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Fish traps on ancient shores

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FISH TRAPS ON ANCIENT SHORES

By

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ABSTRACT

Fish Traps on Ancient Shores

By

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Archaeological investigations associated with the Lake Cahuilla fish traps have been restricted due to the lack of excavation and experimentation. This thesis addresses a new line of researches, which incorporates not only experimentation and excavation, but also the combination of fish trap design and fish behavior, to more fully explain the working mechanics of ancient fish traps. Not only are these issues examined, but other natural phenomenon, that affect the archaeological record, and its understanding are examined. This thesis relies heavily on biology for its conclusions.

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Support for my endeavors came from too many people to mention here. All helped me along the way in one manner or another. Some facilitated this work by voicing their encouragement and others, by contributing their negative predictions. Yet still others' sponsorship stayed with me, but they did not live to see me finish my goal. To those I can see and those I cannot, I owe you all a great debt.

CHAPTER 1

INTRODUCTION

Statement of the Problem

The purpose of this study is to determine how the V-style Lake Cahuilla fish traps functioned in the environment in which they were deployed. This research is the first of its kind, according to Lake Cahuilla researchers and United States Bureau of Reclamation data. I use the archaeological record in my research to establish the importance of fish to the people who lived in the Colorado Desert and to identify the unique and ingenious methods used to catch fish there. This research is a functional analysis of prehistoric Lake Cahuilla fish traps. Lake Cahuilla existed in the same basin as the current Salton Sea, California; however, it was six times the size of the Salton Sea. The unique fish traps found around the extant shorelines of Lake Cahuilla have intrigued researchers for many years. The fishing activities this research addresses took place most recently between 1500 A.D. and 1700 A.D. and were carried out by Native North American people.

In this thesis, I fit fish trap design to fish behavior, incorporate the ethnographic record, and use experimental archaeology to explain the manner in which these traps functioned. Due to the delicate nature of the native fish restoration work being carried out by state and federal agencies, in all but the first experiment, surrogate fish species were used. A main premise of this study is that any hunter, prehistoric or modern, must cater to the behavior of prey animals in order to be successful. Therefore, biology and anthropology are enmeshed in one another.

Previously accepted theories surrounding the function of these traps are incomplete because fish behavior was not considered and no experiments were conducted to test the theorized trap functions. For instance, the myth of tides is commonly used to address trap function in Lake Cahuilla (Wolfe 1928), despite the fact that Lake Cahuilla has not been connected to the ocean for approximately 5-2 million years (Morton 1977). New evidence supplied by using fish behavior as a research approach provides a more plausible theory explaining fish trap function. The hypothesis I am developing suggests that behavior of the native Colorado River fishes dictated the development, application, location, and scheduling of fishing practices used by people on the shores of Lake Cahuilla.

In order to more fully understand the subsistence strategies of ancient people in the Colorado Desert, it is necessary to become familiar with their technology and the constraints of their environment. Historically, the Colorado River carried more sediment than any other river in the world (Kniffen 1931:165). During the middle Pleistocene, sediments from the Colorado Plateau were deposited into the Colorado River Delta and formed a natural sediment dam across the Salton Trough (Downs and Woodward 1961). The Salton Trough is an extension of the Gulf of California rift, created by gradual subsidence of the surrounding mountains during the Miocene, Pliocene, and Pleistocene periods (Dibblee 1954). Approximately 212 million tons of sediment were carried by the river as it left the Grand Canyon (Reclamation unpublished data, 1979) and by the time it reached Yuma, Arizona, it was still carrying approximately 160 million tons (Kniffen 1931: 165).

These numbers demonstrate the turbid nature of the river. As the flow velocity decreased, suspended sediment built up in the river channel and periodically altered the southerly direction of the Colorado River. The river would sometimes be redirected to the north where it would enter the Salton Basin, forming and reforming a large lake, which has been alternately referred to as Lake Cahuilla, Blake Lake, and Lake le Conte by various authors.

The Colorado River would alternate between dumping into the Salton Basin and the Colorado River Delta. After the river found its old watercourse, Lake Cahuilla would recede from evaporation. This evidence is demonstrated by marsh deposits and archaeological sites around the lake. These infillings have lasted as long as several hundred years each.

Weide et al. (1976:97) used radiocarbon dating to produce dates in excess of 50,000 years B.P. for Lake Cahuilla in its ephemeral contexts. While radiocarbon dates which extend that far back cannot be calibrated, this date is provided strictly for general purposes. The highest water surface elevation attained by the reforming lake was 12.8 meters above sea level (Laylander 2007; Waters 1981:383; Wilke 1978:13) and at the lowest level the lake was over 91.5 meters deep or 69.2 meters below mean sea level. Wilke identified three lake intervals between 695 A.D. and 1580 A.D. At its pinnacle, Lake Cahuilla incorporated over 5,697 square kilometers and reached a depth of 96 meters. The lake measured approximately 160 kilometers long and 56 kilometers wide during this "full pool" (highest capacity) (Wilke 1978:12).

The discharge from the Colorado River varied from year to year. For example, in 1905 the water flow was 2,038,671.3 liters per second, and in 1920 the flow increased to

3,680,934.4 liters. By 1935, the flow had receded to 509,667.8 liters per second. The changes in water volume which occurred prior to record keeping must surely reflect the fluctuations mentioned above.

For Lake Cahuilla to reach a "full pool" (highest capacity) height of 12.8 meters above sea level, the Colorado River would need to discharge into the Salton Basin between 12 and 20 years. Additionally, it would require half the annual discharge from the river to maintain Lake Cahuilla using present evaporation and rainfall rates (Waters 1981:375). Lake Cahuilla drained to the Sea of Cortez through the divide at Cerro Prieto, Mexico. It has been estimated that 55-60 years would be required for the basin to dry at an evaporation rate of 1.8 meters per year (Wilke 1978:9).

This thesis attempts to more fully explain the function, seasonality, and placement of the fish traps, therefore providing a more holistic framework with which to interpret Lake Cahuilla fishing sites. Figure 1 depicts the location of ancient Lake Cahuilla and the more recent Salton Sea, south central California.

In this first chapter, the research questions, focus of the thesis, and the significance of the study are presented. Chapter 2 illuminates the fish species on the Colorado River, it provides an overview of fishing methods used around the world, and discloses the resource scheduling common on the Colorado River. Chapter 3 brings the ancient people of the Colorado Desert, Colorado River, and Peninsular Ranges into focus and explains their territory and environment. Chapter 4 discusses the known Colorado River fishing technology and the Lake Cahuilla archaeological record. Chapter 5 discusses the excavations, reconstructions, and survey

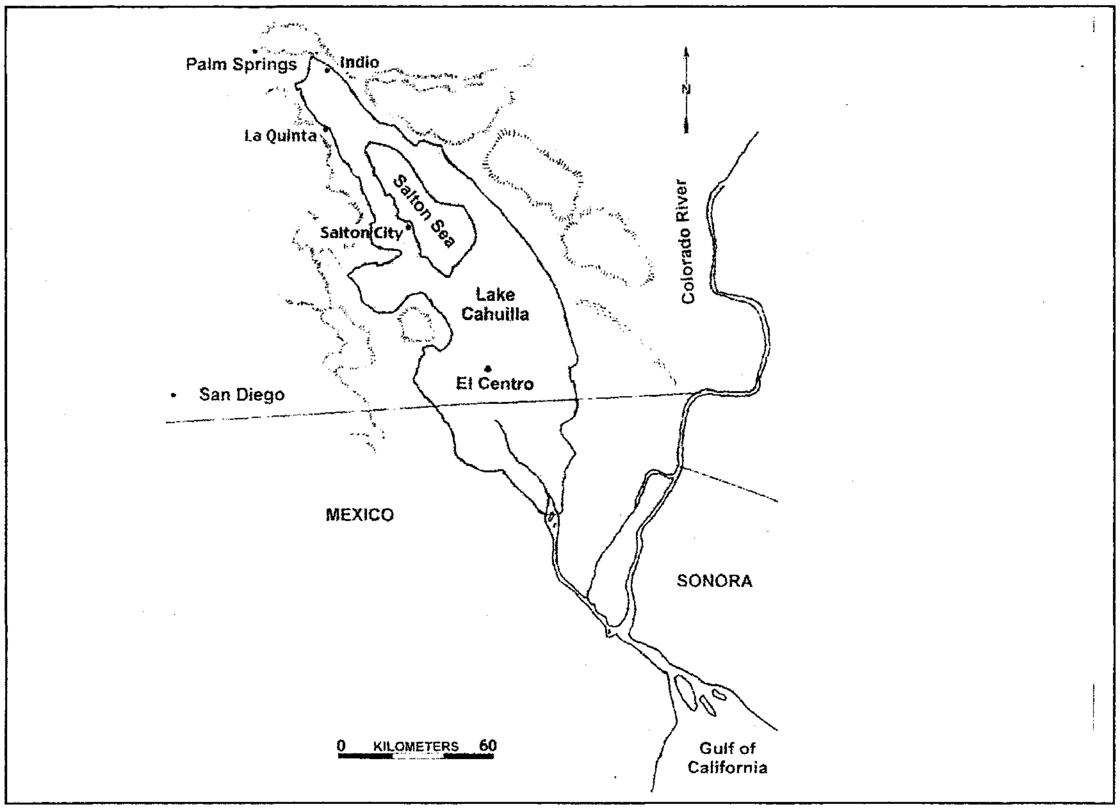

Figure 1. Prehistoric Lake Cahuilla/modern Salton Sea. (Adapted from Gobalet.2000)

conducted by this study. It also looks at the V-style trap, the initial experiments, and artifact reuse. Finally, Chapter 6 presents my conclusions.

Background

Understanding the placement of fish in the subsistence strategies of the unique Colorado Desert people is one of the primary aspects of this study. This research has benefited from 25 years of studies by the Lower Colorado Regional Office of the United States Bureau of Reclamation and their ongoing attempts to recover now endangered populations of the same native fish species that were harvested in Lake Cahuilla between 1500 and 1700 A.D. By using this behavioral information, we gain better insights into past fishing adaptations in the Colorado Desert. A hypothesis of this study is that the location of fishing traps on Lake Cahuilla's alluvial gravels indicate that prehistoric fishermen exploited natural fish spawning habits. Apple (et al. 1998:3-12) notes that "most of these sandstone enclosures are found in association with low sandstone outcrops. Fish bone is frequently found in and adjacent to the rock enclosure." This might seem to imply that house rings and therefore traps would be associated with the rock outcrops.

Unexplained rock alignments on the shores of Lake Cahuilla have intrigued researchers for centuries. Native ethnographies indicate that these features were fishing traps built by ancient Cahuilla and Kumeyaay people (Schaefer 1998) when the Colorado River overflowed its banks, cutting a channel into what is now known as the Salton Basin, forming Lake Cahuilla.

Gobalet (2000) describes the fish remains from 64 archaeological sites in the Salton Basin, California. He concluded that 99% of the fish remains from these sites were either razorback sucker or bonytail. The sites varied as to their ratios of fish species but overall the number of bonytail verses the number of razorbacks was approximately balanced. Gobalet (2000:518) also comments on the uniform size of the bonytail (average size 321 mm), suggesting that weirs may have been used to catch them. The differing species recorded from these sites is supported by United States Bureau of Reclamation data, which indicates that the razorback and the bonytail spawn during separate time periods.

For the purposes of this study, ethnographically documented fishing technologies, including those practiced along the Colorado River, were examined in order to identify the working mechanisms of the Lake Cahuilla fish traps. This interest in the neighboring technology is warranted, as the traps require only small modification to be used in either a riverine or lacustrine environment. Jay von Werlhof (1996:12) recorded 19 variations of the "V-style" trap on alluvial land owned by John Corcoran in Salton City, California; the same land where I conducted test excavations. Fish traps also occur in other contexts; for instance, rows of large holes dug into an ancient talus slope/substrate. One researcher suggested that these excavated holes were antelope hunting blinds (Treganza 1944), although they do not follow the pattern of antelope ambushes.

The most common misconception concerning Lake Cahuilla fish traps is that they were used for active communal fish herding. For example, a report written by Jay von Werlhof (1996: 5) states that teams of Cahuilla fishers would herd schools of fish into the traps, plug the narrow gap with a boulder and then scoop up the ensnared fish.

There are three salient problems with this description. First, attempting to herd fish into one of these traps is similar to attempting to herd birds into a large, open manmade structure of some sort and then trying to keep them there. Both fish and birds react to threats in their environments in the same manner. When we applied pressure to the fish, they scattered in several directions away from the trap. (Our group of "fish herders" numbered only three, therefore greater numbers of herders may have supplied sufficient motivation for the fish to move into a fish trap.) Second, nothing prevents the fish from swimming over the trap walls and escaping; a line of rocks on the bottom of a lake will not contain a wild animal that moves both vertically and horizontally in the water column. Finally, there is no stated method to prevent the fish from escaping in the same manner they entered the trap.

There is a great deal of ethnographic information concerning these traps and their origins. However, many accounts should be carefully scrutinized. One such example was recorded by Bean, Vane, and Young (1981). These authors cite a Native American informant as saying that the people of the Torres (Torres Martinez Band of Cahuilla Indians) moved eastward to the Colorado Desert from west of the San Jacinto Mountains. These people constructed roughly round traps, from .76 to 2.7 meters in diameter that supposedly functioned in conjunction with the low "tides" in ancient Lake Cahuilla.

Another source of the tide theory came from one of the first European immigrants to the Salton Basin, Stephen Bowers, following his tour of the Torres-Martinez area. He surmises the Salton Sea was subject to the "tides of the Ocean" in his article entitled "The Cahuilla Indians" in *The Pacific Monthly Magazine* (Bowers 1891:229-230).

The term "tide" implies a dependable fluctuation of the water level. Dependable, predictable daily or even short-term fluctuations of water level in Lake Cahuilla cannot have occurred as a consequence of any known plausible mechanism. For example, the entire flow of the Colorado River is needed to fill Lake Cahuilla for between 12 and 20 years. Variances (tides) in Lake Cahuilla caused by the discharge of the Colorado River would be impossible on a daily or even weekly basis. Elevational change due to evaporation could reduce the lake level by 15 centimeters per month, but this change is too slow to influence operation of a fish trap by tidal effects.

Furthermore, Lake Superior, one of the largest fresh water lakes in the world, is 560 kilometers long, 256 kilometers wide, and averages 147 meters deep. Its surface area is 16 times that of Lake Cahuilla at its highest level. If any lake were capable of producing tides, Lake Superior would be a strong candidate; however, the gravitational attraction of the moon on this lake is not sufficient to produce tides. Lake Superior is subject to a phenomenon called "seiche," or a piling up of water due to wind or high barometric pressure, and lake levels can vary as much as 30.5 centimeters on opposing shores. Even if this were true in Lake Cahuilla, with its storm winds that sustain excesses of 80 kilometers per hour; fishing would not be possible because of the waves generated by such winds.

Wilke and Lawton (1975:14) state "the fish traps were located where the trails came down from the mountains to convenient locations along the shore." This would seem to imply the traps were placed at the foot of the trails because it was handy. Data generated by this research suggests that this assumption is unlikely, and that the fishes' behavior likely dictates placement of the trails in relation to alluvial fan deposits. Placing a fish trap in a location that fish do not frequent would capture very few fish, so catering to their behavior and choice of spawning locations is key in harvesting an ample supply of fresh meat.

Research Questions

Considering all of the issues pertinent to the operation of the many different types of Lake Cahuilla fish traps is beyond the scope of this thesis. Each type of trap would need to be excavated, simulated, and rebuilt in a lake setting where it could be tested for efficiency. This research focuses on the most salient points concerning the form and function of the V-style fish trap. By focusing primarily on only the V-style trap, it was possible to make a more in depth examination of a single design rather than a broad spectrum shallow view that provided few answers. In this way it was possible to create a starting point for further investigations.

The study addresses the following research questions:

- How did the V-style fish traps function? What were the working components of the traps?
- How many traps were operated at one time?
- Were the traps operated only during the seasonal spawning cycle?
- How many people were required to construct and operate a trap?
- Could these activities have been carried out by a single nuclear family?

Research Design

To answer the first question, "how did the V-style fish traps function," it was necessary to replicate a number of Lake Cahuilla fish traps. Speculation concerning the function of V-style traps needed to be tested. It is the assumption of this researcher that fish behavior has probably not changed in several thousand years, or perhaps several hundred thousand years therefore, fish behavior and trap design combined provided the best avenue for understanding the working components of the V-style trap.

The fish species which are most often recovered from Lake Cahuilla archaeological sites are the razorback sucker (*Xyrauchen texanus*), bonytail (*Gila elegans*), Colorado River pike minnow (*Ptychocheilus lucius*), and striped mullet (*Mugil cephalus*). Technological variation in trap design could be used during different periods in the fishes' lives. For example, the bonytail will exhibit schooling behavior during most of its life. Conversely, the razorback sucker only congregate when they are juveniles and during the spawning period after they become adults. Additionally, Schaefer (1994) describes traps with rock walls up to one meter in height. From the information gathered thus far, high rock walls suggest an entirely different capture strategy. In sum, an in-depth understanding of individual fish behavior is needed to more fully explain the functions of the various trap designs.

The schooling behavior of the bonytail would make it somewhat profitable to exploit during most periods in its life and the Myoma Dunes site demonstrates this quite well. The site was recorded by Wilke (1978) and displays a 16: 7 ratio of bonytail to razorback sucker. The bonytail at the site were identified from 77 coprolites. These fish were juveniles and were consumed whole. This in turn suggests the existence of a profitable fishing method for the smaller fish (Gobalet 2000).

As to the number of traps operated at one time, only archaeological survey and ethnographic research can illuminate this question. To answer this question, I inventoried a group of fish traps on an ancient shoreline using a laser builder's level to determine the number of fish traps constructed at or near a single beach line. The evaporation rate of the ancient lake, the elevations of the fish traps, and the biological habits of the fish were investigated to arrive at a conclusion concerning the number of traps deployed at one time.

Discerning whether single family groups or a larger cultural unit was essential to operate the traps required survey to identify the number of traps which appear to have been operated at one time and experimentation to document the number of hours needed to construct and operate a set of traps. It also required a working fish trap design to begin the experiments. Several components of the traps such as nets, possible cattail block netting, and wooden basket traps, were researched. A single experiment was conducted using the round rock wall design, but this design was not further researched.

CHAPTER 2

FISH SPECIES AND FISH TRAP HISTORY

Most of the fishes of the Colorado River (75 percent) do not exist elsewhere in the world (Mueller 2004). However, the fishing adaptations developed in the Colorado Desert (Lake Cahuilla) appear similar to those invented in other areas, because fish behavior in those areas is somewhat similar. This chapter looks at the fish species of the Colorado River, and provides an overview of a few of the fishing technologies used around the world.

These fish species include the razorback sucker (*Xyrauchen texanus*), also commonly called the Humpback Sucker and the Buffalo Fish, flannelmouth sucker, desert pupfish, humpback chub, bonytail, roundtailed chub, woundfin, sonoran topminnow, and the Colorado pikeminnow.

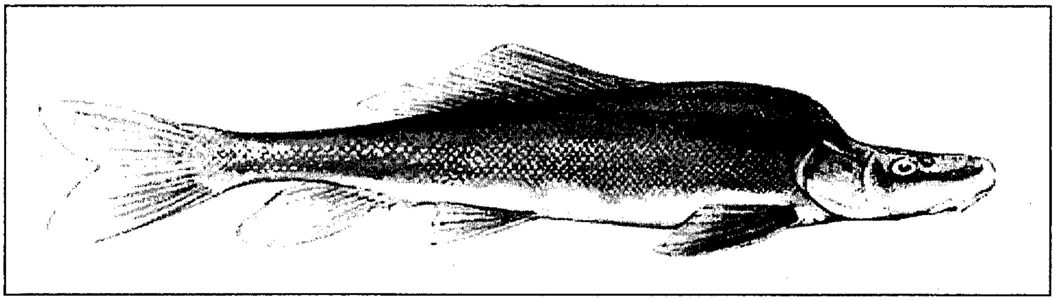

Figure 2. Razorback Sucker. Adapted from Mueller and Marsh 2002

	Species Name	Common Name	Historical Occurrence	Modern Status
Fresh Water				
	Catostomus latipinnis	Flannelmouth Sucker	Rare	Uncommon
	Cyprindon macularius	Desert Pupfish	Abundant in Delta	Endangered, in Delta
	Gila cypha	Humpback Chub	Rare	Endangered, Absent
	Gila elegans	Bonytail	Abundant	Endangered, Stocked
	Gila robusta	Roundtail Chub	Rare	State listed, Absent
	Plagopterus argentissimus	Woundfin	Common	Endangered, Absent
	Poeciliopsis occidentalis occidentalis	Yaqui Sonoran Topminnow	Abundant	Endangered, Absent
	Ptychocheilus lucius	Colorado Pikeminnow	Common	Endangered, Absent
	Xyrauchen texanus	Razorback Sucker	Abundant	Endangered, Stocked
Marine				
	Elops affinis	Pacific Tenpounder	Common in Delta	Common
	Mugil cephalus	Striped Mullet	Common in Delta	Common

Table 1.

Table 1 provides a list of the fish species in the Lower Colorado River (after Mueller and Marsh 2002:40). The razorback sucker commonly lives to forty years of age and fertile females produce up to 200,000 eggs each year. Females choose the shallow spawning site in rivers and lacustrine locations. First year growth of this fish can reach 30.5 centimeters in total length. This species uses the shallows in a lacustrine environment to feed and spawn. A common belief is that the hump on the back of these fish improves stability in turbulent river currents; however, (Mueller 2004) suggests that the hump could have been developed to prevent predation by other fish species. This fish often reaches lengths of 2 feet and can weigh up to 18 pounds (Mueller 2004).

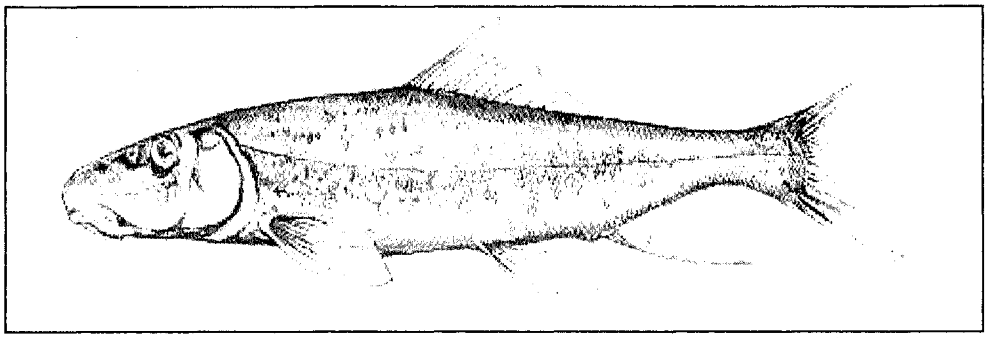

Figure 3. Flannelmouth sucker. Adapted from Mueller and Marsh 2002

The flannelmouth sucker (*Catostomus latipinnis*), commonly called the "Bigtooth Sucker" will attain lengths of 66 centimeters, but are normally recorded around 50.8 centimeters in length. This species feeds on aquatic vegetation, and its spawning behavior is similar to that of the razorback sucker. First year growth of this species can reach 20.3-25.4 centimeters. The flannelmouth prefers flowing streams and avoids reservoirs. This fish has been recorded moving more than 161 kilometers in the Colorado river system (Mueller 2004).

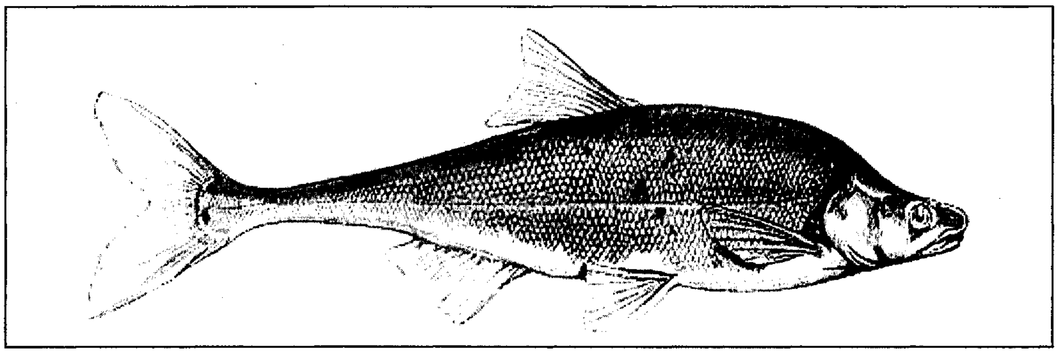

Figure 4. Bonytail. Adapted from Mueller and Marsh 2002

The Bonytail (*Gila elegans*) commonly called the Colorado Chub, Colorado Trout, and the Gila Trout (though the later two names are more properly applied to native trout species of the Colorado and Gila River system) is only found in the Colorado River basin and is the largest of the chubs (Gila spp.). This species reaches a maximum length of 45.7 centimeters and is a long lived species. Not much is known about the spawning activities of these fish, however, spawning adults prefer deeper water during the daylight hours, but congregate in, shallow water at night, . Research suggests (Mueller 2004) they prefer eddies and pools to fast running water. In 1864, W.P. Blake, a mining engineer using a piece of lettuce as bait, caught and sketched one of these fish (Mueller 2004:47).

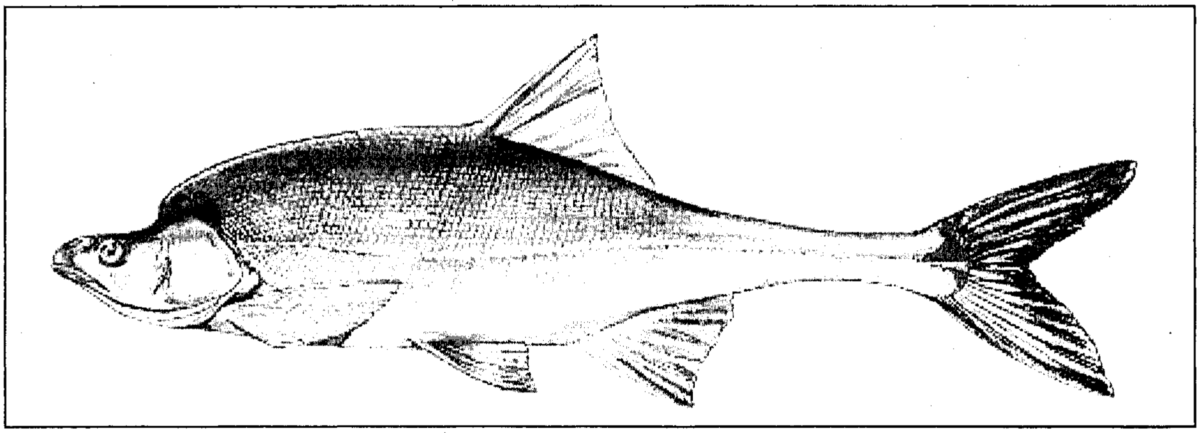

Figure 5. Humpback chub. Adapted from Mueller and Marsh 2002

The humpback chub (*Gila cypha*) has a streamlined and robust body shape similar to that of the bonytail. This fish lives in deep water, canyon habitats exclusively. These fish prefer the main channel habitats where they can reach lengths of 50.8 centimeters. The food sought by this species varies with season and region, but includes terrestrial and aquatic invertebrates, algae, plant material and miscellaneous items. The humpback is thought to live for decades and spawning in the Colorado occurs during high spring runoff (Mueller 2004).

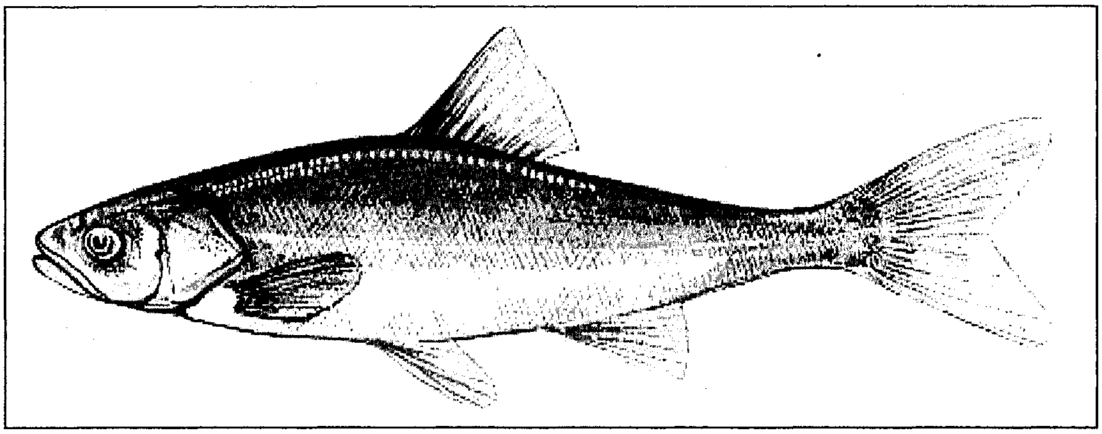

Figure 6. Round tail chub. Adapted from Mueller and Marsh 2002

The roundtail chub (*Gila robusta*) commonly known as the Colorado Chub, Roundtail, and Verde Trout will reach lengths of 40.6 centimeters. This fish is usually found in larger tributaries and is thought to live in excess of a decade. Spawning occurs in water depths of 30.4 centimeters (Mueller 2004). This species feeds on microinvertebrate food resources.

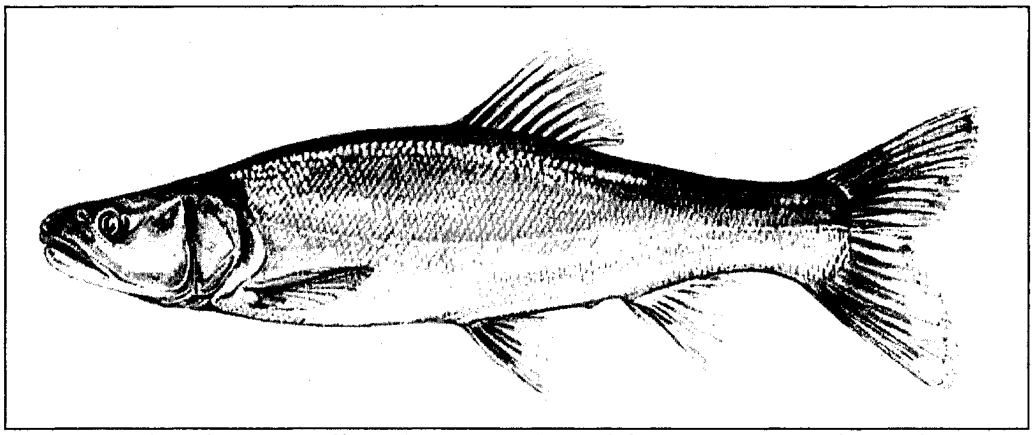

Figure 7. Colorado River pike minnow. Adapted from Mueller and Marsh 2002

The Colorado pike minnow (*Ptychocheilus lucius*), commonly called the Colorado squaw fish, the Colorado salmon, Colorado minnow, and the white salmon, is the largest of the minnow family in North America and only found in the Colorado River drainages. Individuals have been recorded that approach 45.4 kilograms and 1.8 meters in length but few individuals reach this length. Archaeological sites such as Catclaw Cave, below Willow Beach on the Colorado River have produced five individuals, the largest of which was approximated at 1.7 meters in length (Miller 1955:130). This fish inhabits the main river channels and larger tributaries. Spawning pike minnows will travel hundreds of miles and spawning is believed to occur upstream of backwater nurseries and confluences to major tributaries just after the peak runoff occurs. This fish was the top predator in the Colorado River and its tributaries feeding on fish and a variety of terrestrial animals such as muskrats, beavers, all types of lizards, birds, small ducks, and rabbits (Beckman 1952), (Quartarone 1993:11) During historic times, 30 year old fish were common (Mueller 2004:45).

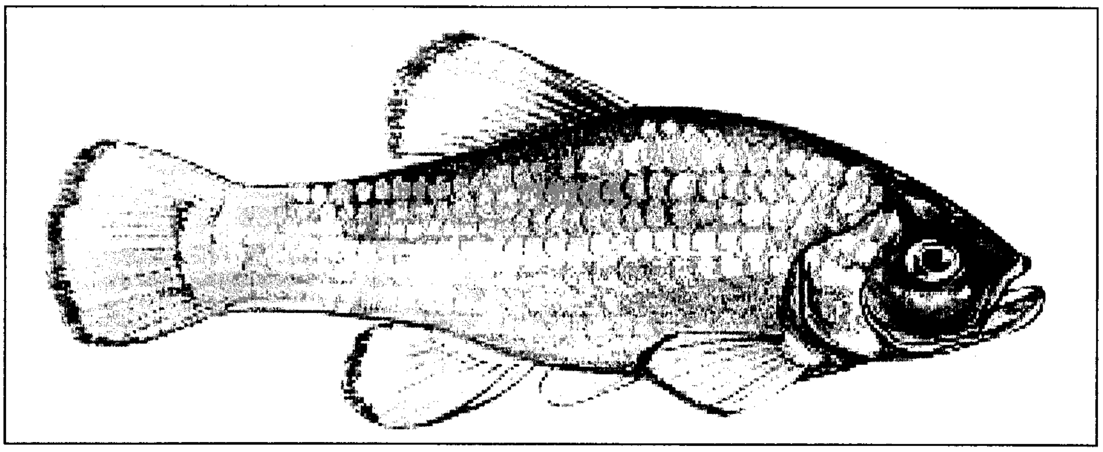

Figure 8. Desert pupfish. Adapted from Mueller and Marsh 2002

The desert pupfish (Cyprinodon *macularius*) commonly called the desert minnow typically measure less than 6.35 centimeters in length. These fish can withstand temperatures of 112 degrees (F) and salinity more than twice that of the ocean. They occur in desert springs, as well as stream margins and feed on invertebrates and algae. These fish usually live no longer than one year (Mueller 2004).

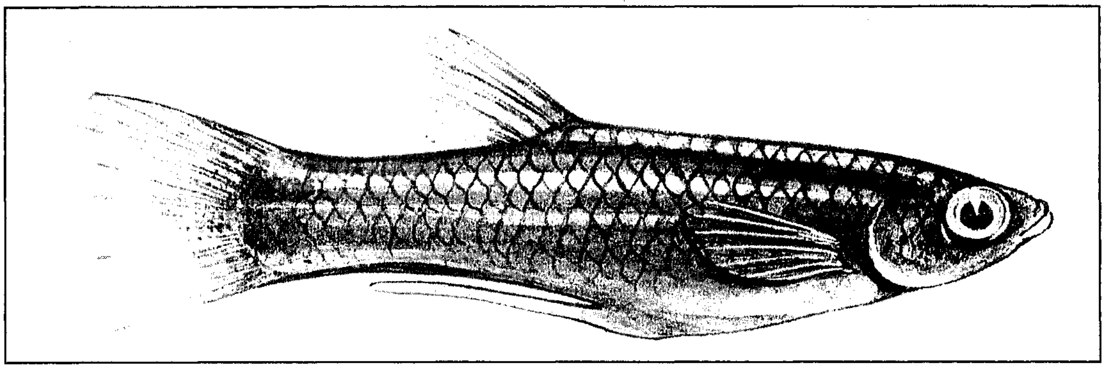

Figure 9. Yaqui topminnow. Adapted from Mueller and Marsh 2002

The Yaqui topminnow (*Poeciliopsis occidentalis*) varies in length by sex. Males are typically less than 2.54 centimeters long and females reach nearly 5 centimeters. These fish prefer shallow margins of springs and streams near aquatic vegetation. These fish feed on insect larvae found near the surface (Mueller 2004).

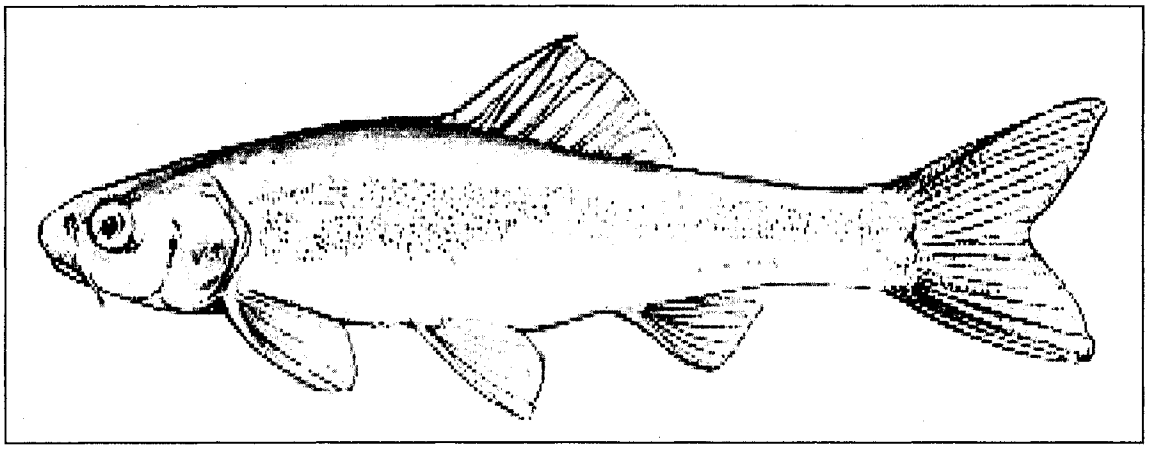

Figure10. Woundfin. Adapted from Mueller and Marsh 2002

The woundfin (*Plagopterus argentissimus*) rarely grows longer than 7.6 centimeters in length. This fish is a channel dwelling species normally found in streams less than .91 meters deep. It feeds on invertebrates, plant material, and detritus (Mueller 2004).

