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## REPORT

# Fish Traps on Ancient Shores: Exploring the Function of Lake Cahuilla Fish Traps

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*This paper examines the use of V-style fish traps on the western recessional shorelines of ancient Lake Cahuilla. We use multiple lines of evidence to examine the function of these traps, including ethnographic data, fish biology, excavations of fish traps, and experimental replication of fish trap designs. Our study indicates that biological characteristics of the fish were central to the effectiveness of the traps and dictated trap placement and design.*

Prehistoric groups living along the shorelines of ancient Lake Cahuilla in southern California practiced a variety of subsistence strategies, and fishing appears to have been one of the major factors that attracted them to these ancient shores. Although many rock constructions that have been called "fish traps" have been recorded along the lake's recessional shorelines, no systematic investigations of these features have been conducted. In this paper, we present the results of a study of Lake Cahuilla fish traps, specifically focusing on the V-shaped trap design. We use multiple lines of evidence—including ethnographic data, fish biology and ecology, excavations of fish traps, and experiments with fish trap construction—to explore how these traps functioned. We argue that by taking this more holistic approach to investigating fish traps, we can gain a better understanding of both how they worked and the part that they played in prehistoric subsistence strategies along the lakeshore.

## ENVIRONMENTAL SETTING

Ancient Lake Cahuilla was located in the Colorado Desert of southern California and northern Baja California and occupied the Salton Trough. Today's Salton Sea occupies the same geographic location, but is much smaller (Fig. 1). The lake formed when the deltaic activity of the Colorado River caused a shift in its course, causing it to flow northward into the Salton Trough and creating a large freshwater lake. Lake Cahuilla was six times the size of the Salton Sea, measuring at its maximum 180 km. in length and 50 km. in width, making it one of the largest Holocene lakes in western North America. The Colorado Desert is one of the most arid regions in the West, so the presence of a large freshwater lake would have been a significant environmental feature to prehistoric groups in the area.

Lake depth and shoreline elevations fluctuated over time (from the lake's maximum shoreline at 12 m.), and the lake occasionally disappeared completely, leaving a series of recessional shorelines. There is continuing debate among scholars concerning the number of in-filling episodes and their duration (Oglesby 2005; Waters 1983; Weide 1976; Wilke 1978). Waters (1983) identified four cycles of in-filling between A.D. 700 and the late 1500s, each lasting up to several hundred years and separated by either complete or incomplete desiccation of the lake. However, Weide (1976) argued that these cycles were shorter (ca. 50 years) and more frequent (but see Laylander 2006).

Schaefer (1994) and Laylander (1997) discuss a final in-filling that occurred between A.D. 1600 and 1700. After this, the lake became so saline that it would not support wildlife; it eventually dried up completely when the deltaic activity of the Colorado River again caused it to change course so that it no longer brought fresh water into the Salton Trough.

## ARCHAEOLOGICAL BACKGROUND

Prehistoric and ethnohistoric groups exploited Lake Cahuilla throughout its existence. The major occupation of the lakeshore appears to have occurred from A.D. 1000 to possibly A.D. 1600 (see below). The earliest occupation of the lakeshore is not known. Love and Dahdul (2002) reported Archaic period campsites in dunes near the maximum shoreline, and Weide (1976) reported a date

