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# TO CATCH A FISH: SOME LIMITATIONS ON PREHISTORIC FISHING IN SOUTHERN CALIFORNIA WITH SPECIAL REFERENCE TO NATIVE PLANT FIBER FISHING LINE

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ABSTRACT.—Prehistoric marine fishing adaptations were limited by both environmental and technological factors which restrained the maritime cultures from expanding into all available fishing resources. For the Southern California prehistoric fishery, the strength of the natural plant fibers in manufactured fishing line was likely a major limiting factor. To test this hypothesis analyses of the characteristics related to catching available fish species, as well as an evaluation of the strength of naturally occurring plant fiber lines, were conducted.

RESUMEN.—Las adaptaciones durante la pesca prehistórica fueron limitadas por dos factores, ambiental y tecnológico, por lo que se restringieron las culturas marítimas y no se extendieron los recursos de la pesca. Con respecto a la pesca prehistórica en el Sur de California la fuerza de las plantas fibrosas que se usaban para manufacturar las lineas que se adaptaban a las cañas de pescar fueron el primordial factor para limitar la pesca. Se conducieron análisis y demonstraciones para analizar las especies de peces, así como la evaluación y la fuerza natural de estas plantas fibrosas.

RESUME.—Certains facteurs ressortissant de l'environnement et de la technologie ont impose des restrictions a l'adaptation prehistorique a la peche marine, empechant les cultures maritimes d'exploiter toutes les ressources disponibles dans le domaine de la peche. En Californie du Sud a l'epoque prehistorique l'un des problemes majeurs pour les activites de peche a probablement ete le degre de solidite des fibres vegetables naturelles servant a fabriquer des cannes a peche. La presente etude part de cette hypothese et comprend une analyse de la facon d'attraper les diverses especes de poisson qui se trouvaient la, ainsi qu'une evaluation de la resistance des cannes a peche faites de fibres naturelles.

## INTRODUCTION

A comprehensive understanding of the prehistoric marine fisheries along the Southern California Bight now combines the identification of contemporary fish habitats and ichthyofauna with traditional piscine osteological evidence excavated from prehistoric fishing villages or camps. These data have provided a basis for economic reconstruction of these prehistoric maritime communities, and their technical adaptation to ecological change (Bleitz-Sanburg 1987; Glassow 1987; Salls 1988). These analytical perspectives stress interpretations which are based more upon the archaeological and biological evidence than upon conflicting ethnohistoric accounts.

Ichthyofaunal studies over the last two decades have described a wide range of marine habitats along the Southern California Bight. Allen (1985) analyzed these studies and has suggested a Bight-wide synthesis of the fish-life assemblages by specific habitat type. These habitats are divided into two major classifications. The first group is made up of the rock-substrate habitats which include: Rocky Intertidal (IT), Shallow Rock Reefs (SRRF), Deep Rock Reefs (RRF), and the Kelp Bed environment (KB). The second classification consists mostly of soft substrate environments. They are categorized as Bay and Estuary (BE), Open Coast Sandy Beach (OC), Nearshore Soft Bottom (NSB), Midwater (MW), and Off-Shore Pelagic (OP) (Allen 1985:133). These marine habitats are generally referred to as nearshore environments, in contrast with offshore environments where light does not penetrate to the substrate and water depths are greater than 61 m (200 ft).

I have analyzed the fish remains and the nearshore marine habitats of numerous coastal archaeological sites along the southern portion of the Bight (Fig. 1). These studies included underwater surveys of the marine habitat and observation of the fish species living in the area. This study incorporated Allen's (1985) habitat classification and utilized several ichthyologists and marine biologists