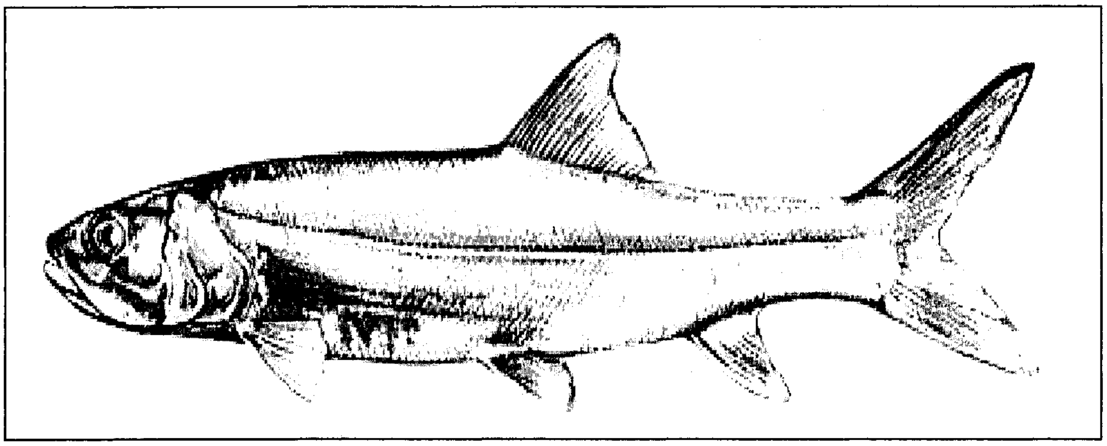

Figure 11. Machette. Adapted from Mueller and Marsh 2002

The machette (*Elops affinis*), commonly called the Pacific tenpounder, tenpounder, or tarpon can reach lengths of three feet, but those entering the Colorado River are rarely over 40.6 centimeters (young fish). This fish is strictly a marine species and spawns in the ocean. This species feeds on detritus, a non-living particulate (organic material) (Mueller 2004), but swims into the lower Colorado River and its tributaries.

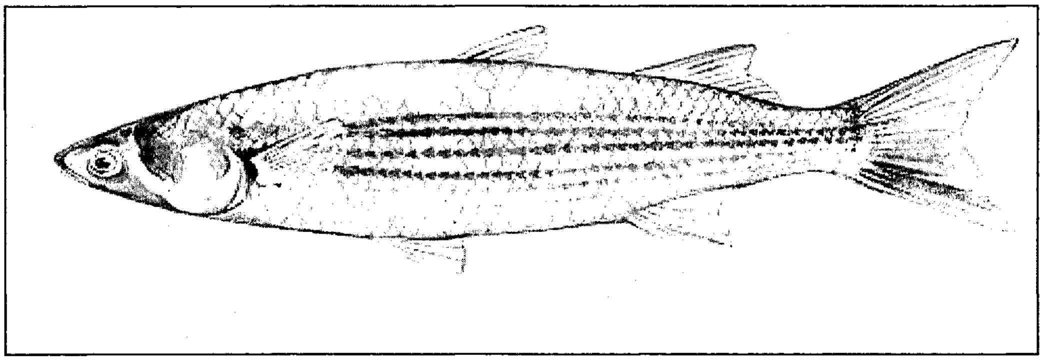

Figure 12. Striped mullet. Adapted from Mueller and Marsh 2002.

The striped mullet (*Mugil cephalus*) commonly called cow-carp or mullet is also a marine fish (Mueller 2004). The maximum length of the striped mullet is approximately 373.4 centimeters, with a maximum weight of 7.98 kilograms. Lifespan is reported to range somewhere between 4 and 16 years. Striped Mullet spawn off shore in large schools.

Individual fish species behavior required the development of various fishing methods. Below is an overview of methods, used around the world. They provide a basis for understanding the unique technology used in Lake Cahuilla. The central hypothesis of this thesis is that placement of fish traps in Lake Cahuilla was based primarily on behavior of female fish. Similar fishing methods from the Colorado River and around the world are examined to illustrate some variations of the unique fishing methods used in Lake Cahuilla.

Even after 25 years of research and restoration by federal and state agencies, more behavioral data are constantly being uncovered concerning the eleven mainstream fish species native to the Colorado River. Regional temperatures govern the timing of many biological functions in the plant and animal world, and in turn dictate the timing and location of human subsistence activities. An important factor to bear in mind when considering the behavior of the Colorado River fish, is that they are all warm water fish species. On current Lake Mohave, the razorbacks can begin spawning as early as November and continue as late as May (normal spawning periods last three months) if temperature regimes remain favorable; yet, these examples represent extremes. Razorback suckers have been observed spawning in very shallow water (some as shallow as ten centimeters). However, the majority of the spawning activities occur at locations where the water depth varies between one and five meters. Native Fish Biologists working at Willow Beach National Fish Hatchery in Arizona indicate that the razorback sucker optimally spawns in temperatures between 18.3 and 26.6 degrees (C). An important factor to bear in mind when considering the behavior of the Colorado River fish is that they are all warm water fish species. In Lake Mohave, razorback suckers have been recorded spawning near thermal springs in Black Canyon where the average water temperature is near 10 degrees (C) (Unpublished USBR data, 2003). Razorback suckers have been observed spawning in very shallow water (some as shallow as 10 centimeters). However, the majority of the spawning activities occur at locations where the water depth varies between one and five meters.

Various Fishing Principles

Fish traps can take many forms. A few of these, such as the Chinese brush fishing methods found on page 25 are referred to as, "artificial structures." Artificial structures, such as hollow reeds have been used for centuries in Japan. In the Philippines brush traps are used for capturing shrimp, and in East Asia ceramic octopus pots create pseudo habitat (Von Brant 1964:56-58). The behavioral principle that makes the V-style fish traps work is called positive and negative thigmotaxis. A positive thigmotaxic response requires the fish to touch something while they are swimming, therefore the stone alignments on the substrate direct the fish into a waiting basket trap device. The same principle facilitates the capture of fish in modern traps. Lake Cahuilla fish traps are smaller and less complex, but strikingly similar in design to modern fish traps. Figure 13 shows a plan (top) view of two four traps as they were deployed in Lake Cahuilla.

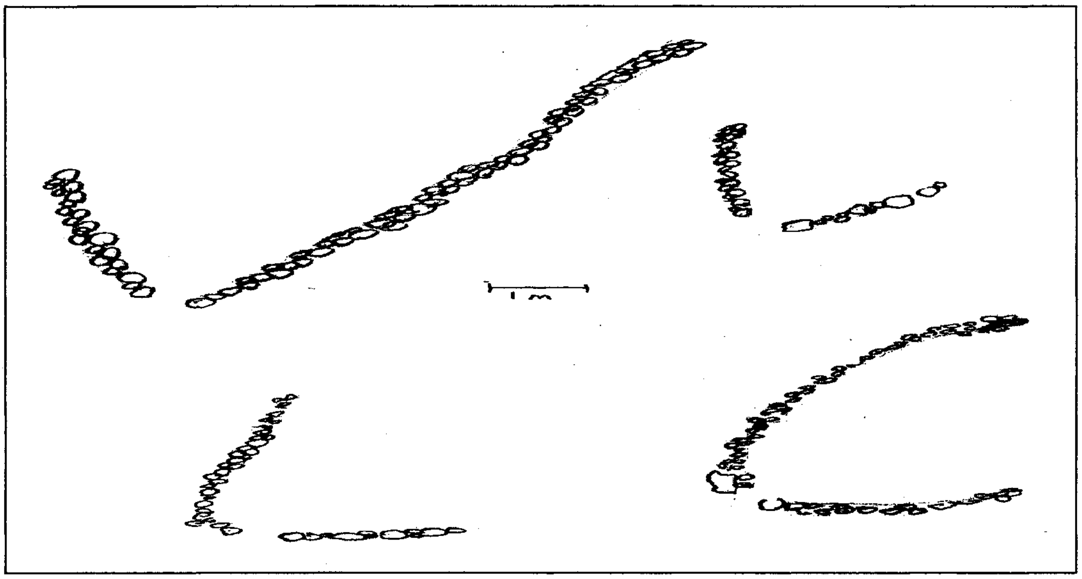

Figure 13. Various trap designs. Drawing adapted from site report; Schaefer 2004.

Figure 14 is a modern commercial fish trap. Note the similarities in design between Figures 13 and 14. They both use a V-style orientation, but the commercial trap is much larger and more complex. The Lake Cahuilla traps are hypothesized to be deployed to trap members of a spawning fish species. Figure 14 illustrates how the modern commercial fish trap directs fish into the catchment device in the apex of the trap.

Pelagic animals such as shoal fish tend to school by nature and generally avoid touching each other, but maintain a set distance between group members. An example of this behavior commonly witnessed is the distance maintained by birds sitting on a fence or telephone wire. This loose herd structure is subject to change when danger is present. In the case of fish they remain tightly packed when a threat is present and increase the distance between themselves when feeding. Pelagic fish also avoid touching other solid

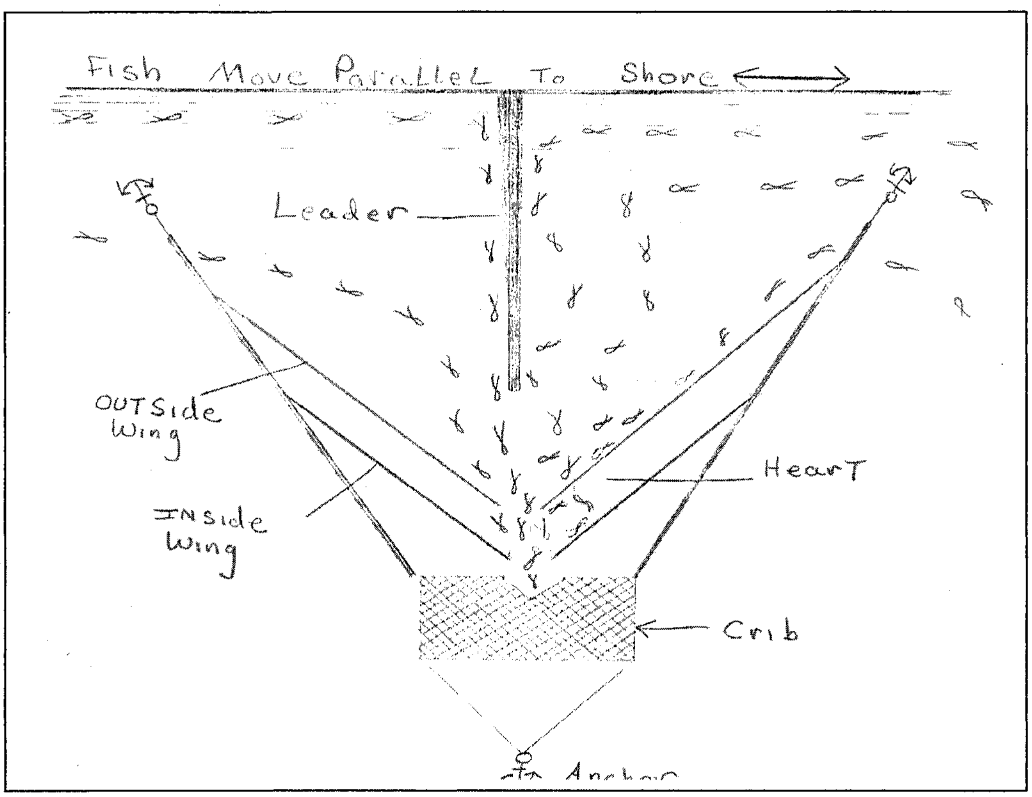

Figure 14. Modern Commercial Fish Trap

objects such as stones or submerged wood. This is called a negative thigmotaxic response. An animal or fish with a negative thigmotaxic response may not come in contact with solid objects but may like seeking refuge near them, and certain species need to find shelter. For example in Japan, the dourados fish will hide directly below a raft. This behavior is well known to Japanese fishermen who developed a fishing strategy that completely encircles the raft with nets and traps the fish. Conversely, other species such as the razorback sucker and the humpback chub, which normally frequent habitat that includes plant and root cover as well as a deep water habitat, display a need to touch something. This behavior is termed positive thigmotaxis and is the mechanism that facilitates the V-style trap design in Lake Cahuilla.

In another type of habitat exploiting strategy, fishermen deploy a constructed hiding place where fish may feel protected. Constructed hiding places include bundles of twigs or branches. This technique is used all over the world (von Brant 1964:49, 57, 78). The bundle of sticks is generally lifted out of the water and shaken or nets encircle the bundle and collect the fish, animals, or crabs, as they attempt to depart.

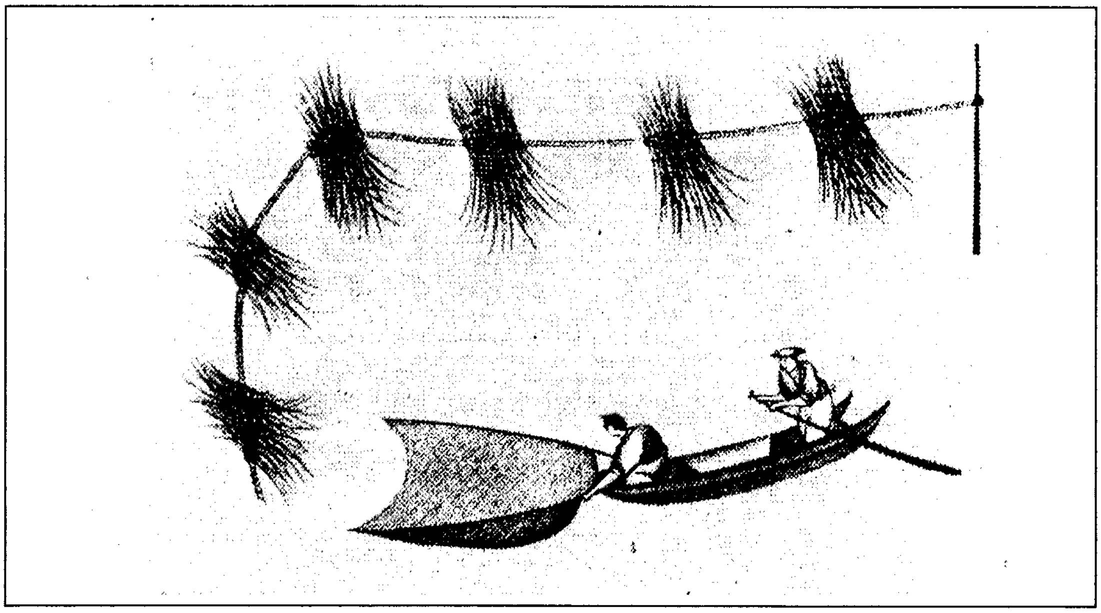

Figure 15. Chinese Brush Fishing. From von Brant 1964

Below, figure 16 displays a Malayan "roempon", which is constructed with a bamboo float on the water's surface, palm leaves suspended in the water column, and an anchor. Fish are attracted to the suspended palm fronds and a net is then pulled up from below the fronds to capture the fish.

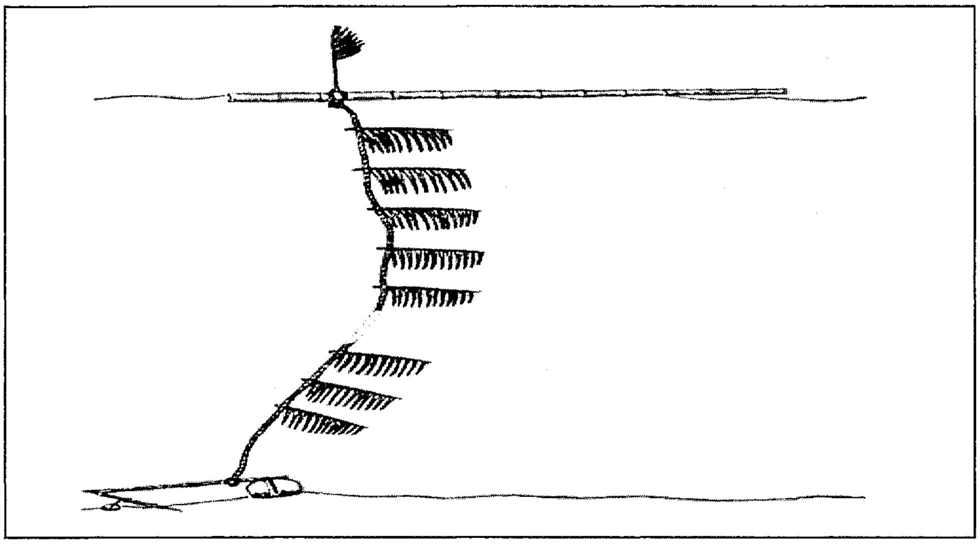

Figure 16. From von Brant 1964

In Japan and other regions around the world tubes are also used to entice fish and eels into taking up residence. Figure 17 depicts a basket trap device from Northern Germany and is used to capture eels, and Figure 18 below is a fish trap from Thailand.

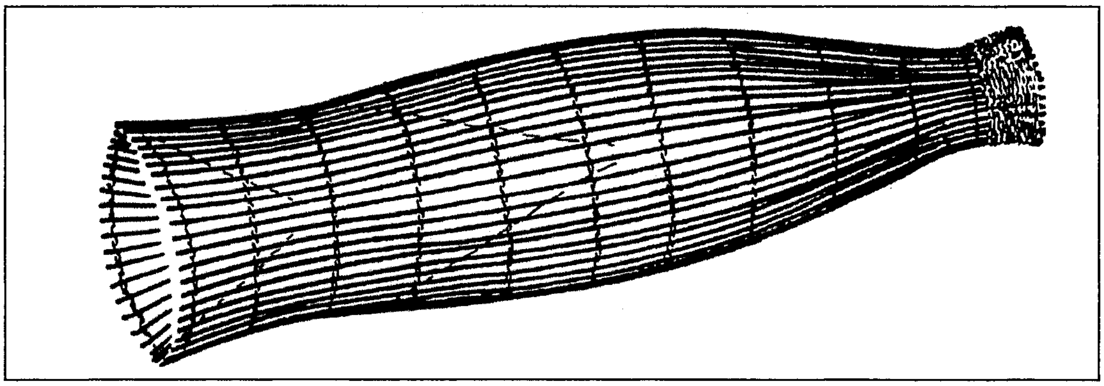

Figure 17. From von Brant 1964:

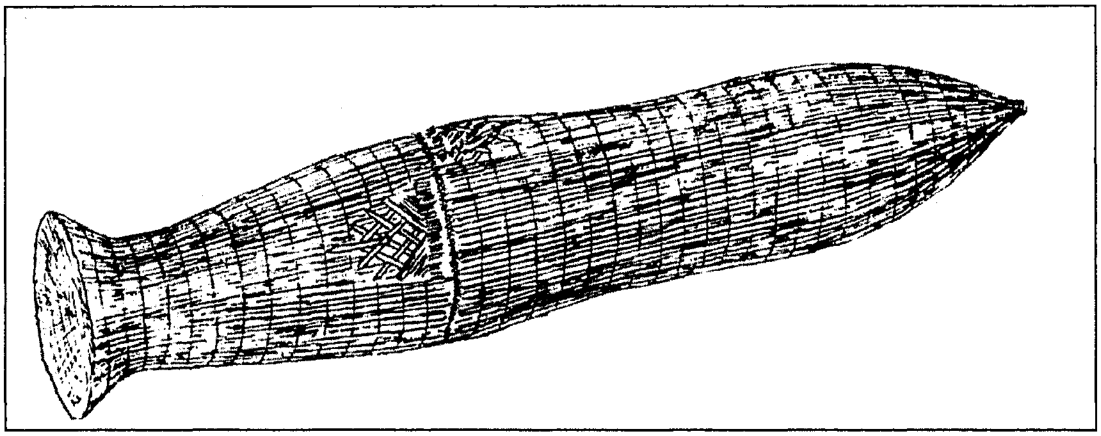

Figure 18. Basket trap from Thailand. From von Brant 1964

In East Asia and in the Mediterranean Sea, it was noted long ago that octopi would use pottery jars as homes, and in the Mediterranean Sea sunken Italian pottery vessels have also been documented as shelters (von Brant 1964:58). This behavior has been exploited by deployment of a large number of these vessels (24-30) tied to a long line and placed on the bottom of the ocean. The only major drawback to this type of hiding place is that it must be retrieved rapidly or the inhabitants escape.

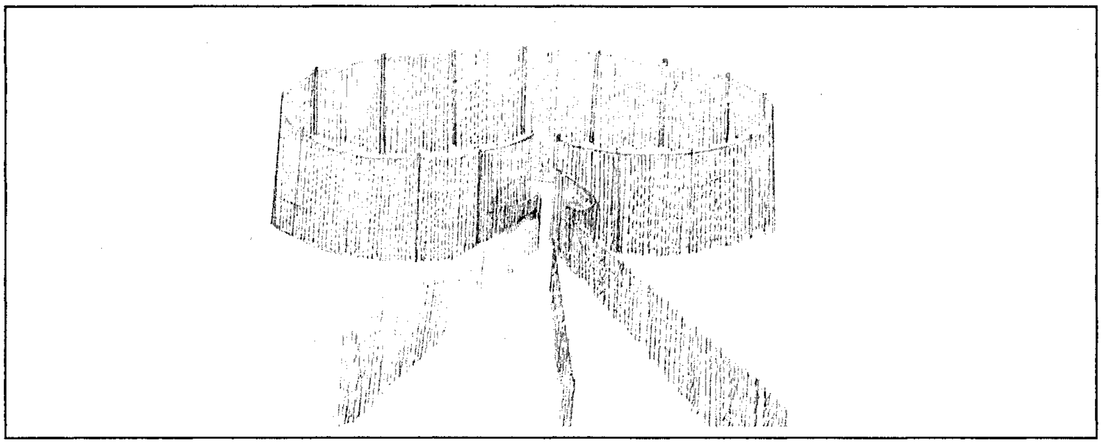

Figure 19. Once inside the fish trap, the design directs fish away from the entrance.

A "trap", on the other hand, forces the fish to remain inside after they enter it because the shape of the opening directs fish away from it. The outside walls of the fish trap utilize the fishes' positive thigmotaxic response. When the fish swim near the entrance, the shape of the walls directs them away from the opening and back across the trap in a figure eight pattern. As the fish needs to touch the walls while they swim, the fish will not swim to the middle of the trap, where it could see the entrance/exit and escape. Modern hoop and fyke nets perform a function similar to traditional basket traps and operate on the same principle as the fish fences. Figure 20 demonstrates two such designs.

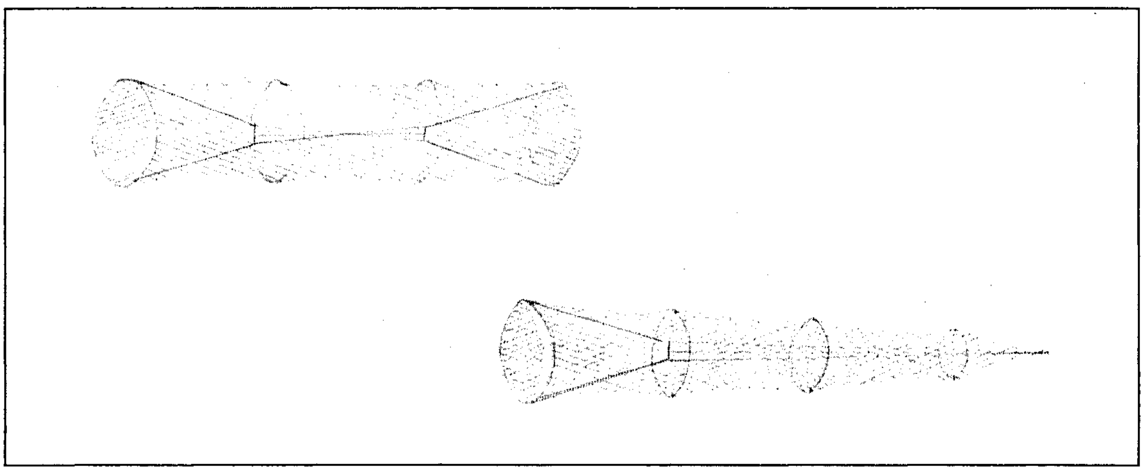

Figure 20. The upper trap is a hoop net and the lower is a fyke net. These traps are approximately one meter in length.

Once a fish gains access to this type of trap they rarely find the entrance from inside. A common thread running through most marine, riverine, and lacustrine cultures around the world was and is the basket trap. Basket traps were constructed from many different types of material. On the Oregon Coast, spruce root was used to build traps because salmon cannot smell it and thus were unable to avoid the traps (Denise

Hockema, personal communication 2002). In the Philippines, small bamboo stalks were used to build large tidal traps, and in India large bamboo stalks were split to form tubular traps (von Brant 1964:76). In Oceania, thorn linings held fish in place in tubular traps after they entered (von Brant 1964:77).

Nets

Nets can function to block fish from exiting a particular component of a trap or they can be used to hold fish in a stationary position when fish contact the net. Information concerning the weight of ancient Native American fishing nets was difficult to obtain. Therefore hunting nets from similarly arid environments were used for comparison purposes. Nets function in the same manor whether for hunting or for fishing. The individual strands of a modern monofilament survey net used by the Bureau of Reclamation are perhaps capable of sustaining ten pounds weight. The entire net is capable of capturing fish in excess of 11.3 kilograms with little or no damage to the net. The net's individual components functions together to form a strong capture devise. Therefore, a net used to capture rabbits in the Arizona desert may well approximate the weight of a fishing net used by Lake Cahuilla fishermen to capture fish.

Kaemlein (1971) describes four hunting nets curated at the Arizona State Museum. The nets are not associated with Lake Cahuilla; however, they are particularly relevant as their length and weight demonstrate the ability to transport fishing gear over a long distance to Lake Cahuilla. A net from Chevlon Creek Cave illustrates this point well; its length is 68 meters and it weights 6.7 kilograms. Kaemlein (1971) describes the characteristics of the net as follows: "The average sizes of the meshes are 6.0 cm. between knots, with a range of ca. 5.5 cm to 6.5cm. The average number of knots in a meter-long section of net is 480." If the netting used by Lake Cahuilla fishers was of similar thickness and the weave was appropriate for gill netting (a much larger weave) then it would weigh even less, making transport that much easier. Stanley A. Freed further supports this theory by stating that the Washo who lived around Lake Tahoe used the same nets for hunting and fishing (Freed 1966:76-77).

Available Data

Since most of the available data are associated with the razorback sucker, I have focused primarily on interpreting the fish traps in connection with that species. Some common behavioral traits, however, are found among fish species in the Colorado River. For instance, they are all bottom oriented, and both the bonytail and the razorback sucker have a long spawning period.

The fish species in the Colorado River are quite unique; however, survival in an arid, periodically flooding environment is not unique to just these Colorado River fish. Van Neer (1989:49) illustrates somewhat similar Nile River fish adaptations to drought. This is of particular interest as it demonstrates how fish in other arid environments have adapted similarly to extreme conditions. *Clarias*, *Protopterus*, *Tilapia*, and *Barbus* are grouped as fish with a prolonged stay on the alluvial plain of the Nile River Valley. Van Neer indicates *Clarias* (catfish), and *Protopterus* (lungfish) are able to resist periods of low oxygen because of accessory breathing organs that allow them to extract oxygen from the air. *Protopterus* burrows into the mud when the flood plain dries out and survives by forming a cocoon, but *Tilapia* and *Barbus* require at least slightly oxygenated pools. Only the species *Protopterus* is able to survive in a totally desiccated floodplain Van Neer 1989:49).

Likewise, the fishes of the Colorado River are capable of withstanding low levels of oxygen. Biologists working with these fish species indicate that the bonytail and the Colorado River pike minnow are capable of withstanding oxygen levels as low as three parts per million (Ty Wolters, personal communication 2005), and the razorback sucker is capable of withstanding oxygen levels as low as one part per million (Gordon Mueller, Personal communication 2006). Also occurring in both geographic settings is the congregation of fish during the spawning cycle in shallow water and their subsequent dispersal into deeper water after its completion.

Van Neer indicates different techniques were used to capture different fish species in the Nile River (Van Neer 1989:53). It is unclear at this time, however, this may be reflected in the various types of rock alignments (fish traps) on the shores of ancient Lake Cahuilla. Wilke (1978:82) uses the fingerling bonytail identified in coprolites at the Myoma Dunes Site to suggest that fish may have been taken all year long in Lake Cahuilla, not just during the spawning period. This may well have been the case as recorded bonytail behavior indicates their schooling behavior occurs during most of their lives if there is sufficient cause. This behavior would make them economically profitable to exploit during their juvenile stages.

Interestingly, Van Neer (1989) notes that fishing is not productive until after the flood waters of the Nile River begin to recede, and that another peak in fishing occurred in the residual ponds left by the flooding. This was also the case on the pre-dam Colorado River; the most productive fishing activities took place when the river was rising to or falling away from the late spring flood. Production levels along the Colorado would also increase when the back water sloughs or oxbows subsided enough to allow fishing activities.

Van Neer (1989:52) pointed to three types of archaeological sites found on the prehistoric Nile River. The first is found in association with the flood plain, the second is found in association with the main river channel, and the third is a mix of both types. The sites mentioned by Van Neer and their associated archaeological assemblages are divided into the three above mentioned categories with the use of fish behavior (e.g., where and how they feed and their habitat preference). Unfortunately any comparison that could be made with the Colorado River must come from ethnologies as the historic dams have inundated most , if not all of the prehistoric fishing evidence, but the informational treasure chest of fish traps located on the shores of ancient Lake Cahuilla are still available for research.

To illustrate the nature of the variables influencing fishing strategies, we can examine fish biology and the fishing strategies that were used in the Colorado River. The Colorado River pike minnow (the top predator in the Colorado River and Lake Cahuilla system) has a terminal mouth (at the end of its body) and its eye orientation indicates it feeds slightly upward. The bonytail feeds in a similar manner, but lacks the size to make it a top predator. Near the edge of the ancient lake the bonytail probably fed in relatively clear water on crickets, grasshoppers, bees, and wasps, and the bonytail can be captured with hook and line techniques. The razorback sucker feeds on zooplankton found through out the water column and has rarely been captured with hook and line techniques. The humpback chub feeds on insects near the surface when young, though when it reaches

150-200 millimeters, it switches to a deepwater environment where it consumes fish as a primary diet (Pam Sponholtz, personal communication 2006).

The life spans of the Colorado River species (the known ones) are very long. The razorback sucker lives in excess of 40 years, the bonytail in excess of 30 years, and the humpback chub in excess of 45 years. The round tail chub lives in slower water adjacent to faster water. They choose to occupy the open segments of river pools and occasionally swift water below rapids. Normally they congregate in small groups in less turbulent segments of cool to warm rivers. Their lifespan is unknown at this time.

Summary

The V-style fish traps operate by using the fishes' behavior against themselves. In some form, all the traps, both modern and prehistoric, discussed in this thesis operate in the same manner. It is worth reiterating that the female fish ultimately decides where the razorback sucker's annual spawning will take place, and it is spawning location that determines where the fish traps are placed in the environment.

Cassetter and Bell (1951:219) validate the data in Table 2 by saying "On the lower Colorado, fish were most abundant in late spring and early fall when the river was rising toward or falling away from the early summer flood. In early spring when fish were the most needed to supplement the scant diet, they were the least plentiful." When Lake Cahuilla was present, spawning would no doubt occur earlier in the lake than the Colorado River, thereby providing an opportunity to acquire fresh meat not available when the lake was dry.

Additionally, the use of fire in fishing activities on the shorelines of Lake Cahuilla may be different from that on the Colorado River because fishing activities were carried out during different seasons. Rose and Bowden-Renna (1998) suggest that fire brands (torches) were associated with fishing along the Colorado River. They further suggest that fire could have been used for light during night fishing practices there. Interestingly, fire heaths have been identified along relict shore lines in association with fishing traps (Apple et al. 1997: 5-26). Considering the season the fish were being exploited in Lake Cahuilla, late winter and early spring, a fire on the shoreline may have been used to provide warmth for those involved in emptying the basket trap components of fish rather than for lighting during night fishing activities. The basket traps were located in the apex of the rock walls in deep water. Additionally, the bonytail (*Gila elegans*) and the razorback sucker (Xyrauchen texanus) are both nocturnal fishes to differing degrees. Therefore, the use of fire for lighting purposes while working the traps may indeed be plausible, but using it for warmth is more likely since every available method of capturing fish was likely used while the fish were available. This means that active methods may have been used as well.

It seems logical to suggest fishing methods must reflect water clarity conditions. If water clarity was good in Lake Cahuilla (absence of current in the lake virtually guarantees increased water clarity), as it is in many southwestern lakes during certain periods during the year, human presence would have been disastrous unless the fishing activities were carried out while the fish were preoccupied with spawning activities. As no studies have been conducted in relation to fire and the Colorado River fish species, nothing can be suggested as to their reaction to it and subsequently, its use or lack of use in fishing methods.

During the spawning season it is possible to get quite close to the razorback sucker. If fishers used long nets it would have been quite possible to cut off and capture a portion of the spawning fish by herding them into the waiting fish trap. Jonez and Sumner (1954:140) describe the only recorded observation of spawning bonytail in their Lake Mohave account. They estimate 500 individuals were spawning over quarter mile long stretch of gravel. These fish averaged 30 centimeters in length. They also indicate that no young bonytail were observed in the spawning area. I also observed the absence of juvenile razorback suckers while their spawning activities took place.

Of special note are the similarities between the Nile River in Egypt and the Colorado River, in the United States. Both exist in extremely arid conditions, and both have fish, which have adapted well to those arid environments. The fishing techniques suggested here may have been developed by Lake Cahuilla fishers and varied according to season, fish species, and the stage of individual species at the time the trap was deployed.

All of this apparent disconnected information, when considered together, provides much clearer insight into the lives, opportunities, and environment of the people who fished in ancient Lake Cahuilla. No experimental research has been done before this thesis to explain the working mechanisms of the Lake Cahuilla fish traps. Therefore, it is hoped that these investigations will illuminate the way for future researchers, both in biology and anthropology, to share ideas and results.

CHAPTER 3

PEOPLE OF THE COLORADO DESERT

The archaeological record supports the idea that people of the Colorado Desert depended on fishing to supplement their subsistence activities when Lake Cahuilla was present. Lake Cahuilla was six times the size of the present Salton Sea and extend south into Mexico. According to Welch (1984:13) the Cahuilla, Kumeyaay, Cocopah, and Quechan Indians all occupied the shores of Lake Cahuilla, while the latter two groups also resided in the East Mesa region. The ethnographic record does not accurately discuss this importance, as the lake was long dried up by the time most anthropologists studied the people in this region. The fishing practices depicted here are based on the archaeological record and my research.

The Kamia / Kumeyaay or Ipai/Tipai: The Prehistoric Period

Many authors use the name Yuman to describe the late milling, or prehistoric residents of southern California and western Arizona (Gladwin & Gladwin 1930), (Rogers 1945), and Yuman also describes a language group. The term Patayan, is used to depict an archeological construction that approximately includes some of the same groups, however, there are objections to its use. Begging the pardon of those who find it distasteful, I will use the term Patayan here only for the sake of convenience.

Generally, the Patayan lived in the Colorado River Borders and nearby regions. The majority of ceramic evidence linking them to the region is paddle and anvil, undecorated wares. The Patayans of the Colorado River and Salton Trough are referred to as Lowland Patayans, these people manufactured Lower Colorado Buffware; those who lived Peninsular Ranges of southern California and Baja California are known as the Upland Patayan, and used Tizon Brownware (Harner 1958). There are three phases of the Patayan culture, which is based on material culture and geographic location. Patayan I, (A.D. 600-1000). The main settlement was in the lower Colorado and Gila River valleys; Patayan II, (A.D. 1000-1500). Pottery technology spread to the Peninsular Ranges of southern California and new forms developed in Colorado and Gila River Valleys and the Salton Trough.; and Patayan III ((A.D. 1500-1769). Agricultural practices appear to have been adopted by the people living in the Peninsular Ranges (Treganza 1947). The end of this period is characterized by the arrival of Europeans and their influences on the Kumeyaay, who dispersed into the Peninsular Ranges of southern California and into the Colorado River Valley (Rogers 1945).