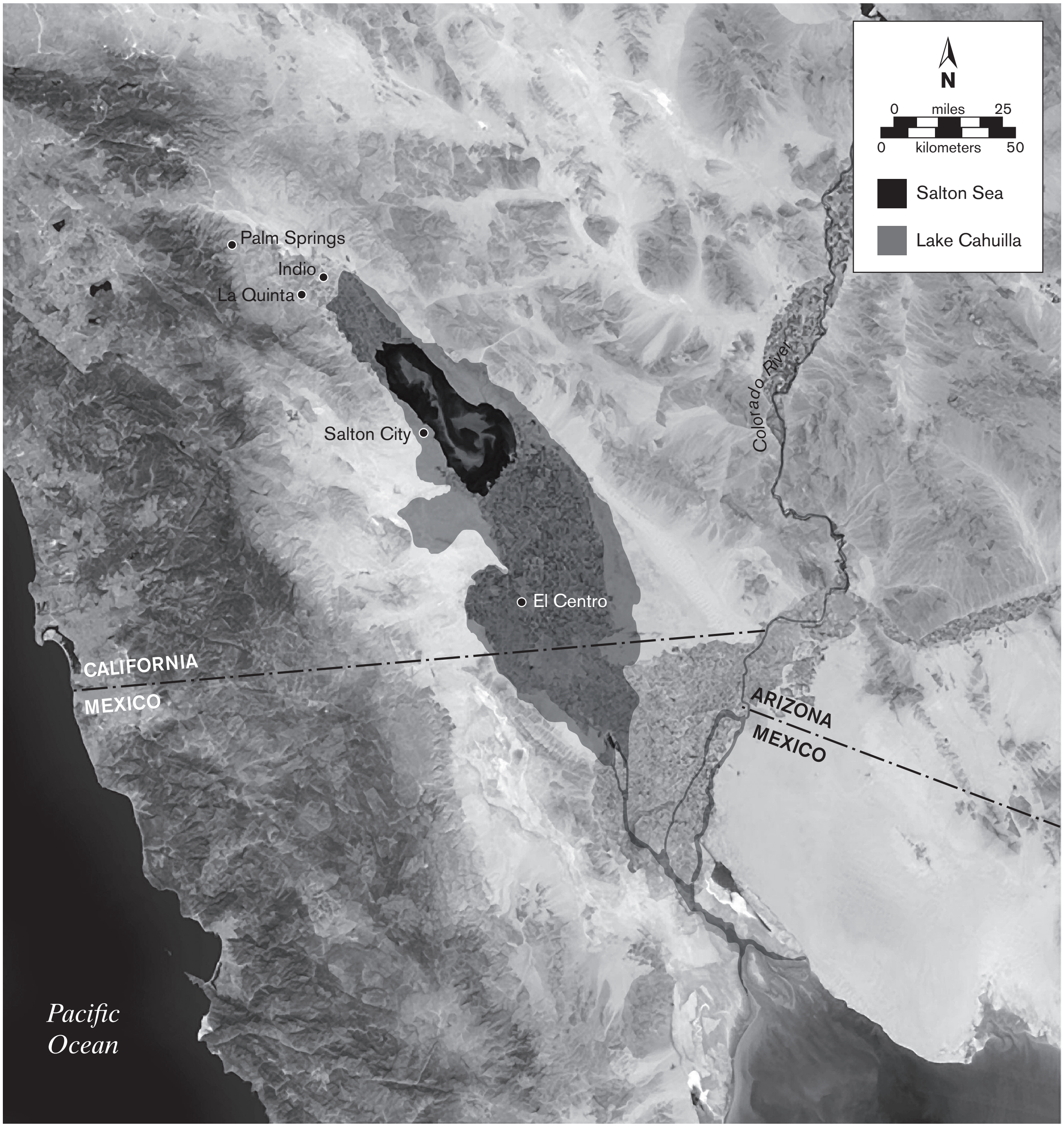


**Figure 1. Lake Cahuilla and the Salton Sea**

of A.D. 370 from one site. As Schaefer and Laylander (2007) note, it is likely that additional early sites existed on the shorelines but have been covered by alluvial deposition or destroyed by agricultural development.

Sites recorded on the lakeshore document diverse activities. Recorded sites types include habitation sites with rock-rings and house pits, middens, and cremations; hunting stations; fish camps; trails; and fish traps. These sites most likely represent occupations by groups from territories adjacent to the shoreline that came to exploit the lake resources. Wilke (1978) has argued that the occupation of the Lake Cahuilla lakeshore involved permanent, year-round settlement, but other researchers disagree, seeing more seasonally-based occupations

(Sutton 1998; Weide 1976). Schaefer and Laylander (2007:255) argue that there was variation in settlement and subsistence organization along different segments of the lakeshore, with more intensive occupation along the northwest side (present day Coachella Valley).

Wilke (1978, 1980) has recorded fish traps on the northwestern recessional shores of Lake Cahuilla that appear to represent annual construction events. Schaefer and Laylander (2007) discuss the presence of fish traps and associated fish camps on recessional beaches along the western lake shore, the area discussed in this paper. It appears from the archaeological evidence that groups along the western shore followed seasonal rounds that incorporated the use of lake resources. Occupation of the lake shore allowed for the exploitation of the abundant lacustrine resources that included freshwater fish and shellfish, aquatic birds, and marsh plants, including cattail and bulrush.

As noted above, stone features known as "fish traps" represent a common feature recorded on the western shoreline, but no systematic investigations of these features have been conducted. Here we focus exclusively on the fish traps and their role in the subsistence strategies of prehistoric and ethnohistoric groups.

