet of water.

Sampling for larvae using crappie lights was initiated in mid-February at Sites 1 and 4, 1 week after the apparent redds were noted (Table 7). No larvae were collected at either site. Sampling in late February at Sites 1, 4, and 5 produced a few larval razorback suckers, for a catch per minute (CPM) of 0.02. On March 12, the catch increased dramatically as large numbers of larvae were collected at Sites 1 and 2 (9.90 CPM). About 500 of the larvae collected on March 12 were retained by the NDOW for captive rearing and eventual stocking back into the lake. The high numbers of larvae at Sites 1 and 2 continued until late April. Larval catch declined in May to a point where no larval razorback suckers were collected by May 20.

Site 1 and Site 2 were the most productive locations for larval sampling at Echo Bay and for all larval fish sampling during 1997 at Lake Mead. Sampling during March, April, and May yielded 3,193 larval razorback sucker in 290 minutes of sampling at Site 1, producing an average CPM of 11.01. During the same time period, Site 2 had a total catch of 1,273 razorback sucker in 130 minutes, producing an average CPM of 9.79. The CPM for Sites 3, 4, and 5 were significantly lower than those for Sites 1 and 2 (Table 7). The differences in catch of larval razorback sucker between Sites 1 and 2 and Sites 3, 4, and 5 are likely due to differences in distance from actual spawning locations. Our sonic tagging and netting observations, as well as visual and snorkeling observations, suggested most spawning activity probably occurred in or near Sites 1 and 2.

**Table 7. Larval razorback sucker collections using crappie lights at five sites at Echo Bay in 1997.<sup>a</sup>**

| DATE  | SITE 1 |      |       | SITE 2 |      |       | SITE 3 |     |      | SITE 4 |     |      | SITE 5 |     |      | TOTAL |      |       |
|-------|--------|------|-------|--------|------|-------|--------|-----|------|--------|-----|------|--------|-----|------|-------|------|-------|
|       | MIN.   | NO.  | CPM   | MIN.   | NO.  | CPM   | MIN.   | NO. | CPM  | MIN.   | NO. | CPM  | MIN.   | NO. | CPM  | MIN.  | NO.  | CPM   |
| 2/18  | 30     | 0    | 0.00  | NS     |      |       | NS     |     |      | 135    | 0   | 0.00 | NS     |     |      | 165   | 0    | 0.00  |
| 2/19  | 30     | 0    | 0.00  | NS     |      |       | NS     |     |      | 135    | 0   | 0.00 | NS     |     |      | 165   | 0    | 0.00  |
| 2/28  | 45     | 4    | 0.10  | NS     |      |       | NS     |     |      | 90     | 0   | 0.00 | 160    | 1   | 0.01 | 295   | 5    | .02   |
| 3/12  | 60     | 946  | 15.80 | 20     | 158  | 7.90  | 20     | 58  | 2.90 | 20     | 24  | 1.20 | NS     |     |      | 120   | 1186 | 9.90  |
| 3/18  | 60     | 1090 | 18.20 | 20     | 250  | 12.50 | 20     | 14  | 0.70 | 20     | 21  | 1.10 | NS     |     |      | 120   | 1375 | 11.50 |
| 3/27  | 60     | 169  | 2.80  | 20     | 180  | 9.00  | 20     | 39  | 2.00 | 20     | 43  | 2.20 | NS     |     |      | 120   | 431  | 3.60  |
| 4/4   | 60     | 858  | 14.30 | 20     | 642  | 32.10 | 20     | 74  | 3.70 | 20     | 171 | 8.60 | NS     |     |      | 120   | 1745 | 14.50 |
| 4/20  | 10     | 83   | 8.30  | 10     | 24   | 2.40  | 10     | 11  | 1.10 | 10     | 3   | 0.30 | 10     | 4   | 0.40 | 50    | 125  | 2.50  |
| 5/7   | 20     | 47   | 2.35  | 20     | 19   | 1.00  | 20     | 27  | 1.35 | 16     | 7   | 0.40 | 20     | 4   | 0.20 | 96    | 104  | 1.10  |
| 5/20  | 20     | 0    | 0.00  | 20     | 0    | 0.00  | NS     |     |      | 70     | 0   | 0.00 | NS     |     |      | 110   | 0    | 0.00  |
| Total | 290    | 3193 | 11.00 | 130    | 1273 | 9.80  | 110    | 223 | 2.03 | 536    | 269 | 0.50 | 190    | 5   | 0.03 | 1256  | 4966 | 3.95  |