Ethno-Historic Period

Priests accompanying the Bautista de Anza expedition in 1775 made the first European descriptions of the Salton Basin. The Kamia, or Kumeyaay, people were described by friars Font and Garces as living in the desert region. Hildebrand and Hagstrum (1995) claim that the Kumeyaay are closely related to the Kimia, and that these two groups may be a single ethnic group, with a material culture that changes along with the environment. The Kumeyaay took advantage of their mountain location by hunting and gathering and the Kimia adapted to their environment by farming in the bottomland of the river valleys, however, there was much interaction between the two groups (Hedges 1975). The area utilized by these two groups stretched from the river bottoms of the Salton Trough and the lowland desert to the interior mountains and the coastal strip. The prehistoric population of these people is challenging to establish, and surely must have varied with the climate zone; Kroeber (1925:712) suggested they numbered 3,000; however, he did not take into account those people living in Baja California. Including this population would bring the high estimate to 26,000 people (Shipek 1993:160).

Economy

The Traditional subsistence economy of the Kumeyaay had flexible social relations as well as spatial organization (Spier 1923). Even before the historic period, the Kumeyaay were organized in autonomous semi-nomadic bands, with exclusive regions. Each region possessed a vertical range of life zones that included the lowland desert, to the highland mountains. Each range contained zone specific animals and flora that ripened during different times of the year (Luomala 1978:593-594, 599-601). Exogamous, patrilineal, clan groups, numbering between 50 and 70, made up the Kumeyaay bands. Each band was comprised of 5 to 15 clans. Portions of clans lived in separate ecological zones; therefore, times of food shortage were dealt with by temporally relocating to a more resource rich area (Luomala 1963).

The western segment of the Kumeyaay region was coastal foothills and mountains, sage-scrub, and oak-chaparral plant zones. Half a dozen oak tree species provided acorns in the fall of the year. Other staples exploited in the western region by the Kumeyaay were seeds (chia and grasses), islaya and prickly pear (*Opuntia* sp.) fruit, and chaparral yucca (Yucca *Whippei*). These were available in the spring and summer.

A xerophytic plant community typified the eastern portion of the Kumeyaay region, which were made up of the interior uplands and Colorado Desert foothills. The primary staple in this area was roasted agave, which was harvested in the spring. Other food resources included seeds of the Mojave yucca (Yucca *schidigera*), cactus fruit and mesquite bean. The Kumeyaay region also included nuts of the pinion pines (Pinus edulis) which were a favored food. These nuts were harvested when they were available or traded for during unproductive years. Fresh foods included goosefoot (Chenopodiaceae family) and miners' lettuces (Claytonia *perfoliata*), clover (Trifolium family), and various grasses stalks and roots.

Winter foraging provided little in the high elevations of the Kumeyaay region. Subsequently temporary large communities were formed in the lower elevations during the cold months. The communities then disband into the interior uplands and foothill areas as the warm weather induced plant food production. Agave is best consumed in the spring when they are sweet and tender (Barrows 1900:58). Good camping areas, such as those adjacent to springs may have been depleted of agave in northern Baja California (Aschmann 1959).

During the summer the Kumeyaay separated into small mountain bands of between 50-100 people. Subsistence practices were comprised of foraging for seeds, cactus fruits, and berries. During the autumn, subsistence activities increased in the oak-chaparral zone. Acorn production fluctuates quite a lot over the course of many years (McCarthy 1993) emphasizing the need to store excess harvest goods. The Kumeyaay used outdoor granaries to store acorns and protect them from pests and moisture. Methods of acorn storage included whole and processed into ground flour. Acorns both processed and whole were also stored in ceramic jars. The jars had their lids hermetically sealed with pine pitch (Spier 1923). Ground acorn flour was placed on sand where the tannic acid was leached out by rinsing with warm water. This was prepared for consumption by grinding again and then cooked with water to create a mush (Spier 1923).

Hunting

The Kumeyaay hunted for both large and small game animals. Large animals included deer, antelope and sheep. Small animals included birds, rodents, rabbits, rodents and reptiles (Spier 1922, Luomala 1978). The most available and therefore the most important game animal s were rabbits, wood rats, and ground squirrels. Additionally, large game animals were more difficult to harvest with native technology and had a limited distribution. Hunting technology included two types of arrows employed by the Kumeyaay hunters; a reed arrow shaft with a wooden fore shaft was used for smaller game such as quail, squirrels, and rabbit and a stick with a sharpened end or a stone projectile point was used for large game (Spier 1923). Rabbits were harvested with a rabbit stick (Spier 1923), which is similar to a boomerang; however, the shape of the tool is not as pronounced as a boomerang.

Rabbits were harvested in group efforts as well. Fire was set in a bush to force the rabbit to flee and they were taken with arrows and rabbit sticks. Rabbit drives employed nets that were set over runs and the animals were driven into them (Spier 1923). Rabbits were hunted heavily, but their rapid reproduction suggests they were not driven to the point of extinction by aboriginal people. Fire was also used to hunt wood rats. As the rat was fleeing the above ground, conical nets it builds it was clubbed or shot with arrows

(Spier 1923). Traditional Kumeyaay bows had an effective range of 50 meters. This made hunting large game difficult as one would need to get very close. Techniques used on deer included running the animal, which could take several days, or ambushing them at water holes (Drucker 1937, 1941). As the above information suggests, hunting small game was a more reliable activity.

The Archaeological Record and Hunting at the Wikalokal Site

Lithic tools were associated with hunting large and small game animals. No doubt, more often for butchering the animals. Proteins from small and large animals were detected on stone tools from the Sam Bernardino Mountains (Sutton 1993). Ground stone was also used for handling small animals as demonstrated by Yohe et al. (1991) and Sutton (1993) using immunological tests.

Three major types of projectile points were recovered from the Wikalokal Site. All have an overall triangular shape; however, they differ in their bases. The first type has a straight base, the second has a concave base, and the third has a concave base with side notches. The side notch point is a time marker for southern California prehistory. It is thought to have come into use after A. D. 1100-1200 and continued to be used into the late prehistoric (Baumhoff & Byrne 1959). The side notch makes up 41 percent of all diagnostic points in the 1-20 centimeter levels, but it encompasses 70 percent of the diagnostic points in the 20-80 centimeter levels illustrating its more prolific use during the more distant past at the Wikalokal Site.

There seemed to be a constant diminishing of hunting associated artifacts in the 0-20 centimeter levels of the site, suggesting a decline in the reliance on large game in the later period. The later period was also characterized by a reduction in time invested in the production of projectile points; the later points were triangular without the side notch. The amount of debitage from projectile point and tool manufacturing also decreased during the later period. A smaller assemblage of all sizes of animal bones in the later period suggests that fewer animals were processed at the site. An increase in plant food processing tools and small animal hunting seem to replace the large animal subsistence strategies of the earlier periods.

Fishing

The importance of saltwater fish, freshwater fish, and shell fish varied with location in the Kumeyaay diet. Camp sites along the Pacific Ocean indicate that fish and shell fish were an important component of their diet. Early Spanish explorers recorded fish and shellfish as the largest foods consumed by Native Americans especially in San Diego Bay (Costansõ 1911).

Fishing activities were often carried out with the aid of a reed canoe (balsa), however, these boats were not adapted for the open sea. They functioned well in sheltered bays and estuaries (Heizer & Massy 1953). While fish and shellfish occupied an important place in the Kumeyaay substance economy of these people when they were on the coast, these foods do not appear to have been transported inland in great number. The Kumeyaay region did not possess a large amount of fishing locations except along the Colorado River and at Lake Cahuilla when it was present.

Lewis (1973) and Bean & Lawton (1973) have suggested that native Californians actively manipulated their environment as a part of their subsistence practices, especially with controlled burns to generate a better plant and animal resource base (Lewis 1973). Controlled burn area produces more plants that provide better forage for animals as well as humans. Burning also kills parasites and fungi that attack resource rich trees such as palm and oak.

Kumeyaay ethnographic information suggests that animal foods supplied a lesser portion of their diet than plant foods in spite of a substantial commitment of men's time to hunting (Hicks 1963).

Historic Period

The mid-16th century saw the first Europeans coming into southern California. By the late 18th century colonization of the area had begun in earnest. During this period a trail for Spanish settlers was created across thee interior desert and missions were built on Kumeyaay land on the Pacific coast. The arrival of Entrepreneurs, missionaries, settlers, and military personnel in the late 18th and 19th centuries permanently changed the Kumeyaay way of life. Alien occupation in Kumeyaay territory affected their regional organization, causing native people to move east and south to join related clans or create new sociopolitical groups (Phillips 1975). A new labor system was also introduced by the immigrants (Castillo 1978) and disease reduced the Kumeyaay numbers by 20-30 percent (Kroeber 1925). Alien occupation affected the Kumeyaay food sources by establishing a new facet of competition in addition to new perceptions of property rights and new technology, plants, and animals. Collective hunts for deer and rabbits were curtailed by wide-ranging European agriculture. Fences prevented women from gathering acorns from oak groves (Castillo 1978). Domestic animals changed the plant ecology, and the primary grasses were supplanted by European grasses and weeds. Increased erosion was brought on by over grazing, which also reduced the availability of surface water. Large mammals like bear and antelope vanished. Mountain sheep and lions almost became extinct, and deer were reduced in number and range as was the access to coastal foods (Shipek 1978).

Each subsequent association/takeover by Europeans, Mexicans, and finally Americans, destroyed traditional subsistence patterns to varying degrees. Isolation from the latest immigrants dictated the degree of cultural erosion. Shipek (1978) indicated the more rugged mountains and desert reaches of Kumeyaay territories remained somewhat independent until 1850 and some as late as 1910. Between 1850 and 1910 settlers took the best lands and forced the Kumeyaay onto reservations (Shipek 1978).

The Cahuilla

The Cahuilla people live in south central California. The origin of this word is unknown, however, it may stem from a word (káwiya) within their own language signifying master or boss (Kroeber 1925). Their language is subsumed under the Takic family of Uto-Aztecan stock. The topographical region utilized by the Cahuilla is complex in nature with mountain ranges, dissecting passes, canyons, valleys, and desert. Elevations range from 3354 meters above sea level in the San Bernardino Mountains to 83 meters below sea level in the Salton Sink. This group lived in and utilized most of the area between the highest peak in San Bernardino Mountains in the north to the Chocolate Mountains in the east and Borrego Springs, as was the San Jacinto Plain adjacent to the city of Riverside, California, and the eastern gradient of Palomar Mountain.

Geographical features seem to merge with the desert in this region. The alluvial fans turn into valleys varying between 6.4 and 25.6 kilometers in length and several miles wide. These transform into mountain valleys bordered by large vertical scarps, and as a result, individual environmental zones were created, i.e. Lower Sonoran, Upper Sonoran, Canadian-Hudsonian (Hall and Grinnell 1919). Variability in temperature, precipitation, and wind patterns create an inconsistent supply of floral and faunal resources across this region. Seasonal variability also adds to the patchy nature of these resources (Bean 1978:575). The region commonly experiences dry and high velocity winds; these affect the potential of locating food by drying out plant resources.

Some years produce abundant rainfall; however, dry years decrease plant growth and faunal populations. Arid conditions did not affect permanent springs and tinajas, in fact these were common. Seasonal and yearly variation did occur with respect to lakes, rivers, streams, springs, sloughs, and marshes. Ephemeral lakes in the Salton Basin reached lengths of 96.6 kilometers, these were caused by overflow from the Colorado River, snow melts, and seasonal down pours. The variable water table allowed walk-in wells to be dug during wet periods (Bean 1978:575).

Territory

The Cahuilla Group is located near the geographic center of California. Their territory was divided by the Cocopa-Maricopa Trail, a major trade route, and was close to two others; the Santa Fe, and the Yuman trails. The geographic boundary of the Colorado Desert separated the Cahuilla from the Mojave, Halchidhoma, Tipai, and Ipai. The mountains, plains, and hills separated them from other groups such as the Luiseño, Serrano, and the Gabrieleno (Bean 1978:575). The Cahuilla were most interactive with the Serrano and the Gabrieleno, but also shared a common tradition with the Luiseño as well (and other Takic speakers). Activities such as war, trade, ritual, and marriage were regularly engaged in with all the above mentioned groups (Bean 1978:575).

Villages

The locations of villages were generally near plentiful resources. These locations also provided protection from the prevailing winds. The land directly adjacent to the village was the common property of the inhabitants. However, individuals, clans, and families controlled specific parcels of land. Cahuilla villages were inter-connected by trails used for trading, hunting and social interaction. Each village lineage was associated with sacred petroglyph and pictograph sites. Cahuilla people generally lived in a village setting and only left for hunting gathering, trade, ritual, or social occasions. House placement within the village took every advantage of privacy. The largest exodus of village occupants occurred during the acorn harvest when people would leave for several weeks.

Buildings varied in size and design from brush shelters to dome or rectangular shaped houses. The houses were 15-20 feet in length and fitted each individual family's needs. The larger, more strategically located house generally belonged to the village leader or "net" (Bean 1978:577), and was built adjacent to the ceremonial building that held recreational, rituals, and curing activities. In addition to this overall pattern, a men's sweathouse and many granaries were constructed around the ceremonial house (Bean 1972:70-75).

Economic Activities

Many different hunting strategies were used by the Cahuilla men. Stalking, chasing prey down trails into waiting pits, running prey to exhaustion so that clubbing could dispatch them, maneuvering animals within range of their bows, and the use of hunting blinds were all employed. Small animals, such as rabbits, were shot with bow and arrows. They were also stunned with throwing sticks, as well as harvested with the use of nets, snares, and traps. Bush thickets were set on fire to make small animals vulnerable to these tactics. A sexual division of labor existed where men skinned animals and women cooked them. Meat preparation before consumption consisted of three common methods; roasting, boiling, and cutting into strips for sun drying. Animal bone marrow was obtained by cracking the bones. The bones were then ground into powder and added to other foods. A leather pouch or segment of gut was used to carry blood which had been cooked, and blood was also consumed fresh (Bean 1978:578).

Flora

The Cahuilla people posses a vast floral knowledge as their territory spans many different floral zones. The variety of plants that are known to these people runs into the thousands and several hundred were used for medicine, food, and raw materials (Bean and Saubel 1972). The most salient of these plant resources were acorns from the six varieties of oaks, mesquite, pinion pine nuts, and fresh buds from various cacti. Supplemental foods included many species of seeds, wild fruits, and berries, tubers, roots, and greens (Bean 1972). The Cahuilla possessed marginal and proto-agricultural techniques. The most commonly raised plant foods were corn, beans, and squash, as well as melons of the type grown by the Colorado River groups (Lawton and Bean 1968). In excess of 200 plants were used by the Cahuilla for infection control, disease cures, and to stimulate physical activities (Bean and Saubel 1972).

Food processing can be segregated as to the types of tools required to perform certain tasks. Stone mortars and pestles were used to grind acorn and dried berries. Stone metates and manos were used to process hard seeds and soft nuts such as pinion. Wooden mortars were used to crush honey mesquite. Flour was manufactured by sifting the larger particles from what was already ground and the larger particles were then ground again.

Women generally preformed most aspects of food processing. Parching preceded grinding and was carried out in a basket or ceramic tray. Leaching acorn meal was done in a basket or sand basin. Stone lined pits or "ovens" were built to bake yucca, agave, and tule-potatoes. Fruits, blossoms, and buds were sun-dried. A variety of foods were cooked in baskets, and occasionally in ceramic vessels with liquid.

Hermetic sealing of ceramic vessels and baskets facilitated food preservation. Sealing was accomplished with the use of pine pitch. Large granaries were used to store large amounts of food such as acorns, while smaller seeds were stored in ollas. During times of extreme resource hardship, the food cashes of rodents and birds were utilized by the Cahuilla people (Bean 1972).

Material Culture

Grass (*Epicampes rigens*) was used for warp materials in basket manufacture and reed grass (*Juncus robustus* or *Rhus trilobata*) was used for the weft. Black dye was made from either elder or suede. Juncus in varying amounts provided yellow, red, brown, and greenish colors. Coiled baskets were manufactured in four styles: flat baskets for trays, plates or winnowing, shallow baskets for food receptacles, parching corn seeds and large deep baskets, shaped like inverted cones were carried with a net; globular, flat-bottomed baskets were used to organize small utensils and trinkets. To decorate these baskets, the Cahuilla mainly wove "noteworthy being" designs (núkatem) such as eagles, lightening, and stars into them (Bean 1972; Kroeber 1925).

Cahuilla pottery vessels were made from ropes of clay and were smoothed by paddle and anvil. These vessels were often insized and painted, but generally were a thin, brittle brown or buff ware. Pottery forms took five general shapes: pots used for cooking, jars with small mouths, pipes, open bowls and dishes (Kroeber 1908b). Soapstone arrow straighters were among the tools made from this stone. Ownership of these tools was evident by the use of a distinct linear design containing magic connotations (Kroeber 1908b).

Implements used for ceremony included charm stones, bullroarers, clappers, rattles, feathered headdresses, wands, and eagle feathered skirts that were worn by participants in ceremonies. The most sacred object was the (máyswat) a surf grass mat bundle that held ceremonial items. This item was brought from the Ocean by Coyote. It was also referred to as the "heart of the house" and was passed down the paternal line of clan leaders (Bean 1972).

Wooden implements included bows. Bows were constructed from willow or mesquite and these tended to be narrow and thick. A string made form mescal fibers most often completed the bow. Arrows varied in size, shape, and design depending on the functions they served (Kroeber 1908b).

Flaked stone tools were used to process mescal plant and the plant is then used to make a number of other items. Sandals made from mescal fibers were soaked in mud to whiten them, and fastened to the foot by strips of the same fiber or buckskin. Mescal was also used to manufacture rope and cordage. Mesquite bark was used to make women's skirts, as was tules and skins. This bark was also used for baby's diapers. Men generally wore a loin cloth and hide shoes or sandals. Clothing for warmth was a blanket, either of rabbit skins or made from other materials (Kroeber 1908b).

Games and Music

Games were central to Cahuilla culture. Men's games involved very strenuous physical activity and were based on endurance and withstanding physical punishment. Competing moieties played each other, lineages competed, as did individuals, and wagering was a component of many Cahuilla competitions. Men's competition involved such activities as foot races, archery competitions, and playing a guessing game called "hiding each other". Women's competitions included foot races, juggling, guessing games, cat's cradle, top spinning, jackstones, and balancing objects.

Music was an integral part of all events. Tribal cosmological and historical accounts were recorded in songs. Songs also accompanied games, secular dances, shamanistic rituals, as well as, hunting, and food gathering practices. Elder provided the raw material for flutes. Bone was used to create whistles, pan-pipes, and flageolets. Rattles were made from a wide variety of materials such as turtle shell, deer hoofs, split sticks, seashells, gourds, and dried cocoons. Many instruments were made by the Cahuilla, however, the majority of musical expression was vocal (Bean 1972).

Hygiene

Cleanliness of body was important to Cahuilla people; systematic bathing and sweating were part of the Cahuilla lifestyle (Strong 1929:138). Cooking items were maintained in a hygienic fashion. It was considered a great disgrace to have unclean mortars, manos, baskets, or ollas lying about. The health problems known to the Cahuilla included: bronchial infections, gastrointestinal disorders, tuberculosis, hepatitis, infections in wounds and sores, blood poisoning, rheumatism, and arthritis. Trichinae and tularemia may have been an issue because of consuming poorly cooked meats. Hanging meat that was infected can cause this condition.

Sociopolitical Organization.

The prehistoric Cahuilla groups were a nonpolitical, cultural nationality that spoke the same language. These people recognized two non- territorial, nonpolitical patrimonies or moiets; the wildcats and the coyotes (Kroeber 1962). The Cahuilla were organized into Political-ritual- elements. These clans numbered between three and ten lineages that were dialectally different, with individual names, claiming a single family origin. Small groups banded together for defense purposes, and participated in subsistence and ritual activities. Many times original lineages claimed the right to keep the acting ritual leader, ritual house, and the ritual bundle. Other ritual offices were distributed throughout the clan. Each linage owned the land the village was built on and specific gathering and hunting locations, however, most of the land was open to all people who called themselves Cahuilla (Bean 1978: 580).

The title of lineage leader was generally passed down from father to son in direct family decent. The net (clan leader) was liable for ritual preservation, guardianship of the ritual bundle, and maintenance of the ritual house. His responsibilities included determining the location of gatherings and hunting activities, administering first-fruit rights, determining the proper manner to store collected foodstuffs and the issues of trade or sharing foodstuffs with other groups. His responsibilities also included group/individual boundary and ownership rights, and he mitigated disputes with compelling decisions. The symbolic representation of the lineage provided the authority he needed to govern and maintain the link between the sacred past and the present (Bean 1978:580). He arranged marriages, trade agreements, declarations of war, land use disputes and boundaries, as well as ritual resolutions.

The Cahuilla net had an administrative assistant called a Paxa?. The position of Paxa? was generally hereditary. The Paxa? arranged the details into appropriate order for a number of rituals. He also sought out and punished transgressors of ritual norms. He decided the timing of ritual activities, contacted persons responsible for food donations, instructed them as to what to bring, and maintained protocol in food distribution activities.

In addition, the song leader in the Cahuilla group was a "ceremonial talker, singer." He controlled, as well as sang songs used in ritual activities such as rites of passage, and intensification. Many song cycles were complex enough to require a number of days to complete. The song leader trained singers and dancers so that enactments of mythical events could take place.

The shamans or puvalam were among the most cherished and feared individuals in the Cahuilla community. Shamans were, without exception, male, and they preformed many other functions in the community. Their power originated in the manipulation of the supernatural. Functions such as curing illness, divination, controlling physical forces such as rain, food production, witching, and protecting members of the group from ghosts and the like during rituals were among their obligations. Shamanistic powers were balanced within the group by those of the (Net) who were frequently also (puvalam).

Extremely powerful shamans (pá?va?uls) had the ability to transform themselves into animals, and even kill a person by the use of supernatural methods. In order to maintain their status, shamans preformed public and private demonstrations.

In the event of a disaster or epidemic, the shaman, nét, and paxa? would combine their influence to make necessary decisions. This was done to a lesser degree during periods of less stress. The net and pá?va?ul would weave the political structure of the group into a tightly interacting unit, this was carried out for the increase of their own power over the community. Finding lost items, trespassers to clan or lineage properties, foretelling the future, locating new resource patches and game animals were the responsibilities of a diviner in the Cahuilla society. It was possible for persons within the group to obtain supernatural power without having any social status. These persons were referred to as (nenananaiš). Women were said to have this gift and to be able to predict the future, as well as exert magical control over others.

The Cahuilla doctor on the other hand was not necessarily connected to the supernatural world. Most doctors were women who acquired their craft from other doctors or shamans. After doctors gained experience in their community, they were employed to cure the sick. The professional doctors were generally middle-aged and had an extensive understanding of the properties of the plant community. They specialized in childbirth, wounds, broken bones, and intestinal discomfort.

Marriage and Kinship

Spouses were selected by parents from opposite moiety groups less than five generations distant and unrelated (Bean 1978:581). Ideal husbands were responsible to their kinship obligations, skilled and intelligent in economic endeavors or religious insight. Young women were expected to get along with their in-laws, generate food efficiently, and produce male children. After a marriage, the groom's family presented food and goods as gifts to the bride's kin group. She was then brought to the house of the mother-in-law and taught appropriate wifely duties. A long range economic and social alliance was created between the two families as a result of a child being born. Subsequently, numerous reciprocal interactions would take place where resource and wealth gifts were exchanged. Usually, marriages took place between Cahuilla group members, however, cross-cultural marriages took place with the Luiseño, Gabrieleno, and the Chemehuevi. The death of a spouse did not dissolve the bond created between two families. In such cases, sororate and levirate marriages were common.

Memorization of kin relationships were accomplished while individuals were very young. These were founded on the criteria of age, sex, and lineality. Affinity, sex of the presenter, sex of the linking relative, and perhaps region were also criterion (Bean 1978:582). Relationships of a formal joking nature existed between kin. These consisted of verbal jokes, horseplay, and ribald references. Such activities correlated closely with the foundations of Cahuilla values, because age, generation, and lineality indicated the character of the affiliation. Familiar kin expressions, similar to daddy and mom were used, but restricted to collateral, affinal, or female lineal relatives, therefore, people who lived outside ego's (the lineage originator) village. Appropriate social and economic role differences were clearly reflected in the Cahuilla kinship structure. This reached well outside the nuclear family and included relatives five generations distant from ego. The rules of kinship were defined by corporate assets, rights, and responsibilities within the lineage (Gifford 1918).

Disaster situations such as widowhood and orphanism, with their accompanying economic and emotional hardships, were provided for within the Cahuilla social system. The eldest brother's responsibilities included that of being a surrogate father to his younger brothers. Differentiation of age and directness function to ensure equitable and clearly defines distribution of cooperate goods and decision-making powers within the lineage (Bean 1972, Bean 1978:582).

Law and Property

Oral traditions personified Cahuilla laws. This equipped Cahuilla leaders with the authority to enforce proper behavioral standards within the group. Laws were strengthened through story, ritual, anecdote, and action. Retribution from the supernatural was believed to be automatic when an individual's actions contradicted tradition, however, human retribution graded between ridicule and execution.

Territorial areas were indicated with the use of petroglyphs, stones, or geographic features, and oral traditions. The later providing the most exact boundary. Individual lineages owned specific regions of land that included village sites, resource gathering and hunting areas, areas where raw materials could be found, and traditional songs and anecdotes. Individual people owned ritual and subsistence equipment, however, these items could change ownership or be loaned (Strong 1929).

Trade and War

Some Cahuilla members specialized in the trading of goods, an activity that occurred frequently. Their trade routes took them as far east as the Gila River and as far west as Santa Catalina Island. Items traded by the Gabrieleno for food were, furs, hides, obsidian, salt, steatite, asphaltum, and shell beads. Songs and rituals were also exchanged. Tourmaline was acquired from the Luiseno, and Joshua tree blossoms were obtained from the Serrano living in the Mojave Desert (Bean 1978:582). The people along the Colorado River exchanged food items such as corn, squash, melons, and gourds, as well as, grooved axes and turquoise were obtained from the pueblos. Craftsmen exchanged wares such as baskets, eagle feather skirts, ceramics, as well as bows and arrows for services and merchandise. The most common medium of exchange was the shell bead (Strong 1966).

Failure to complete reciprocal responsibilities within the system, poaching or trespassing, sorcery, against another lineage, non-payment of bride prices, and the kidnapping of women were sufficient for generating disputes and even war between groups. The act of war was proclaimed only as a last recourse. The position of war party leader was filled by the nét or a capable warrior. A community ritual was enacted prior to and following any conflict. Weapons used in conflict were bows and arrows with poisoned arrowheads, and war clubs. Conflicts between groups were generally sprung from ambush (Bean 1972).

Cosmology

The prehistoric Cahuilla believe in an unstable and unpredictable universe. A power source known as ʔivaʔal is responsible for the methodical creation of that same universe. The universal creator is neither positive nor negative, but idealistic, thereby making all things extremely receptive to erratic change. Constant change filled the Cahuilla environment creating an atmosphere of real apprehension for the present and future. An individual's power was responsible for their unusual talents, any uncommon events that took place, as well as different levels of cultural achievement. Every event associated with ʔivaʔal had the potential to carry either positive or negative results, and people were prepared to act on the positive or negative nature of all events. The concept of action and reaction throughout all areas of the cosmos were reflected in the belief that man and woman are components of nature, as well as the interactive universe, and as such were subject to any broader reactions therein (Bean 1978:582).

Many types of beings inhabited the Cahuilla universe. A number of these took part in Cahuilla dealings as symbols, recapping "early times", while others exerted some control over ʔivaʔal. Soul sprits existed within an individual's body and continued on after the death of that person. At the time of death, they traveled east of Cahuilla territory to the land of the dead where the soul-spirits of the recently departed and the first people created lived. In order for the soul-sprit to reach this land, participants in the human world and the recently departed had to participate in rigorous rituals. Communication between the land of the dead and the living were common in Cahuilla cosmology; they were directly involved in the social lives of the Cahuilla, advising them on matters of sanctioning, and generally aiding those still living (Bean 1972).

The value system of the Cahuilla was plainly connected to their basic environmental and economic conditions. Tradition was the standard the present and the future were measured against. Access to power was gained by appropriate behavior; therefore, innovative action could compromise that access creating dangerous circumstances. In crisis situations, oral literature was consulted.

Advanced age provided access to power, honor, and privilege in the Cahuilla society. The spirits of creation struggled among themselves and the victorious one, múkat demonstrated that older people were more wary, meticulous, and organized with greater creative abilities than were younger people. Older people served as information storage, facilitating the ongoing ability to live in varied and harsh environments. These stored skills also included those necessary to maintain a balanced, healthy social community. Older women performed time consuming activities, such as sewing rabbit skin blankets and grinding seeds. Older men created arrow points, bows, rabbit sticks, and hunting nets. Young girls were instructed in the values of womanhood. Boys were taught hunting methods and were educated in the traditional values (Bean 1978:583).

The theme of reciprocity was echoed in every corner of Cahuilla life and in the cosmos. In Cahuilla everyday life, a rigidly enforced, well-balanced system of reciprocity existed. Cahuilla social teachings encouraged the sharing of food, possessions, and capital equipment. Proper etiquette required no formal recognition for either giving or receiving; however, failure to reciprocate was a severe violation of group customs. Such a violation was addressed with community bans and scorn. Lineages reciprocated for the privilege of collecting by inviting those who gave to them, opportunity to collect and hunt in their regions when excess was evident.

According to Cahuilla beliefs, swift actions and misplaced compassion created improper events in the realities of the world. Slow, thoughtful, systematic dealings, consideration of all the consequences of one's actions were the ideal in Cahuilla social interactions. The function of rituals was to bring error under control in an unpredictable existence. Honesty and reliability were sought after continuously and were obvious in the way in which Cahuilla offered information to each other. The ideal action was clear and direct so there would be no misunderstanding as to intent. The guarded use of information brought admiration and rewards, however, failure produced severe penalties.

Rituals

Cahuilla existence was sewn with the threads of ritual. Rituals occurred on a regular basis and other rituals were periodic or only occurred in a certain set of circumstances. Approximately 10 types of rituals are most salient in the Cahuilla culture, but the most significant is the annual morning ceremony, eagle ceremony and certain rites of passage. Certain rites of passage were exceptionally important such as birth, naming, adolescent initiation, and marriage. Other important rituals were the accession of a new nét and those that improved food resources. The execution of cosmological song cycles, which were designed to place the universe into perspective, remained the focus of most of the Cahuilla rituals. These reminded Cahuilla individuals, as well as, the group of their connection to the cosmos, to the present, to one another, and to the past.

European Contact

The first recorded Cahuilla's exposure to Europeans was in 1774 during the Anza Expedition and their response was fearful and suspicious for the most part. The reception received by the Spanish expedition led by explorer Juan Bautista de Anza may have been a product of pre-contact events. These may have been disease or economic disturbance. Additionally, the Quechan closed the land route in 1781; therefore, the Europeans used sea routes to colonize California from the south. As a result of these events the Cahuilla were not exposed to a great deal of direct contact with Europeans except through the mission systems located at San Diego, San Gabriel, and san Luis Rey. Several sub-missions were erected in 1819 near Cahuilla territory at locations like San Bernardino, Santa Ysabel, and Pala. Subsequently, through contact with the Spanish the Cahuilla adopted some European lifeways such as irrigation agriculture, trade, language, clothing, raising cattle, and the Catholic religion (Beattie and Beattie 1939).

The size of aboriginal Cahuilla populations are subject to speculation. These may have reached between 6,000 and 10,000 persons, but this was based on lineage estimates. Kroeber (1925: 883) places a conservative estimate at 2,500 people. A census conducted by the government in the 1850s suggests the conservative estimate was more nearly accurate. A greater number of people may have required lacustrine conditions to generate sufficient resources.

The Cahuilla use of the landscape was only minimally affected by cattle ranching. The Spaniards hired seasonal Cahuilla workers, but despite Spanish and American occupation the Cahuilla did not relinquish their political and economic autonomy. The largest impact to Cahuilla lifeways came with the smallpox epidemic of 1863. This epidemic killed great numbers of Cahuilla and changed the balance of power in favor of the immigrating Europeans (Beattie and Beattie 1939; Phillips 1971).

Reservations were founded for the Cahuilla in 1877 and Federal direction became prominent by 1891. After this time the Cahuilla lost control of large portions of their traditional territory and gradually adopted the economic practices of European immigrants. Many members of the Cahuilla were trained as menial laborers in urban areas and Anglo farms. The remaining Cahuilla political and religious culture was further suppressed by Protestant missionaries (Bean 1978:584). The allotment Act of 1891 ended the diversified subsistence strategy practiced by most Cahuilla by separating lands into areas that were too small to pursue agricultural development (Bean 1972).

Tipai- Ipai: The People

The names Tipai and Ipai are terms that mean 'people.' Since the 1950's anthropologists have begun to use these terms rather than Diegueño and Kamia to describe these tightly related groups of people. When contact with Europeans was initiated during the sixteenth century, Yuman-speaking people occupied nearly all of the most southern parts of California and northern Baja. The Kamia practiced a relaxed form of horticulture while the other Yuman-speaking groups hunted small and large game and occasionally fished. Luomala (1978:592) defines the Ipai, the northern dialect, as including the Northern or Northwestern, Coastal, Western, and mountain Diegueño. She also defines the Tipai, the southern dialect, to include the southern, or Eastern, or Southeastern Diegueño, Kamia, Bajeño, or Mexican Diegueño, and the southern parts of Western and Mountain Diegueño. Anthropologists agree the divisions between these groups are hazy and each cultural and environmental difference between the groups actually fades into the next. The term "mission Indians" applied to all southern California groups. "San Diegueño" is Spanish in origin and was applied to the Native Americans living near the presidio and mission of San Diego de Alcalã. The application of the name was broadened to include the culturally and linguistically related groups south and east of the mission including those groups who continued to practice their native religions, groups who were geographically isolated, as well as groups who adopted the religion of the Dominican or Franciscans (Luomala 1978:592). The term Diegueño makes salient their existing homogeneity and distinguishes them from other groups. Calling the Imperial County groups Kamia creates confusion about their relationship to other

Diegueños, especially Tipais. The names Tipai and Ipai demonstrate their individual origin and yet show overlapping identities.

Luomala (1963) argues that the aboriginal groups in this area lacked organization, as well as social and political unity. The group included over thirty semi-nomadic, individual patrilineal clans, some hostile to each other having no collective tribal name. Neither did individual clans have a name. An individual identified him or herself by their clan and by the territory of that clan even if the settlements were only occupied intermittently during the year. The Imperial Valley being the exception, there clan names loosely referred to the band's territory. Localized territory continued for some time after missionization in Tipais and Ipais lands.

Language

The Diegueno within the larger Yuman group, is the language classification of these people. Their Hokan origins distinguish them from the other Yuman speakers to the west of the Colorado River, as well as the Takic family in northern San Diego County. In the 1940's, two prominent dialects and many sub-dialects within this language group were officially recognized by linguists. Those people living at opposite ends of the region had difficulty communicating with each other, demonstrating the linguistic variation that lies within the overall group. The geographic boundaries are somewhat disputed by experts, however, the descriptions of these languages are quite similar (Luomala 1978:592-593). Ipai is spoken from the Pacific Ocean into north and central San Diego County and is bordered to the north by Takic speakers. Santa Ysabel and Mesa Grande are also Ipai speaking communities. To the south the language grades into Tipai in settlements such as Jamul, Campo, Manzanita, Cuyapaipe and the Imperial

Valley. Some researchers hypothesize a third dialect which includes the peninsular communities of San Jose de la Zorra, Ha'a, La Huerta de los Indios, and Ensenada existed. Santa Catarina supports an enclave of three Tipai-speaking families (Luomala 1978:593). Figure 21 illustrates the location of the various groups who may have fished at Lake Cahuilla.