## ARCHAEOLOGICAL EVIDENCE OF FISH TRAPS AT LAKE CAHUILLA

The archaeological record provides only incomplete information on fish traps and their associated technology. Two types of fish traps have been identified along the shorelines of Lake Cahuilla (Oglesby 2005; Wilke 1978). The first type is composed of V- (or U-) shaped traps located on alluvial fans adjacent to the lakeshore (Fig. 2). These consist of rows of rock, with the convergent ends pointed toward the water and with divergent ends that face toward the shore. We hypothesize that the rock walls functioned to funnel fish into a basket trap, which was placed in the apex of the convergent walls in deeper water. Jay von Werlhof (1996) recorded 19 variations of the V-style trap on alluvial shores in Salton City, California, and Wilke and Lawton (1975) reported on V-style traps on the northwestern shores of the lake. Wilke (1978:10) described these as "semi-circular U- or V-shaped rock constructions of dry laid masonry, one-to-several courses high and about 5 to 15 feet long, extending from the former shoreline." He speculated that they may have been used in conjunction with dipping nets to catch fish when they were spawning and/or feeding.

**Figure 2. Excavating a V-Style Fish Trap**

Connaway (2007) called these traps "longshore weirs," and noted that cross-cultural ethnographic data suggest that they were constructed using stakes or rocks with netting placed in between. He argued that they were designed to trap spawning fish or those feeding along the shorelines, and noted that they were essentially "self-operating" in that they only required a few individuals to operate them.

A second trap design found along Lake Cahuilla is a circular stone feature built along the lake shore, often on talus slopes (Treganza 1945). Oglesby (2005) described these as consisting of semi-circular to circular depressions with rock walls. Although one researcher (Treganza 1945) suggested that these served as antelope hunting blinds, their location and characteristics indicate that they were fish traps.

The many drying and refilling episodes of Lake Cahuilla apparently resulted in repeated episodes of fish trap building over time, given the presence of rows of fish traps on multiple recessional beach lines (Wilke 1978, 1980). These fish traps are often found in rows 1.8 to 2.0 m. apart, which appear to mark recessional events. Wilke (1978) identified 15 successive episodes of trap construction at progressively lower elevations along the northwestern shore of Lake Cahuilla. Schaefer (personal communication 2006) has noted that some fish-trap stones exhibit separate build-ups of tufa, perhaps resulting from different lacustrine in-fillings, although Laylander (personal communication 2009) has suggested that these may represent the reuse of rocks from earlier lake stands.

The southeast portion of Lake Cahuilla has a number of recorded fish camps with abundant fish bones, but no stone fish traps. One possible explanation for this is that groups along this portion of the lake used nets. Kaemlein (1971) suggested that large nets could have been carried from the Colorado River to the lake shore and then carried back to the river at the end of fishing activities along the lake, leaving little evidence of fish catching. Given ethnographic data indicating that net fishing was common along the river (see below), this remains a viable hypothesis.

The present study focuses specifically on the V-style fish trap, which is the most common type found along the western Lake Cahuilla shoreline. To supplement the existing archaeological data, we incorporate ethnographic data on fish trap use, fish biology and ecology, archaeological excavations, and experiments with fish trap design to gain a better understanding of how the traps were deployed. Connaway (2007:14) has argued that fish traps are generally similar cross-culturally, and are built in response to fish habits and hydrological conditions. We explore this idea further below.

## ETHNOGRAPHIC DATA ON FISH TRAP USE

For this study, ethnographically documented fishing techniques, including those practiced along the Colorado River, were explored to help us reconstruct the working mechanisms underlying the Lake Cahuilla fish traps. No direct ethnographic observations of fish trap use along Lake Cahuilla are available, of course, because the lake had dried up before early ethnographers began working in the area. Although limited ethnographic accounts on the use of the traps exist from consultant data, these accounts must be used with caution. For example, Bean et al. (1981) cited a Native American consultant's statement that people from the Torres Band of the Cahuilla Indians moved east into the Colorado Desert and built round traps that functioned in conjunction with the low tides in ancient Lake Cahuilla. The term "tide" implies the existence of dependable fluctuations in water level. However, variances in Lake Cahuilla were the result of variances in water flow from the Colorado River and evaporation; these were unlikely to have produced variations in lake levels on a daily or even weekly basis. Variations in river flow were more likely to have occured on a monthly or seasonal basis, which is too slow a time period to have influenced the operation of fish traps using "tidal" effects.