<sup>a</sup>Min. = minutes sampled  
No. = number of larval razorbacks collected  
CPM = catch per minute

In addition to larval sampling at the five designated sites, sampling was conducted in other parts of Echo Bay on April 9 to see how widely distributed the larvae were in the bay. Sampling was conducted in several areas along the northern shore of Echo Bay and in small bays near the marina. Larvae were found in all areas. A total of 60 minutes was employed overall, with a catch of 59 razorback sucker larvae. On April 20, sampling was also conducted in Rogers Bay, which is located about 1 mile north of Echo Bay (Figure 3), because this area was occasionally used by adult sonic-tagged razorback suckers throughout the spawning period. A total of 40 minutes of light sampling resulted in no larvae being collected.

Larval sampling with light traps at Echo Bay had poor results compared to results obtained with 12-volt "crappie" lights that were used during the same times and in the same areas. The best results for larval light trapping occurred on March 12, 1997, when 18 larval razorback sucker were captured in 260 minutes of effort (Table 8). For direct comparison between the two methods, the results for the light traps would have to be doubled, because two crappie lights were used to sample each site. Even if this is considered, there is still one order of magnitude difference between CPM for these two sampling methods. Larval light traps were not used after these initial tests.

**Table 8. Comparison of crappie light vs. larval light trap sampling results for larval razorback sucker at Echo Bay, March 1997.<sup>a</sup>**

| Tadpole Buck Cuckoo at Long Bay, March 1994 |        |      |       |        |     |       |        |    |       |        |    |      |        |    |       |
|---------------------------------------------|--------|------|-------|--------|-----|-------|--------|----|-------|--------|----|------|--------|----|-------|
|                                             | SITE 1 |      |       | SITE 2 |     |       | SITE 3 |    |       | SITE 4 |    |      | SITE 5 |    |       |
| Date                                        | Min    | No   | CPM   | Min    | No  | CPM   | Min    | No | CPM   | Min    | No | CPM  | Min    | No | CPM   |
| Crappie Light                               |        |      |       |        |     |       |        |    |       |        |    |      |        |    |       |
| 3/12                                        | 60     | 946  | 15.80 | 20     | 158 | 7.90  | 20     | 58 | 2.90  | 20     | 24 | 1.20 | NS     |    |       |
| 3/18                                        | 60     | 1090 | 18.20 | 20     | 250 | 12.50 | 20     | 14 | 0.70  | 20     | 21 | 1.10 | NS     |    |       |
| Larval Light Trap                           |        |      |       |        |     |       |        |    |       |        |    |      |        |    |       |
| 3/12                                        | 260    | 18   | .07   | NS     |     |       | 261    | 1  | 0.004 | 235    | 0  | 0.00 | 244    | 1  | 0.004 |
| 3/18                                        | 285    | 0    | 0.00  | 275    | 0   | 0.00  | 270    | 1  | 0.004 | 265    | 0  | 0.00 | NS     |    |       |

<sup>a</sup>Min. = minutes sampled

No. = number of larval razorbacks collected

CPM = catch per minute

## Las Vegas Bay

Larval sampling at Las Vegas Bay did not locate concentrated groupings of razorback sucker larvae as were found in Echo Bay. Sonic-tagged and trammel net-caught adults suggested that spawning was occurring in the Blackbird Point area, thus this area was the most heavily and frequently sampled site for larvae. Sampling was initiated on February 25 and continued into March, but larvae were not found until March 26 (Table 9). In April, other portions of the bay were sampled and larvae were found in various areas, including the area behind the marina, cove areas along the north shore of the bay, and areas near the inflow of Las Vegas Wash. But larval numbers were small in all cases (Table 9) and provided relatively few insights into potential spawning locations.