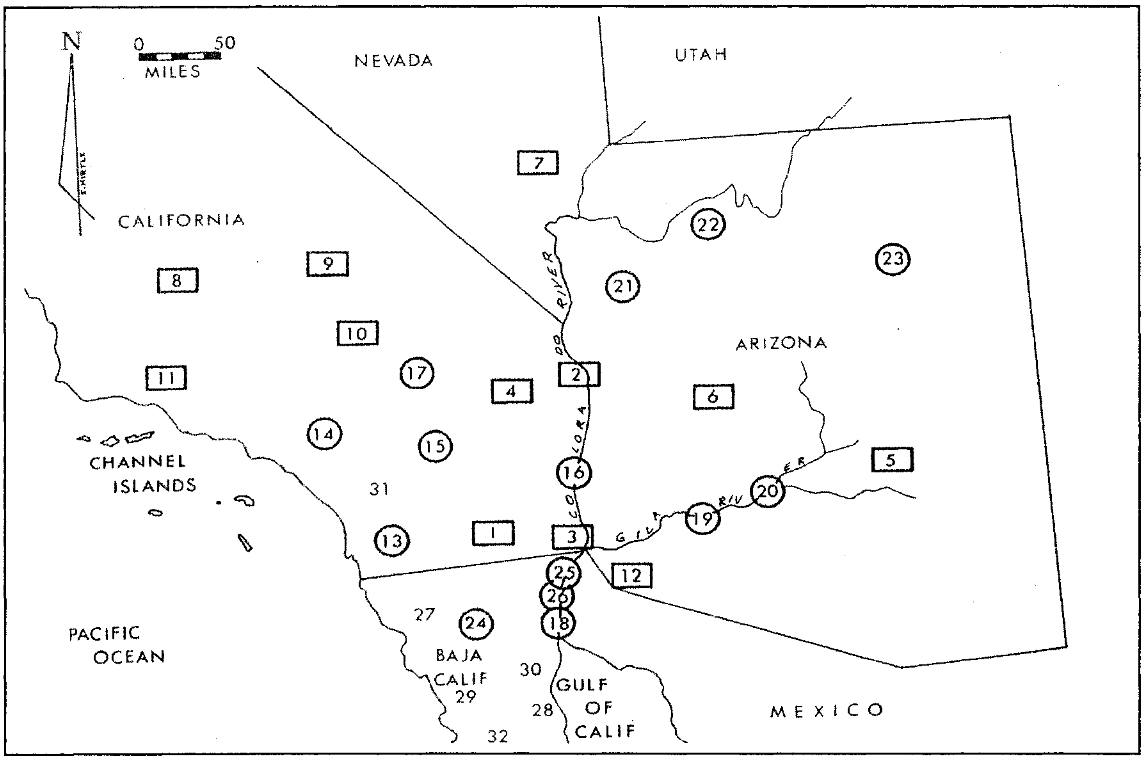

Figure 21. Historic Native American Alliance Groups Associated with Lower Colorado River Groups (adapted from White 1974:128).

□ =

1. Kamia; 2. Mohave; 3. Yuma; 4. Chemhuevi; 5. Apache; 6. Yavapai; 7. Southern Paiute; 8. Yokuts; 9. Tubatulabal; 10. Northern Serrano; 11. Chumash; 12. Papago

○

13. Diegueño; 14. Gabrielino; 15. Cahuilla; 16. Halchidhoma; 17. Serrano; 18. Cocopa; 19. Maricopa; 20. Pima; 21. Walapai; 22. Havasupai; 23. Hopi; 24. Paipai; 25. Kohuana; 26. Halikwamai

At least two separate languages were spoken in western Baja California Tipai was taught first to the children and Spanish was a second language usually learned as an adult. North of the Mexican border the number of native speakers continued to decline. In the 1960's, Mesa Grande had only a dozen of these. An Ipai Indian cited by Luomala (1978:593) recalls that in 1891, at the age of 14, he only spoke Diegueño. Older people learned Spanish as well as English from mission or reservation schools; however, their first language was Diegueño. They also spoke a few words from other Takic or Yuman dialects which may have been learned in any number of situations.

Territory and Environment

Prehistorically, the land utilized by the Ipai-Tipai may have included 33 degrees latitude, with the San Luis Rey River mouth as a landmark in the north to approximately 31 degrees 30 minutes latitude in the south with the Todos Santos Bay as a probable marker (Luomala 1978:593). These suggested boundaries were considered fluid by Spanish missionaries as Luiseños in the north occupied territory south of the San Luis

Rey River mouth. This occupation displaced the Ipais south in the direction of Agua Hedionda. Additionally, the Tipais graded into the Imperial Valley between Sierras de Juárez and San Perdo de Mártir where Dominicans built the Santa Catalina Mission. Additionally, the people living near the Pacific Ocean extended into San Diego and Imperial counties from approximately 18 degrees (C) west longitude using the Sand Hills as a territorial marker. The exception to this is just south of the Mexican/American border where Mexican Tipais were split into two groups by other Yuman speakers: one in the west between the ocean and the lower slopes of Sierra de Juárez and the other to the east near the sloughs between the Cocopa Mountains and the Colorado Delta.

The eastern extent of their territory was made up by the southern end of the Salton Sea. Here, other Yuman speakers kept the border fluid because of feuds, changes in the Colorado floodplain (Luomala 1978: 593), and changes in the river course itself. It was in these floodplains most Yuman speakers planted gardens. The Tipai living in the most eastern portion resided near the New River slough and in the adjacent desert. A few Tipais lived among the Quechan prehistorically and these are the only members of this group known to have lived near the Colorado River. The northern slough Tipais and those who became refugees from the western Dominican missions made up the eastern Tipais. These people moved south down the sloughs and intermingled with the delta Yuman speakers. Bordering the Ipais to the north were the Luiseños, Cahuilla, and Cupeño. Interestingly, an acceleration of physical and cultural intermingling took place that confused cultural boundaries with the Tipai and was a product of European contact.

The Tipai territory includes the coast, the mountains, and the desert. From west to east the topography begins with a gently sloping coastal belt, a series of granitic fault block plateaus, and creates a transition zone, each one higher than the last. The plateau stages end in the central mountain belt. The tallest peak in the Cuyamaca and Laguna mountains, American California, reaches a height of over 6,500 feet. The foothills like the mountain belt are dissected by narrow canyons, flats, and rocky hills. Jacumba pass is typical of the eastern scarp and is typified by rocky cliffs and boulder strewn slopes that terminate in the Colorado Desert. Modern irrigation has transformed the Salton Sink into an agriculturally productive region. Prior to this transformation, Tipai used the Valley especially when it contained the fresh water Lake Cahuilla (Luomala 1978:593).

The topography shaped the seasonal subsistence pattern of the Tipai-Ipai from valley bottom to mountain slope. The arid or semi-arid climate with Mediterranean winters (rains) and summer drought provided a large assortment of food plants and raw materials. Life zones such as upper and lower Sonoran and transitional zones intermingle and alternate. The topography in each zone, create stair-like sub-habitats where water, directional sun exposure, and slope of canyon, hill, and flat conspire to generate varied flora and fauna.

The greatest vegetation belt west of the desert consisted of the Upper Sonoran chaparral which had chamiso (*Adenostoma*) associated with oaks (*Quwecus*), wild lilac (*Ceanothus*), and elderberry (*Sambucus*), to mention a few. The Ipais who lived north of the Tipais had less agave, opuntias, yucca, and other xerophytic plants. The southern chaparral region around Jacumba and down to the Imperial Valley graded to bush desert and eventually true desert. To the east, on dry mountain slopes, occasional sprinklings of pinion pine and juniper dotted the landscape and open forests of yellow pine grew at higher elevations in transitional zones. Along the coast grew beach and marsh plants.

Inland, grasslands and savannas were common. Native bunch grass became extinct in the historic period due to several causes, one being introduced wild oats and chaparral (Luomala 1978:594).

Prehistory

A somewhat dated version of the Tipai-Ipai prehistory can be found in the "Handbook of North American Indians" by Luomala (1978). The depth of time assigned by Luomala is too great as her article was written when Early Man advocates, now discredited, were in vogue. Her 20,000 year date for human occupation on the California coast may be replaced with a much more reasonable 12,000-10,000 year cultural history model. The addition of a few more thousand years may be acceptable with the inclusion of the recent maritime models (Jerry Schaefer, personal communication 2006).

Native Americans believe they were created and have lived in this region forever. Some Yumans along the Colorado River traditionally view their creation as occurring at Spirit Mountain in the very recent past followed by a migration down the Colorado River. The Yuman Glottochronology suggests an origin in the Colorado River Delta area approximately 1,200-2,000 years ago followed by a spread west and north. Following this model, they would have displaced some unknown linguistic/ethnic groups of the Archaic period in the western Colorado Desert, Peninsular Ranges, and Pacific Coastal areas. This displacement is supposedly reflected in the archaeological record with the spread of ceramics, cremation burials, and bow and arrow technology, however, these factors may be alternatively explained (Jerry Schaefer, personal communication 2006).

European Contact

The Tipai-Ipai have maintained their pre-Columbian territory through Spanish, Mexican, and Anglo-American control. This was due to a lack of outside effort to alter their lifestyle until 1769 (Luomala 1978:594). Additionally, attempts to colonize these people did not begin until 1821. The most salient reason for their long-lasting intact culture was that no effort to Christianize them or teach them agriculture and crafts was made on a large scale. The conversion methods focused instead on the few Ipais who lived and worked at the mission. This failed and other Ipai were captured and more attempts at conversion were made (Luomala 1978:594). The reason for small scale conversion attempts lie with incomplete efforts to irrigate large fields, as food was needed to feed large numbers of converted people near the San Diego mission. Accounts of conversion are described as slow in the first decade. The Tipai and Ipai were the most resistant of California groups to Franciscan and Dominican control. The most disruptive change to Tipai-Ipai life styles was the forced transformation from semi-nomadic lifestyle to a completely sedentary one (Luomala 1978:595). These confrontations often were quite violent, in fact, two such attacks on the San Diego Mission ended in fatalities within the first six years (Luomala 1978:595). In 1776, a full year after relocating native habitations away from the presidio, 800 people from 70 villages gathered to burn the mission. A single priest was among the dead, and he was given the distinction of being the only martyr in the California missions (Luomala 1978:595).

Changing national control was a constant for more than two decades, however, rigorous native independence continued for at least the next one hundred years. The first change from independent autonomy occurred as a result of domination by the Mexican

Government in 1821. Their lands were confiscated in 1834, however, half was returned for "use only" (Luomala 1978:595). American control began in 1846, and in 1852 the United States Senate rejected a treaty proposed by "the nation of Diegueño Indians." After the United States Civil War ended and gold was discovered in California, Tipai-Ipai land holdings further diminished as white settlers moved into the region and seized these.

Following 1884, the San Diego slums and adjoining hills were the home of many Coastal Ipai, whose reservation had been overrun by white immigrants. By the 1890's many men and women, who were industrious but poor, labored in mines, on ranches, or in towns in the region. In the 1930's, the Mission Indian Federation formed to provide itself a government with captains, judges, and armed policemen thereby challenging federal authority. Changes to federal and state Indian policy have further divided the Tipai and Ipai people in the mid-twentieth century. As of 1972, with respect to the social structure, the federal, state, and county social structure of the Tipai -Ipai closely resembles that of the Luiseno.

Summary

The number of Native American groups who fished on the shores of Lake Cahuilla is not known at this time. Little or no information is available on the fishing techniques used there. Likely the groups south of Yuma, Arizona, such as the Cocopah and the Quechan visited the ancient shores when the Colorado River diverted its course eight miles above Yuma, Arizona, and removed the most precious of necessities from them, water. I have included those groups whose territory ranges I feel may have included Lake Cahuilla.

The people of the Colorado Desert are diverse and share a rich history. Little was known about the fishing technology of these people prior to this research. The placement of villages was dictated mainly by water and other available resources. The subsistence adaptations of the various groups changed with the differing environments. For example the Serrano were mountain dwellers and exploited mountain sheep, deer, rabbits, acorns, various seeds, piñon nuts, bulbs and tubers, shoots, roots, berries, and mesquite. The Cahuilla exploited the majority of these resources as well; however, their territory did not allow them to hunt mountain sheep. The majority of the groups in the Colorado Desert lived in relatively small hunter-gatherer groups. With the occurrence of Lake Cahuilla and its fish and bird resources, dramatic changes must have occurred in resource scheduling.

During the early part of the 20th century, California ethnographers were engaged in "salvage anthropology" as elders were dying and assimilation processes continued. They attempted to follow Alfred Kroeber's direction by gathering as much information on religion, social organization, and oral histories as they could. Many of the traditional economies and technologies were fading from the scene at this point; therefore those aspects of Native American life are not well described. The ethnographers spent only a short time in the field gathering information so their coverage is not complete (Luomala 1978:594).

Supporting evidence for a more complete subsistence picture can also be extracted from the recorded subsistence practices of the Yuman groups along the Colorado River. Although little written evidence exists, Table 2 provides subsistence scheduling for the Yuman speaking cultural groups living on the Colorado River. It is quite apparent from the table that the availability of fish in the Colorado River is high throughout the summer months. The geographic location of Lake Cahuilla would provide a ready supply of the same fish species during the colder winter months, even as early as December-February, when fishing was less productive on the Colorado River because its geographic location would allow it to warm up before the most of the river did. Fish traps and fish bones at Lake Cahuilla archaeological sites attest to the importance of fish in the diet of the Colorado Desert people.

Table 2. Resource Scheduling for Colorado River Groups

Month	Agriculture Strategy	Gathering Strategy	Hunting Strategy	Fishing Strategy
January	Stored mesquite beans and crops	Tubers gathered. Few wild recourses available	Rabbits, rats, and birds	Fishing important, but supply diminishing
February	Stored mesquite beans and crops	Tubers gathered. Few wild recourses available	Rabbits, rats, and birds	Fishing important, but supply diminishing
March	Clearing of new farm plots	Tubers gathered. Few wild recourses available	Primary dependence on hunting	Fishing important, but supply diminishing
April	Clearing of old farm plots. Flooding starts.	Tubers gathered. Few wild recourses available	Rabbits, birds. Game is scarce.	Fishing important, but supply diminishing
May	Flooding occurs.	Tubers gathered. Few wild recourses available. Cocopa gather wild rice.	Rabbits, birds. Game is scarce.	Supply of fish increases with flooding events.
June	Peak Flooding	Few wild plants available	Rabbits, birds. Game is scarce	Fish are plentiful
July	Planting	Mesquite beans. Amaranth greens.	Rabbits	Fish are plentiful
August	Weeding	Mesquite and storage of screwbeans. Storage of	Rabbits and small game	Fish are plentiful

		mesquite.		
Septemb er	Weeding	Screwbeans	Rabbits and small game	Fish are plentiful
October	Harvesting	Greens and grass seeds	Rabbits and small game	Fish are diminishing in number, but still important
Novembe r	Storage	Greens and grass seeds	Rabbits and small game	Fishing important, but supply diminishing
Decembe r	Stored crops	Limited gathering	Ducks, quail, rabbits and small game	Fishing important, but supply diminishing

Table 2. Adapted from Stone (1981 and 1991).

CHAPTER 4

KNOWN REGIONAL FISHING TECHNIQUES AND THEIR ORIGINS

Ethnographic and historically accepted accounts of the functions of Lake Cahuilla fish traps were examined by systematically building the V-style (see chapter 5 and 6) and one type of round rock walled fish trap. Ethnographers did not witness and record fishing practices at Lake Cahuilla; therefore the inferences made here for possible fishing techniques in Lake Cahuilla are suggested by incorporating key components such as bait, nets, and trap functions from the Colorado River and other arid land fishing techniques (Stewart 1957; Huseman 1995; Wallace 1955; Spier 1933; Gifford 1933; Patencio 1943) and by reconstructing the fish traps that were in Lake Cahuilla. The investigations then examined the missing components necessary to make them function, or inferred these components on the basis of similar technology in the lower Colorado River region.

Lake Cahuilla Fish Traps

The majority of the stone fish traps on Lake Cahuilla have been recorded on the west and northern shores. These occur from the Torres-Martinez Reservation in the north to the Fish Creek Mountains in the south, and numerous variations are seemingly expressed. Small group size and a large capacity for mobility obscure the identification of some archaeological sites on ancient Lake Cahuilla. Single, dual, or tri-monthly occupation on the ancient shorelines produce a comparatively low visibility pattern compared to permanent settlements as groups engaging in fishing activities during the late winter/early spring produce limited artifact assemblages. This is not to say that the artifacts left behind do not suggest subsistence strategies, and even some gendered activities. For example, during the 2004 spring excavation and survey, grinding stones were identified. Figure 14, illustrates a "miniature" trap and its association with a working trap. The smaller trap may be the product of children emulating their parents.

The trap depicted in Figure 22 appears to have functioned during a three months of fishing activities. A detailed plan and profile view of Figure 22 is presented in chapter 6 along with a possible explanation as to how the stair-stepped trap may have functioned.

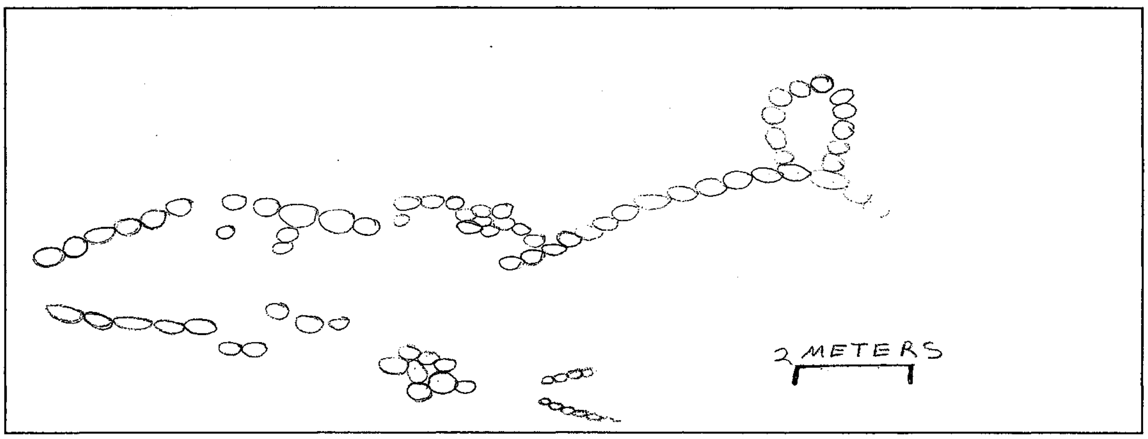

Figure 22. Three Lake Cahuilla fish traps conjoined.

The trap illustrated in Figure 22 is located on a section of substrate which is comparatively steep. The trap's total elevational variance falls within the 45 cm range of evaporation, which would take place during a three month period, as per (Wilke 1978). In addition to the down slope "extensions," and a miniature fish trap, this alignment has an attached (top right) circular feature, which could have functioned as the base of a holding "pen" for unprocessed fish.

Interestingly, an upslope trap in the same area was constructed from relatively small stones as well. The idea that these were the work of a child may be inaccurate; however, larger stones were available for fish trap construction. There may be enumerable scenarios where small stones would be preferred to larger ones; but structurally speaking, smaller stones are more easily displaced by wave action.

Many different types of rock alignments have been recorded on the shores of ancient Lake Cahuilla. Treganza (1944) describes two types of features believed to have been fish traps at the base of the Santa Rosa Mountains on the west side of the Coachella Valley, California. The first are pit-type features in a talus slope, which Treganza quotes Malcolm Rodgers as suggesting they were houses in a row 450 yards long. The second is a rectangular pile of rocks built up on undisturbed ancient substrate. Treganza (1944:287-288) cites the migration story told by Akasem Levi, a Cahuilla informant. He makes three deductions from Levi's story. Interestingly, the last deduction concerns the use of nets for fishing. Treganza specifically notes the lack of stone traps in the story (this is evidence for more than one method of fishing, perhaps more than one technological origin as well), implying that these features were not houses, or fish traps, but antelope hunting blinds. He suggests eighty hunting blinds were concentrated in 411 linear meters. This is a fascinating idea; however, the location and the design of the proposed ambush are not recorded antelope ambush hunting techniques.

As not much information is available concerning the fishing methods along Lake Cahuilla, fishing methods from areas in close proximity to Lake Cahuilla were examined in an attempt to locate something similar. The Yuman language speakers occupied the land on both sides of the Colorado and Virgin Rivers; however, the Paiute and the Chemehuevi groups spoke a Uto-Aztecan dialect. The individual Yuman groups associated with the Colorado and Virgin Rivers included the Havasupai, Hualapai, Mojave, Halchidhoma, Quechan, and Cocopah.

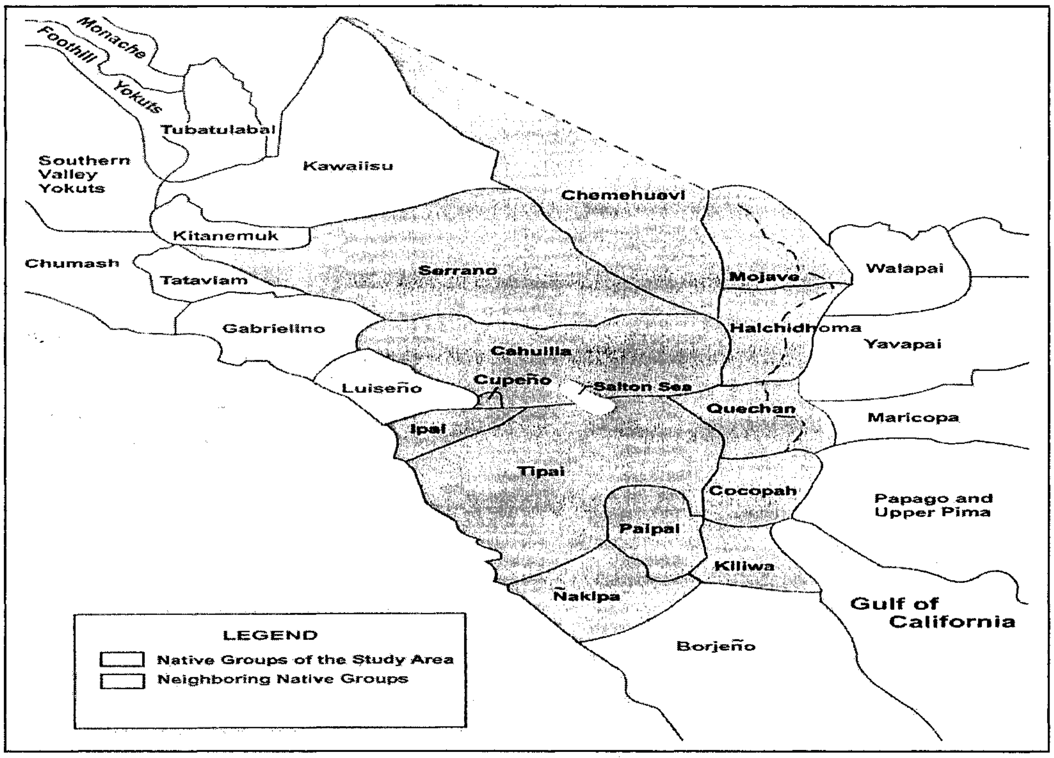

Figure 23 shows the settlement pattern surrounding Lake Cahuilla.

Mojave Fishing Methods

The Mojave were at the northern reaches of the Yuman-speaking groups on the lower Colorado River in the prehistoric period. These people may have come from the Mohave Desert originally as early as 1150 A.D. (Schroeder 1952:29). The region occupied by the Mojave people began approximately 15 miles above the present day Davis Dam and extended south to the area of the present day town of Needles, California (Stewart 1983:55). However, Mojave stories demonstrate intimate knowledge of geological features as far north as Eldorado Canyon (Linda Otero, personal communication 2006), just south Boulder City, Nevada. Relations with neighboring groups were varied. The Maricopa, Pima, and the Papago were considered enemies of the Mojave, whereas the Yavapai were friendly with the Quechan and the Mojave.

Wallace (1955:87-92) describes some of the Mojave group's fishing equipment, and it is necessary to consider this technology, as a version of these may have been used on the shores of Lake Cahuilla. Nets were valuable items as Wallace notes the construction of a fishing net could take several months. The net cordage was twisted on the thigh and then the process was completed in a shuttle. Nets often were twenty to thirty feet in length and six feet deep, and the net weave was generally six inches. This acted to gill the larger "humpback suckers" which were probably razorback suckers *(Xyrauchen texanus*), while the occasional very large Colorado pike minnow (*Ptychocheilus lucius)* was removed by hand immediately because their great size would rend a net, requiring massive repairs. Nets were deployed across small inlets to move fish into a centralized location where they could be taken with greater ease.

In muddy conditions on the Colorado River a dip net (suaku) was used to capture fish (Wallace 1955:88). It was constructed from bean fiber and was bag shaped with ten foot poles on either side. This style of net was used while standing in the river. The net was allowed to drift and open with the current. The fisher periodically raised the lowered the net as turbid conditions in the river prevented seeing the fish (Wallace 1955:88). Fish pounds were another type of technique used by the Mojave group. This trap was deployed in shallow water by building a semi-circular fence. Arrow weed or willow branches were inserted into the soft mud at the bottom of the river. The structure was twenty to thirty feet across and four feet high. An opening of two feet was left in the trap to allow fish to enter. Crushed watermelon seeds and maize kernels were sometimes scattered on the surface of the water to attract fish into the trap.

The watermelon plant originated in West African and was therefore introduced during the historic period. Because of this, the use of watermelon seeds has been excluded from this research. Interestingly, the plant feeding behavior of many fish species is well documented elsewhere by (Bonar et al. 2002) where he states some fish species consume vegetal matter on a regular basis.

Rectangular nets up to 9.1 meters long (rhulja) and 1.2- 1.8 meters high were made from the inner bark of the willow. These were stiffened with vertical branches of arrow weed and weights were attached to the bottom of the net. A pole was attached at each end so two men could move it through shallow water while others beat the water with sticks to frighten fish into the net. These longer nets were often set in the river so fish would entangle (gilled) themselves in it (Wallace 1955:89). Wallace also refers to a fish scoop made from willow and arrow weed, and depending its size, it could be used by several people in a backwater or by a lone person in the river to dip the "fish" from the water. The scoop was roughly canoe shaped and functioned as a large dip net.

Another fishing method suggests specific fish behavior was responsible for the development of certain fishing methods in the Colorado River. The use of arrow weed and willow bark torches are cited for the attraction of "fish", and "Native fish did not nibble bait on a hook made from a barrel-cactus needle, but bolted it hook and all, and were killed by the wounds made in their gills" Wallace (1955). Wallace (1955:91) also mentions that Mojave men would dive under the surface of the river and catch "fish" by hand. Recent supporting evidence for the hand capture method comes from razorback sucker behavior. Mueller (2002:42) describes the razorback sucker as docile when handled.

Fishing can somehow bring forth the image of tall tales and dubious characters. In any event, much urban legend has been and is still associated with fishing. Von Brant (1964:25) illustrates a night fishing scene with an engraving done by the Frenchman, Duhamel Du Monceau, showing two people actively engaging in spear fishing by torchlight. Here again, we see the connection between fishing and light. It is therefore

understandable that prior to researching the behavioral aspect of fish, one could draw upon past stories and assume all fish are attracted to light.

Wallace mentions the use of fire on nights without a moon. This practice reportedly brought the fish to the surface where they were caught by hand (Wallace 1955:92). The turbid nature of the Colorado River and also possibly Lake Cahuilla as Forde (1931) suggests may pose unresolved research questions concerning fishing techniques and their effectiveness in murky water verses clear water. Such as, "Does fire indeed attract these fish in murky water?" My observations during the razorback sucker spawning period suggests the fish are not attracted to light in a clear body of water. To the contrarily, when light and human presence are detected the fish generally move away from the light toward deeper water. While certainly informative to read, the accounts of native fishing techniques described by both Wallace (1955) and Stewart (1983) are somewhat general. The anonymous native "fish," described by these two ethnographers encompass thirteen individual species, with several different feeding niches, and three of these species are essentially marine.

Ruppert (1976: 22-23) recorded eight fishing methods used by Mojave Groups. The first description includes a reference to "cowpea" (Vigna *unguiculata*). It is important to acknowledge the origin of this plant as Africa and not America, however, the mode of fish catchment described, a fishing net, is of Paleo-Indian origin from the Pacific Coast.

> 1) "Ihuly: which is a seine or drag net, approximately 25 feet long and 8 feet high, was made of tough cowpea fibers and weighted with stones attached to arrowweed sticks placed vertically through it. Poles were attached to each end of the net and two men dragged it through the water.
> 2) Suak: A net six feet in length and four feet deep, the suak was attached to two poles and dipped into the water by one man. Another man beat the water with sticks, driving the fish toward the net. The net man brought the sticks together, thus trapping fish in the closed net.
> 3) Acisayul: A small suak used in shallow water, this device required no beater. The net man merely watched for fish swimming near the net.
> 4) Kwithata: The Kwithata was a fish scoop, five feet long and 18 inches wide, made of willow. A handle attached to the willow allowed one man to manage the scoop. It was used only in sloughs and lagoons.
> 5) Acucukpe: This brush "fence" or, 10 to 15 feet in length, was constructed of willow twigs and poles set in the mud. One man with a dip net (suak) stationed himself in the opening and scooped out the fish when they became trapped.
> 6) Acinuya: A semi-circular baited with pumpkin seeds, this trap was constructed much like the acucukpe, but the procedure for catching the fish differed. The fisherman, after baiting the, would leave for several hours. If the willow sticks set in the mud were moving when he returned, he merely scooped up the fish with a suak.
> 7) Hook and line: A Mojave occasionally used a barrel cactus spine (heated and bent into shape) for a hook, in conjunction with a willow pole and cowpea fiber line. Bait included worms, grasshoppers, and small fish. Stewart (1957:201) doubts that this method was used commonly by the Mojaves, as fish could more easily be caught with traps and scoops.
> 8) Bow and arrow: The bow and arrow rarely were used to fish and then only by old men in sloughs and lagoons.

Fish were prepared and cooked by Mojave men, as a meat. Women were responsible for cooking agricultural products and wild seeds. Fish was eaten fresh and normally was prepared by broiling on hot coals or by broiling in a stew to which cornmeal was added."

The Quechan

The Quechan people spoke a Hokan dialect. The first mention of these people living on the Colorado Desert occurred in the late seventeenth century. Like many of the other Yuman groups these people lived on both sides of the Colorado River and east into the Gila River region. According to Bee (1983), the desiccation of Lake Cahuilla, between 1400 A.D. and 1500 A.D., caused the Quechan and Mohave people to move back to the Colorado River. The desiccation of the lake would mean the Colorado River had returned to its old watercourse and food would be again accessible from its shores. Women used their grass skirts and their hands to capture the razorback sucker and the Colorado River pike minnow in the Colorado River (Pauline Jose, personal communication 2004).

Cocopa Fishing Methods

Cassetter and Bell (1951:219) suggest that fishing was important to the Cocopa people who fished on both the Colorado and Gila rivers and landlocked bodies of water. Lake fishing was especially important to the Cocopa, as they were from the extreme southern region of the Colorado River, the Gulf of California. In this region, permanent lakes west of the Hardy River provided many fish. The Cocopa also fished in the Gulf of California, harvesting sardines and small-scaled bass. The latter was about four feet long and taken with a wooden screw bean spear. The Cocopah are the only group on the

Colorado River to have used a spear for fishing. This river group would also be the hardest hit when the Colorado River changed its course and began filling Lake Cahuilla.

Cassetter and Bell (1951: 220) indicate fish were taken in the Colorado River, especially during flood stage by the Yuma using the following methods: gill, dip, and drag nets in lagoons and the river. These nets were described as being about eight feet high and thirty feet long. Additionally, Gifford (1933:268) describes the deployment of Cocopa dip net and gill nets. He also indicates it taking two months to construct fishing nets from cowpea-fiber string; making these nets extremely valuable. Cocopah fishing nets were deployed with the use of phragmities floats (Gifford 1933:268). Interestingly, no rock alignments were used in these deployments (Lisa Wanstall, personal communication 2005). The Cocopa also used a bow and featherless arrow to shoot fish.

Fishing Sites and the Changing Salton Sink

The high water line of Lake Cahuilla (12.8 meters above sea level) is still distinguishable in the Southern California city of La Quinta on the Santa Rosa Mountains. The remainder of the fishing sites are spread out around the lake and only a small proportion occur on the eastern shore. Figure 24 illustrates the placement of the recorded traps.

Lake Cahuilla Archaeological Record

A variety of situations can affect the Lake Cahuilla archaeological record. One such factor is the constraints of a mobile group and the difficulty involved in carrying a large number of possessions (Schiffer 1991:41). This is especially pertinent to this study. The southeast segment of the lake has fishing camps without any detectable stone fish traps. One possible explanation for this seeming peculiarity is the light weight nature of fishing/hunting nets. The evidence supplied by Kaemlein (1971) suggests that large nets could have been carried from the Colorado River or beyond to the shores of ancient Lake

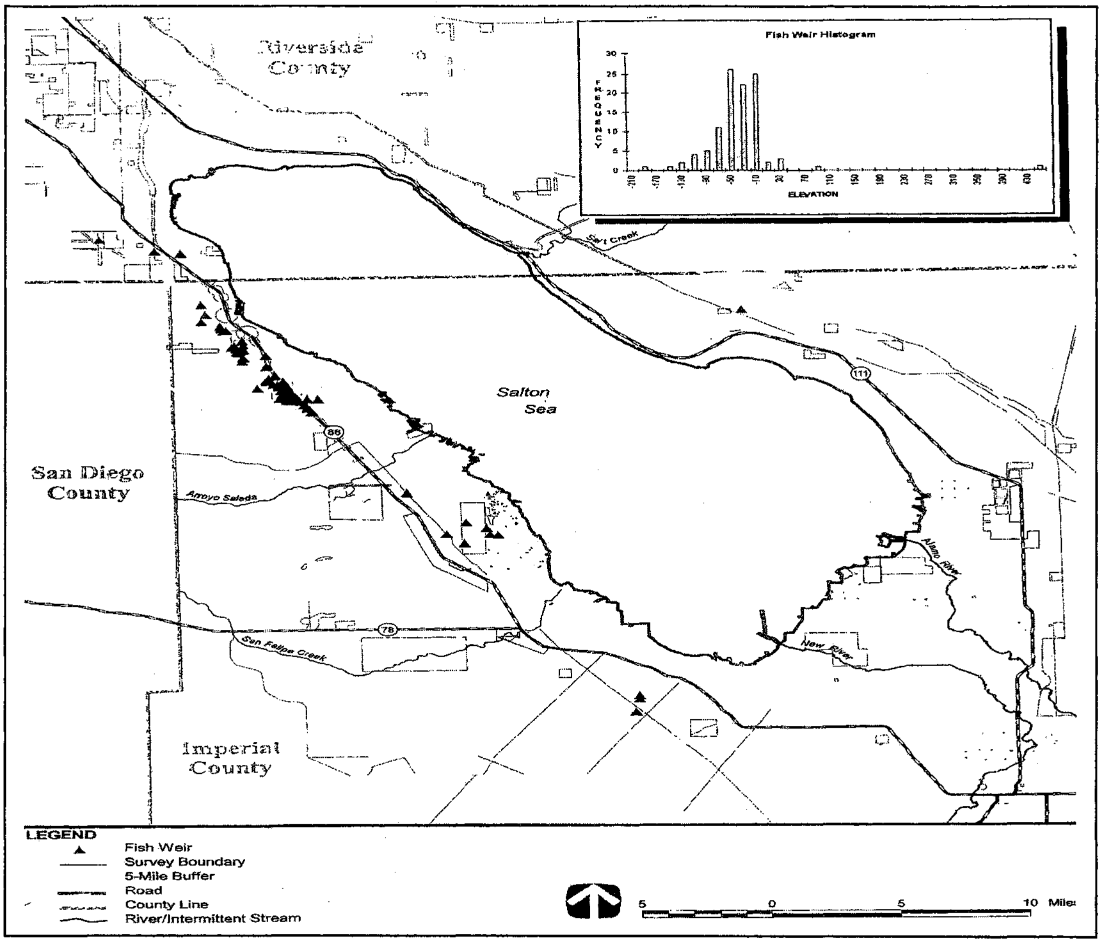

Figure 24. Map showing the distribution of fish traps around the Salton Sea. Adapted from Tetra Tech INC. (1999)

Cahuilla. The nets could then be carried back when fishing activities came to a close, leaving no "stone" traps at the fishing sites. A direct cultural affiliation can not be drawn at this time; however, it is interesting to note that Cocopah fishing traps do not incorporate the use of stone alignments, but consist of nets only. The Cocopah group would have been one of the hardest hit by the diversion of the Colorado River into the Salton trough. The main differences in trap designs in the Lake Cahuilla region lie in their form, which may be affected by the availability of local building materials used by the different geographic groups who may have fished there. For instance, the Mojave, Quechan, and Cocopah may have used nets in Lake Cahuilla to catch fish. This does not seem an inappropriate stretch of the imagination, as their river fishing technology already incorporated nets. Figure 25 demonstrates the infilling regimes, which occurred at Lake Cahuilla.