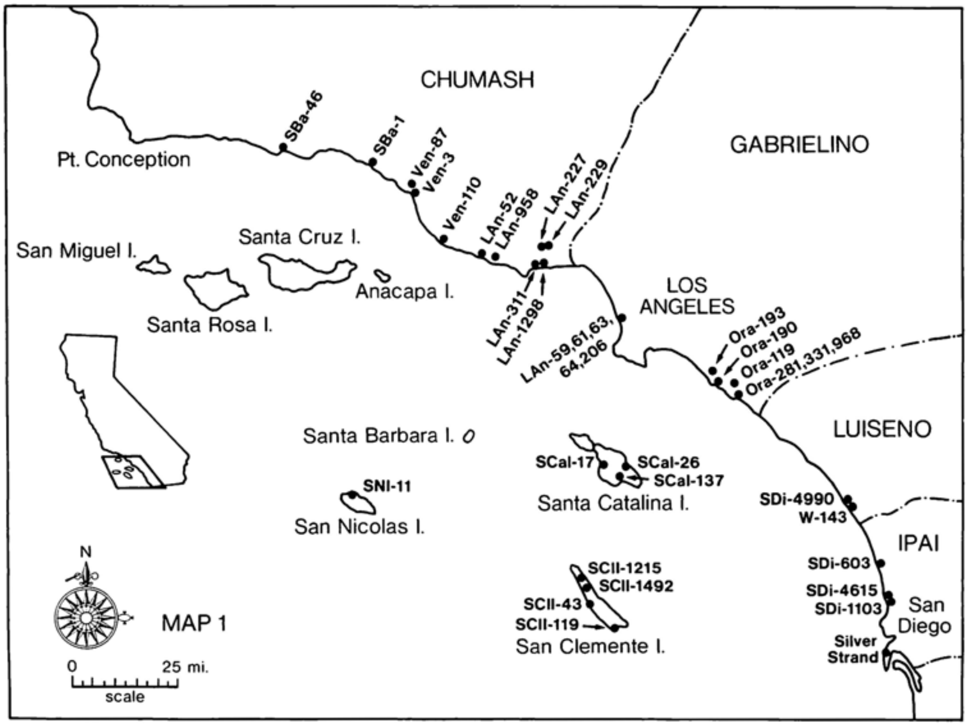


FIG. 1. Map of the Southern California Bight with site locations discussed in the text.

to determine species clusters by habitat type. The fish clusters (as evidenced by identified fish elements) in the prehistoric middens were quite similar to the modern clusters.

The archaeological evidence from these sites indicates that nearshore habitat exploitation was the predominant fishing strategy. The Eel Point site (SCII-43) provides one of the best examples of the expanding nearshore fishery. A large site, approximately four acres in extent, SCII-43 provides a chronological midden sequence from 4-5 m in depth which is undisturbed due to the absence of burrowing rodents or other forms of bioturbation on the island. A series of radiocarbon dates ranging between 9,775 + 165 years and 1050 ± 25 years B.P. are recorded for the site (Salls 1988:359-372). this nearshore fishery apparently began even earlier than 9,775 B.P., since fish elements have been recovered in a sequence extending a meter below the dated cultural strata. The lowermost stratum contained evidence that the fishermen were fishing from the shore because intertidal species were the only species present in the fish faunal assemblage. As one progresses through the faunal assemblages collected in the subsequent strata, additional SRRF and KB fishes begin to appear. In the late levels RRF species were added to the range of species clusters present in the midden.

The SRRF and KB species appear in the late levels of Eel Point locus B (SCII-43B) at about 6,000 B.P., but are not abundant. with the appearance of the single-piece shell fishhook (4500 ± 350 years B.P., UCLA-2574) these species and a few RRF fishes begin to appear more frequently in the ascending strata. By 3150 years B.P. (UCLA-2757H) during the early phase of Eel Point locus C (SCII-43C), there is a sudden explostion in the numbers of identified fish species as well as a seven-fold increase in fishing as indicated in the volume of fish bone per cubic meter (Fig. 2). It could be argued that some of this increase may be due to differential preservation. The validity of this argument is somewhat reduced because the high pH value of the Eel Point shell dune has promoted excellent preservation of the midden constituents. For example, it is difficult to distinguish differences in preservation between abalone (*Haliotis* sp.) shells from the 9,000 year-B.P.-level and those of the 1050 year-B.P.-level. Radiocarbon dating of each level, therefore, is required for these distinctions. Although the catch increased over time at Eel Point, the prehistoric fishery remained a nearshore adaptation despite the islands favorable location as a potential tuna fishery (Holder 1910:143).