**Table 9. Larval razorback sucker collections in Las Vegas Bay in 1997.<sup>a</sup>**

| Date | BLACKBIRD POINT |     |      | OTHER AREAS |     |      | TOTAL |     |      |
|------|-----------------|-----|------|-------------|-----|------|-------|-----|------|
|      | Min.            | No. | CPM  | Min.        | No. | CPM  | Min.  | No. | CPM  |
| 2/25 | 50              | 0   | 0.00 | 50          | 0   | 0.00 | 100   | 0   | 0.00 |
| 3/7  | 120             | 0   | 0.00 | NS          |     |      | 120   | 0   | 0.00 |
| 3/11 | 150             | 0   | 0.00 | NS          |     |      | 150   | 0   | 0.00 |
| 3/26 | 75              | 8   | 0.10 | 20          | 4   | 0.20 | 95    | 12  | 0.10 |
| 4/5  | 80              | 6   | 0.08 | 40          | 0   | 0.00 | 120   | 6   | 0.05 |
| 4/6  | NS              |     |      | 62          | 2   | 0.03 | 62    | 2   | 0.03 |
| 4/7  | NS              |     |      | 60          | 2   | 0.03 | 60    | 2   | 0.03 |
| 4/8  | NS              |     |      | 60          | 0   | 0.00 | 60    | 0   | 0.00 |
| 4/16 | 60              | 3   | 0.05 | NS          |     |      | 60    | 3   | 0.05 |
| 5/22 | 40              | 0   | 0.00 | 40          | 0   | 0.00 | 80    | 0   | 0.00 |

<sup>a</sup>Min. = minutes sampled

No. = number of larval razorbacks collected

CPM = catch per minute

## **Juvenile Sampling**

Limited sampling for juvenile razorback sucker in Lake Mead was initiated in May 1997. Several techniques were used to sample for juvenile razorback suckers, including minnow traps, hoop and fyke nets, seining, and fine-mesh gill nets. Table 10 shows the sampling effort expended for juvenile razorback sucker for each type of gear used, and Figures 2 and 3 show the sampling locations at Las Vegas Bay and Echo Bay.

All seining was done at the Echo Bay site. Seine samples were not taken at Las Vegas Bay because conditions at this site made seining problematic. A total of 26,900 square feet was sampled at Echo Bay in May using a 30' x 6' x 0.25" mesh bag seine. A 15' x 4' x 0.125" mesh standard seine was used to sample 3,410 ft<sup>2</sup> in May, and 6,310 ft<sup>2</sup> in June. One razorback sucker larvae (20mm TL) was captured using the 15' seine on May 21. The sample was taken along the north shore of Echo Bay near the wash inflow area, in an area of inundated tamarisk with a predominately silt substrate and an average water depth of 29 inches. Other fish species collected in seine samples included 82 juvenile largemouth bass (*Micropterus salmoides*), 8 green sunfish (*Lepomis cyanellus*), 8 mosquitofish (*Gambusia affinis*), 7 threadfin shad (*Dorosoma petenense*), 4 bluegill (*Lepomis macrochirus*), and 1 channel catfish.