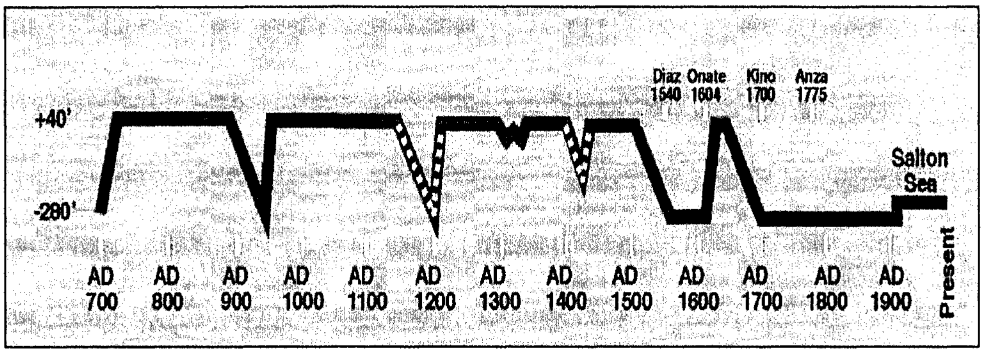

Figure 25. Adapted from the website of KEA Environmental.

At the full pool elevation of Lake Cahuilla, the runoff waters drained into the Alamo River and eventually into the Sea of Cortez. Depending on the length of the recession episode, fish populations in the lake may have varied. As with any new lake, sediments in the dry soil create a chain reaction or a “bio-bloom” causing an unnaturally large fish population during the first few years of a small lake’s existence; this is known as the maturation process. Wilke (1978) commented that “when Lake Cahuilla remained at its maximum level for several generations, native populations increased.” The maturation/bio-bloom process could be the impetus for the population growth. Wilke (1978) also suggests a permanent population was present at Lake Cahuilla and cites varying seasons of resource use and a large number of Patayan II settlements along the shoreline as evidence.

Because of the extremely large area Lake Cahuilla incorporated, the bio-bloom may have lasted as long as 30-40 years (Tom Burke, Personal Communication 2006).

This is corroborated by an explosion in the striped mullet population shortly after heavy rains and the melting snow pack in the Rocky Mountains combined to cause the Colorado River to once more jump its banks and begin filling the Salton Trough forming the Salton Sea in 1905. By 1915 a population of striped mullet had grown adequately to support a commercial fishery until 1921, when over fishing caused a massive population decline. Sufficient nutrients remained in the bio-bloom, however, to facilitate the rise of a second population of striped mullet (planted by the California Department of Fish and Game) and the commercial fishery was resumed between the years of 1943 and 1953.

It is possible to see from the chart above that Lake Cahuilla was a lake more often than it was a desert; however, the many drying and refilling episodes that took place here must have caused much fish trap rebuilding over the centuries, and possibly with the same materials. Supporting this idea is an observation made by one Lake Cahuilla researcher (Jerry Schaefer, Personal communication 2006), indicating some fish trap stones exhibit several separate build-ups of tufa, from different lacustrine infillings.

Cultural and environmental disturbance processes may vary in intensity. The creation of a reservoir or lake may subject artifacts to destructive forces specifically, wave action and water logging. Reverse stratification is another force that affects the depositional processes occurring at Lake Cahuilla. The process erodes artifacts from their original contexts and redeposits them in a mixed-up stratigraphy. Several factors affect the reverse stratification of a deposit: the intensity of space use, the duration of occupation, and extent of reoccupation (Schiffer1996:140). Similar disturbance processes occur when the level of the lake fluctuates. Likewise wave action can "wash out" artifacts and abrade them. Specifically, it can expose the stones used for construction to wind blown sand which, erodes the tufa deposits built up on their exterior and in some cases, the wind blown salt will remove the exterior of the stones. This process also leaves the artifacts vulnerable to tread damage from humans and animals.

Ceramic artifacts are particularly vulnerable to the chemical leaching processes in most depositional environments. In the same sense, wet–dry cycling will produce an equivalent effect (Schiffer 1996:158). The pottery on the surface of the ancient lake's shore is exposed to both of these decompositional forces. Colorado Buff Ware was identified on the ground surface during the survey and no ceramics were associated with the excavations. No ceramics, lithics, or any other type of artifacts were collected during any of the six fish trap excavations or during the survey component of the study.

CHAPTER 5

METHODS OF EXCAVATION, RECONSTRUCTION, AND SURVEY

Overall, this thesis is an exercise in experimental archaeology. The goal of archaeology is to explain the behavior of human kind. Archaeology is the study of human interaction with material objects such as tools, settings, and situations found in the environment. The methods used to address the research questions included ethnographic investigation, experimental archaeology, survey, and test excavations. Various types of data retrieval require different techniques. The act of collecting data in the pursuit of archaeological research is known as methodology (Ingersoll et al. 1977:xii).

Experimental Archaeology, for the purpose of this thesis, will be defined as replicative studies, which include the processes of site formation, use, and decomposition. Experimental archaeology attempts to test, evaluate, and explicate method, techniques, assumptions, hypotheses, and theories at any and all levels of research. Therefore, this research attempts to explain the working mechanisms of the Lake Cahuilla fish traps and attempts to identify the trap's place in the subsistence strategies of the inhabitants of the Colorado Desert by examining the fish trap's productive potential.

The definition of "experiment", which will be used here, is a test where at least one variable is controlled. More useful experiments are extremely rigorous and employ a number of variables; the most productive experiments are those that control all but one variable, the one being tested. This method is what was employed during the majority of my research. The one variable tested here is the presence or absence of fish captured in my simulations of Lake Cahuilla fish traps. The last experiment, however, used two variables and examined the productivity of the baits used in recorded fishing activities, as well as the function of the rock wall component.

Within the archaeological discipline there are four categories of experiments: Controlled replication of recovered artifacts, known data results, contextual site formation, and ethnoarchaeology (Ingersoll et al. 1977:xii). First, on the list of categories is controlled replication of recovered artifacts. By way of imitation, we learn about the once understood process of building Lake Cahuilla fish traps, what factors the fish consider when they make their choice of spawning locations, the most productive location in which to build them, and an idea of the number of fish that could be captured in the traps.

This knowledge can then be used to infer seasonality of fish trap deployment, which in turn allows the inference of what plants were available and further suggests the ease of subsistence procurement experienced by Native Americans during this time period. Most experiments produce a negative product, that is, they illuminate what could not have taken place. These experiments do not actually "prove" anything; they simply offer an alternative explanation to the prior conceptions concerning how the fish traps functioned.

The second class of archaeological experiments attempts to determine the validity of methodological assumptions by applying them to known data or known results. This type of inquiry is difficult to use in this research, as the Lake Cahuilla traps have no prehistoric counterpart anywhere in the world; however, some assumptions have been made concerning the working mechanisms of these traps by modern researchers and others such as "fish herding". These were tested and will be addressed later.

The third class of experiments is contextual. This application attempts to define specifically, how a site was created and how it deteriorates over time. I listed only a few of the post depositional forces present in the recharging life cycles of Lake Cahuilla. The time component of this research is difficult as the sediments surrounding Lake Cahuilla are not conducive to preservation of organic material. Shell is present on the ancient shorelines, but has inherent problems with accurate dating (Jerry Schaefer Personal Communication 2004). No experiments as yet have been conducted that document the deterioration process of the organic components specific to the fish traps such as a basket trap or nets that may have been used.

The fourth and final experimental category is ethnoarchaeology. Information supplied by a living informant furnishes archeologists and social anthropologists with a foundation for experimental assumptions concerning past societies. This portion of my research includes verification by a Cahuilla fish trap practitioner as to the form and function of these traps in a mountain river setting.

It is the first category, controlled replication of recovered artifacts that is the main focus of my investigations. The initial experiments were conducted on an alluvial fan in modern Lake Mohave, Nevada in March of 2004 with Lake Cahuilla researcher Dr. Jerry Schaffer and his associate Sherri Andrews. Originally we consulted Mr. Tom Burke at the United States Bureau of Reclamation. Mr. Burke is a fish biologist and has worked with the native fish of the Colorado River for over 30 years.

V-style Traps

The most apparent seeming design variations are the "V" and "U" types, which have their divergent ends toward the shore, funneling the fish into what was most likely a basket trap placed in the apex of the trap, in deeper water. Additional trap styles include rows of parallel stones, spherical alignments, and strings of excavated pits along the ancient shoreline.

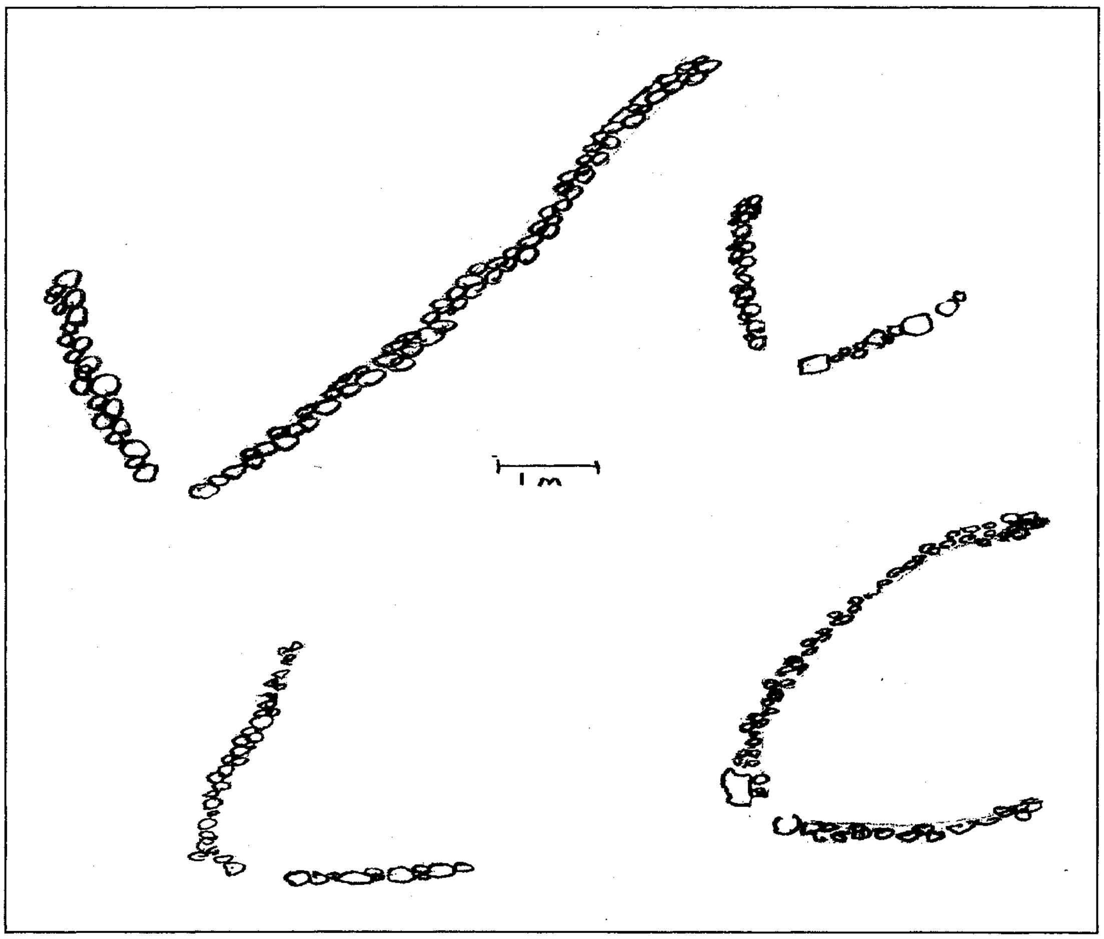

Figure 26. Several types of Lake Cahuilla fish traps.

Depressions in the talus slope may have functioned as fish traps. If we consider biological factors which effect juvenile fish, we see that these depressions, if filled

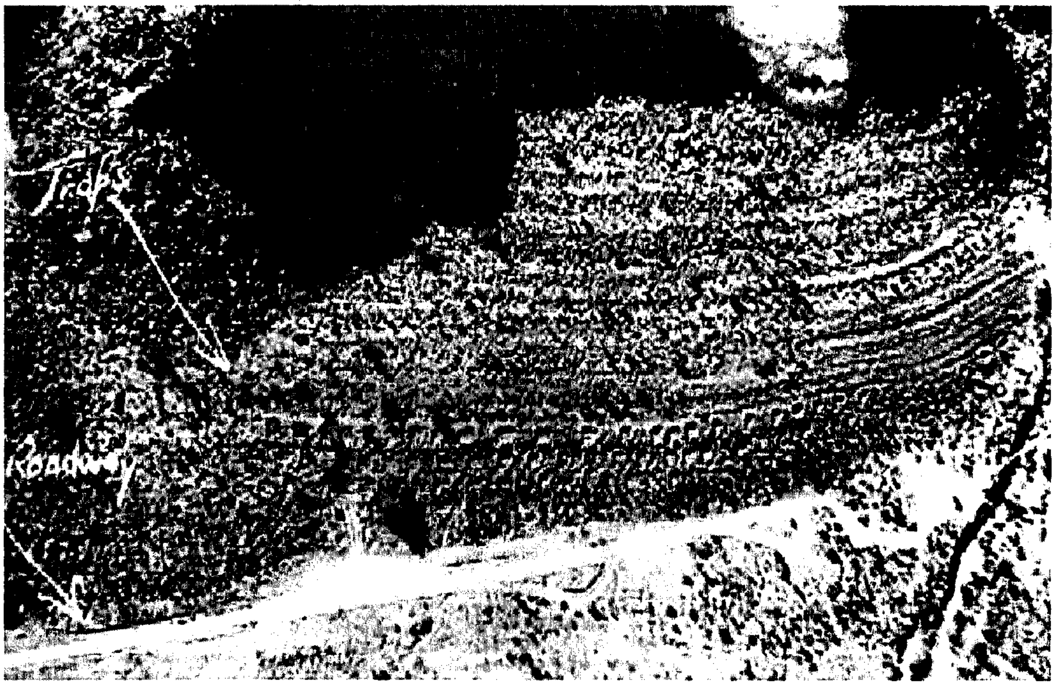

Figure 27. (Adapted from Ancient Lake Cahuilla Web-page 2006) Rows of fish traps in a talus slope.

with brush, would provide ideal habitat. The talus slope where the traps are located represent an unbroken substrate surface. Consultation with a fisheries biologist suggest the best setting for a fish trap is on an unbroken surface between two habitat locations. In this way, the fish view the trap as cover or habitat. These "traps" may have operated by placing small weave nets or mats of arrow weed in the bottom of the holes. The nets and brush would then be raised when schools of small fish swim into the traps during the daylight hours seeking shelter from the sun and larger predatory fish. Here again, the smaller fish of both the bonytail and the razorback sucker species are nocturnal. This strategy is particularly relevant for the Myoma Dunes site where whole juvenile bonytail were identified in over seventy human coprolites. The two sites are separated by a distance of 80 kilometers; however, the technology may have been applied.

Figure 28 demonstrates an unresearched "fish trap" design.

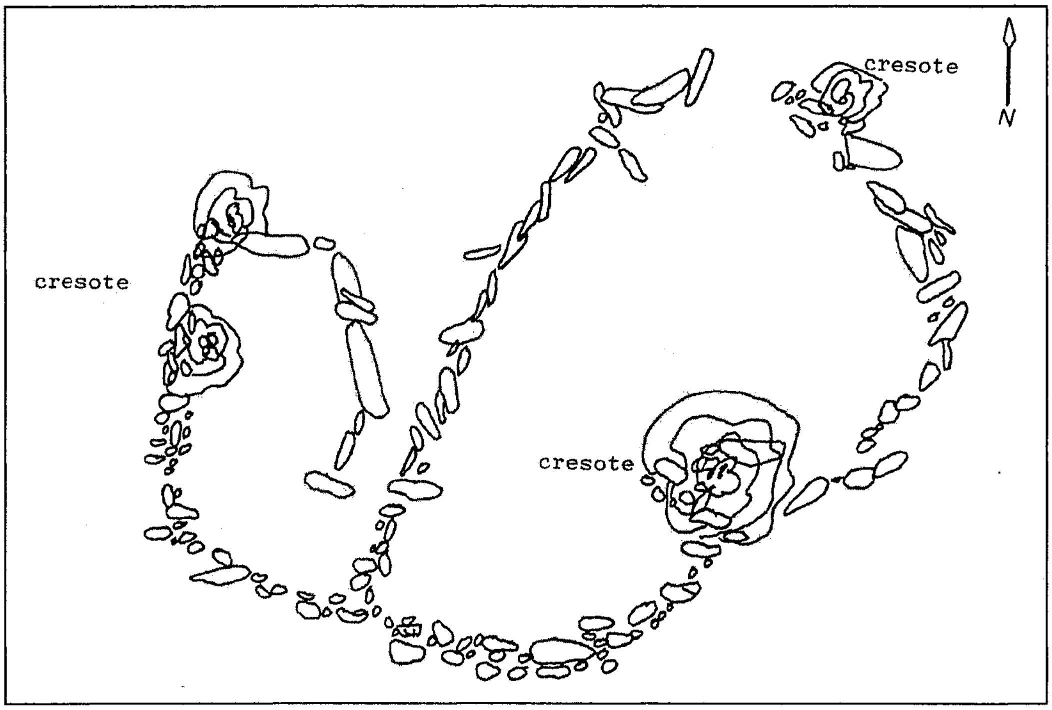

Figure 28. Unexcavated, unresearched rock alignment.

This trap may have also functioned by creating pseudo habitat, however, without more excavation and experimentation to determine the nature of the design, it is difficult to do more than superficial speculation. Figure 29 illustrates the movement of fish in association with a commercial fish trap.

The commercial trap functions under the same principle as the Lake Cahuilla traps. Fish are directed into a holding device in the apex of the "V" and held there for processing. The fish's natural thigmotaxic response to this type of structure is to follow the walls, touching them as they move. Once the fish are in the trap and they draw near the entrance from the inside, they are directed away from the opening by the angles of the walls. Their need to touch something while moving restricts the fish from swimming into the middle of the structure and exiting the same way they entered.

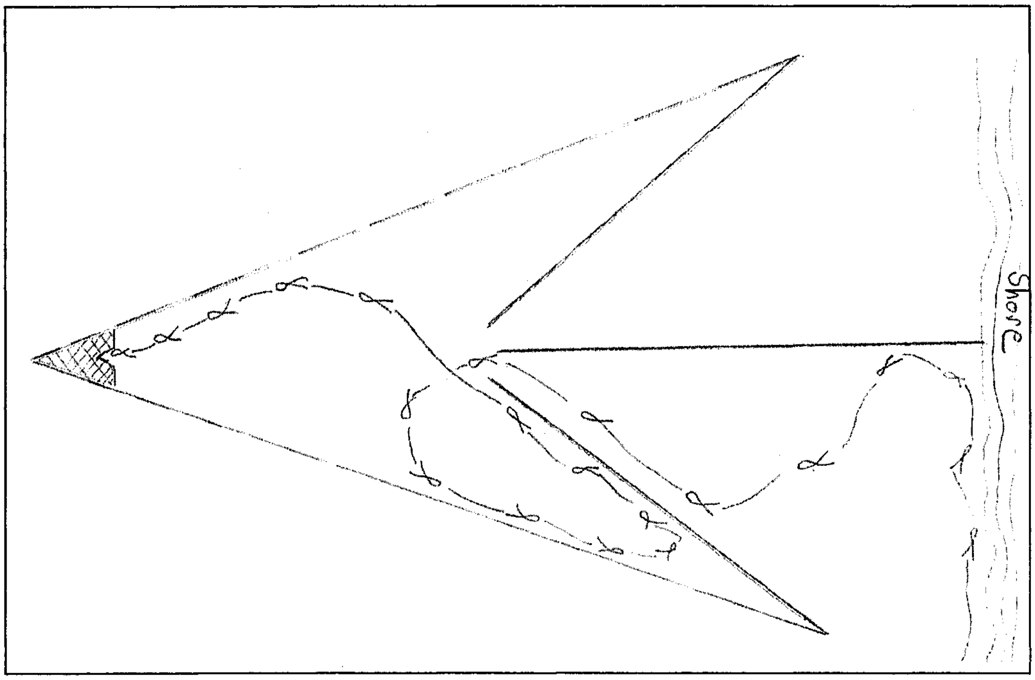

Figure 29. Commercial fish trap design.

The Initial Experiments

The first experiment consisted of two fish traps on a razorback sucker spawning area at the end of the spawning season. The first traps had several components, as we misguidedly believed that the rock alignments were not sufficient to direct fish into a basket trap devise. We surmised that netting of some sort was secured to the substrate by the rock alignments and this netting would direct the fish into the traps. The use of nets was supported somewhat by Treganza (1944) where he speaks about nets being employed by the Cahuilla people for fishing.

Our intention was to use the rock alignments to secure the netting to the substrate and use wooden stakes (prehistoric materials) to stretch the netting, creating the classic V-style fish trap. These attempts failed as the substrate contained a substantial amount of large rocks, which broke our wooden stakes when we attempted to drive them. We completed the deployment of the wall netting with the aid of steel stakes. A modern nylon and fiberglass fyke net was used in place of a wooden basket trap. Figure 30 demonstrates the first style of fish trap.

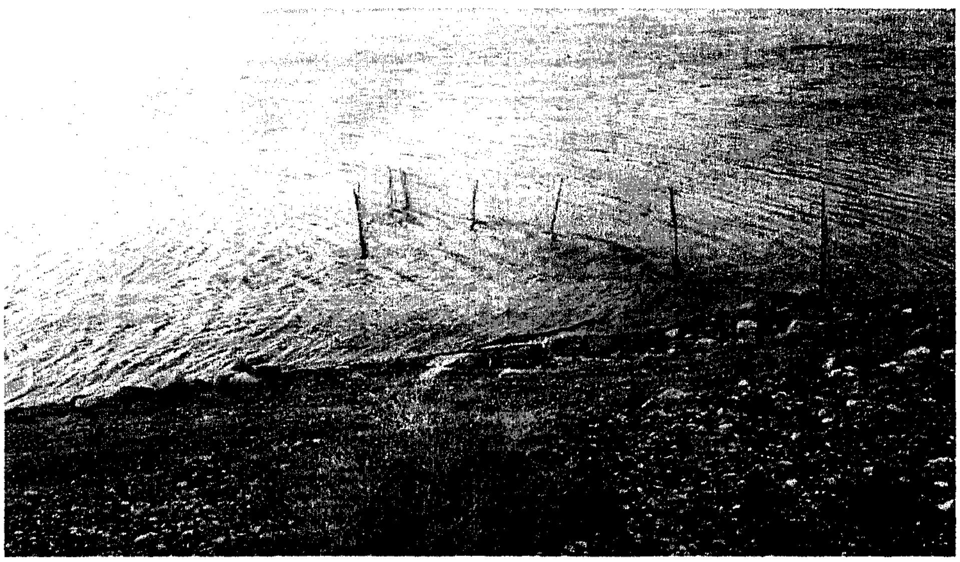

Figure 30. The prototype fish trap deployment.

Our experiments covered a period of two days, but my observations of the spawning fish's behavior began much earlier. A noteworthy observation was the carp who gathered to eat the eggs of the spawning razorback suckers. I was to encounter this egg feeding behavior again in later experiments and it generated confusion because I believed the fish in Lake Cahuilla may have acted in the same manner. A single razorback sucker was captured in the initial experiments. When the experiment was concluded, we failed to capture sufficient numbers of fish to warrant the construction of the fish traps. Subsequently, this caused a reevaluation of the trap design.

The failure to produce an adequate food supply generated a more in-depth investigation of the ethnographic record. The material already covered was revisited and examined with closer scrutiny and new references were also examined. Gifford (1933:268) provided a single sentence indicating the Cocopa had used a two-foot net float of phragmities, every five feet on the upper margins of their fishing nets. Gifford's wording seemed to suggest that a single stalk of phragmities was able to float an entire five-foot section of net. This may have been the case if the net used was a gill net, however, the netting used in these experiments was heavier than the recorded Cocopa gill netting because the weave was tighter (one inch verses four inches). A gill net functions by slipping over the fishes' head and locking into place under the gill plates. This can cause severe damage to the fish, but it secures them neatly.

The sparseness of the net weave appears to allow the fish clear passage through it. It may appear as natural vegetation to them, and natural vegetation will give way to the pressure of their bodies. The nets used in my experiments merely blocked the fish from swimming through it; however they are three times as dense. For that reason, I tied five stalks of two-foot long phragmities together. These bundles provided the buoyancy needed to float the one-inch mesh netting. In conjunction with the netting my next fish trap experiments integrated the use of bait.

Stewart (1957) spoke of using ground corn and pumpkin seeds secured in a ball of clay or mud to attract fish. Additionally, Ruppert (1976: 22-23) describes two specific types of fish traps that where pumpkin seeds were used as bait:

Acucukpe: This brush “fence,” 10 to 15 feet in length, was constructed of willow twigs and poles set in the mud. One man with a dip net (suak) stationed himself in the opening and scooped out the fish when they became trapped.

Acinuya: A semi-circular trap baited with pumpkin seeds. This trap was constructed much like the acucukpe, but the procedure for catching the fish differed. The fisherman, after baiting the net, would leave for several hours. If the willow sticks set in the mud were moving when he returned, he merely scooped up the fish with a suak (a type of dip net).

Feeding experiments, conducted at Willow Beach National Fish Hatchery, Arizona, in 2004 clearly demonstrated that both the razorback sucker and the bonytail preferred ground corn to pumpkin, or squash seeds. Subsequently, both phragmities net floats and ground corn became standard components of my fish trap experiments. Numerous experiments were conducted in varying lacustrine environments, and the results were always positive with the two mentioned changes that were made to the fish traps. For the bait container, I used a small glass jar with a metal screw-on lid. Into the metal lid I punched a hole to allow the aroma of the bait to escape without allowing the fish to consume it. Within the jar I placed ground sweet, seed corn, which had not been roasted.

During another notable experiment, a trap was placed in living and dead vegetation on an alluvial fan. The level of Lake Mohave fluctuates annually, inundating and killing plants, then exposing them while new ones grow and then inundating them once again. This trap experiment marked the beginning of greatly increased fish catches. The increase in catch size is attributed to the placement of the trap near five green sunfish spawning beds. The fish (carp) captured in the trap had gathered to consume the eggs of the sunfish. Having this egg feeding agenda already, they were caught somewhat off guard by the presence of what appeared to be an additional free meal.

The large size of the predatory fish and the small amount of green sunfish eggs only added vigor to the appetites of the carp. This may have been one of the methods used on the shores of ancient Lake Cahuilla, but there is no evidence to support this behavior in the observations of Jonez and Sumner (1954), Minckley (1973), or La Rivers (1962), all of which are fish biologists and made observations concerning bonytail and razorbacks in the Lower Colorado River region.

I also sprinkled ground corn in the floor of the trap to entice the fish to the vicinity of the basket trap and the waiting bait inside it. The prior experiments produced an average of 3 pounds of catfish, sunfish, or carp per single evening setting. This experiment produced approximately 15 pounds of carp and one green sunfish. Figure 31 shows the proximity to the green sunfish spawning beds.

Figure 31. The dark areas in the foreground are sunfish spawning beds.

Excavations

The excavations conducted during this research are the first professional excavations of any Lake Cahuilla fish traps that I am aware of. They were conducted at the Aggregate Products Inc. quarry site in Slaton City, California, and were preformed in two sessions. The first was between the dates of December 15th and January 1st 2005 and the second was conducted between March 15th and March 30th of 2005. The excavations were carried out on private land, which was slated for development. The landowner, Mr. John Corcoran had previously allowed Jay von Werlhof to record what von Werlhof believed were numerous styles of fish traps on this same property in 1995. As the property was slated for development, it offered a solution to the time constraints of conducting research for a Master's thesis without engaging in a lengthy permit process. I conducted six separate fish trap excavations, two of which I rebuilt. All excavations were conducted with a brush and trowel. A one-quarter inch screen was used for the first two excavations, and as no artifacts were recovered from the screening, the process was then abandoned. The traps were excavated using a non-traditional grid pattern. Finally, the fish traps were evaluated for excavation on the basis of their being complete.

I chose to excavate from the apex (the end of the trap where the walls almost meet), the portion of the trap that would have been in the deepest water, and proceeded upslope for 50 centimeters and then down slope for 50 centimeters, or a total distance of one meter.

Initially, I sought the remnants of basket trap devices, which I suspected were used to contain the fish until humans could process them. The excavations followed the shape of the rock walls and ceased when it became apparent that the stones were no longer associated with the traps. Additional units were only excavated in traps 2 and 3, and these traps were partially and fully reconstructed, respectively. Time constraints admonished me to gain as much information as possible in a short period. This said, future researchers may want to consider screening, as some artifacts must have been missed by limiting the process. During this investigation no processing stations were identified. Only house rings and fish traps were recorded.

Table 3 displays the excavated trap data.

Fish Trap Number	Right Arm Length/ Degrees	Left Arm Length/ Degrees	Apex Measurements cm	Widest Measurements cm	Shape of Apex	Side Excavation
1	330 cm	245 cm	15.5 cm	250 cm	Conical	No
2	720cm/237°	420cm/220°	30 cm	260 cm	Conical	No
3	400cm/250°	365cm/220°	27 cm	257 cm	Conical	No
4	320 cm/57°	350cm/80°	50 cm	240 cm	Convergent	Yes
5	377 cm/30°	370cm/76°	40 cm	210 cm	Convergent	Yes
6	446cm/880°	160cm/106°	40 cm	166	Convergent	Yes

Table 3. Demonstrating the characteristics of the excavated traps.

The excavations at this site began with Trap 1. As can be seen in Figure 32, no sediment remains to conceal artifacts or a gastropod layer. This area has been deflated. The excavations began at the apex of this trap and worked down slope for 50 centimeters (50 x 50 centimeters). Only one, 0-10 cm level was at trap 1. The color of the soil remained consistent and no change in stratigraphy was detected. The depth of this trap was approximately 10 cm. It was during this initial excavation that it became apparent the sediment was too coarse for good preservation of basket trap or netting materials.

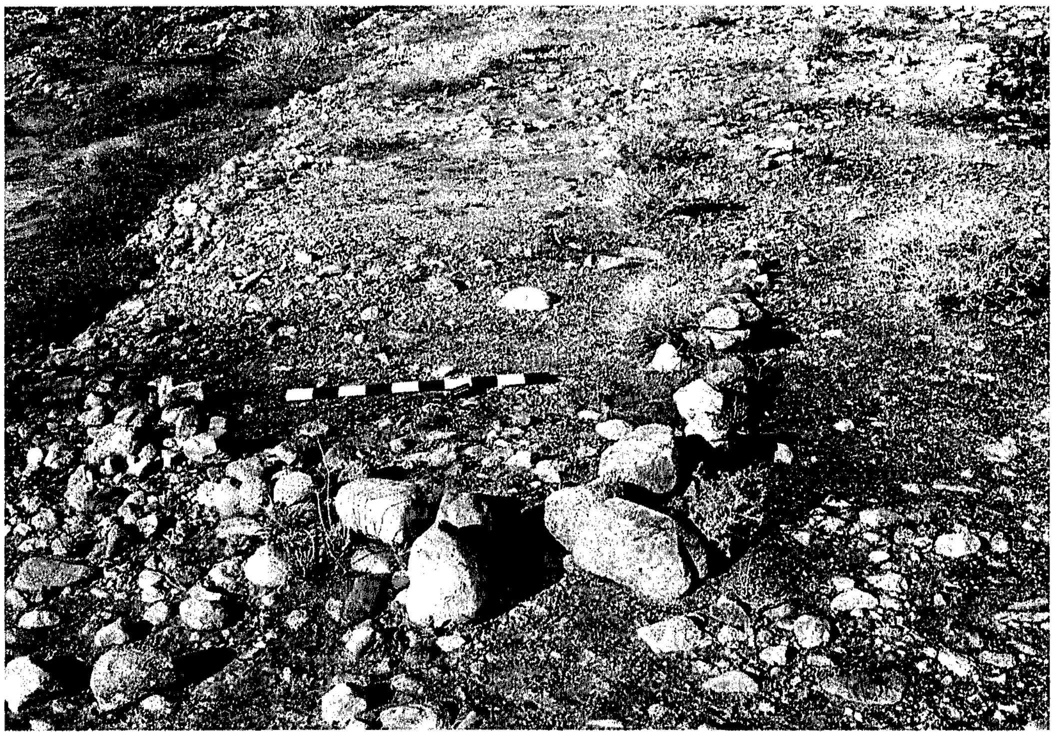

Figure 32. This figure demonstrates the deflated nature of the sediment around trap 1

Beginning with Trap 2, I used a laser builder's level to establish a level line around the entire trap. Four stakes were driven in the ground, one at each end of the rock walls. A level mark was made on each stake and a string was tied between each level mark. Over the course of 7 meters (the length of the long wall in Trap 2) a line level can be off quite a bit. The laser level also offered the advantage of being operated by a single person where a traditional transit type builder's level often requires the assistance of two-three persons.

From this level line it was possible to measure down and record the height of the larger stones in the walls. All of these were very close to the same height, suggesting that they were in their original contexts. Later when I rebuilt the trap, and replaced the displaced stones into the walls, the stones brought the walls up to the same height as the existing larger stones. Therefore, I believe that the original trap height can be established using a string and a builder's level.

The excavations from the apex followed the outline of the trap walls outward from the trap, until the stones from the demolished trap walls feathered into intermittent sheet-wash deposited stones. Identifying the outside parameter of the displaced wall stones is not difficult if you observe the old substrate around the trap. The two types of rock placement patterns are quite different. Additionally, the excavations illuminated the shape differences between the trap at the surface of the ground and the buried base of the walls. The entire trap was not buried in sediment. Only the lower section near the apex required excavation, and Trap 2 was only partially reconstructed. Figure 41 demonstrates the 2004 excavations.

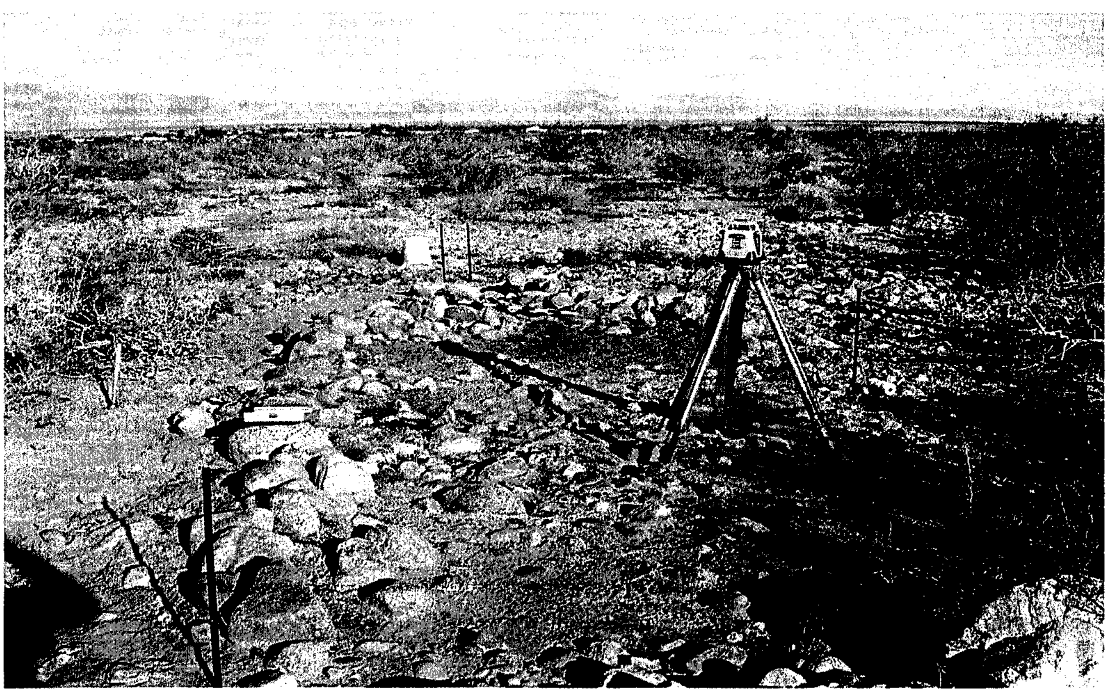

Figure 33. Demonstrates the laser technology that was used to "shoot" a level line around trap 2

The longest wall of Trap 2 measures 7 meters. This trap occurs on a relatively flat substrate and the trap walls are approximately 40 centimeters high in the apex. The excavations here were 10 centimeters deep and began at the apex and continued down-slope for 50 centimeters, then upslope, to the end of the shortest wall, and across the trap to the other wall where they stopped. Figure 34 shows the height of trap 2 (~ 40 cm) in the apex area where the basket trap device is believed to have been placed.