The Mohave represent a group who fished along the Colorado River, often concentrating on lagoons and sloughs created by the river; their fishing techniques have been described by Wallace (1955) and Ruppert (1976). Ruppert (1976) recorded eight fishing methods used by Mohave groups, including drag nets, two types of dip nets, a fish scoop, a brush fence, a semi-circular baited trap, hook and line, and the bow and arrow. Fishing nets were valuable items and ranged from 20 to 30 feet in length. These nets were placed across small inlets and were used to capture razorback suckers. In the muddy conditions along the Colorado River, a dip net was often used to capture fish (Wallace 1955:88). The net was constructed with ten-foot-long poles on either side and was used while standing in the river. It was allowed to drift and open with the current. Wallace (1955) also described a fish scoop made from willow and arrow weed that could be used (depending on its size) by several people in a backwater area or by a lone person in the river. In essence, the scoop functioned as a large dip net.

The Mohave also used a form of fish trap that was deployed in shallow water and consisted of a small, semi-circular fence of arrow weed or willow branches that were inserted into the soft mud of the bottom of the river (Smith 1977). A small opening was left in the trap to allow fish to enter, and crushed watermelon seeds and maize kernels were sometimes scattered on the surface of the water to attract fish into the trap.

Wallace (1955:91) mentioned that Mohave men would sometimes dive under the surface of the river and catch fish by hand. Recent supporting evidence for the hand capture method comes from a study of razorback sucker behavior; Mueller and Marsh (2002:42) have described the razorback sucker as being docile when handled.

Ruppert noted that Mohave men occasionally used a barrel cactus spine that had been heated and bent into shape as a fish hook, and that was employed in conjunction with a willow pole and cowpea fiber line;

the hook was baited with worms, grasshoppers, and small fish. However, Stewart (1957:201) expressed doubts that this method was commonly used by the Mohave, since fish could more easily be caught with traps and scoops.

The Cocopa also fished along the Colorado River and in the Gulf of California (Castetter and Bell 1951; Gifford 1933). Fish were taken using gill, dip, and drag nets in lagoons and rivers. Cocopa fishing nets were described as being approximately 30 feet long, with phragmities floats (Gifford 1933:268). No rock alignments were used in these deployments (Lisa Wanstall, personal communication 2005). The Cocopa also used a bow and arrow to shoot fish.

## FISH BIOLOGY AND FISH TRAP DESIGN

A basic premise of this study is that fish traps were designed in accordance with an understanding of fish behavior; therefore, fish biology and human behavior were intricately linked. We argue that the behavior of native Colorado River fishes dictated the development, application, location, and scheduling of fishing practices along Lake Cahuilla. A major hypothesis underlying this research was that fish traps were placed on Lake Cahuilla's alluvial gravels to exploit natural fish spawning habitats (see Oglesby 2005; Connaway 2007).

The fish species most commonly recovered from Lake Cahuilla archaeological sites are the razorback sucker (*Xyrauchen texanus*; also called the humpback sucker) and the bonytail chub (*Gila elegans*). Gobalet and Wake (2000) described the fish remains from 64 archaeological sites in the Salton Basin and reported that 99 percent of the fish remains from these sites were from either razorback sucker or bonytail. The ratio of fish species varied between sites, but overall the number of bonytail versus razorbacks was consistent, with the number of bonytail being consistently higher. Gobalet and Wake (2000:518) commented on the uniform size of the bonytail, and suggested that weirs may have been used to catch them during their spawning activities. Data from coprolites recovered at the Myoma Dunes site (Wilke 1978) also indicate a focus on bonytail versus razorback; it appears that juvenile bonytail were consumed whole.

All of the species used prehistorically were warm-water, bottom-oriented, and semi-nocturnal to nocturnal. Bonytail are the largest of the chub species. They feed in relatively clear water on crickets, grasshoppers, bees, and wasps. Spawning populations of this species have been observed to involve up to 500 individuals.

Razorback suckers can reach lengths of up to two feet and a weight of up to 18 lbs. (Mueller and Marsh 2002). They feed on zooplankton found throughout the water column. The only time that adult razorback suckers congregate is during the spawning period, making prehistoric exploitation difficult during other times of the year. Both bonytail and razorback suckers have long life spans, ranging from 40 to 45 years.