Three types of minnow traps were used for juvenile sampling: 0.25" galvanized wire mesh traps, 0.125–0.25" black plastic traps, and 0.125" nylon net traps. Approximately 50 percent of the traps set were baited with dog food. During the month of May, each trap type was set for 40 trap nights (one trap set over one night) at Las Vegas Bay and 80 trap nights at Echo Bay. Total trap nights at Echo Bay for June 1 through 13 were 57 for galvanized wire mesh and black plastic traps, and 60 for

**Table 10. Sampling effort for juvenile razorback sucker in Lake Mead during 1997 at each study site by gear type.**

| GEAR TYPE                                   | EFFORT                  |                          |                |
|---------------------------------------------|-------------------------|--------------------------|----------------|
|                                             | MAY 1997                | JUNE 1997 <sup>a</sup>   |                |
|                                             | LAS VEGAS WASH          | ECHO BAY                 | ECHO BAY       |
| Gill Net                                    |                         |                          |                |
| (100' x 4', experimental mesh) <sup>b</sup> |                         |                          | 6.2 net hours  |
| Seines                                      |                         |                          |                |
| 30' x 6', 0.125" mesh bag seine             | 3,410 feet <sup>2</sup> | 26,900 feet <sup>2</sup> |                |
| 15' x 4', 0.125" mesh                       |                         | 6,310 feet <sup>2</sup>  |                |
| Hoop/Fyke Nets                              |                         |                          |                |
| 2' hoop, 0.25" mesh                         | 6 net nights            | 6 net nights             | 9 net nights   |
| 3' hoop, 0.25" mesh                         | 2 net nights            | 3 net nights             |                |
| 3' fyke, 0.125" mesh                        | 2 net nights            | 3 net nights             | 3 net nights   |
| 4' fyke, 0.25" mesh                         | 2 net nights            | 3 net nights             |                |
| Minnow Traps                                |                         |                          |                |
| 0.25" galvanized wire mesh                  | 40 trap nights          | 80 trap nights           | 57 trap nights |
| 0.125 - 0.25" black plastic mesh            | 40 trap nights          | 80 trap nights           | 57 trap nights |
| 0.125" nylon mesh                           | 40 trap nights          | 80 trap nights           | 60 trap nights |

<sup>a</sup>covers sampling period through June 13, 1997

<sup>b</sup>mesh size starts at 0.05" and increases to 2.0" in 0.05" increments

nylon mesh traps (Table 10). No traps were set at Las Vegas Bay in June. No razorback sucker were collected in minnow traps. Fish species caught in minnow traps were similar to those captured in seine samples.

Hoop and fyke nets were set for a total of 10 net nights at Las Vegas Bay during May; no nets were set at this location during June (Table 10). Effort for hoop/fyke nets at Echo Bay totaled 14 net nights during May and 15 net nights through June 13. No razorback sucker were collected in hoop or fyke nets. Other fish species captured with this sampling technique were similar to those collected seining.

Use of fine-mesh gill nets to sample for juvenile razorback sucker was initiated in June. Experimental mesh (mesh size starts at 0.05" and increases to 2" in 0.05" increments) 100' x 4' gill nets were set near emergent vegetation in Echo Bay for a total of 6.2 net hours. No razorback sucker were collected with gill nets. Fish species captured using gill nets included 1 striped bass, 2 common carp, 3 channel catfish, and 15 threadfin shad.

## **New Population Estimate**

Sampling from October 1996 to June 1997 provided an additional 61 razorback sucker captures, including several recaptures, to use in a new population estimate (Table 5). 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, separate population estimates were made for each location. Capture data from 1990 to 1995 had been assimilated and used in the initial population estimate by year, so that protocol was followed with the new information. Collections from October through December 1996 were lumped with the spring 1996 collections of the NDOW as the 1996 capture data, and the January through May 1997 sampling was lumped as the 1997 capture data. Stocked fish were not used in the population estimates, including the recaptured stocked fish.

Table 11 shows the results of the population modeling using the Schnabel model and six different models from the program CAPTURE, the same estimators used in the initial population estimate. The capture of primarily unmarked fish at Las Vegas Wash increased the population estimate in that area to 300 to 400 individuals. The capture of a higher percentage of marked fish at Echo Bay caused the population estimate there to remain very similar to the initial estimate, about 50 to 60 individuals. This analysis suggests the total population in Lake Mead is 400 to 450 individual razorback suckers. Confidence limits, especially for the Las Vegas Bay population, are still very high, indicating additional mark/recapture data is needed to obtain a better estimate.