Figure 34. This photo illustrates the rebuilt apex of trap 2

Trap 3 is the best documented in these investigations. Again, through trial and error the excavation methods grew as this research progressed. It became quite clear while excavating this trap that the surface of the trap did not resemble the base of the walls. Again, this is due to many factors, such as wave action in the ancient lake, plants growing within the walls after the lake had receded, human and animal disturbance, and erosion.

Figure 35. This photo exemplifies the altered surface condition of Trap 3

The initial excavations of Trap 3 occurred in January of 2004. These excavations began in the apex and moved downslope 50 centimeters and ceased. No basket trap material was identified. It then followed the wall outline upslope to the middle of the trap where a one meter by "the trap width" unit was excavated. Later, the excavations continued to the up-slope end of the trap. The remainder of the trap was excavated in the second session and rebuilt. This occurred in March of 2004. Figure 37 illustrates the non-traditional excavation units which were used.

The excavations again stopped when the stones from the traps walls began to feather into intermittent sheet-washed stones. At this location, the dense concentration of gastropods in the substrate the trap was built on was quite easy to follow over the entire length of the trap. This snail concentration was approximately 2-3 centimeters thick and mixed with beach sand.

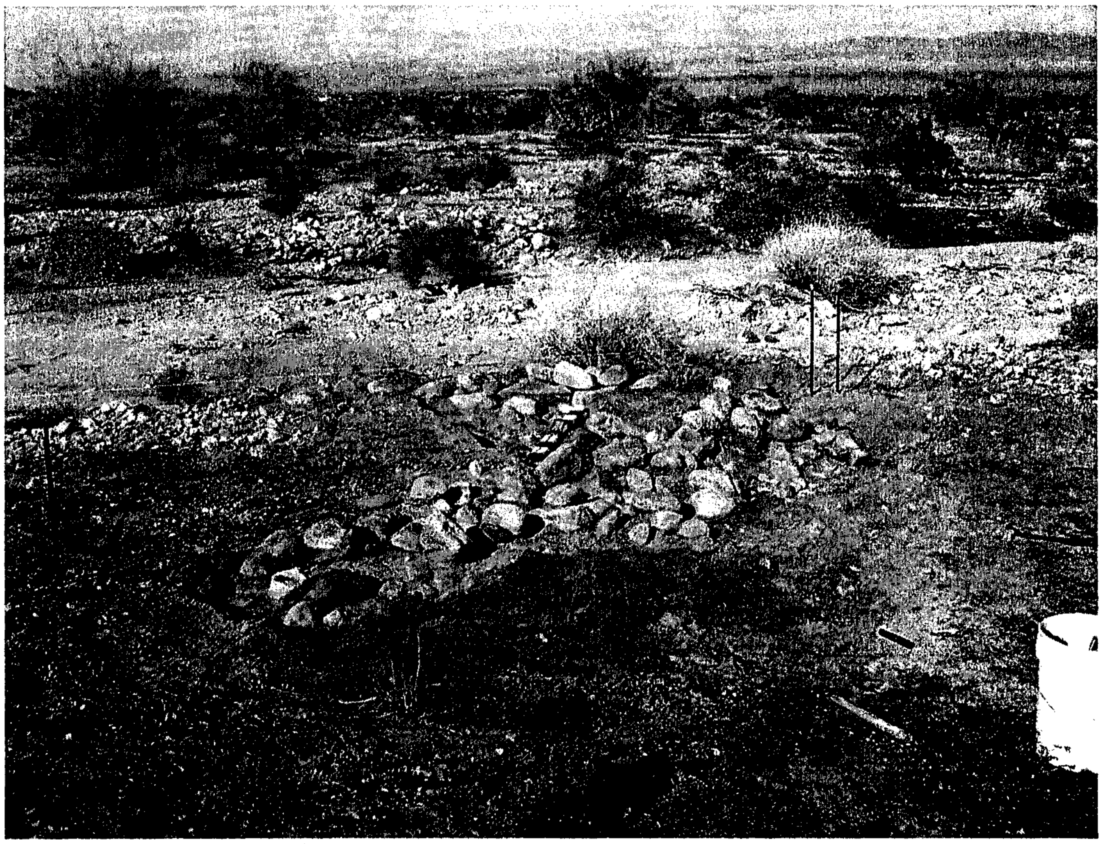

Figure 36. This photo shows a partially excavated Trap 3

Brushing was the method used to remove sediment between the stones, therefore it was more efficient to begin digging/brushing on one outside margin and proceed to the other. In this way, it was not necessary to continually remove sediment from previously cleaned areas. Here again, four stakes were set, one at each end of the tap walls and a level line was established above the entire wall with the laser level. This trap offered seven measurements from the string to the top of the largest stones, which were very similar in height. As a result, it seemed obvious where the original height of the walls had been. Like Trap 2, the stones were placed back into the walls and their mass brought the walls up to the calculated height under the string. The sediment deposits inside this fish trap were sufficient to profile. Figure 38 demonstrates the reconstructed trap. The eolian

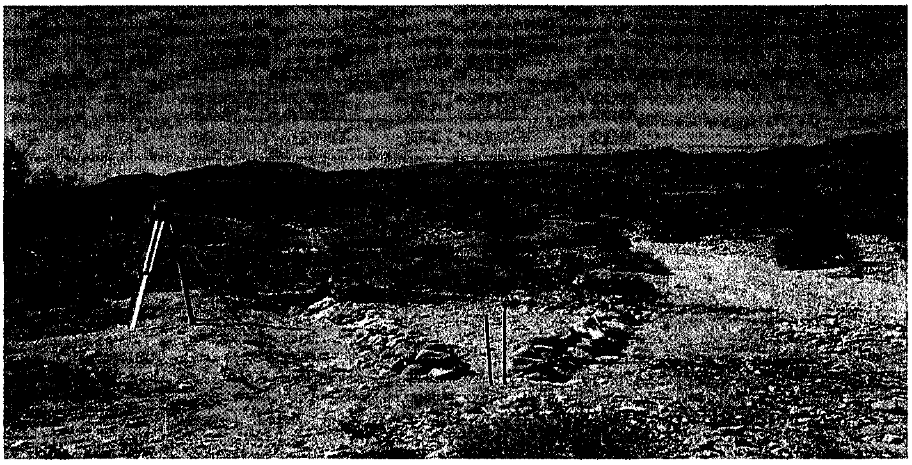

Figure 37. This photo demonstrates a fully excavated and reconstructed Trap 3

sediment collected by the now dead mesquite bush in the background of figure 38 measured 22 centimeters deep and demonstrates another method of deposition. The sediment profile from this trap was quite clear as Figure 39 illustrates.

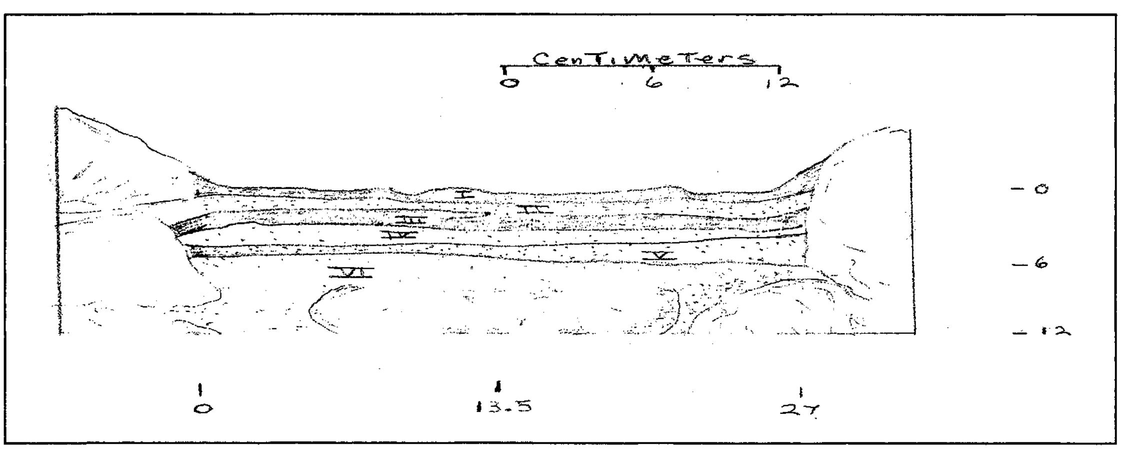

Figure 38. Soil profile from trap 3

Stratigraphic level I is a thin clay layer three millimeters thick. Level II represents a sheet-wash event or the buildup of eolian material and is fine sand. Level III is a four millimeters thick clay layer. Level IV is a layer of sand that tapers from 20 millimeters thick on the west side of the trap to almost nothing on the east side. Level V is another extremely thin layer of clay, and the last level, VI, is another fine sand layer. The snail layer, Level VII, lies at bottom of Figure 39 and denotes the substrate on which the trap was built.

As noted above, this trap exhibits oscillating soil building regimes and sheet-wash or eolian deposition. The profile was very clear when first excavated during January of 2004; however, in March the ground moisture had evaporated making it all but impossible to maintain side walls or to identify the separate depositional layers, even though a spray bottle was used to wet the side walls.

Trap 4 was excavated during the second session and the apex profile was completed with the use of a spray bottle. Figure 39 illustrates the shape of the trap, as well as the vegetation, which displaced wall stones.

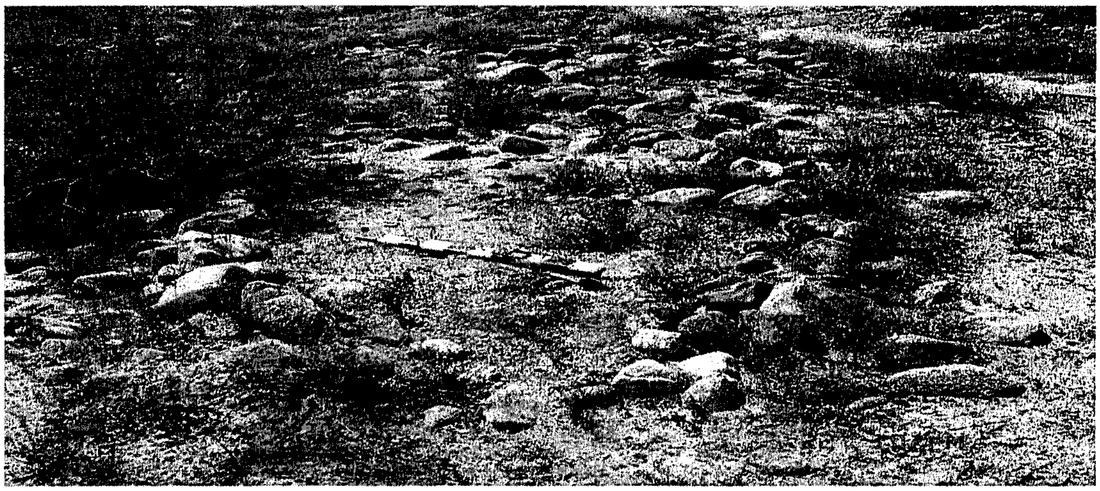

Figure 39. This photo illustrates the surface condition of Trap 4

Figure 40 demonstrates the soil building regimes that took place in Trap 4.

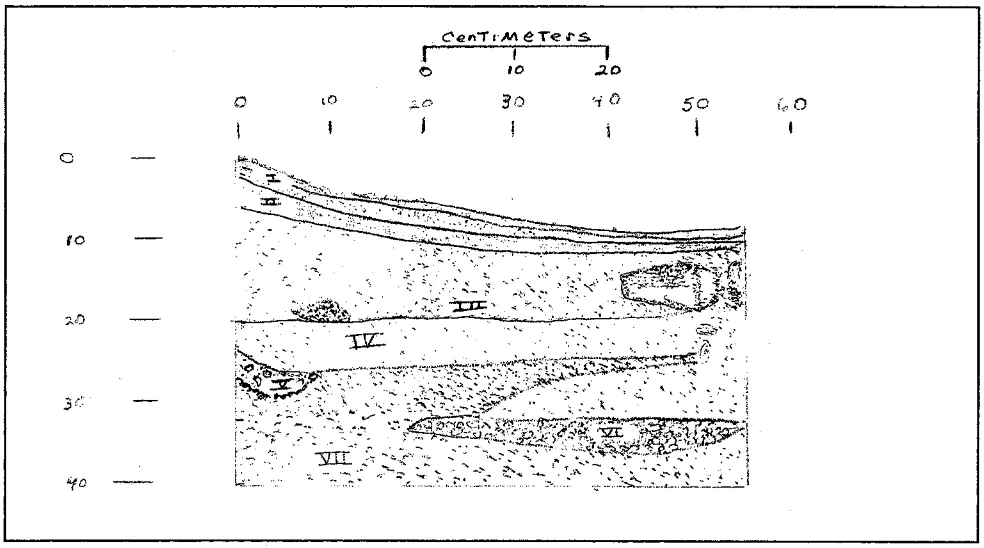

Figure 40. Uneven deposition of sediment which can occur within the traps.

Level I and II are both clay layers, with a tiny sheet-wash or eolian material layer between them. Level III is another layer of sheet-wash and or eolian material with sand grains between 0.5-0.2 millimeters in the matrix. Between levels III and IV exists the latest substrate. A decision was made at this time to excavate deeper into the alluvial gravels to determine if another substrate existed and if so, to measure the amount of sediment between the two substrates. The substrate was again identified by a layer of gastropods. Level IV is made up of fine eolian or sheet-wash sediments with more clay than Level III. A pebble and coarse sand lens makes up level V. Level VI is very coarse beach sand. At the bottom of Level VI, is a pocket containing an isolated concentration of gastropods.

Traps 5 and 6 denoted another type of experiment. These two traps were excavated from the outside-in, to determine if a better method of excavating the fish traps existed. This method was found to be inferior to beginning from the apex and proceeding upslope. In fact, this method created great difficulty when identifying the bottom dimension of the trap. Such a large excavation unit was required that locating the latest substrate, the interior dimensions of the trap, or any other levels, became difficult. Figure 41 illustrates the side of fish trap 5.

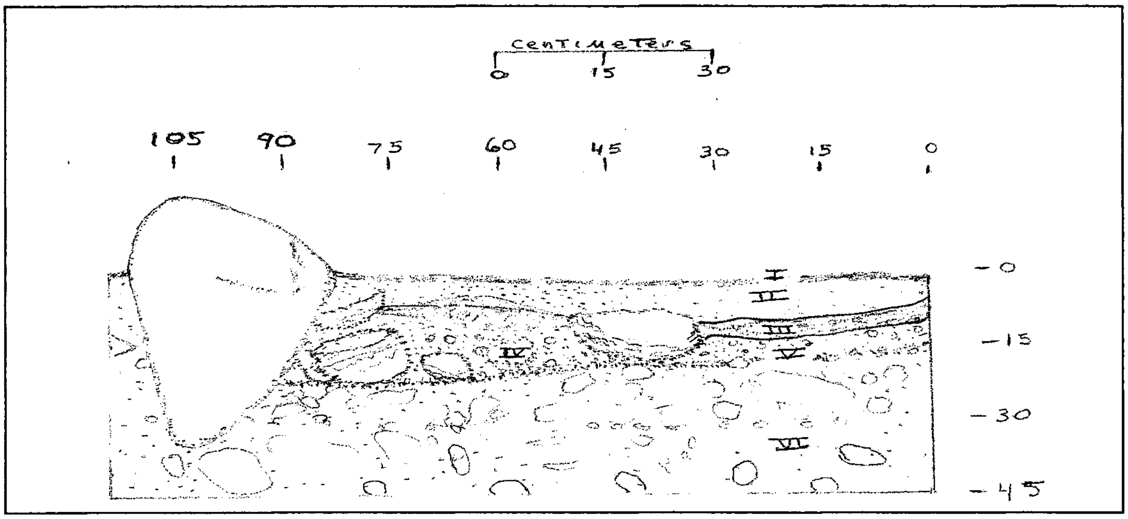

Figure 41. An outside wall profile of trap 5

The first level of Trap 5 is a clay layer. Level II is made up of fine eolian or sheet-wash material. The third level is another clay layer. Level IV consists of fine eolian material with 3 centimeter pebbles incorporated in to the matrix. The bottom of Level V is the elevation of the latest substrate of Lake Cahuilla. This layer is easily identified by the extremely large number of small gastropods. Level VI is made up of alluvial material. Once the side profile was exposed, it is not possible to excavate from the apex and get a clear profile for illustrating.

Trap 6 is the last trap which was excavated during the 2004 investigations. Again, this trap was excavated from the side similar to Trap 5. Figure 43 illustrates the variability in the subsurface component which is present in this region of Lake Cahuilla. Level I is a clay layer and Level II is eolian or sheet-wash material. Level III's most salient attribute is the tufa on stones in the fish trap wall. The differing orientation of the tufa clearly demonstrates that the tufa did not grow on the stones while they were in the fish trap wall. The stone in the center of the highest tier and the stone in the far right hand section of the drawing both have intact tufa below the surface of the sediment; above the sediment, however, the tufa has been removed by wind blown particles of sand. Level IV is alluvial sediments.

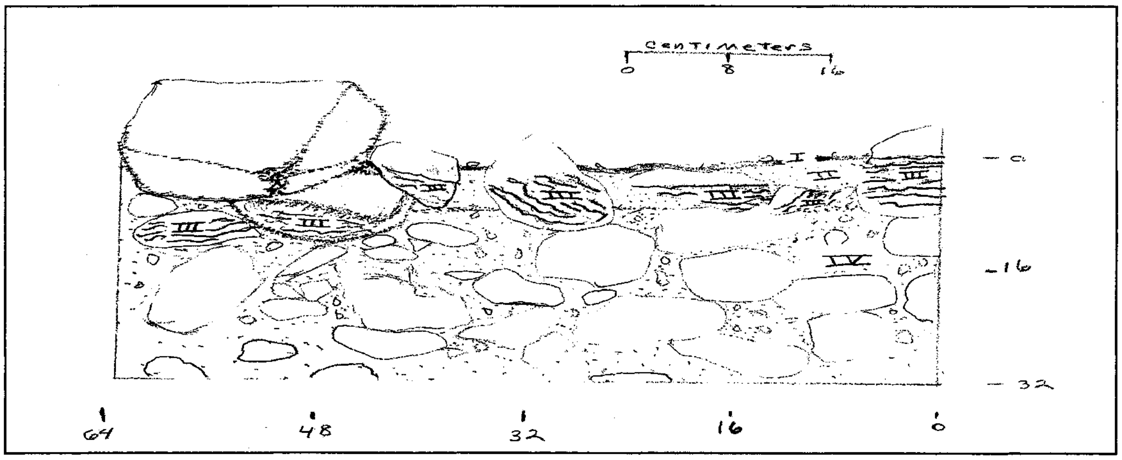

Figure 42. Side view of Trap 6.

At the end of these excavations, it seemed clear that a variety of fish trap wall heights were used in exploiting the native fish of the Colorado River. These variances raised more questions than they answered concerning the function of the stone walls versus walls made from netting. This issue will be addressed in Chapter 6.

Survey

A number of the fish traps, including those excavated in this research appeared to be built on a single beach line. During the survey component of this research, this possibility was investigated. A laser level was also used during the survey component of the investigations to identify the difference in fish trap elevations. The laser level preformed admirably, its only limiting factor was not being able to "shoot" a laser beam through the trees and bushes on the surface of the old lake shore. It was possible to shoot all of the fish traps within the group pertinent to this study. Unfortunately, time did not permit compiling a complete record of the lower group of fish traps.

The differing wall heights, which were recorded earlier, seemed to support the idea the fish traps could have all been built and operated at the same time. When the data was inspected in the light of the three month spawning period of the razorback sucker or the bonytail, an interesting development became visible. Table 4 shows the differing wall lengths and angles, elevations, and apex measurements of fish traps located on the Aggregate Products INC. land in Salton City, California. Table 4 illustrates the characteristics of the fish traps in the research area.

Fish Trap Number	Right Arm Length/ Degrees	Left Arm Length/ Degrees	Apex Measurements cm	Widest Measurements cm	Elevation cm
1	320 cm/57°	350 cm/ 80°	50 cm	240 cm	0
2	377 cm/ 30°	340 cm/ 76°	40 cm	210 cm	-27 cm
3	446 cm/ 80°	160 cm/ 106°	40 cm	166 cm	-13 cm
4	460 cm/57°	354	40 cm	226 cm	-12 cm

		cm/80°			
5	840 cm/82°	500 cm/90°	40 cm	338 cm	-10 cm
6	306 cm/75°	294 cm/108°	20 cm/caved in	216 cm	-16
7	206 cm/98°	235 cm/105°	30 cm	175 cm	-14 cm
8	250 cm/34°	258 cm/58°	40 cm	200 cm	-6 cm
9	265 cm/18°	292 cm/35°	35 cm	182 cm	-24 cm
10	178 cm/10°	300 cm/70°	30 cm	290 cm	-31.5 cm
11	283 cm/20°	356 cm/70°	20 cm	306 cm	-24.5
12	380 cm/58°	340 cm/84°	27 cm	215 cm	-28.5
13	310 cm/84°	483 cm/ 38°	40 cm	210 cm	-21 cm
14	376 cm/40°	396 cm/90°	30 cm/caved in	336 cm	-30 cm
15	310 cm/42°	424 cm/82°	Caved in	303 cm	-14.5 cm
16	390 cm/32°	287 cm/68°	30 cm	185 cm	-19 cm
17	390 cm/38°	350 cm/70°	Caved in	285 cm	-41 cm
18	336 cm/50°	297 cm/85°	Right-30cm, Left-33 cm	266 cm	-37.5
19	375 cm/4°	345 cm/42°	40 cm	246 cm	-12 cm
20	490 cm/50°	406 cm/80°	40 cm	225 cm	-139.5 cm
21	480 cm/0°	190 cm/18°	20 cm	240 cm	-169
22	200 cm/25°	250 cm/75°	30 cm	200 cm	-185 cm
23	360 cm/32°	280 cm/65°	Destroyed	260 cm	-184
24	90 cm/65°	147 cm/80°	30 cm	140	-184

Table 4. Fish Trap Characteristics from the Aggregate Products Inc. Site.

By applying Waters' (1983) calculations concerning the amount of recession which took place in Lake Cahuilla over the course of a single year (1.8 meters), it may be possible to determine the number of fish traps built and operated each month. It was also possible to establish when the fish began to move away from the spawning area because the trap building tapered off. This is discussed in detail in chapter 6.

Post Depositional Disturbance

van Werlhof (1996:12) recorded 19 different styles of traps near Salton City, California on a relatively small section of land. My own excavations at that same location indicate post depositional forces may have acted to create the illusion of trap design variability. von Werlhof's inferences made concerning the number of trap designs did not include the luxury of excavation, and were based solely on surface observations. Figure 43 demonstrates von Werlhof's fish trap types. Figures 44, 45, and 46 illuminate the difference between suspected trap designs and actual trap design.

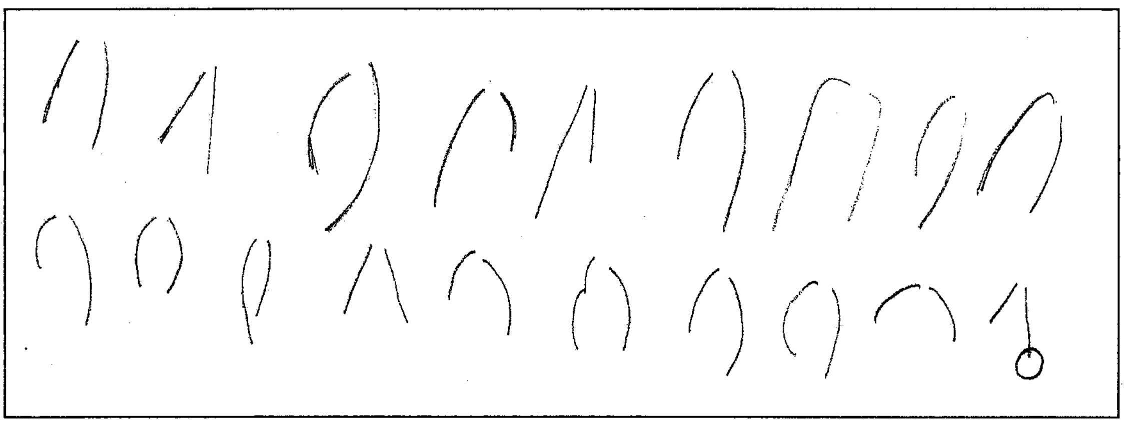

Figure 43. V-Style fish trap variations recorded by Von Werlhof.

Animal burrows were encountered inside the traps, adding more displacement to the wall materials. In some cases the eolian material deposited within and around the traps has been so great that only the uppermost tiers of stones are visible. This exemplifies the need for more research and excavation when attempting to establish the shape of the fish traps.

Figure 44. Surface of unexcavated trap 3.

From the surface, Trap 3 almost appears U-shaped, and gives little indication of the outline of the bottom of the walls. After excavation and reconstruction, it became apparent that the shape was that of a typical V–style trap. The base of the wall was not a perfectly straight line, but a perfectly straight wall line is not necessary in order to catch fish as the final experiment in Chapter 6 discloses. As the excavations worked outward from the inside of the walls, it became clear where the wall stones ended and intermittent rocks , which were washed in during sheet wash events began.


Figure 45. Partially excavated trap 3; wall fall exposed.

When examining a sediment profile within the trap's apex, it is easy to distinguish several A-horizons that are present in varying thicknesses. Intermittent sheet wash events are also visible. Within both the sheet wash and A-horizons, tiny snails can be found. In the A-horizon, these snails appear to be a product of erosion upslope and subsequent wind and water deposition. The force of the wind in the Salton Basin can be quite intense often reaching sustained speeds of 80 kilometers per hour. Continued exposure to rain can deflate an area by removing the fine particles similar to wind deflation (Schiffer 1996:250).

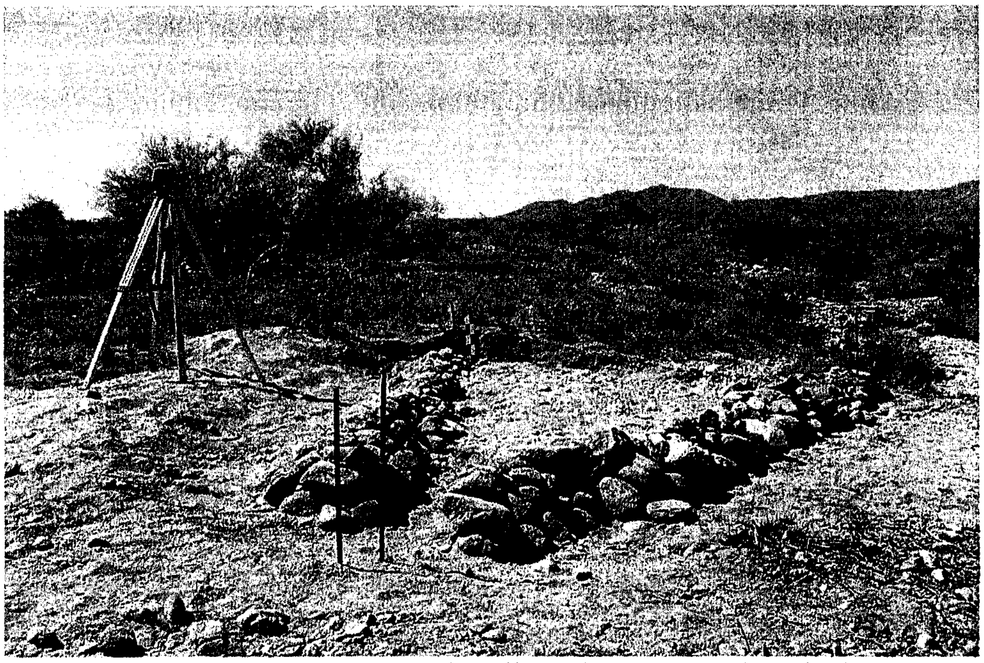
Figure 46 demonstrates the original outline of trap 3 based on the lowest part of the walls.

Interestingly, the Lake Cahuilla fish traps are, by their very nature, self-destructive. Soil stratigraphy and composition within the traps sometimes differs dramatically from that found outside them because the fish traps act as a natural eolian sediment trap. Soils outside the traps are a homogenous layer of sheet- washed sediments down to the latest substrate of Lake Cahuilla. Within the fish traps, eolian material overlays the latest substrate of Lake Cahuilla. The distance from the surface of the eolian sediment to the last substrate is usually much less in the middle of the trap than it is on the sides because the trap stones catch and hold eolian material around them. Intermixed with this eolian material are small amount of gastropods.

Fine sand particle accumulations of 5 cm have been recorded in some archaeological sites in a single windy weekend (Schiffer 1996:200). Sediment captured within the traps forms clay layers, which in turn trap moisture and wind blown seeds, creating a fertile micro-environment for plants. When plant stalks and/or roots take hold in the rock walls, displacement of wall stones occurs, sometimes to a very large extent. Plants such as mesquite, palo verde, and creosote have been recorded growing inside the rock walls of numerous traps. The displacement of fish trap wall stones by a palo verde tree is clearly visible in Figure 47.

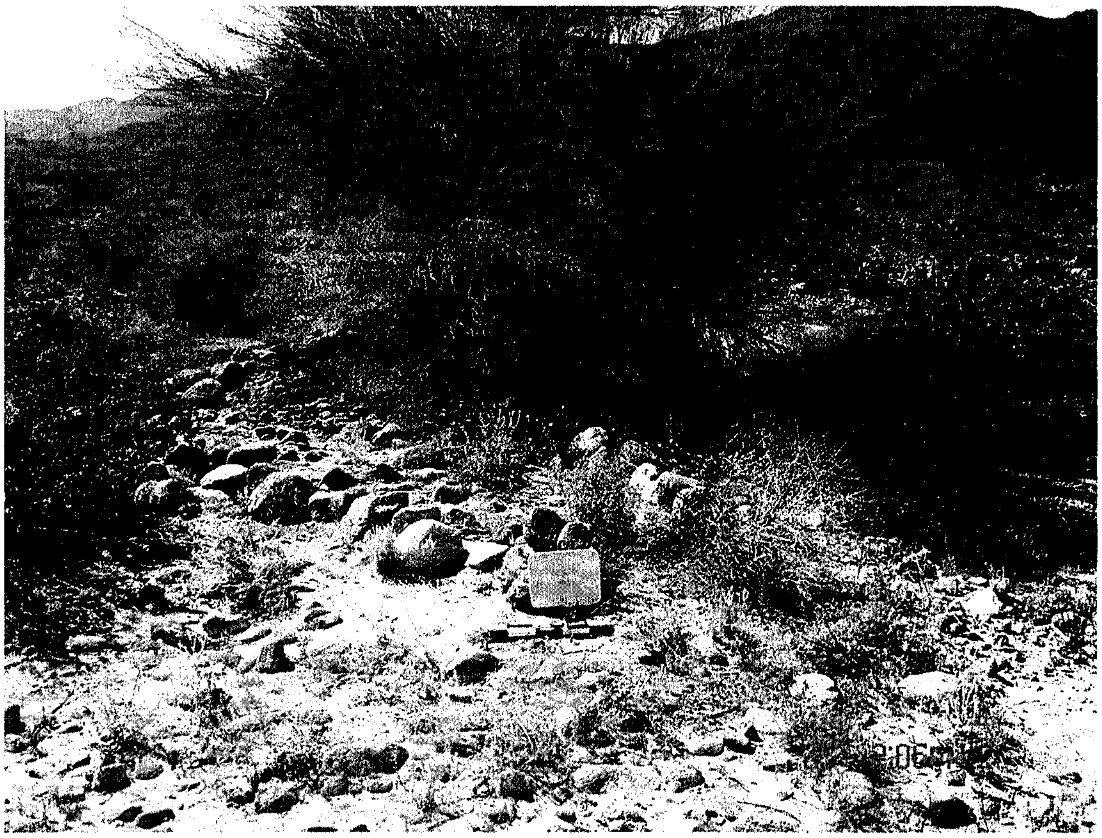

Figure 47 illustrates a palo verde tree which is growing in the divergent end of a fish trap

Weathering

Salt weathering affects fish bone to a great degree. As is the case with most house rings around Lake Cahuilla, the presence of buried fish bone is visible on the surface or suspected in the sediments. Fish bones were identified, but not to species, on the surface in at least two sites during the survey conducted in the spring of 2005. No excavations were conducted on house rings during these investigations, however. The fish bone data may appear to be only marginally related to depositional processes but, establishing their connection in space and time supports an association of fish traps and house sites and may therefore provide a method to date groups of fish traps.

Figure 48 demonstrates the insitu placement of dislodged fish trap stones before reconstruction.

Several stones display a tufa layer, an inorganic buildup or coating now found on stones used in trap construction. Wind blown sand particles have removed the above ground portion of tufa on many stones. Some buried stones near the traps have tufa coatings. The presence of the stones having tufa on their exterior appears to be part of one or more sheet-wash events. The identification of these sheet washed stones is fairly easy, as the orientation of the tufa on the stones is inconsistent with the natural build-up of this material.

Finally, earth quake activity in this region has always been high and can be a major factor in dislodging fish trap walls. Illustrating the potential of earth quakes to topple fish traps is the 1979 Imperial Valley quake. The vertical ground movement recorded at Imperial Valley College during this event was 4.6 meters per second. Quakes of this magnitude are not uncommon in this region. Continued exposure to earthquakes would no doubt spread fish trap stones over a small area.

In order to illustrate the importance of rainwater as a formidable depositional factor in the arid region of the Indio California, I present the average rainfall recorded between the years of 1877 and 1887 in Indio, California. During this time the locality received a yearly average of 14 centimeters of rain. This amount may appear minuscule; however, rain can be concentrated into flash flooding events that both remove and deposit large amounts of sediment. This sediment is capable of burying a site to considerable depths in a short period of time or a single high-energy rain event can erode new arroyos two meters deep within several hours.

As seen in Trap 3 (Figure 49), the A-horizon (upper sediment layer) is relatively young and thin (3mm), but readily visible. Directly below the first A-horizon is the first of two B-horizons. This suggests that a stable soil building environment has been punctuated by a rapid sediment accumulation in the B-horizon, either as a result of wind, or fine sediment deposition due to low energy water transport. Directly below the first B-horizon is a second, more robust, A-horizon. This second A-horizon is considerably thicker (at least 5mm), suggesting a longer period of soil building took place there. The small gastropod shell layer located in the bottom of the first B-horizon could be a result of the strong winds that frequent the Salton Sea area. Certainly their numbers are not sufficient to be classified as a substrate.

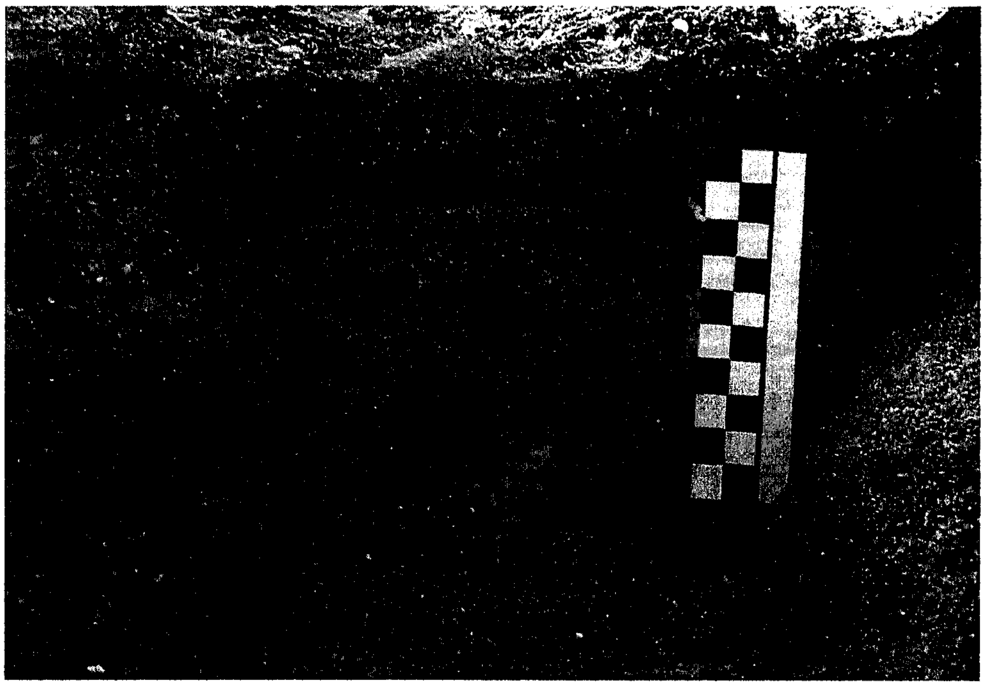

Figure 49. Soil profile within Trap 3. Scale is in centimeters.