The information on fish spawning behavior utilized for this study was gleaned from Bureau of Reclamation research and restoration efforts along the Colorado River and at modern Lake Mohave. Both razorbacks and bonytail have long spawning periods, and Bureau of Reclamation data indicate that they spawn during separate time periods. At current Lake Mohave, razorbacks can begin spawning as early as November and continue as late as May if temperature regimes remain favorable, with a normal spawning period of three months. Razorbacks generally congregate in shallow waters during their spawning cycle, dispersing to deeper waters once spawning is completed. The majority of spawning activities occur in water depths from one to five meters, although they can spawn in very shallow water.

Jonez and Sumner (1954:140) have described the only recorded observation of spawning bonytail in their account of fishing along Lake Mohave. They estimated that there were 500 fish spawning over a quarter mile-long stretch of gravel. These were adult fish over 30 cm. in length; no young bonytail were observed. Wilke (1978) suggested that bonytail were taken all year long, not just during the spawning season, based on the recovery of juvenile bonytail remains from coprolites at the Myoma Dunes site. This may have been the case, as recorded bonytail behavior indicates that their schooling behavior occurs during most of their life span. This behavior would make them economically profitable to exploit during their juvenile stage.

Given the above description of fish behavior, it is likely that the fish traps were used primarily to trap members of spawning fish species. This may have been especially true of the V-trap design. The majority of V-style fishing traps were found close to the mountains

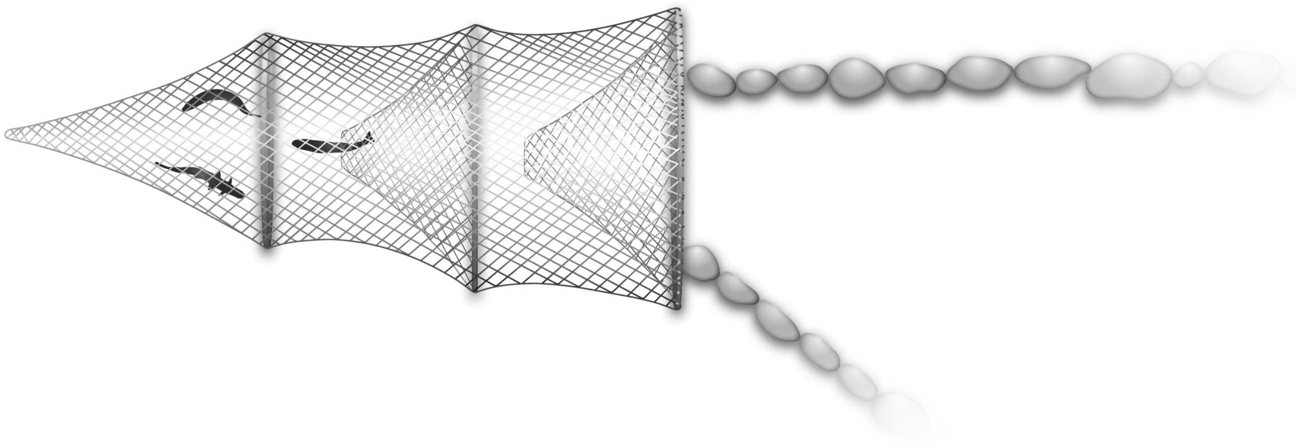

**Figure 3. Reconstruction of Basket Trap Device**

on the northwestern shores of Lake Cahuilla (Wilke 1978, 1980). These concentrations can be explained to some extent by the spawning requirements of the razorback sucker and bonytail chub, and by human cultural responses to this behavior. The fish chose specific sizes of gravels on which to spawn, and these gravels were more often located near the mountains as part of alluvial fan aggregates. These areas also provided boulders of appropriate size for fish trap construction.

One final aspect of fish behavior likely conditioned the use of the V-style trap. The basic behavioral principle that makes the V-style trap work is called positive thigmotaxis. A positive thigmotaxic response requires fish to touch something while they are swimming; therefore, the stone alignments on the substrate direct the fish into the basket trap device (for example, see Fig. 3). Nets could have been used to block fish from exiting the trap. Both razorback suckers and bonytail display this type of positive thigmotaxic response; thus the V-style trap could have been used to successfully capture them. Negative thigmotaxic responses occur when fish avoid touching each other or other solid objects. A fish with a negative thigmotaxic response may not come in contact with solid objects, but may seek refuge near them. The circular rock-walled traps found along Lake Cahuilla may have been used to provide a hiding place where fish felt protected, a response that is exploited cross-culturally in fish trap construction (von Brant 1964), and which may have been more useful for trapping fish species with negative thigmotaxic responses.