## **DISCUSSION**

The information gathered during the first year of the Lake Mead razorback sucker study produced a number of important findings. Two razorback sucker spawning areas were identified in areas where they had been suspected previously by the NDOW, at Blackbird Point and in Echo Bay. Use of sonic-tagged fish and more intensive trammel netting provided additional detail on the probable location of actual spawning at both areas. Sonic-tagged fish also used the upper portion of Las Vegas Bay during the spawning period, but no concentrations of suckers were found to suggest actual

**Table 11. Comparison of initial population estimates for Lake Mead razorback sucker using data collected by the Nevada Division of Wildlife from 1990 to 1996 with new estimates using additional data collected by BIO/WEST in 1996 and 1997.**

| ESTIMATOR       | INITIAL<br>LAS VEGAS BAY |          | NEW<br>LAS VEGAS BAY |          | INITIAL<br>ECHO BAY |          | NEW<br>ECHO BAY |          |
|-----------------|--------------------------|----------|----------------------|----------|---------------------|----------|-----------------|----------|
|                 | MEAN                     | 95% c.i. | MEAN                 | 95% c.i. | MEAN                | 95% c.i. | MEAN            | 95% c.i. |
| Schnabel $M_t$  | 149                      | 52-722   | 282                  | 106-1014 | 48                  | 27-168   | 52              | 41-109   |
| Model $M_0$     | 191                      | 78-578   | 399                  | 165-1114 | 69                  | 38-165   | 62              | 48-92    |
| Darroch $M_t$   | 217                      | 83-703   | 342                  | 155-862  | 57                  | 34-126   | 57              | 46-82    |
| Chao $M_t$      | 158                      | 69-455   | 286                  | 133-727  | 50                  | 32-110   | 50              | 42-72    |
| Chao $M_h$      | 273                      | 93-981   | 452                  | 177-1325 | 74                  | 38-192   | 59              | 46-94    |
| Chao $M_{th}$   | 247                      | 87-878   | 398                  | 158-1181 | 70                  | 37-190   | 57              | 45-87    |
| Jackknife $M_h$ | 105                      | 79-146   | 167                  | 133-216  | 57                  | 42-86    | 62              | 50-86    |

spawning. Trammel netting and tracking of sonic-tagged fish did not result in the identification of any other spawning areas for these two groups of fish. Although sampling during nonspawning periods was short, razorback suckers associated with Blackbird Point appear to stay within Las Vegas Bay during the nonspawning period, whereas Echo Bay fish move north to Rogers Bay and even further up the Overton Arm of Lake Mead. Since sampling outside the two primary areas was small, there still is a good chance that other "populations" may exist in the lake that use other spawning sites. Overall movement of Lake Mead razorback suckers appears reduced compared to movement of Lake Mohave fish based on preliminary information. Lake Mohave sonic tracking studies have shown movement up to 35 miles in relatively short periods of time, and relatively large amounts of movement for most tagged fish (G. Mueller 1997, pers. comm.).

Population estimates have provided a better perspective of the number of razorback suckers in Lake Mead. The initial estimate of about 200 individual adult fish has been doubled to 400 to 450 individuals. The population in Las Vegas Bay appears to be much larger than the Echo Bay population. The latest population estimate indicated about 400 adults at Las Vegas Bay and about 50 in Echo Bay.

At this time it is not known how different lake levels may affect spawning success at either location. The spawning area at Echo Bay identified on Figure 3 was largely out of the water in October when this study began, and was well out of the water in 1994 and 1995 when the lake elevation was at about 1180 feet (Figure 16). Obviously, spawning would have had to occur in different portions of Echo Bay during those years. The relatively deep probable spawning area at Blackbird Point was also of interest and was much deeper than reported Lake Mohave spawning areas, which occur in 1 to 15 feet of water and often in wave-washed shorelines (Minckley 1983, Minckley et al. 1991). Depths of 60 to 80 feet at Blackbird Point seem very deep for a species that evolved in relatively shallow rivers. However, due to a much lower lake level (1170 to 1180 feet), this spawning location was only 30 to 50 feet deep during 1992 and 1993 when fish were collected there by the NDOW.