Figure 49, shows that decomposing plant material, chemical action, and microbiological interaction have united, turning the A-horizons a dark color. The B-horizon located directly below the A-horizon is lighter in color, and is made up of larger particles. Percolation is responsible for the migration of these particles from the A-horizon to the B-horizon, as well as their more compact setting, and the B-horizon is generally less organic in nature. Due to the alluvial nature of the substrate, the C-Horizon, which is not parent material, extends to an unknown depth at this location. Deeper excavations (40 cm) revealed that numerous episodes may have been a result of wind and water erosion as well as sheet wash. These events are easily detectable as tightly interlocked pebbles and sediment of varying sizes.

Gastropods

Several gastropod species were identified during the excavations. The first is *Physella sp.*, and this species can inhabit a wide range of environments. It is capable of tolerating fresh to slightly saline water, usually found in shallow water, and is widespread geographically. The second gastropod species is *Tryonia porrecta* and it is still found today in the Salton Sea locality. This species inhabits thermal springs, and is often called the "spring snail." Juveniles of this species are present, indicating the environment facilitated reproduction. The third species of gastropod found at the excavation site is from the *Hydrobiidae* family. There may be several different genera of *Hydrobiidae* present including the *Tryonia porrecta* and these occur in different environments. In any case, juveniles are present here as well indicating good reproductive success in their environment. These data indicate two separate lacustrine environments existed and produced young. Unfortunately, this evidence provides no clues as to the clarity of the water at the time the lake was present, but the data thus far suggests that passive fishing methods were most likely used.

Stone Reuse Observations

As mentioned above, fish trap stones have been reused to build house foundations. On two occasions during the survey, partially intact fish trap walls were discovered. The first was a trap directly adjacent to a small wash. One half of the trap may have been the victim of erosion, but the large stones that frequently make up the traps were not identified in the adjacent wash.

The placement of this "half trap" was just below several other complete traps, which shared a single elevation. Therefore, it appears as if the half trap was partially reused when the receding lake level revealed stones suitable for building material. Coincidently, the size of the stones used in constructing both the fish traps and the house rings are the same. In another instance, a partial trap and several fully constructed traps were recorded slightly downslope of two house rings. The close proximity of the house rings and the fish traps suggest the house rings were constructed from materials used to build the fish traps, not the reverse. If the reverse were true, then there would be partially constructed house ring(s). Fish bone and ceramics were associated with the house rings suggesting the structure was indeed a house, and not another style of fish trap.

Archaeological Site Formation and Destruction Processes

One of the major inherent qualities of a lake is its predisposition to rise and fall. This is especially true of Lake Cahuilla. The retreat of the lake varied each time a recessional event took place because the starting point of the recession would vary. This was due to the amount of inflow from the Colorado River and the evaporation rate, which would have fluctuated somewhat each year depending upon seasonal temperatures. The highest elevation maintained by the lake was 12.8 meters above sea level.

As the lake continued to fill and recede, organic artifacts such as basket traps, netting, wooden artifacts, and house ring superstructures would decompose. Pollen and some seed varieties are carried long distances by streams and ephemeral streams, which can misrepresent the floral community surrounding the lake; however, their presence provides a record of larger scale environmental factors.

Schiffer (1996:30) indicates that the reuse of artifacts of all types is a common phenomenon associated with the archaeological site record. Identifying reuse situations that took place on Lake Cahuilla seems straight forward. Stones from fishing traps operated during previous inundation periods appear to have been reused to create for new fishing traps, as well as the bases for house circles. The stones mentioned here are large and are present in the alluvial gravels of Lake Cahuilla; however, they are by no means abundant. Therefore, reusing these stones was far easier than searching for and transporting new ones back to the current spawning area, which may change over time.

Evaporation

These archaeological investigations also seem to substantiate the scenario of a three month fishing season in Lake Cahuilla. Waters (1981:375) suggests that Lake Cahuilla receded approximately 1.8 meters per year due to evaporation. The slope of the ground in the research area is three centimeters of vertical fall to one horizontal meter (very flat). Therefore, the total vertical distance recorded between the highest and the lowest fish trap was 41 centimeters, the horizontal shoreline displacement for a three month period in this area would be 13.66 meters, making this period of time easily visible on the ancient shoreline.

The 41 centimeter vertical distance is caused by three months of evaporation and includes the three month spawning period of the razorback sucker. It is not possible pinpoint the three month spawning period of the razorback sucker or the bonytail in Lake Cahuilla, it is only possible to suggest a time frame based on observed temperatures, which cause these fish to begin spawning in modern Lake Mohave. Average monthly evaporation would reduce the lake level by 15 centimeters, requiring a new trap to be constructed regularly if the traps were shallowly placed in the chilly waters. Observations made during this research suggest shallowly placed traps (less than three feet) would produce fish for consumption.

The two large trap complexes that were examined and partially recorded were not placed on an exact 1.8-meter vertical interval; some variability existed as would be expected with natural evaporation rates. Even with the slowed evaporation rates, which would occur in the cool portion of the year when the fish are spawning, a 41 centimeter reduction in the lake level is not unreasonable (Paul Matuska, personal communication 2006).

The majority of the V-style fishing traps were found close to the western mountains. These concentrations can be explained by some of the razorback sucker spawning requirements. For example, the fish choose specific diameter gravels in which to spawn: these gravels are more often located near the mountains as part of alluvial fan aggregates. Also, these gravels must be clean. Wind and wave action may have been responsible for cleaning gravels in the past as current wind conditions on the Salton Sea display strong activity. Again, thermal activity in this area may suggest the fish were seeking their optimum spawning temperature.

Summary

There are many powerful depositional agents creating the archaeological record around Lake Cahuilla. Understanding these processes is critical to interpreting this record. A process, which would greatly effect deposition, is the recession and recharging levels of the lake. This would govern wave action and its affects on the traps. It would also dictate the placement of the house rings, as they would need to be places far enough from the beach so as to not disturb the activities within the fish traps. Secondly, this region has a history of earthquakes. For example, an earthquake with a vertical acceleration of approximately one "G" occurred every 10 years prior to 1980, and since the area has been relatively quiet for several decades, geologists believe a large quake is overdue. It is not possible to know the exact amount of ancient tectonic activity in this area, however, if modern ground movement is any indication, quakes measuring 6 or better on the Richter Scale, occur regularly. A quake of this magnitude is certainly capable of changing the shape of a stone walled fish trap. Next, wind can remove or deposit great quantities of sediment, enough to obscure a trap's outline. Wind can generate waves that redistribute fish trap materials. Additionally, wind transports seeds of plants, bushes, and trees. These in turn are capable of moving stones over a great area. Human activity can also moves the stones in fish traps, whether it be for constructing new fish traps, house rings, or purposes yet unidentified. Lastly, animal burrows mix sediments and displace stones within the traps.

Great numbers of sherds and small lithics may also be removed from the site due to erosion. Alternatively, it may have been possible to cover entire traps in just one or two flood events (depending on the energy levels of the water and availability of the source material). The use of Ground Penetrating Radar (GPR) in the study area may be problematic as the background noise (stones of similar size) is great in the research area. Not all substrates around the lake are of the same type; therefore GPR may work in identifying buried fishing traps where the substrate is composed of smaller lithic or sand components.

As we can see, many factors have governed the depositional events at Lake Cahuilla. Identifying these events in the archaeological record can add definition to the pictures we attempt to paint. They create a rich holistic view of the lives that ancient people experienced. They also illuminate the issues these people faced and the innovations they responded with.

CHAPTER 6

RESULTS AND CONCLUSIONS

This research incorporated ethnographic, replicative, and experimental archaeology to gain insights into fish trap function, resource scheduling, and group organization. As people in this region generally lived from resource patch to resource patch, the Lake Cahuilla fish traps provide an intriguing and salient resource patch that required unique technologies in order to exploit. Until the spring of 2004, no in depth investigations had been conducted concerning the working mechanics of Lake Cahuilla fishing traps.

The biological needs of the fish are central to the effectiveness of the traps; fish biology dictates the placement of the trap in the lake environment as well as the design of the trap. By more fully understanding the biological needs of the fish we can begin to comprehend the selection of spawning locations made by the female fish. If one only considers the agency of humans, it is unclear as to why the fishing locations were chosen. If we include fish behavior in our interpretation, a more complete view of inter-species relationships within a given environment is then possible.

This chapter provides the results of two years of fish trap experimentation. This research provides insights and possible explanations for fish trap operations based primarily on fish behavior and fish trap design. All experiments were carried out under the direction of the Nevada Department of Fish and Wildlife. The block nets referred to here were designed only to redirect the movements of fish, not to detain them in any way, and the basket trap devices used were modern fyke nets. All of the captured fish were recorded and then released unharmed. The understanding gained by this research has come full circle. Initially it was thought that the stone alignments found on the ancient shores of Lake Cahuilla were used to secure fishing nets to the substrate. As this discussion progresses it will become clear that the stone fish traps can function quite well without the use of netting.

A somewhat recent but interesting technique was used by the Cocopah people in irrigation canals shortly after their construction in Yuma, Arizona. A mat of arrow weed was placed on the bottom of a canal, usually under a bridge. People would enter the canal both up and downstream from the bridge. Fish were then "herded" toward the bridge from both directions (fish will not as readily escape when herded in a canal as it limits their escape options) and when the herders were at an appropriate distance, the mat was raised from the bottom of the canal and the fish were removed. This may be the origin of the "fish herding" theory that permeates the Salton Sea area.

The Research Begins

In the summer of 2004, research began to define the operational mechanisms of the V-style fishing trap and round rock walled fish trap found on the shores of Lake Cahuilla. Until 2004, knowledge pertaining to the Lake Cahuilla fish traps was restricted to several early ethnographies, such as Keno (1701-1702), and Anza (1774-1775). A number of explorers (24) visited the Colorado River region between 1539 and 1872, but most were only able to spend a short time recording the local people and their activities.

Some in-depth documentation of the fishing practices along the river did occur (Spier 1933; Huseman 1995; Wright 1954; Gifford 1933; Stewart 1983; Kniffen 1931; Forde 1931; Kroeber 1908; Miller 1961, 1955), and it is those recorded practices that provide the clues with which to begin reconstructing the technology found on the shores of Lake Cahuilla.

We deliberated between using active and passive fishing methods and decided, due to the extreme water clarity in current Lake Mohave, to apply only passive techniques. Our decision was influenced by Mr. Burke's experience and the ethnographic record where Wallace (1959:89) spoke of using active fishing methods in the Colorado River when the waters were murky. Attempts to recreate the fish herding practices which permeate Lake Cahuilla lore only caused the fish to flee in all directions and move toward deep water away from the fish traps. The best results came from leaving the fish alone to interact with the baited trap during the dark hours.

All spawning period experiments and observations, as well as feeding experiments were conducted in modern Lake Mohave between May of 2004 and December of 2005. Each test trap was constructed in a different lacustrine setting. A few of these setting were, but not limited to: a 15 degree slope of gravelly substrate near deep water; on a 6 degree shallow, sandy substrate located in a deep cove that supported bulrushes (fish habitat); on a 6 degree gravelly alluvial fan amid live and dead vegetation.

The first experiment was modeled after a researched but modified approximation of a Cocopa fish trap. This modified trap used nylon block nets rather than the cotton fiber gill nets noted by Cassetter and Bell (1951:221) or the Mojave willow bark nets recorded by Wallace (1955:89) because damage to the fish would have been inevitable, and it was not necessary to kill fish to demonstrate the effective nature of the V-style fish trap. The trap also included the standard 30-40 centimeter opening found in the apex of most V-style traps.

The Cocopah methods were initially emulated because as Wallace (1955:219) writes, "Lake fishing was especially important to the Cocopa living in the southwestern section of the Colorado River, because there were permanent lakes there." This research also suggests the Cocopah would have strong reasons to fish in Lake Cahuilla when the Colorado River diverted into the Salton Trough above current Yuma, Arizona, leaving them without their main water supply and the resources that accompanied it.

During the experiments, the angle of the fish trap walls was varied to examine any potential difference in fish capturing efficiency. None was found. Originally it was speculated that modified Colorado River fishing techniques may have been employed by the fishers at Lake Cahuilla. Later in 2006, I spoke with a Cahuilla tribal member and discovered my interpretation of Cahuilla fish traps was correct. This confirmation came from a Cahuilla elder who had seen fish traps deployed in the mountain streams near Anza, California (Maurice Chacon, personal communication 2006). River and stream fish traps can be quite similar to those used in lakes.

The general idea is to place a fish trap in an open section of river, out of the strongest current. The trap should be located between two areas that fish use for habitat, creating the illusion that the trap is also habitat. The basket trap opening is orientated down stream; this allows fish to swim into it more readily as they tend to be current orientated. This means that they generally keep their noses pointed up stream to get ventilation across their gills facilitating oxygen absorption, and this also allows them to look for food moving down stream. This same style of trap can be deployed in a lake setting. These are deployed with the basket trap component in deep water and the opening facing the shoreline. Here, the basket trap is baited and its attraction is not strictly to serve as habitat. The fish can smell the bait and enter the basket trap hoping to feed on it. Once inside the trap, they cannot get out.

Replicative Experiments

The first experiments demonstrated that stretching a net with sticks or arrow weed may have been the method used in the soft sediments of the Colorado River (Stewart 1957), however, the use of sticks to stretch and secure netting to the rocky alluvial substrate was problematic. The large number of sizable rocks prevented driving wooden cedar stakes into the substrate. The use of mesquite or another hardwood may have allowed the stakes to be driven into the rocky substrate further; however, long straight branches from this species were not prolific near Lake Mohave. The first traps were built under the assumption that nets made up the trap walls and stakes were used to stretch the nets. These traps took four man hours and two people each to set up. Here again, the results of this experiment seemed problematic. Prehistoric Native Americans were no doubt much hardier than I, and could endure longer exposure to the elements, however, two hours, chest deep in the wintry waters, seemed a bit excessive to build a single fish trap.

As the substrate confounded the use of wooden stakes, the experiment was completed using half inch steel rebar to support the nets. Figure 55 illustrates the use of long steel stakes to support the netting, rocks to secure the netting to the substrate and a steel stake to deploy the basket trap device. Despite the capture of a female razorback sucker during the first experiment (Figure 51), the first to be captured in a Lake Cahuilla fish trap in 250 years, the conclusion of the experiment marked the need to rigorously research recorded fishing practices from the entire region for an appropriate method of trap deployment on the alluvial gravels.

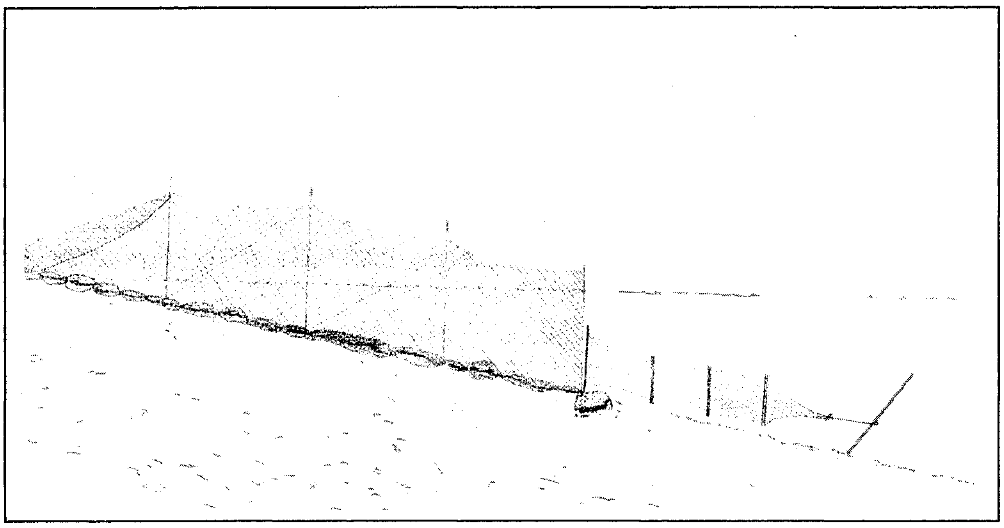

Figure 50. Design of Trap Styles 1 and 2.

Another event that occurred during these first experiments was the observation of a coyote fishing. Despite our presence at the spawning location, a coyote waded into the water between the two original fish traps and attempted to capture a fish. Comments made by Mr. Burke, indicate that on more than one occasion fish biologists have witnessed a number of successful fishing attempts by coyotes at several razorback sucker spawning locations around Lake Mohave.

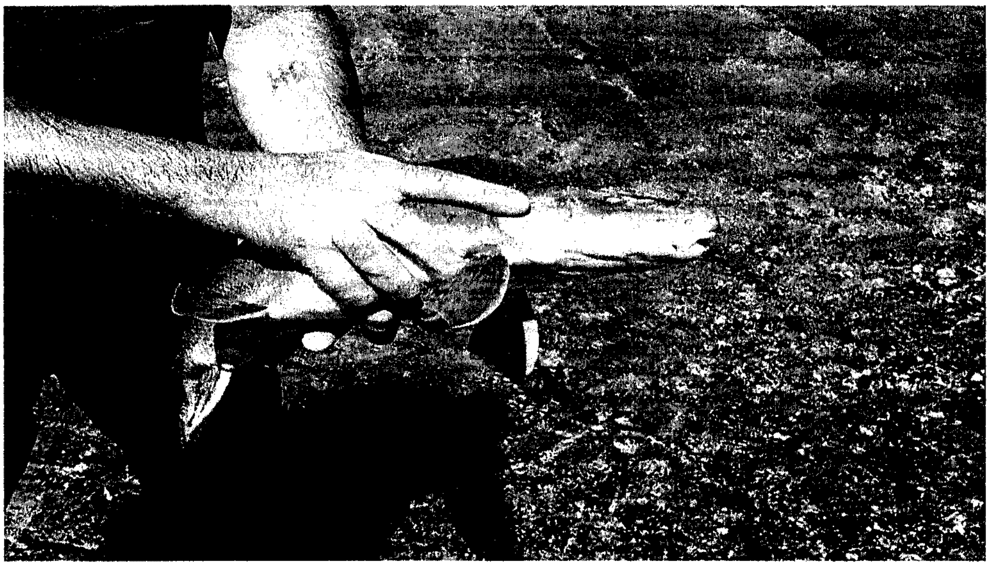
Figure 51. The first razorback sucker captured in a Lake Cahuilla trap in 250 years.

Although this female razorback was captured using the prototype fish trap, its capture does not signify initial success in testing this fish trap design. In fact, its capture is the result of applying another fishing technique. As mentioned in Chapter 1, the fish at this location were extremely nervous in the presence of the two fish traps and human activity, even though they were engaged in their annual spawning activities and had little else on their minds. After observing several razorback suckers swim in and out of the net walls, with no apparent desire to enter the basket trap in the apex, I entered a fish trap directly behind the next fish.

I slapped the surface of the water and stomped my feet on the substrate in an effort to herd the fish into the basket trap device. I succeeded only in making the fish swim into first one net wall and then the opposing wall, perhaps believing the nets were vegetation, which would give way. The fish then attempted to swim back the way it had entered the trap, but I repeatedly blocked its somewhat slow movements with my legs and hands. It bounced off the net, my legs, and hands for a full 15 seconds before coming near enough to the surface of the water that I could grab it with both hands around the dorsal and pectoral fins. Upon close examination of the fish it was discovered to be a female, about 40 years of age, and almost completely blind. The fish was, however, captured in a traditional manner, by hand.

The trap only served to impede its escape until it presented an opportunity to grab it. The razorback sucker was photographed and returned to its environment unharmed. Another similar attempt at capturing a razorback sucker proved fruitless as the fish's movements were anything but slow. Apparently it had full use of its eyes and was sufficiently strong enough to elude capture. Also the angle of the trap walls was greater forcing me to cover a larger escape route.

The above results suggested a world of variable possibilities. Why had the fishes not entered the basket trap? What would cause them to enter the trap? What was wrong with the design? What had we left out? It was clearly apparent that something was missing from the fish trap and that a renewed search was in order.

As noted earlier, no ethnographic reports described the function of the fish traps used on Lake Cahuilla. A very close examination of new reference material and already reviewed reports produced the first and second design change from the prototype traps.

Gifford (1931:268) stated two foot phragmities net floats were attached to the upper edge of Cocopah fishing nets at five foot intervals, and Wallace (1955:88) indicated the use of ground maize for bait. During the next stage of experiments net floats of phragmities and ground corn became integral components in the traps. When traps styles 3, 4, and 5 were deployed with bait and net floats, they never failed to produce at least three pounds of fish. During most of the experiments, the baited traps produced in excess of 5 pounds of fish per single deployment, per evening.

Figure 53 demonstrates the modifications made to the original trap. The netting no longer protruded above the water line, the entire net moved with the water as a result of attaching floats to the upper edge, presumably making the trap seem less threatening to the fish. The number of people required to construct a trap diminished with the new

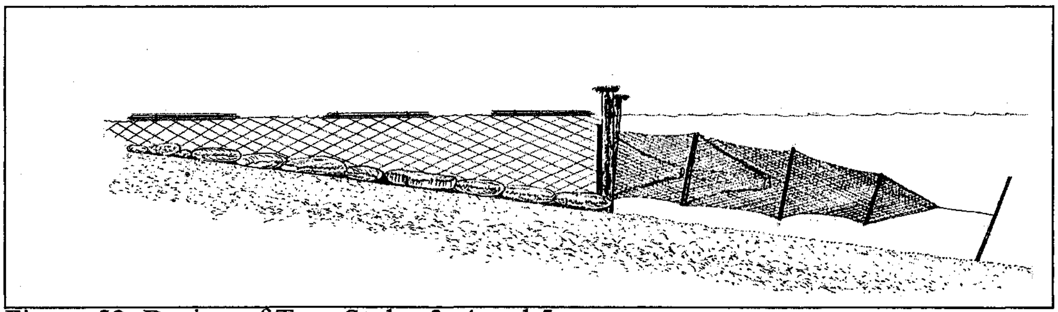

Figure 52. Design of Trap Styles 3, 4 and 5.

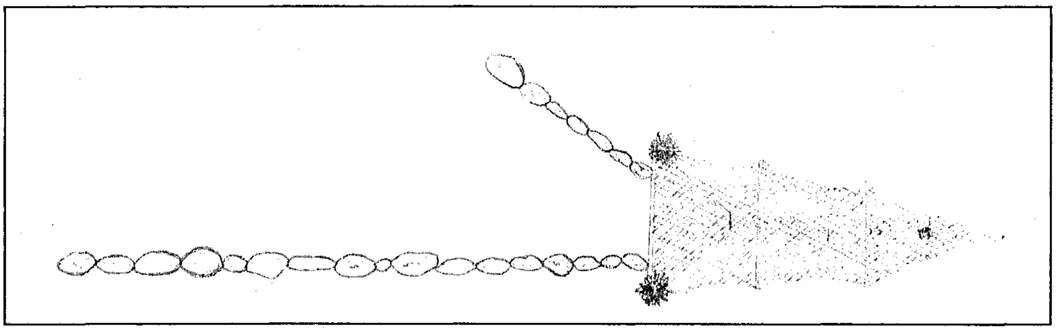

Figure 53. Plan View of Trap Styles 1,2,3,4, and 5.

design modifications. It no longer required two people to build this model of fish trap. A single person could assemble and deploy the trap in one hour. If the components were already assembled, it could be deployed in half that time.

Experiment 3 was carried out on a shallow flat sand bar between deep water and large amount of bulrush (plant) habitat was present at the rear of the cove. The edges of the sand bar were very steep creating a plateau effect near the shore. This trap took an hour to construct as the components were fastened together in the water. During this experiment, the continuous rock alignment, which had been used in the past to secure the nets to the substrate was discontinued in favor of placing rocks every four feet to secure the two wing nets.

This method of securing the nets to the substrate was used successful until the final experiment, where the entire trap (except the basket trap device) was built of rocks. This less labor intense method of securing the nets to the substrate also cut the time required to build the traps to approximately 20 minutes. Several species of fish (catfish, green sun fish, and carp) were observed in the immediate vicinity; however, only green sunfish were captured in this experiment. The bait used in this experiment was ground sweet corn in a small glass jar with a hole punched in the metal lid. Seven sunfish approximating 3 total pounds were recorded and then released.

Experiments 4 and 5 were conducted on a fairly steep substrate near deep water. The location was between two habitat zones, on a beach between a point of land that jutted into Lake Mohave and a shallow cove. The time required to construct experimental trap 4 was reduced to 20 minutes because the components were fastened together on the shore before it was moved into the water and deployed. The bait used here was once again the jar of ground sweet corn. Catfish and green sunfish approximating 3 total pounds were the catch during the deployment of this trap.

Experiment 5 provided feasibility information for the "round rock wall" fish trap. While in the process of constructing this trap a school of green sunfish moved into it before it was half complete, thereby demonstrating the attraction this type of habitat creates. After the walls were finished, leafed branches were placed on top of the trap to complete the "cave" atmosphere.

This experiment was modeled after my understanding of Figures 58 and 59, which may prove to be incomplete. Figures 54 and 55 represent unexcavated rock alignments from the Lake Cahuilla archaeological site record. The lower left photograph

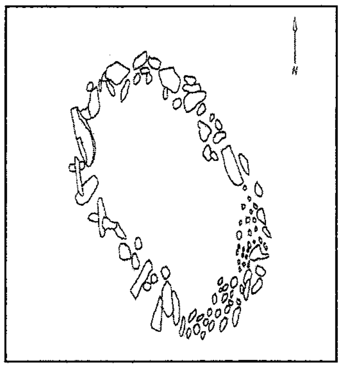

Figure 54.

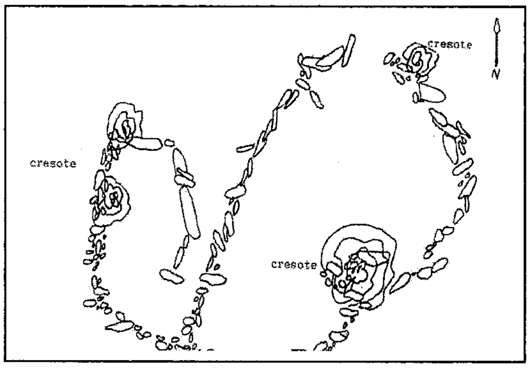

Figure 55.

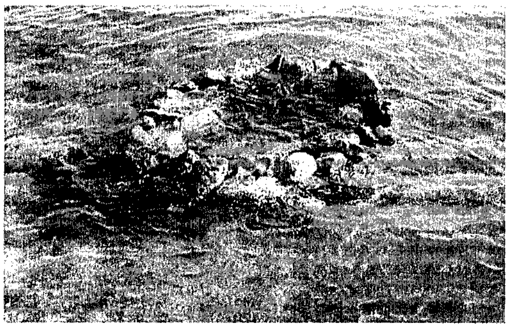

Figure 56.

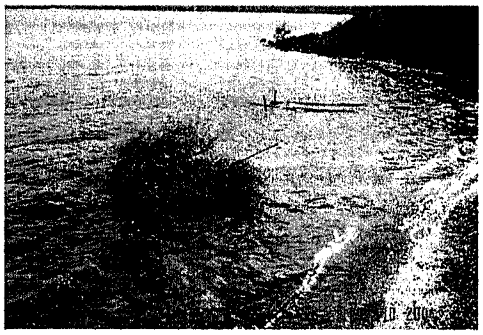

Figure 57.

Figures 58 and 59 illustrate my simulation of these traps. Figure 58 shows the trap covered with brush, also Trap 4 can be seen in the background. I operated under the assumption that the round rock walls were pseudo–habitat traps. Hence, I left a single opening in the base of the round rock structure for fish to enter. A door type device had been secured to place in front of the opening at first light of the following day to keep the fish from escaping. It was the premise of this experiment that the potential for habitat alone would lead to its success.

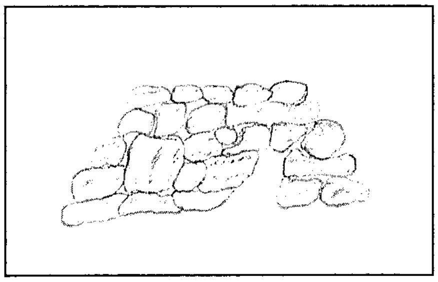

Figure 58. Profile of Trap 6.

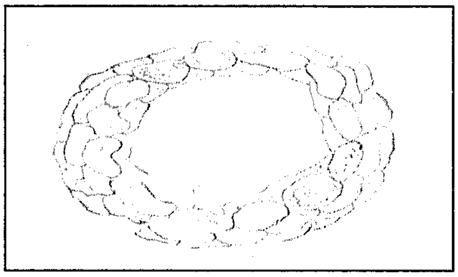

Figure 59. Plan View of Trap 6.

Similar features have been called fish traps by many different authors. Figure 61 illustrates one such "fish trap." Please notice the opening points upslope rather than downslope like the V-style traps.

Figure 60. A "fish trap" adapted from the Great Outdoors Palm Springs Chapter website presented on the World-wide-web.

The results of this experiment were thought provoking. Small wave action generated by boat traffic on Lake Mohave eroded the sand and gravel substrate directly in front of the trap. The trap did not remain functional throughout the night and the walls collapsed. The primarily result of this experiment was the realization that these structures would not served as pseudo habitat traps and if they were indeed fish traps, they operated in another capacity. Most likely, however, is the idea these were house rings and their association with groups of fish traps can be explained by the availability of building materials. If the rock rings were used as live wells to contain fish until the fishers were ready to process them, there would have been no break in the rock wall, which would allow fish to escape.

Experiment number 6 was conducted on an alluvial fan. A single fish trap was placed amongst the living and dead vegetation in the water. This trap was set up directly adjacent to five green sunfish (*Lepomis cyanellus*) spawning beds. This trap produced the largest quantity of fish yet captured. The reason for the large fish capture lays in the fact that predatory fish had come to that location to feed on eggs deposited by the green sunfish. Having a feeding agenda already in place predisposed the predators to consuming the bait within the waiting basket trap device.

Gobalet (2000:514-519) provides the numbers of fish elements recovered from 64 archeological sites in the Salton Basin. The vast majority (99 percent) of the elements were from two species; the bonytail and the razorback. The proportion of the two species varied from site to site, however, what did not vary is one species greatly out numbered the other in each site. If one is not careful it could seem supporting evidence for the egg feeding theory, however, as mentioned earlier, there are no observations of either bonytail at a razorback spawning location, or razorbacks at a bonytail spawning location.

The ratio of captured fish species from experiment 6 reflects the Myoma Dunes site on the shore of ancient Lake Cahuilla, and most of the bonytail/razorback ratios the archaeological sites mentioned by Gobalet (2000). At the Myoma Dunes site, the remains of bonytail outnumber those of the razorback suckers 16: 7. Whole finger-sized bonytail were recorded in 77 coprolites at this site. Juvenile bonytail will eat the eggs of spawning razorback suckers and other fish, however, due to the small size of the bonytail, the proposed brush trap method, used in the excavated holes in the talus slope discussed in Chapter 1 may have been employed to capture the small fish rather than a basket trap devise. Small weave seine nets were also used by Jonez and Sumner (1954: 171) to capture juvenile bonytail in the Colorado River. Support for a non-spawning period method for capturing juvenile bonytail comes from Jonez and Sumner (1954:140), where they state that during their observations of spawning bonytail, no young fish were in seen in a spawning group of 500 individuals in Lake Mohave.

The faunal report from the Indian Hill Rock Shelter shows that 106 bonytail bones and 12 razorback suckers bones were recovered (McDonald 1992:308-309). This fish bone ratio suggests the opportunistic feeding behavior of the bonytail made them more economically profitable to exploit during all seasons, whereas the razorback sucker is strictly a zooplankton (microscopic animal) feeder, making their capture difficult and infrequent except during the spawning period. The higher frequency of bonytail within the archaeological record of Lake Cahuilla can also be attributed to their predisposition to live in schools during most of their lives making even juvenile fish profitable targets for ancient fishers. Jonez et al. (1954) also observed bonytail in schools of approximately 10 fish during the non-spawning period in Lake Mead. Another technique that may have been used in Lake Cahuilla is the use of gill nets. Jonez et al. (1954) used a gill net in a two hour set on a bonytail spawning area to capture 42 males and 21 females. The Lake Mohave population in 1953 may or may not be reflective of that in Lake Cahuilla and would certainly reflect the stage of the maturation process in Lake Cahuilla.

Much more research needs to be conducted concerning the effectiveness of these types of traps on native fish species. Many of the traps could target different life stages of specific fish species. Therefore, much more attention needs to be focused on identifying the fish bones to the species level and include the fish size. This would illuminate human activities such as specific fishing technologies used during specific periods of the year to capture specific fish species.

As a result of these initial investigations, new opportunities have come to light. The first of these is the establishment of a subsurface component for some of the Lake Cahuilla fishing traps. This research changes the way we view fishing trap design by demonstrating that what is visible on the surface of some traps is not necessarily a correct representation of that trap's original design.

All of the results thus far indicated that another experiment needed to be conducted using stones in place of netting for walls. The final trap experiment was conducted on a flank of a vegetated alluvial fan. This location was midway between deep water and vegetative habitat used by fish. The final trap resembled but little the original V-style features found on the ancient shorelines. The step angle of the substrate dictated a shorter trap; however, at this time it was believed the length of the walls played a critical role in maximizing the number of fish captured. As much wall length as possible was maintained by changing the shape somewhat to fit the contour of the substrate. Figure 62 illustrates the profile of the final trap and Figure 64 provides a plan view of the trap.

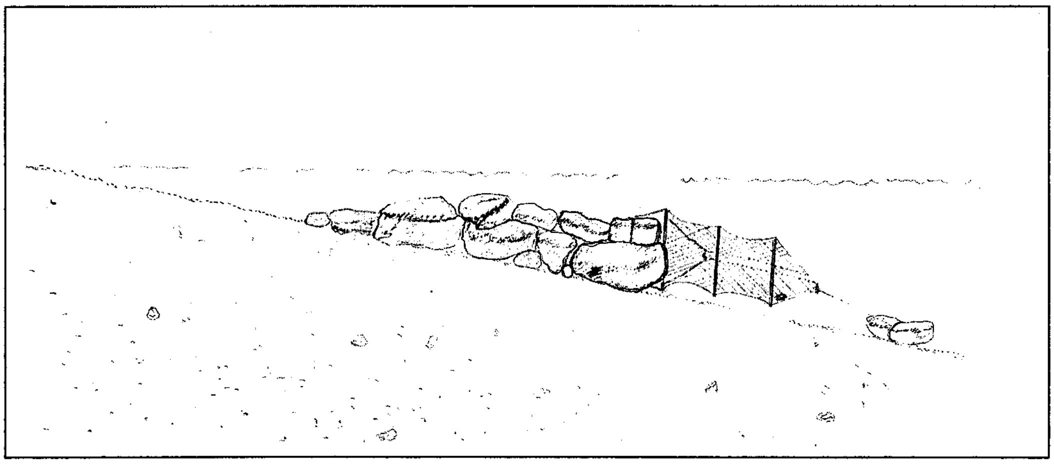

Figure 61 demonstrates the profile of the last experimental trap.

The rope tied to the bush is securing the entrance end of the basket trap device.

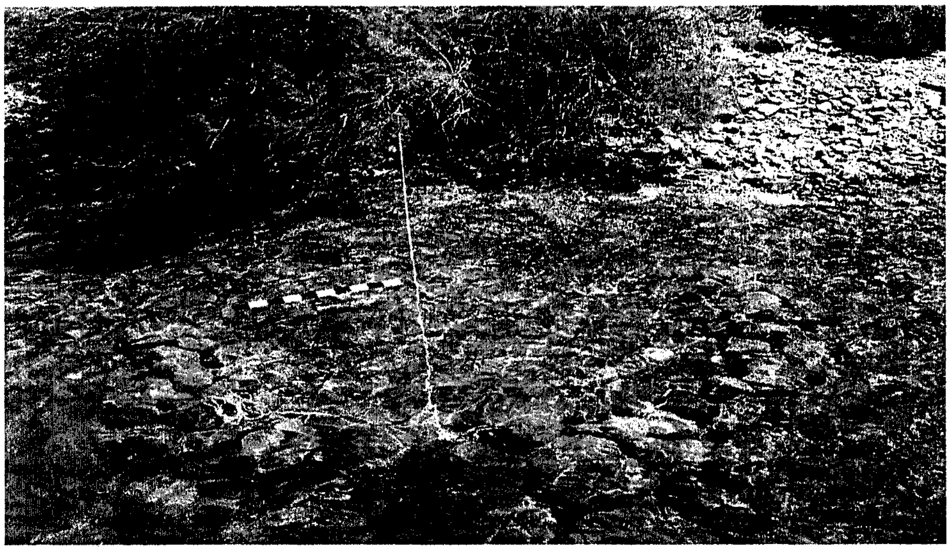

Figure 62. The final fish trap experiment

During this last experiment, the walls of this trap were built to reach the surface of the water. By the time I returned the next day to check the contents of the basket trap device, the lake level had increased 20.3 vertical centimeters. As with the last experiment, ground corn was placed on the floor between the trap walls. This worked in conjunction with the shape of the trap walls to direct fish to the opening in the basket trap device. The results of this portion of the experiment suggested the height of the rock walls was insignificant, as it was the shape and bait within the walls that directed the fish into the basket trap devise. There was no need to block fish access to or from the outside of the trap.