By taking into account fish behavior, we can also illuminate a common misconception concerning the deployment of Lake Cahuilla fish traps. This is the idea that traps were used for active communal fish herding. Von Werlhof (1996:5) stated that teams of Cahuilla fishers would herd schools of fish into traps, plug the narrow gap with a boulder, and then scoop up the ensnared fish. The senior author conducted experiments to test this hypothesis and found that there are two salient problems with this method of fish entrapment. First, attempting to herd fish into one of these traps is similar to attempting to herd birds into a large, open man-made structure and trying to keep them there; when the fish were herded, they scattered in several directions away from the trap. Second, even if fish were to enter the trap, nothing prevents them from swimming over the top of the walls and escaping. Thus, other methods for capturing fish would have been more productive.

## EXCAVATIONS OF V-STYLE TRAPS ALONG LAKE CAHUILLA

The excavations carried out during this project represent the first professional excavations of any Lake Cahuilla fish traps. Excavations were conducted at the Aggregate Products, Inc. quarry site in Salton City, California on private land slated for development. Six fish traps were excavated, and two of these were then rebuilt as part of the experimental phase of this project. These traps were part of a group of traps first recorded by von Werlhof (1996), and were located on recessional shorelines between 18 and 21 m. below sea level. The fish traps were excavated as archaeological features using a trowel and brush. All material from the first two traps was screened through 1/4-inch mesh screen. No artifacts were found during this screening, so no screening was done of material from the final four traps. (In retrospect, all sediment excavated from the traps should have been screened.)

The traps were excavated starting at the apex, the end of the trap where the walls almost meet that represents the portion of the trap that would have been in the deepest water. The initial goal was to recover remnants of basket trap devices at the apex. The excavations followed the alignment of the rock walls and ceased when stones were no longer present. The outside perimeters of the trap walls were relatively easy to identify, as the original substrate surrounding the trap was readily apparent during excavation. The excavations also documented clear differences between what was observed of the trap at the ground surface and what could be seen in the buried portion of the walls.

Trap 1 was very shallow; only a small, 50 x 50 cm. section of the apex was excavated to a depth of 10 cm. No evidence of basket traps or nets was found during the excavation of this trap, and none were found in any of the other traps; this is likely due to preservation issues. For Trap 2, a laser level was used to establish a line around the trap, and excavations proceeded from that line, enabling the recording of the height of the larger stones in the walls, all of which were at the same height. As was the case with Trap 1, most of the trap was exposed on the surface; only a small part was buried in sediment toward the apex. The trap walls were approximately 40 cm. high at the apex, where a basket would have been placed.

Trap 3 was more substantial and had more depth. The excavations began at the apex and continued to a point where the walls began to feather into a substrate of sheet-washed stones. A dense concentration of gastropods was found in the substrate upon which the trap was built; the gastropod layer was followed out for the length of the trap. This gastropod level consisted of shell mixed with beach sand. It was approximately 2-3 cm. thick and was located 12 cm. below the surface at the apex of the trap. A soil profile revealed alluvial sheet wash and a thin clay level above it.

Trap 4 was more ephemeral, and vegetation growing within and around it had displaced the wall stones. The apex contained deep sediments, extending to 40 cm. below the ground surface, that displayed alluvial and clay deposits similar to those identified in Trap 3. The substrate upon which the trap was built was again represented by a layer of gastropods.

Traps 5 and 6 were excavated using a different technique, to determine if a better method for excavating the traps existed. Instead of starting at the apex, excavations proceeded from the side walls of the trap toward the center. This method was found to be inferior to excavating from the apex, as it was difficult to identify the base of the trap, the interior dimensions, and the trap design features. The lower gastropod level was again identified, but it was difficult to follow.

These excavations established the basic features of the V-style fish trap design, and documented that a variety of fish trap wall heights was used. Although von Werlhof (1996) recorded 19 different styles of traps in this same portion of the Lake Cahuilla shoreline, our excavations indicate that post-depositional forces may have acted to create the illusion of trap design variability. Animal burrowing, vegetation growth, and water action all cause displacement of the wall materials, and variation in the amount of alluvial and aeolian deposition affects the visibility of the trap on the surface. Trap 3, for example, appeared from the surface to be U-shaped, and no evidence of the outline of the bases of the walls was visible. However, after excavation it was apparent that this was a typical V-style trap. A final conclusion that can be drawn from these excavations is that rock wall heights can be greater than surface indications suggest. These findings demonstrate the need for more research, including excavation, on these traps.