A review of the Southern California Bight archaeological literature, pertaining to fish bone analysis (Table 1) indicates that the preponderance of identified species from most sites were also from nearshore environments (Bleitz-Sanburg 1985; Fitch 1969, 1975; Follett 1963a, 1963b, 1966, 1976; Huddleston & Barker 1978; Johnson 1982; Peterson 1984; Roeder 1977, 1986, 1987; Salls 1988). Investigations into the prehistoric utilization of avian species on San Nicolas Island also supports nearshore fishing. The avian remains from the Thousand Springs site (SNI-11) indicate that the birds were opportunistic by-products of nearshore kelp bed fishing activities (Bleitz-Sanburg 1987:298).

The fact that open-water or mid-channel fishing is poorly represented in the archaeological record is not surprising if one considers the biological abundance quotient for near shore and off shore areas. The nearshore marine

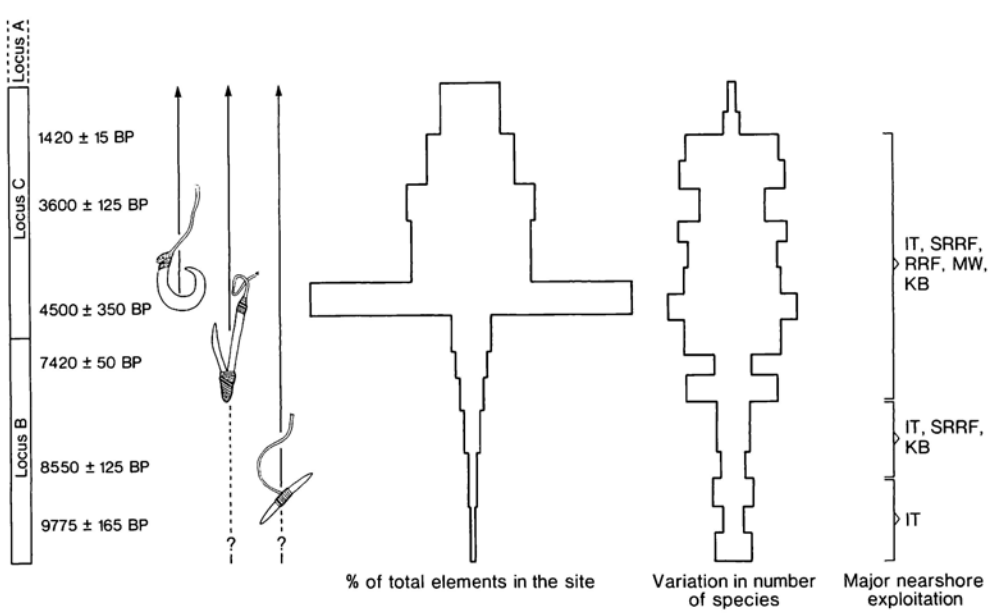


FIG. 2. Technology and nearshore fisheries at Eel Point, San Clemente Island, California. (IT = Intertidal, KB = Kelpbed, SRRF = Shallow Rocky Reef, MW = Mid Water, RRF = Deep Rock Reef).

environments have abundant sunlight for plant and animal life and there is natural cover for protection from predators. The archaeological predominance of nearshore varieties may, therefore, be due to their availability and dependability as a resource.

The open water channel on the other hand lacks these life-giving constants. Channel species depend upon plankton as the basis of the food chain. Individual survival is enhanced by protective schooling behavior, as demonstrated by large shoals of pelagic fish. However, plankton and pelagic fish are always transient and undependable food sources (Clemens 1961:35). The dependence upon such resources would require equipment that is able to remain at sea for many months, which was not possible for the aboriginal watercraft (Landberg 1975). Although some of the medium-sized pelagic fish such as albacore *(Thunnus alalunga)* and skipjack *(Euthynnus pelamis)* were present in a few of the sites investigated, their bone elements were always of extremely low frequency and of small size. These pelagic species often enter the Midwater habitat (MW) just outside the kelp beds and along Deep Rocky Reefs (RF) in pursuit of sardines *(Sardinops sagax)* and anchovies *(Engraulis mordax)*.