An additional variable in this experiment was the baiting method Stewart (1957) recorded. This was a "bait ball" used by the Mojave Tribe and this technique proved astoundingly successful. Stewart did not provide the amounts of necessary ingredients, but these results suggest my estimate is close to acceptable. The Mojave bait ball technique began with a fist sized amount of very rich clay, secured from Eldorado Wash (near the fish trap deployment area).The clay ball absorbed three times its own volume of ground roasted corn and still retained its structural integrity. I allowed the ball to dry to the consistency of wet shoe leather. If the ball is deployed when too wet, it would dissolve too quickly and if too dry, it would crumble as soon as it came in contact with the water. The bait ball was allowed to slowly dry in a Tupperware™ container with the lid slightly ajar (24 hours).

Upon fully opening the Tupperware™ container, an incredibly strong aroma indicated the corn in the bait ball had begun to ferment. This was placed in the basket trap with almost magical results. Several ounces of ground roasted (unfermented) corn was placed on the floor of the stone walled trap, but the fish were no doubt attracted by the stronger aroma of the fermented corn bait ball placed in the basket trap device. If the fish followed the direction of the converging walls, they would become aware of the opening in the basket trap device located in the apex.

This single deployment produced the largest amount of fish (20-25 lbs) captured in any of the Lake Cahuilla fish trap replications thus far. It was not clear from these experiments if the people emptying the basket traps of fish were the same people processing the fish if this catch represents anything similar to those on Lake Cahuilla. The number of traps (8) recorded in this area on the receding beach line and their total high yield potential (200 lbs a day or more) suggests that the majority of the fish may have been transported elsewhere for consumption if all the traps were filled each day to capacity.

Taking a step back in time, early Euro American settlers describe the Colorado as "too thick to drink and too thin to plow," illustrating the water clarity was extremely poor. How ingenious is it then to invent bait that advertises its presence by an attractive pungent aroma? It is very thought provoking that the Colorado River was the only recorded location where this bait was recorded. The effective nature of this bait would surely travel across cultural boundaries, as today it is common knowledge that very aromatic bait attracts catfish, whether they swim in the Nile River of Egypt or in the Columbia River of the western United States. It seems logical then to suggest that this bait was known to many people in the Colorado River and Desert regions and perhaps beyond. It seems clear judging by these experiments that bait was an integral component of the fish traps. The initial traps were deployed for two days without bait with no real results. Later experiments consistently produced fish with escalating results with the use of bait.

Another similarity between the Colorado River and the Nile River may lie in preservation of food. As noted earlier, the people living in the Colorado Desert and River regions did little to preserve fish. This may be due to the dermestid beetle infestation. These beetles were very common in the American Southwest and in the Nile River region. More research needs to be conducted in this area as well.

Subsistence Patterns

During the survey component of this study, 19 fish traps were recorded on what appeared to be a single shoreline. A laser builder's level was used to plot the fish traps in an elevational sequence. The elevations were taken from the divergent end of the fish traps, on the most recent substrate. Varying amounts of eolian or sheet-wash sediments were displaced in order to expose the substrate surfaces within the traps. At this time, Ms. Andrews identified the association of a house ring 60 meters upslope from the upper fish trap complex. An association between groups of fish traps and round rock enclosures was also noted by Apple et al. (1997:3-12).

The upper house ring was photographed, but not recorded with a GPS unit. Therefore, an approximate location has been placed on the map to better visualize the relationship of these two types of features. Figure 63 shows the distribution of traps and house circles. The house circles are represented by the word "circle." The spatial distance between the two structure types can be better understood if examined in the context of not disturbing the fish and fish trap interaction.

For example, while conducting the first fish trap experiments in modern Lake Mohave, I observed the razorback suckers becoming "edgy" when footsteps dislodged stone on the shore twenty meters away. The noise was detectable by the fish quite easily at that distance. Therefore, I believe the houses and the traps had an appropriate expanse between them.

Additionally, the results of this survey suggest that fishing activities took place during a three month period of time at the site. This period of three months coincides with the spawning period of the razorback sucker (Bureau of Reclamation data). Reuse of Lake Cahuilla fishing structures also became apparent during this survey. The active coexistence of these two types of structures could not have occurred simultaneously. It seems logical that the house rings were built upslope from the lower group of active fish traps, and were constructed from materials used to build fish traps during the previous year. The two groups of fish traps are located approximately 1.8 vertical meters from each other, which is in line with what Wilke (1978) indicated about the yearly rescission of Lake Cahuilla. Both sets of fish traps were associated with at least one house ring. Unfortunately, time constraints prevented the lower group of fish traps from being completely recorded. Another point of interest is both years' house rings appear to have been built to the south east of their particular group of fish traps. The significance of this was not examined in this study.

With the use of a laser level or another similar instrument, it is possible to get a rough idea of how many fish traps were deployed during the latest inundation at any particular level. Currently work is being done by ASM Affiliates in California to determine the amount of calories each fish possessed. With this information it might have be possible to estimate the number of people that could have occupied the ancient shores during the spawning period. However, many of these fish traps were destroyed to make room for modern agriculture and other activities. It is distressing to contemplate the amount of untapped information which was lost when these traps were destroyed. Figure 68 represents only a small portion of the ancient lake.

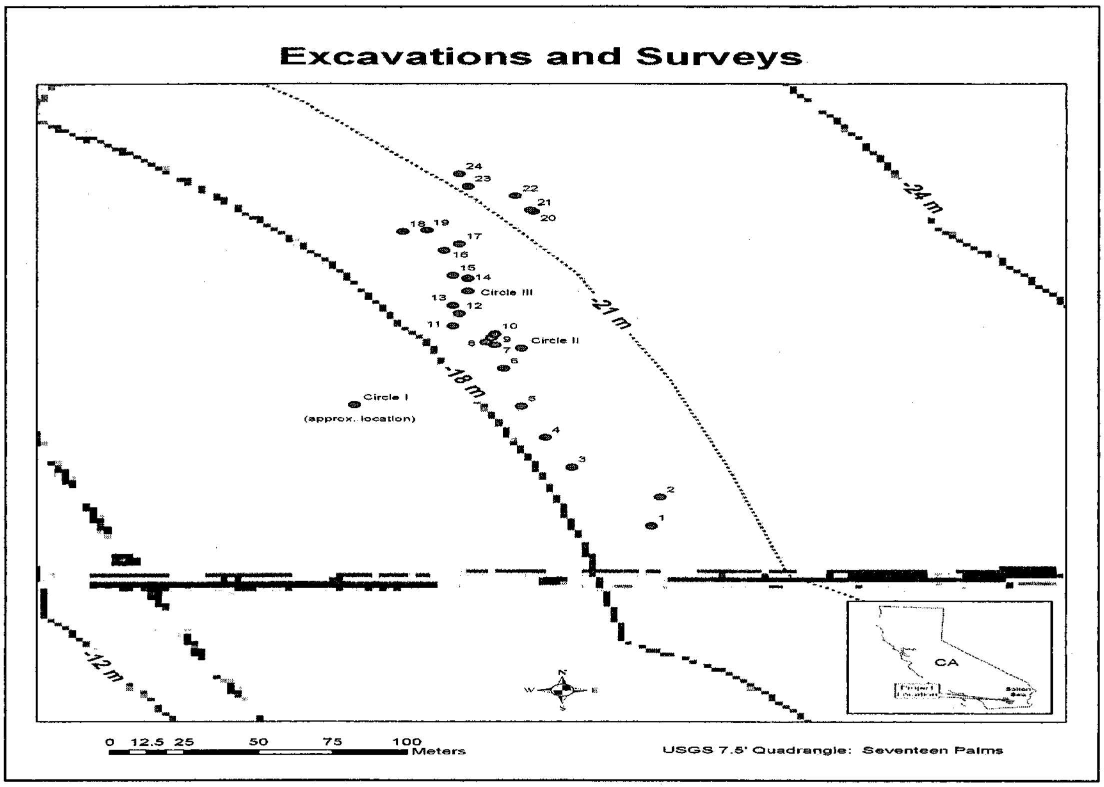

Figure 63 shows the location of house rings and fish traps

Research Questions

In this section, I address questions posed at the beginning of the thesis, using data gathered during my experiments and fieldwork.

- How did the V-style fish traps function? What were the working components of the traps?

My research demonstrates one possible manner in which the Lake Cahuilla V-style trap may have functioned. I believe there are design similarities between modern commercial fish traps and the traps found on the ancient shore lines of Lake Cahuilla. The function of the stone fish traps appears to have moved fish in a general direction rather than force them into a holding device as modern traps do. Modern traps use nets that reach the surface of the water and block the fish's exit from the trap. My research demonstrates that the stone walls did not need to reach the surface of the water in order to be effective. The natural thigmotaxic response of the fish (a need to touch something) and the shape of the stone alignments on the substrate direct the fish towards the apex of the trap. As mentioned earlier, the consistently sized openings in the apex of the traps suggests that a standardized basket trap (which was probably baited) was placed there to collect fish.

In my later experiments, I sprinkled corn on the floor of the fish trap as Ruppert (1976: 22-23) describes the Mojave doing with pumpkin seeds in their river traps. This would attract the fish to the vicinity of the fish trap and eventually to the basket trap in the apex. My final experiments used the Mojave bait ball described by Stewart (1957) in the basket trap. The rock walls may have offered cover to the feeding fish within them, which may have been an additional attraction to them. These components may not be a complete list of those used by the ancient Cahuilla fishers, however, they were sufficient to capture large quantities of fish in Lake Mohave.

- How many traps were operated at one time?

To address the number of traps deployed at one time, I used a laser level to record the elevation of all of the fish traps in the research area. The traps varied in elevation, but with the fluctuation in lake elevation during the last experiment, it certainly seemed of no particular consequence to have a variety of wall heights, none of which reached the surface of the water. The final experiment showed that trap walls merely indicated a direction for the fish to move while they were seeking the bait in the basket trap devise; it is not necessary for them to reach the surface of the water to make the trap effective.

With the laser level it was possible to put the traps into a relative chronology. The overall height difference between the highest and lowest trap was 41 centimeters.

Using Waters (1983) calculations of lake's recession, a 45 centimeter drop in elevation was proposed for a three month period (15 centimeters per month). Given the variance in actual evaporation rates, the difference of four centimeters is negligible. Also, this period of three months just happens to coincide with the length of the spawning period for the razorback sucker (Bureau of Reclamation information).

By cross referencing archaeological data (number of traps) with the biological data (the length of the spawning period), and the hydro-data (evaporation rates), it is possible to examine the suggested scenario and determine if it is feasible or not. According to this research eight traps, were constructed during the first and second month, while only three were built during the third month. If these calculations are correct, the final month was comparatively unproductive, as the fish began dispersing back into the lacustrine environment. I believe this is a correct model because modern observations correlate the dispersal of the razor back sucker back into the environment during the third month.

Chart 1 illustrates this three month period and demonstrates the total number of traps used during each month's fishing activities.

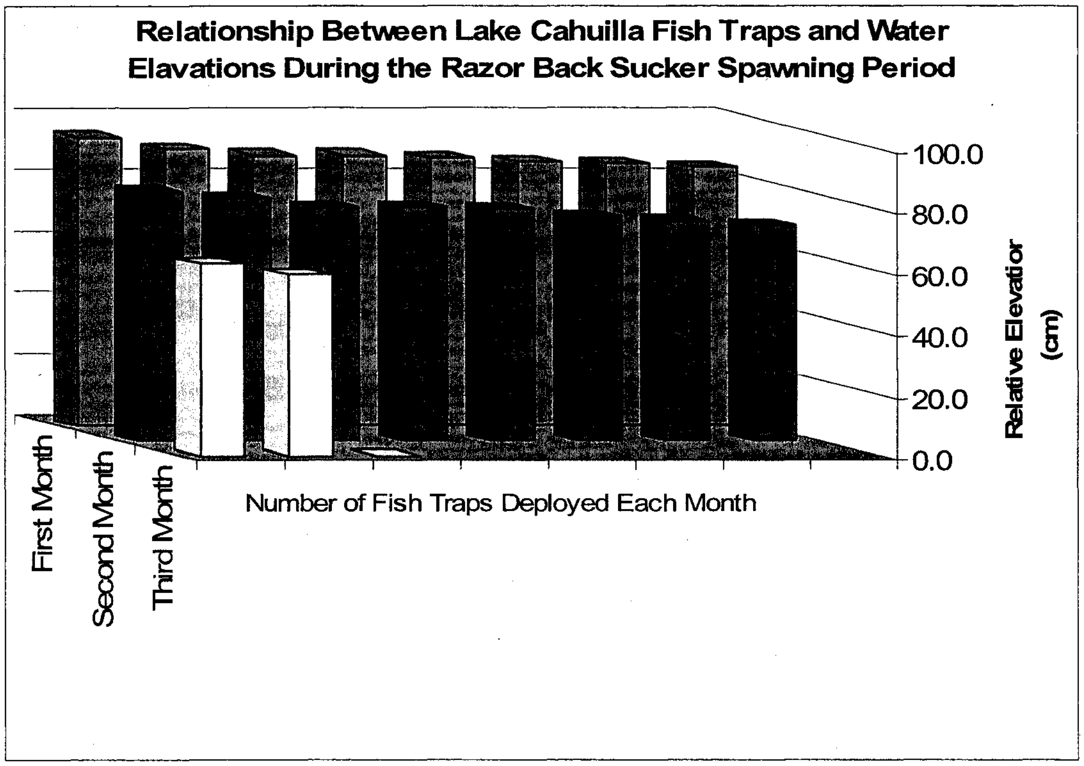

Chart 1

- Were the traps operated only during the seasonal spawning cycle?

As mentioned earlier, some of the traps may have been operated during non-spawning periods; several designs have not been researched. The traps excavated into the talus slope appear to have been a different type than the V-style trap, which is the target of this research. Figure 24 in Chapter 5 illustrates these pits and provides a discussion. My research indicates that the V-style trap was capable of capturing fish during any season; however, a large segment of the archaeological record at Lake Cahuilla should be consulted to determine if V-style traps occur only in groups at 1.8 meter intervals or if they are also found during the interim between intervals. My research was restricted to a small segment of the ancient shoreline. If the traps only occur at 1.8 meter intervals then it is safe to assume they were only operated during the spawning season. If they occur in the interim, they probably functioned as feeding traps. If this is the case, they may have functioned during the spawning period as feeding traps for scavenging fish species and therefore not directed at the spawning fish species.

Gastropods from four fish traps, three of which were built adjacent to one another, and charcoal recovered from them were selected for radiocarbon dates. The dates did not correlate with the traps that appeared to be on the same annual beach line. The dates came back spread over a 1,000 year period, illustrating the time lag inherent when snails accumulate older carbonate from a lacustrine setting. It is also possible that the traps that appear to have functioned at the same time were built during a separate inundation period. More research is needed to identify a method for accurately establishing a fish trap chronology.

Chart 2 illustrates the spread of dates from snails gathered from the substrate directly under four fish traps. A charcoal date appears to coincide with one fish trap date, however, the trap and the recovered charcoal are from traps that were not adjacent to one another, nor on the same annual beach line.

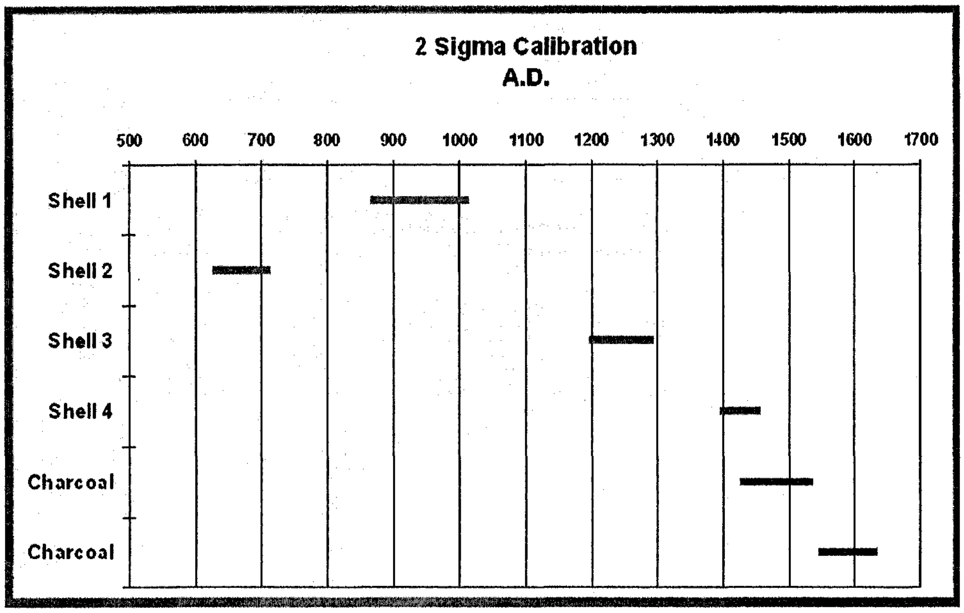

Chart 2

In addition to the stone traps we find left behind by the ancient fishers, any number of other on-the-spot strategies may have been used on the ancient shores. Families or groups of people who fished in a specific area for several decades may have used several unknown techniques to capture fish. The majority of these opportunistic technologies may never be identified.

- How many people were required to construct and operate a trap?

During the initial experiments, two people were required to build the traps for a period of two hours per trap. Later as the design was refined, the number of people was cut in half, as was the time requirement. By the time phragmities was used for net floats, it only required one person half an hour to set up a trap. This time frame remained the same in the final experiment when the trap walls were built from stones.

Without knowing the number of fish captured in the ancient traps it is impossible to speculate on the number of people required to operate a given number of fish traps. It is even impossible to accurately speculate on the species of fish actually captured in the traps. What we do know is the razorback sucker and the bonytail both have an extended spawning period, so it is likely that the fish spawning at this location were one of these two species.

- Could these activities have been carried out by a single nuclear family?

Certainly a single nuclear family could have operated eight traps at one time. Evidence found at the research area suggests a whole family was present as the grinding equipment and the miniature trap indicate.

Unique Technology

A distinctive trap (Trap 23) appears to have been used for an entire three month spawning period. This is unique because the majority of the traps are single event constructions. This trap appears to have been added onto twice. Trap 23 also had a number of possible components, including a smaller trap directly adjacent to the main one, and a round feature, which may have functioned as a holding pen for captured fish. The size of the stones in the small trap suggested this may have functioned as a learning tool, perhaps for a child.

The upper half of Figure 65 is a plan view of Trap 23, and the lower half is a profile view illustrating how the trap may have worked over the course of three months. Remodeling of the trap seems apparent. Piles of stones lay in the place of rock alignments, suggesting further modifications may have been planned for, but never completed.

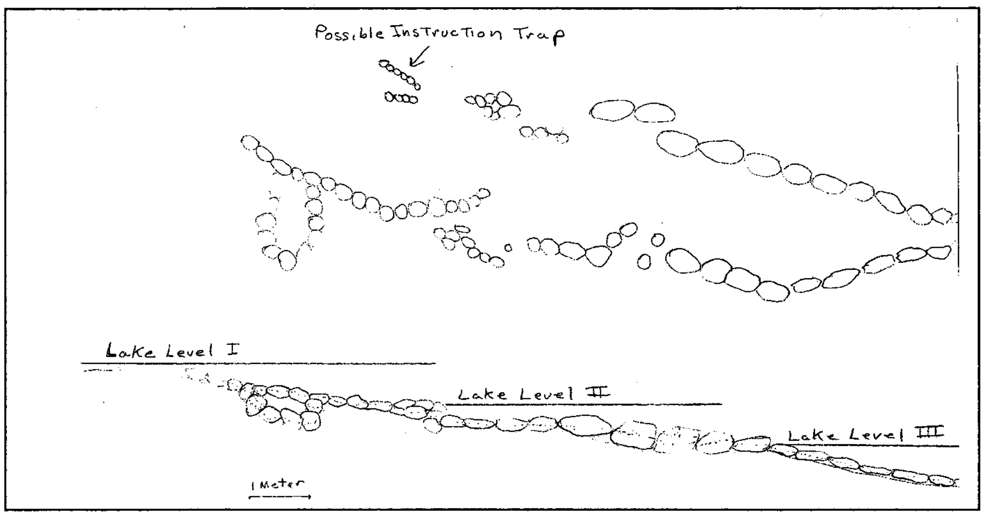

Figure 64 illustrates the plan view, profile, and possible chronology of trap 23.

Traps 9 and 10 were also similarly conjoined, but these two traps only show a two month correlation. If these calculations are correct, the final month was comparatively unproductive anyway, as the fish began dispersing back into the lacustrine environment.

It is important to remember that any time a small new lake is created, the nutrients within the sediments generate a massive bio- bloom that results in an elevated fish population during the first two years (Reclamation data 2007). In the case of Lake Cahuilla, however, the bio-bloom may have lasted considerably longer, perhaps as long as 30-40 years. This extended bio-bloom would have been an artifact of the sheer size of the forming lake and the amount of nutrients locked up in the soil the new lake inundated. To a lesser degree a similar yearly cycle occurs in lakes whose level changes with the season. As the water is drawn down during the summer months, the bio-mass decreases, and with the spring and the influx of new water, the bio-mass increases.

Evidence for a bio-bloom is supported in the most recent infilling of the Salton Sea. The Salton Basin began filling as a result of a massive snow melt in the Rocky Mountains and heavy local rains in the Lower Colorado River region after being dry since 1700 A.D. This flood occurred in 1905, and by 1915 a commercial fishery for striped mullet existed on the Salton Sea, which lasted until 1921 when fishing activities decimated the fish population. The California Department of Fish and Game restocked striped mullet in the Salton Sea and a commercial fishery was reestablished between the years of 1943 and 1953.

Distinguishing between fish traps built on a new lakeshore and those built on a mature lakeshore is extremely important for extrapolating the human carrying capacity of the region. Again, much more research needs to be conducted while we are still able to validate our investigative theories using the behavior of the native fish of the Colorado River and the fish trap designs still on the ancient substrate. Of the greatest import to this research is the ability to use fish behavior to explain human activities, which took place on the shores of Lake Cahuilla.

Issues surrounding the technological origins of the stone walled fish traps from the shores of Lake Cahuilla cannot be resolved here, and they may never be resolved. What seems pertinent to fish trap origin is the extremely soft and fine sediments found in the valleys of the Colorado River. Additionally, the constant meandering of the water course would either devour, bury, or leave behind any permanent traps. The great amount of weight that would be produced by the stone fish traps would surely cause them to sink into the fine sediments, not to mention the calorie cost of transporting stones from the upper river terraces to the flood plains. These physical limitations appear to be reflected in the ethnographies record, as most of the traps were built from local wood like willow or were nets that could be moved when the river flooded annually. The development of stone walled Lake Cahuilla technology may have occurred in place. Other technologies may reflect other groups who came to the lake to fish.

The excavation method described here appears thus far to be appropriate as it leaves most of the trap intact for future methodological innovations. By beginning excavations from the apex, it is possible to secure a good soil profile if done early enough in the year before regional temperatures remove the ground moisture. Continued pursuit of basket trap or netting material in the apex of these traps may yet produce the concrete evidence we seek.

As to the use of fire and fishing, currently we know that the bonytail specifically, and the razorback sucker during some portions of their lives are negatively phototacic (light repels them). Therefore it seems likely that the torches could have been used as a means of light in order to work at night while the summer temperatures are somewhat reduced on the Colorado River. Any use of fire at Lake Cahuilla may have been to warm the fishers as they emptied the basket traps of fish, rebaited them, and replaced them back into the cold wintry waters during the daylight hours. Excessive human activity (noise) could cause the fish to leave the area until it subsides.

This research assumes that a standardized basket trap was placed in the apex of each v-shaped stone trap. Lake Cahuilla researchers suggested this idea as the apex openings of the V-style traps consistently measure between 20 and 40 centimeters, most often between 30 and 40 centimeters. It is worth noting here that every fishing culture around the world has some sort of basket trap device.

Without intimate foreknowledge of fish behavior, humans could not plan profitable subsistence strategies. This research strongly suggests that humans took advantage of fish behavior in order to capture them. It also provides a small insight into the relationship both fish and humans had with the ancient Lake Cahuilla environment.

Now that a few possible scenarios have been suggested as a result of considering the biological needs of the fish, it is possible to get a clearer view of prehistoric human life on these ancient shores. This research has merely opened doors to innumerable questions surrounding the functions of Lake Cahuilla fish traps and the people who invented them.

Conclusions

For this thesis, I used ancient fish trap design in concert with fish behavior, ethnographic data, and experimental archaeology to explain the working mechanisms of Lake Cahuilla fish traps. As a result of these experiments and excavations, some of the practices used by the Colorado Desert People became much clearer. By understanding more of the conditions and opportunities that existed in the world of these ancient peoples, it is possible to better understand their subsistence options and reconstruct past behavior.

Ancient Lake Cahuilla is situated in southern California and occupied the same location as the modern Salton Sea. Lake Cahuilla; however, it was six times the size of the Salton Sea and fluctuated in elevation, often evaporating completely for short periods of time. The lake was 160 kilometers long and 56 kilometers wide, making it one of the largest lakes on the west coast.

The archaeological record provides us with only incomplete remains of fish traps and bits and pieces of information are stored in the ethnographic record. It was necessary to use biology to complete this research into the mechanical functions of the fish traps to better understand how the traps were used. Many people came to the alluvial shores of Lake Cahuilla each year to fish during the native fishes' spawning periods. Rows of fish traps occur at 1.8 meter horizontal intervals along the ancient shore. This spacing corresponds to the amount of evaporation that occurred in Lake Cahuilla in a one year period. Each time the lake recharged after a period of desiccation a biological bloom occurred, which caused elevated fish population. In turn this raised fish population may have supported more humans than the region could have done normally.

The majority of the fish species in the Colorado River (75%) do not exist elsewhere in the world. These fish species are all bottom oriented. The largest predator in Lake Cahuilla was the Colorado River pike minnow. This fish reaches lengths of over 180 cm, weights of up to 45 kg, and is the largest member of the minnow family in the world. When this fish became entangled in prehistoric fishing nets, it was removed quickly as it could do great damage in a short time. Prehistoric fishing nets were valuable; they took two to three months to construct. Consequently, fishing methods for this species may have been confined to capture when the backwaters of the Colorado River began to recede. Excavations at Catclaw Cave on modern Lake Mohave produced skeletal material from five members of this species suggesting that just such a backwater existed near the cave and was frequented by large pike minnows during annual periods of high water. This species did not reach the prolific numbers in Lake Cahuilla as did the other native fish species because it requires tributaries to spawn in, often traveling distances of 100 miles up such tributaries to reach spawning locations.

The bonytail chub is another species most frequently found in archaeological assemblages around Lake Cahuilla. This species is the most nocturnal of the species we have information for at this time. It is not large in size compared to other Colorado River species; adults reach a maximum length of 45 cm and weigh between 2 and 3 kg. Spawning populations of this species have been observed reaching 500 individuals. Juveniles of this species have been recovered from archaeological sites, suggesting that their schooling behavior made them economically profitable to exploit during times other than just the spawning period. This species can be taken with hook and line techniques.

The razorback sucker is the final fish species whose numbers have been identified often in archaeological sites around Lake Cahuilla. Currently we know more about this species than any other. This fish is semi-nocturnal until it reaches adulthood when it feeds predominantly during the dark hours on zooplankton, but can also be observed moving about during the day. It weighs between 4 and 7 kg and reached lengths of 60 cm. It is not readily taken using hook and line techniques. This species only congregates as adults during the spawning period making prehistoric exploitation difficult at other times of the year.

The number of traps built in one location tends to provide clues as to the number of fish that used the area to spawn. This area needs more experimentation to get an idea of the capturing ability of the traps during the spawning period. As the traps were generally constructed with a standard opening in the apex of 30-40 centimeters, researchers suggest that a basket trap device was placed there. Quite often a much larger stone will be found at or near the apex suggesting it was used to hold the wooden basket trap to the substrate. A great deal of time and effort was expended to build these traps, which may, but most likely would not be, reused during the following year. This suggests that the returns were great. Storage of the dried fish was not practiced because of the presence of dermestid beetles who will consume dried meat.

As part of this research, experiments were done to determine how the traps were used. The Lake Cahuilla fish traps bear a close resemblance to those used by modern commercial fisheries. Therefore, Dr. Jerry Schaefer and I chose to incorporate nets as a component of the first trap experiment. This supposition was supported by the ethnographic record. The Cahuilla and all of the River Yuman tribes used fishing nets as a regular part of their fishing technology. Interestingly, the Washoe Tribe of western Nevada used the same nets for hunting and fishing, suggesting that other groups could have journeyed to the ancient shores during difficult times and fished with little additional effort expended in creating a fishing technology.

The V-style traps that were the primary focus of this research appear to be a less complex version of the modern commercial fish trap. In our first experiment we used wooden stakes to deploy the nets, as per the ethnographic record for the Colorado River. This had very limited success as the alluvial substrate contained a great number of large stones that either stopped the stakes or broke them while they were being driven. We completed the experiment using steel stakes; however, no bait was placed in the basket trap. The initial traps made the fish edgy. It may have been the netting protruding above the water's surface or the smell of the steel stakes that caused the unease. In any event, fish swam into the traps and then swam out without gaining access to the basket trap device located in the apex. Our version the fish trap failed to catch any fish.

The ethnographic record states that people herded fish into the fish traps, and then placed a rock in the apex hole to prevent them from escaping. Our initial experience seemed to support this statement, as the fish tolerated our presence as close as 10 meters from them. The herding statement proved to be erroneous, however. When we tried to herd fish into the trap, our efforts were rewarded by fish scattering in all directions and eventually going into deep water, away from the fish trap. Had the prehistoric fisherman/herders been using a net to encircle and direct the preoccupied/spawning fish into a trap, the scenario may have been plausible. The ethnographic record only states that people herded fish into a "trap." Additionally, my experiments show clearly that the above mentioned traps had no method of containing fish without a basket trap device.

I spent several days observing the spawning razorback suckers prior to constructing the fish traps. The females spawn with several males at a time and this occurs in all of the spawning locations around the lake. Fish travel from location to location producing the maximum genetic diversity and the best chance of reproductive success. During these observations I noticed the females running more or less without direction from suitors when the number of suitors became too many. I thought perhaps this was the behavioral principal behind the V-style trap. Perhaps the female would see the trap and especially the basket trap as a place to hide from the pursuing males. Much more research is needed in this area.

With the failure of our version of the Lake Cahuilla fish trap, it was clear that a paradigm shift was in order. We were allowed to set up at the tail end of the razorback spawning period, so we had no clear observations of the interaction between a complete population of spawning fish and our version of the Lake Cahuilla fish traps. The focus of my experiments thus changed from a spawning to a feeding approach.

During these first experiments carp were observed eating the eggs of the razorback sucker as soon as they were deposited. This being the case, I thought that the traps may have been deployed not to capture fish that had come to the area to spawn, but to capture fish that came to feed on the eggs of the spawning fish. This seemed a plausible deduction, as the spawning fish do not appear to be interested in feeding while they are engaged in reproductive activities. However, the only recorded observation of a spawning native population of razorbacks and bonytail does not mention razorbacks present at the bonytail spawning area nor does it mention bonytail present at the razorback spawning area. Either this behavior did not happen, or the observers did not think it important enough to mention at the time. In any case, there is evidence to indicate egg scavenging occurs regularly between fish species.

I then further examined the ethnographic record and found references to phragmities net floats and fish bait. Subsequent fish trap simulations were done that included the use of bait and net floats made from phragmities. The net floats had a distinct effect on the nets. They seemed to act more naturally, very similar to aquatic vegetation that moved with the motion of the water. The nets no longer protruded above the water, which is where many natural threats to the fish come from. Rock alignments were used to hold the block nets to the substrate forming a barrier that diverted fish to the mouth of the basket trap. Feeding experiments were also conducted on both bonytail and razorbacks at the Willow Beach National Fish Hatchery. The outcome was quiet clear;

the fish preferred ground seed corn to ground squash and pumpkin seeds, all of which are mentioned as bait in the ethnographic record. The ground corn and the net floats facilitated a consistent capture of fish from that point forward.

Experiments were conducted in many different habitat settings. The new traps consistently captured fish. I then set up an experiment on an alluvial fan, which is similar to the setting for fish trap deployment along Lake Cahuilla. This particular location had vegetation growing in and above the waterline due to lake level fluctuations. My next trap experiment was set up near a number of green sunfish beds. In this experiment, I sprinkled ground corn on the floor of the trap as per the ethnographic record for the Colorado River. This trap produced three very large carp and one green sunfish (approximately 15 pounds of fish). This strengthened the idea that the Lake Cahuilla traps were aimed at scavenging fish rather than those who had come to spawn.

Using data gathered form these initial experiments, I then examined other recorded rock alignments found in archaeological site records for Lake Cahuilla. Numerous round alignments had been recorded. Noting that bonytail like underwater caves and the fact that the shape of these round rock alignments could suggest a cave-shaped trap, I constructed what I thought was a suitable replication of a round trap, measuring one meter across and slightly less than one meter high. While I was building it, a school of green sunfish moved into the trap. This predisposition to use this type of pseudo-habitat gave support to my theory. The replication was completed by covering the rock structure with a brush roof. Small wave action from boats and a storm during the night eroded a hole in the substrate directly in front of the trap, which caused the trap to tumble into the hole. A V-style trap built adjacent to the round structure survived intact and captured fish that same evening. The netting that made up the walls of the V-style trap allowed the waves to move through it without damaging it. This suggests that the round structures, if indeed they were fish traps were made of material that allowed the waves to pass through unencumbered.

The final experiment and the only one to use just rocks for wall material was conducted during a subsequent green sunfish spawning period. Rocks were piled up to the surface of the water and a basket trap device was placed in the apex. The trap was not placed adjacent to the spawning sunfish, but was located between habitats in an open setting. As per the ethnographic record and Dr. Schaefer's suggestion, I created a bait ball of clay and fermented corn, used by the Mojave Tribe.

After deploying the rock walled trap and the bait ball in the basket trap device, I left the trap overnight. Upon returning in the morning, the lake had risen eight inches, creating larger openings in the shore-side ends of the walls and allowing access/exit over the top of the walls. The catch produced by this trap was extremely large (25-30 pounds). The consequences of this experiment suggest that the walls do not need to reach the surface of the water to direct fish into the opening of the basket trap. The shape of the walls and the bait scattered on the floor of the trap facilitate the movement of fish toward the mouth of the basket trap and the waiting bait inside it. The bait ball was extremely effective at capturing fish and this technique was likely known by very pre-European group in the entire region who had a fishing technology.

After conducting the experiments, I was given permission to conduct the first-ever excavations of a Lake Cahuilla first trap on land slated for development in Salton City, California. Nineteen different V-style fish trap variations had been recorded from the same property and several of these were chosen for excavation. These excavations revealed the original size and configuration of the traps. By establishing a level line around the fish trap, I was able to estimate the original height of the traps.

By identifying a layer of gastropods directly under the trap, it was possible to determine the substrate that the traps rested on. A second substrate was identified 30 centimeters below the first. A different species of snail was recovered from this second substrate. This indicates that a different lacustrine environment existed. At this time, little is understood concerning the differences in these two environments. Radiocarbon dates from snail and charcoal suggest a time lag of approximately 900 years may be present at Lake Cahuilla; however, much more work is needed to compile a data base that will accurately identify the construction date of the traps.

Finally, I believe it is possible to see gender in the archaeological assemblage at Lake Cahuilla. We identified grinding equipment and pottery at fishing/house sites associated with the traps. Other lines of evidence include a mock or miniature fishing trap near a full sized fish trap, which suggests it may have been used for instruction. Thus, family groups, rather than task-specific groups, likely came to the lakeshore to fish.

By combining biology, ethnography, experimental archaeology, and excavation, this project has provided a more accurate and in depth picture of the lives of the people who fished along Lake Cahuilla. My experiments have shown that fish behavior influenced the way that these traps functioned, and prehistoric groups constructed their traps using their knowledge of fish behavior.

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