## EXPERIMENTAL FISH TRAP DESIGN

Because the primary goal of this project was to determine how fish traps functioned, an important component of the research involved replications of, and experiments using, both V-style and round, rock-walled traps. This aspect of the project was especially important, given the lack of ethnographic accounts describing the use of the Lake Cahuilla fish traps. Information on bait, nets, and other trap elements was incorporated into the experiments, drawing on ethnographic and historical data on arid-land fishing techniques elsewhere. The experiments were conducted by the senior author at modern Lake Mohave, Nevada, between May, 2004 and December, 2005.

The experimental traps were constructed in different lacustrine settings. The trials were carried out during the early evening, as all of the fish species were active during this time. Data on all of the captured fish were recorded and the fish released unharmed. We initially deliberated between using active and passive fishing methods, and decided (given the extreme clarity of the water in current Lake Mohave) to use passive techniques. Our decision was influenced by ethnographic data, as Wallace (1955:89) had discussed the use of active fishing (e.g., hook and line, dip net) methods in the Colorado River when waters were murky.

The first experiment involved the construction of two fish traps on a gravel-covered alluvial fan, in a razorback sucker spawning area at the end of the spawning season. These traps had several components, as we mistakenly believed that rock alignments were not sufficient to direct fish into a basket trap device. White surmised that netting of some kind was secured to the substrate by rocks and that this netting was used to direct fish into the traps. His intention was to use the rock alignments to secure the netting to the substrate, and then use wooden stakes (made of materials available to prehistoric groups) to stretch the netting, thus creating a V-style trap. To avoid damage to the fish, he used nylon block nets rather than the cotton fiber gill nets noted by Castetter and Bell (1951) or the Mojave willow bark nets noted by Wallace (1955). These initial experiments failed, as the substrate contained substantial numbers of large rocks, making it impossible to drive in the wooden stakes without breaking them. Only one female razorback sucker was captured in this initial experiment. The lack of success in catching fish caused White to reevaluate the trap design.

For the next experiment, White tied stalks of phragmities together to form two-foot-long net floats which were placed every five feet, following information gleaned from Gifford's (1933) description of the use of phragmities net floats attached to the upper edge of Cocopa fishing nets. These bundles provided the buoyancy needed to float one-inch mesh netting. The netting no longer protruded above the water line; instead, the entire net moved with the water. The number of people required for the construction of a trap decreased with these new design modifications. A minimum of two people were needed to construct the first traps, whereas a single person could assemble and deploy the new trap design in one hour. If the components were already assembled, the trap could be deployed in half that time.

In conjunction with this change in net deployment, White also used bait, following Wallace's (1955:88) description of the use of ground corn for bait, and Stewart's (1957) description of the use of ground corn and pumpkin seeds secured in a ball of clay or mud to attract fish. Feeding experiments conducted at the Willow Beach National Fish Hatchery, Arizona, in 2004 demonstrated that both the razorback sucker and bonytail preferred ground corn to pumpkin or squash seeds. Ground corn was thus added as a component of the fish traps. Subsequent experiments were conducted in varying lacustrine settings using the net floats and bait. The results were always positive, with an average of three pounds of catfish, sunfish, or carp captured per single evening setting.

The third experiment involved the construction of a trap on a shallow, flat sand bar between deep water and a large stand of bulrush plants, which provided habitat for the fish. The edges of the sand bar were steep, creating a kind of plateau effect near the shore line. During this experiment, the continuous rock alignment used in previous experiments to secure the nets to the substrate was discontinued in favor of placing rocks every four feet to secure the wing nets.

Experiments 4 and 5 involved traps built on a fairly steep substrate near deep water. Experiment 4 involved a V-style trap constructed in the same manner as in Experiment 3. Experiment 5 involved a round, rock-walled trap built on the lakeshore. After the walls were finished, leafed branches were placed on top of the trap. During the construction of this trap, a school of green sunfish moved into it before it was half finished. Unfortunately, small wave action generated by boat traffic along Lake Mohave eroded the sand and gravel substrate in front of the trap, and it did not remain functional throughout the night because the walls collapsed.