Increases in small pelagic fishes such as sardines, anchovies, mackerel *(Scomber japonicus)*, and bonito *(Sarda chiliensis)* noted in the diet of Southern California coastal Indians from the intermediate Period (3500 years B.P.) to AD 1800 was not an indication of a new pelagic fishery. These same species, although less abundant, are evident in earlier sites as well (Table 2). Underwater surveys suggest that these species are abundant in MW, and OC habitats as well as along the outer fringes of the kelp forest. In fact, anchovies *(Engraulis mordax)*, sardines *(Sardinops sagax)*, grunion *(Leuresthes tenuis)*, jacksmelt *(Atherinopsis californiensis)*, and topsmelt *(Atherinops affins)* were all observed in Open Coast Sandy Beach (OC) habitats in the crests of waves and along the outer edge of the kelp in vast schools during the underwater surveys. This suggests that nets could be used by shore or tule balsa (reed boat) fishermen to obtain these small fishes without exposing themselves to the hazards of mid-channel open water fishing (Landberg 1975).

The larger scombrids, such as bluefin *(Thunnus thynnus)* and yellowfin *(Thunnus albacares)* tuna, are so rare in Southern California archaeological sites that they may be discounted as a significant part of the fishing strategy. Only one site, the Little Harbor site on Santa Catalina Island (SCal-17) presented significant indicators of an offshore fishery. Significantly, this site is unusual in that it has a deep submarine canyon extending into the nearshore environment. This canyon may be the reason that the Little Harbor site is unique for the large proportion of open channel scombroids such as *Thunnus* and *Euthunnus* (cf. Holder 1910:145; Roeder 1987:12; Salls 1988:194-203).

There is no evidence that the Indian groups of the Bight hunted the fast swimming whales but they did harvest stranded specimens (Landberg 1965:64). It is suspected that the even faster moving tunas also fall into this non-hunted but incidentally taken category. How do we account for the scarcity of these large fish in prehistoric sites? It is suggested that the infrequent encounters with the elements of these larger hard-striking fish in the middens of Southern California are the result of three limiting factors: fishing technology, especially fishing line; range of Scombrid species distribution; and the problem of "Scombrid poisoning."

## FISHING LINE

The fishing technology of the Southern California Indians, although sophisticated, was limited in strength. Powerful fish, such as the tunas, require very strong tackle. The small size of most of the skipjack and albacore elements is Southern California coastal middens suggests possible limitations in the strength of aboriginal fishing line. "The scant attention paid to the cordage of primitive man and to the ability shown by him in choosing available raw materials and preparing them for use in no way compares to the importance of cordage as a universal and fundamental need." (Hoover 1974:VII). Archaeological cordage specimens are seldom encountered in the open-air sites of the Southern California Bight. The few specimens that have been described in site reports have not addressed the subject of their utility. Fishing line would appear to be an element of the fishing tool assemblage with a role which was at least as important as the function of fishhooks, and probably more so. One can spear, snag or hook a fish with almost any sharp, pointed instrument, but landing the catch is entirely another matter.

The importance of fishing cordage is mentioned in only two historic accounts. Both describe the Indians fishing around Santa Catalina Island. Sebastian Viscaino (1967:84) wrote, in 1602, that the Indians traded "nets, thread, and very well

TABLE 1.—*Prehistoric Fish Habitat Exploitation on the Southern California Bight.*