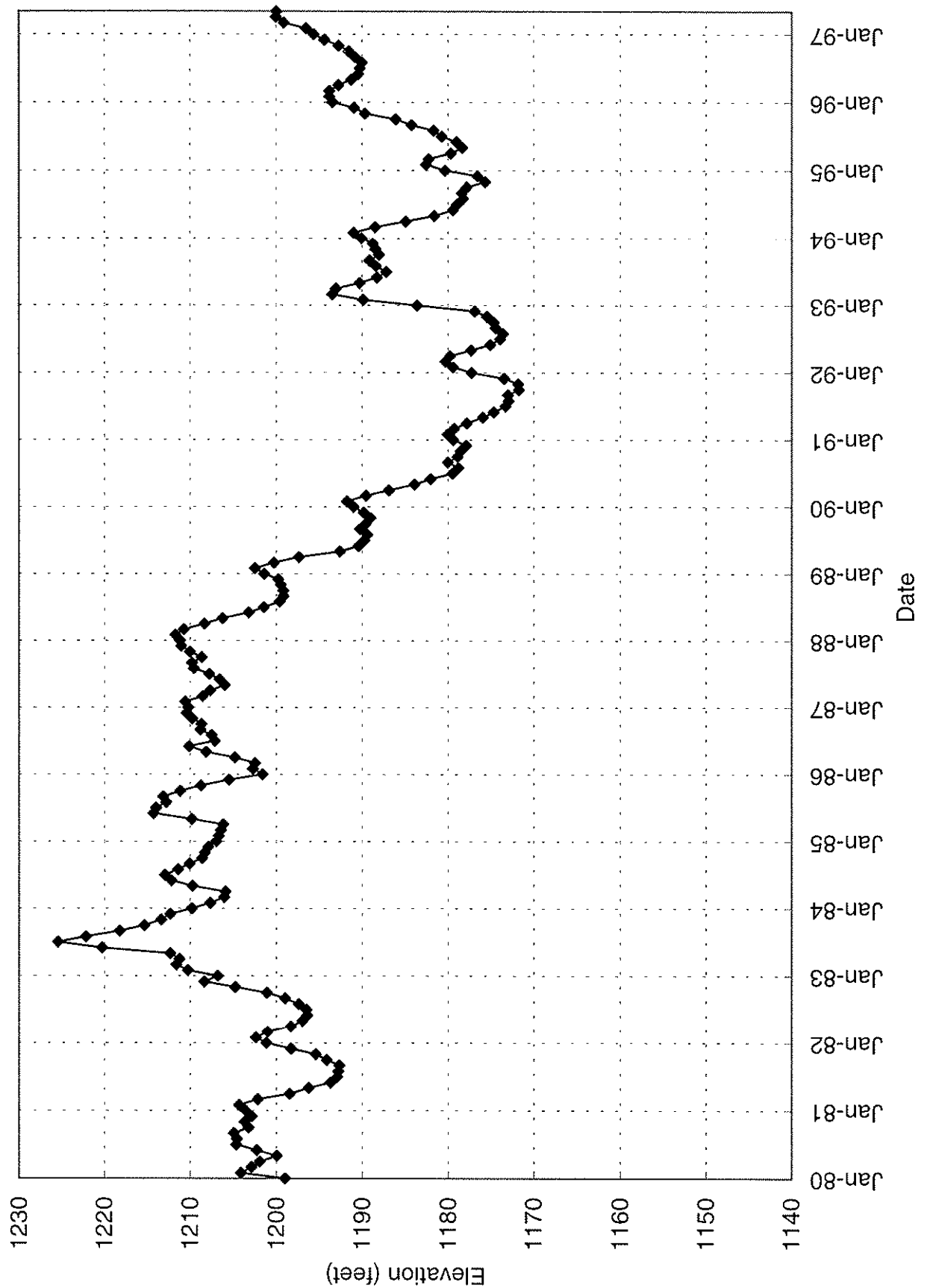


Figure 16. Lake Mead month-end elevations from 1980 to 1996.