For the sixth experiment, a trap was built on a flat, gravel-covered alluvial fan containing both living and dead vegetation. The trap was constructed directly adjacent to five green sunfish spawning beds. This experiment resulted in a greatly increased fish catch, producing approximately 15 pounds of carp and one green sunfish. This increase in catch size can be attributed to the placement of the trap near the sunfish spawning beds, as the fish captured in the trap (carp) had gathered to eat the eggs of the sunfish. Prehistoric groups may have been aware of this type of fish behavior near spawning locations, and may have taken advantage of it, although it is not mentioned in ethnographic accounts.

The final experiment involved the construction of a trap on the edge of a vegetation-covered alluvial fan. The entire trap (except for the basket-trap device) was built of rocks; no netting was used, and the rock walls were built high enough to reach the surface of the water. The trap was built midway between deep water and a vegetative habitat used by fish. The steep angle of the substrate necessitated building a shorter trap. For this experiment, a “bait ball” was placed in the basket trap and ground roasted corn was sprinkled on the trap floor between the trap walls. According to Stewart (1957), a bait ball was used by the Mojave Indians that consisted of clay mixed with ground corn. In this experiment, the clay ball absorbed three times its own volume of ground corn and still retained its integrity. It was allowed to dry slowly in a plastic container, and the corn fermented during the drying phase. The bait ball was then placed in the basket trap device, and its strong aroma apparently attracted fish. This experiment resulted in the largest amount of fish (20–25 pounds) captured in any of the experimental traps.

During the experiments, the angle of the fish trap walls was varied in order to determine if wall angles affected the efficiency of capturing fish. No differences in efficiency were observed. The results also indicated that the height of the rock walls was insignificant, as the shape of the trap and the presence of bait directed the fish into the basket trap device. Overall, the best results from the fish trap experiments came from leaving the fish alone to explore the baited trap during evening hours, with the trap placed in or near locations that fish used for habitat, creating the illusion that the trap was also habitat. It was concluded that the basket trap component should be in deep water, with the opening facing the shore line. Bait placed within the trap serves to attract the fish, and once inside, they can not get out. These experiments suggest that bait was an integral component of the fish traps.

## USING MULTIPLE LINES OF EVIDENCE TO INFER FISH TRAP DESIGN

This study represents the first of its kind, combining data from archaeology, ethnography, experimental procedures, and fish biology to examine the use of V-style fish traps along Lake Cahuilla. The Lake Cahuilla fish traps represent the use of a highly productive resource patch that required the development of a unique technology for its exploitation. According to our research, the biological characteristics of the fish were central to the effectiveness of the traps, and dictated both their placement in the lake environment and their design. Traps were placed near spawning areas and in areas with vegetation that served as fish habitat. Our research also suggests that rock walls or nets were used to direct the fish into baited basket traps, taking advantage of their positive thigmotaxic responses. By more fully understanding the biological characteristics of the fish, we can begin to examine the distribution and nature of the fish traps in relationship to the lacustrine environment.

To address the question of the number of traps deployed at one time, a laser level was used to record the elevation of all of the fish traps (N=11) in the area where excavations were conducted. The difference in elevation between the highest and lowest trap was 41 cm. Waters (1983) presented calculations of lake recession that indicated a 15 cm. drop in elevation occurred per month. If these figures are correct, then 45 cm. would encompass a time period of three months. This three-month time span coincides with the length of the spawning period for the razorback sucker. It is thus plausible that the use of these traps coincided with spawning activities. However, Laylander (1997:48) has argued that evaporation rates were highly seasonal and that lake recession rates would thus be lower than those proposed by Waters. It is therefore possible that these fish traps represent longer spans of use than the three-month spawning cycle.

The round rock-walled traps, often excavated into talus slopes, appear to represent a different pattern of fish trap use, involving the creation of a pseudo-habitat to catch fish. If we consider the biological factors that affect juvenile fish (e.g., predation), then it is apparent that these traps would provide an ideal habitat.

## CONCLUSIONS

By integrating archaeological data, fish biology, excavations, and experimental data, it is possible to gain a better understanding of fish trap design and function along the shores of Lake Cahuilla. Clearly, much more research needs to be done concerning the effectiveness of these types of traps in capturing native fish species. It is possible that the diversity of traps recorded along Lake Cahuilla is a result of the use of different kinds of traps that targeted specific fish species during different times of the year. Therefore, more attention needs to be focused on identifying fish bones to species level and determining fish size. The research described here strongly indicates that humans took full advantage of fish behavior in order to capture this important resource. Our holistic approach better illuminates the significant role played by fishing technology along these ancient shores.

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