| | | [Net and Hook and Line fishing] | | | | [Harpooning] | | |
|---|---|---|---|---|---|---|---|---|
| Site | Occupation Time | Nearshore Species | MNI | Tuna 6 | MNI | LPS [MNI] | Swordfish MNI | Citation |
| SBa-46 | Late Prehistoric | 46 | ** | 2 | ** | 0 | 0 | 4,5 |
| SBA-1 | 3,500-Late Prehistoric | 37 | 549 | 0 | 0 | 3 | 1 | 6 |
| Ven-87 | Late Prehistoric-Historic | 18 | ** | 0 | 0 | 0 | 0 | 2 |
| Ven-3 | Late Prehistoric | 45 | ** | 0 | 0 | 4 | 1 | 2 |
| Ven-110 | Late Prehistoric-Historic | 54 | 174 | 2 | 9 | 1 | 0 | 8 |
| LAn-52 | 3,000-15,000 yr. BP | 15 | 19 | 2 | 2 | 2 | @ | 3 |
| LAN-958 | Late Millingstone | 10 | 6 | 0 | 0 | 0 | 0 | 10 |
| LAn-311 | Late Prehistoric-Historic | 17 | 27 | 1 | 1 | 2 | 0 | 10 |
| LAn-1298 | Late Prehistoric-Historic | 2 | 2 | 0 | 0 | 0 | 0 | 10 |
| LAn-227 | Late Prehistoric-Historic | 16 | 17 | 2 | 3 | 1 | 0 | 3 |
| LAn-229 | Late Prehistoric-Historic | 27 | 400 | 1 | 4 | 3 | 0 | 7 |
| LAn-59 | AD 400-900 | 41 | 330 | 2 | 9 | 2 | 0 | 1 |
| LAn-61A | 2980-1280 BP | 35 | 215 | 1 | 1 | 12 | 0 | 10 |
| LAn-61B | 3770-1860 BP | 45 | 252 | 2 | 3 | 4 | 0 | 10 |
| LAn-61C | 420 BP-Historic | 11 | 37 | 0 | 0 | 0 | 0 | 10 |
| LAn-63 | AD 110-AD 670 | 59 | 497 | 3 | 5 | 11 | 0 | 10 |
| LAn-206 | 6610 BP (Millingstone) | 19 | 51 | 0 | 0 | 0 | 0 | 10 |
| LAn-64 | 2160 BP (Intermediate) | 10 | 19 | 0 | 0 | 0 | 0 | 10 |
| Ora-193 | AD 800-1300 | 14 | ** | 1 | 1 | 0 | 0 | 5 |
| Ora-190 | AD 405-AD 1100 | 10 | 12 | 0 | 0 | 0 | 0 | 2 |
| Ora-119A | 5750 BP-AD 1560 | 7 | 7 | 0 | 0 | 0 | 0 | 3,8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ora-281 | 4310-980 BP | 23 | 30 | 0 | 0 | 0 | 0 | 10 |
| Ora-331 | 1480 BP | 19 | 40 | 0 | 0 | 0 | 0 | 10 |
| Ora-968 | 1290-170 BP | 22 | 56 | 0 | 0 | 0 | 0 | 10 |
| SDI-4990 | Late Prehistoric (pottery) | 6 | 9 | 0 | 0 | 0 | 0 | 9 |
| SDM-W-143 | 2830-440 BP | 40 | ** | 1 | 1 | 2 | 0 | 9 |
| SDI-4615 | 7150-3980 BP | 15 | 19 | 0 | 0 | 0 | 0 | 10 |
| SDI-1103 | 6310-5020 BP | 10 | 12 | 1 | 1 | 0 | 0 | 10 |
| Silver Strand | 270 BP-AD 1680 | 9 | 12 | 0 | 0 | 0 | 0 | 3 |
| SDI-603 | 7300-3000 BP | 4 | 7 | 0 | 0 | 0 | 0 | 10 |
| SCII-43B | 9775-4300 BP | 26 | 188 | 4 | 4 | 0 | 0 | 10 |
| SCII-43C | 3400-1050 BP | 40 | 924 | 3 | 3 | 1 | 0 | 10 |
| SCII-1492 | AD 1500 (trade beads) | 15 | 84 | 0 | 0 | 0 | 0 | 10 |
| SCII-1215 | 1490 BP | 23 | 111 | 2 | 3 | 0 | 0 | 10 |
| SCLI-119 | Historic (1800?) | 23 | 105 | 0 | 0 | 0 | 0 | 10 |
| SCal-17 | 3680 BP | 17 | 106 | 3 | 46 | 0 | 0 | 10 |
| SCal-137 | AD 430-400 BP | 8 | 107 | 0 | 0 | 1 | 1 | 9 |
| SCal-26 | 420-220 BP | 45 | 366 | 2 | 6 | 1 | 0 | 10 |
| SNI-11 | 6800-700 BP | 51 | 741 | 1 | 6 | 0 | 1 | 10 |
| Total MNI | | | 5590 | | 107 | 58 | 4 | |

† = Larger offshore species only including all species of *Thunnus and Euthunnus* (bluefin, yellowfin, albacore, and skipjack).
** = MNI not reported. @ = Present from personal surface observations.
LPS (Large Pelagic Sharks) - Most large sharks enter OC and BE habitats and cannot be considered only offshore deep water species.
This table compled from the works of: Bleitz-Sanburg 1985; Fitch 1967, 1969, 1975; Follett 1963a and b, 1966, 1976; Glenn 1988; Huddleston 1981, 1985; Huddleston and Barker 1978; Johnson 1982; Kroeper 1978; Kroeper and Fouste 1977; Roeder 1977, 1986, 1987, 1988; and Salls 1988.