The collection of relatively large numbers of larval razorback suckers at Echo Bay proved that, similar to Lake Mohave, spawning is successful in that larvae are produced in large numbers. Smaller numbers of larvae at Las Vegas Bay may explain why earlier attempts at larval collection in that area were generally unsuccessful. Perhaps the difference in success of capturing larvae between Echo Bay and Las Vegas Bay was due to the location of the respective spawning areas. The Echo Bay spawning area was in shallow water within two small coves and along shorelines that were relatively protected from wind. Emerging larvae had cover nearby and did not have currents to contend with, allowing them to remain concentrated. At Las Vegas Bay, the spawning area appeared to be much deeper and further from emergent vegetation and shorelines. Currents produced by winds and the inflow from Las Vegas Wash probably spread the larvae out rather than concentrating them in nearby areas.

Spawning time for razorback sucker can be developed from the collection of ripe fish, the behavior of sonic tagged fish, and the collection of larvae. Spawning appeared to be initiated in Echo Bay by mid-February, and may have lagged slightly until late February or early March at Las Vegas Bay. Spawning occurred until the end of April or early May at Echo Bay, and until late April at Las Vegas Bay. The capture of larvae at Echo Bay (Table 7) suggests the major spawning activity occurred from early March to mid-April.

The inability to find juveniles after thousands of larvae were collected is similar to results found at Lake Mohave. But juvenile sampling effort was relatively small since it was not anticipated during development of this study.

Growth of Lake Mead adults appears to be the highest recorded from 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 millimeters per year. McAda and Wydoski (1980) and Tyus (1987) indicated growth estimates from the Green River population of razorback suckers based on mark/recaptured fish was 2 to 3 mm per year. The 10 mm per year growth estimate for our mark/recaptured fish is three or more times greater than these other estimates. Since the overall body size of the Lake Mead razorback suckers is not greater than seen in other populations, perhaps this faster growth suggests a younger population.

The information collected on stocked razorback suckers from trammel netting and sonic tracking suggested they have become somewhat assimilated into the two populations. They appear to be participating in spawning activities and are generally using the same areas as the wild fish. Their faster rate of growth is interesting and unexplainable at this time.

The most disappointing result during the first year of this study has been the relatively low number of sonic tagged fish that still were active in June 1997. The reasons why 8 of the 21 tags stopped moving but still can be located are not known, but three general possibilities are considered the most likely reasons. First, the fish may have died. Fish 285 may have died since it did not move from the point of release and was showing signs of stress when it was released. All of the other fish were released in good condition and moved somewhat before they stopped.

A second explanation for the lack of movement is the possibility that the tag was expelled. Tag 2264 that was recovered with SCUBA was found in about 21 feet of water near a set of cliffs and overhanging bedrock, lying on a silt substrate covered with a thin layer of green algae. It was half buried in the silt. The exposed half of the tag was very visible from above. No carcass or fish bones were found, and the surrounding area did not appear to be disturbed, as would be expected if the fish had died and been eaten by channel catfish, other fish, or turtles, and the tag was expelled during feeding activity. The appearance of the tag and surrounding area suggested the tag dropped out of the fish as it swam over the area.