TABLE 2.—The Cultural Periods of the Southern California Bight.

| Years | Rogers (1929) | Wallace (1955) | Warren (1968) | Salls (1988) |
|---|---|---|---|---|
| 1782 | | | | |
| 1500 | | Horizon IV Late Prehistoric | Chumash Tradition | Formative Canalino |
| 1000 | | | | |
| 500 | Canalino | | ? – ? | |
| AD | People | | | |
| 0 | | | | |
| BC | | Horizon III Intermediate | Campbell Tradition | |
| 500 | | | | Archaic |
| 1000 | | | | Canalino |
| 200 | | | | |
| 2500 | Hunting People | | | |
| 3000 | | | | |
| 3500 | | | | |
| 4000 | Oak Grove People | Horizon I Millingstone | Eicintas Tradition | |
| 4500 | | | | |
| 5000 | | | | Early Mariners |
| 5500 | | | | |
| | | Horizon I Early Man | | |
| 6000 | | | | |
| 7000 | | | | |
| 8000 | | | | |
| 9000 | | | | |
| 10000 | ? | ? | ? | ? |

twisted ropes, these in great quantities and resembling linen." It was also suggested in a different translation of Viscaino's notes, that the Indians possessed "flax like that of Castile, hemp and cotton, from which they make fishing lines . . ." (Griffin 1891:72, quoted in Hudson & Blackburn 1982:165). The sea diary of Fr. Juan Vizcaino, written in 1769, notes that fur robes were held together "with small cords which look like hemp and the color of coconut husk . . . they gave me a cord strong enough to hold a fishhook" (Viscaino 1959:12). Although the word "cotton" was probably mistranslated from the original Spanish (cotton is not native to California), the hemp-like and flax-like descriptions are accurate in describing Indian hemp *(Apocynum cannabinum)* and nettle *(Urtica holosericea)* respectively.

Ethnographic accounts and museum specimens indicate that Spanish bayonet (a term often applied to native yuca species), yucca, and surf grass *(Phyllospadix)* were also used to make cordage (Harrington 1942:14; Rozaire 1957:20; Sparkman 1908:200). A 1,490-year-old surf grass fishing pouch recovered from San Clemente Island's open-air Nursery Site (SCII-1215) testifies to the strength and resilence of the surf-grass material (Bleitz-Sanburg and Salls in press).

## FIBER PRODUCING PLANTS OF ETHNOGRAPHY

The ethnographic descriptions of cordage are somewhat fragmentary and, as with all the ethnographic data from Southern California, suffer from long exposure of native informants to European and Mexican influence. These accounts, such as they are, indicate that the Chumash and Gabrielino Indians of Southern California made cordage from Indian hemp or dogbane *(Apocynum cannabinum)*, nettle *(Urtica holosericea)*, milkweed *(Ascepias* sp.) and sometimes human hair (Harrington 1942:24). The Luiseno on the other hand used the same plants for utility cordage but not for marine fishing. The coastal Luiseno fishermen made fishing line from the yucca plant (Sparkman 1908:200-202).

*Yucca*—The mohave yucca described by sparkman *(Yucca mohavensis)* is found along the San Diego County coast and inland to the desert areas of San Diego, Riverside, and San Bernardino Counties. The mohave yucca is presently known by the scientific name *Yucca schidigera* (Munz 1974:867). The various subspecies of *Yucca whipplei* were also available in aboriginal times from Monterey County to northern Luiseno territory in Orange County (Munz 1974:867-868). The *Yucca* fibers are "pulped" from the leaves of the plant by scraping out the parenchymatous tissue with a scraper plane (Salls 1985:103-106). The resulting fibers are similar to *Agave* leaf fibers, course and somewhat sisal-like in consistency.