Expulsion of tags may be fairly common with razorback suckers. Razorback suckers surgically implanted with radio tags for use in the San Juan River of the Upper Basin experienced a fairly high degree of tag shedding when held in experimental ponds (Burdick and Bonar 1997; D. Ryden 1997, pers. comm.). The ponds at Wahweap, Utah, had concrete sections that the researchers thought the fish used to rub the sutures open and expel the tags. This occurred over a 2-year period when 20 to 30 fish were tagged per year and the expulsion rate was 30 to 50 per cent. Very few of the fish died from this experience, and the opened sutures healed quickly. Most of the fish were reimplanted on the other side of the abdomen and stocked into the San Juan River. This information, as well as the location of tag 2264 in Lake Mead, suggests that some of the immobile tags may have been expelled by the fish.

A third possibility is that the fish may still be alive and holding the tag, since some tags have only recently stopped moving in the Echo Bay area. This could be the case for tag 2273, which recently stopped moving in the Rogers Bay area. Discussions with other researchers have indicated that they have seen razorback suckers that have not moved for a period of 2 months or more, but still were alive and apparently healthy. Fish 294 at Las Vegas Bay did not move for over 1 month from one location and then started moving again, indicating some of the recent nonmovement may not be permanent.

The reasons why six fish have not been found during recent tracking are also not known, but may be explained in one of three ways. First, the tag may have malfunctioned for some reason. Tag 339, which appeared to lose strength just before it disappeared, and tag 258, which disappeared within a couple of days after release, may both have malfunctioned. A second explanation would be the fish have moved beyond the search area. Other fish disappeared (or were not located) for a period of time, but then would reappear in either Echo Bay or Las Vegas Bay. Perhaps some of the missing fish have moved further than the tracking that has occurred and they will reappear next spawning season. Tracking has been conducted throughout Boulder Basin and the Overton Arm of the lake (Figure 1) on a few occasions, but this larger area has not been consistently surveyed for tagged fish. A third explanation is that the fish are located in habitats that mask the tag signal. Since signal strength is affected by vegetation, fish in heavy vegetation could easily be missed. Also, sonic-tagged fish in caves or in areas behind underwater rocks or other obstructions may not be heard. Therefore, there are a number of possible reasons why tags have stopped moving or have not been found for some time; most of them do not include mortality of the fish.

The frequency with which sonic-tagged fish appeared to either expel tags or disappear following tagging is frustrating and of concern. Although earlier BIO/WEST telemetry studies of razorback

sucker (Valdez and Masslich 1989) did not have the nearly 50 percent loss found in this study, other recent studies have indicated these results appear to be the norm. Burdick and Bonar (1997) experienced more than a 50 percent loss of tagged fish in the upper Colorado River due to a suspected variety of reasons. Sonic tracking studies on Lake Mohave and Lake Powell also have shown relatively high levels of fish that are lost or stationary (G. Mueller 1997, pers. comm.). The hatchery pond experience that resulted in expulsion of nearly 50 percent of implanted radio tags discussed above may provide a clue as to the cause of some of the stationary tags in this and other studies. The data for this study has been reviewed for some lead concerning the cause of tag expulsion, but nothing related to time of year, sex, size of fish, or implantation techniques has been found.

The first year of study of razorback sucker in Lake Mead has resulted in obtaining considerable additional insight into the populations that exist in the lake. The objectives of the study were met in that initial information on population size, habitat use, life history characteristics, spawning locations, and habitat were determined. In addition, larval razorback suckers were found in large numbers for the first time in the lake. It is anticipated that the study will continue for at least 2 more years, which should provide additional insight into the population size and life history characteristics of this species in Lake Mead.

## **RECOMMENDATIONS FOR THE SECOND YEAR OF STUDY**

The continuation of general studies initiated in 1996 include the following:

- Trammel netting monthly in areas of razorback sucker concentration;
- Tracking sonic-tagged fish;
- Implanting another 10 sonic tags (for a total of 31 tags);
- Sampling for larval fish at both study locations during the spawning period; and
- Sampling for juvenile suckers at both study sites.

The primary funding provided by the SNWA will allow all of the above activities to continue during 1997-1998 at a level similar to those conducted in 1996-1997.

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