*Nettle*—The nettle plant *(Urtica holosericea)* provides a silky, fiber thread that is stripped from the cambium of the stalk. It is found cismontane in many plant communities throughout California in low, damp locations below 2743 m (9,000 ft) elevation and on Santa Catalina and Santa Cruz Islands (Munz 1974:847).

*Indian hemp*—The Apocynaceae as a family is widespread in California. The species *Apocynum cannabinum* (Indian hemp or dogbane) yields a hemp-like fiber of a "coconut husk color" from the stalk or stem. Generally rare, this species is only occasionally found in damp places below 1829 m (6,000 ft) elevation (Munz 1974:85). Although difficult to discover because of its rarity, it is often locally abundant. This local abundance at particular places would have made stands of Indian hemp a valuable property resource in California prehistory.

*Milkweed*—The Asclepiadaceae or milkweed family is represented by five genera in California (Munz 1974:91). The genus *Asclepias* contains nine species with two available to the Southern California Indians. Both species are found in dry places below 2134 m (7,000 ft). *Asclepius eriocarpa* favors many areas, while *Asclepias facicularis* is usually found away from the coast and on Santa Catalina and Santa Cruz Islands (Munz 1974:93). a white flax-like fiber is obtained from the stem of the plant.

## METHOD OF CORDAGE MANUFACTURE

Research by Hoover (1974) and Mathewson (1985) have provided the best in-depth studies on aboriginal cordage for Western North America. The production of dressed fiber cordage was a process utilizing the bast fibers (any fiber from woody plants) of annual growth or annual and perennial structural fibers of various plant species (Hoover 1974:6). Discussing the use of Indian hemp in the manufacture of cordage, Hoover notes that it was cut and gathered in the fall and allowed to dry in the sun for two weeks. The stalks were then tied into bundles and stored. As coradage was needed individual stalks were processed by splitting the thin outer layer of cambium with the thumbnail. This was accomplished by forcing the thumbnail through the thin cambium to the hollow center pith at one end of the stalk and then sliding the thumbnail down the stalk to the other end, effectively splitting the stalk in half. The halves could then be split into quarters by the same method.

The flat sections of the stalk were then available for fiber removal. This process involved peeling from the center of the stalk towards both ends releasing the outer fibers from the cambium. The resulting fibers could be dressed by scraping with a stone tool and rubbing the fibers between the palms of the hands (Hoover 1974:8). The final process was to twist the bast into twine or cord. This method entailed holding each strand of fiber separately with one hand and twisting the fibers together by rubbing the free portion of the strands against the thigh with the opposite hand.

The grip on the fiber ends would then be released so that the strands could twist back against each other. Finally, the cord would be tightened by rolling it in the opposite direction along the thigh while securing each end with the hands (Harrington 1942:25; Hoover 1971:1; Rozaire 1957:26; Sparkman 1908:202). The resulting strong and resilient cordage would have the appearance of modern hemp string.

Historically the Ventureno Chumash, Gabrielino and Luiseno manufactured four-ply cordage (Harrington 1942:24; Sparkman 1908:203). Four-ply cordage may have been introduced after Spanish contact as two-ply and rarely three-ply line, appears to have been the norm along the Bight prior to European contact (Hoover 1974:2; Kroeber 1922:827; Sparkman 1908:203).

An example of fishline made from Indian hemp was described in Harrington's notes as consisting of three plies and was 15 m (50 ft) in length (Hudson, Timbrook & Rempe 1978:129). Fernando Librado, an alleged Chumash consultant, describes twisting fiber into string by rubbing on the bare thigh (Hudson & Blackburn 1982:166). He also stated that 3 ply nettle fiber ropes reaching lengths of 73 m (240 ft) were made in the same manner. Nettle or dogbane fibers were twisted into two-ply strands, although three-ply and four-ply cords were not unusual.

## EXPERIMENTAL TESTS ON MATERIALS UTILIZED FOR PREHISTORIC FISHING LINES

As a consequence of the analysis of numerous marine adapted archaeological sites along the Southern California Bight an important factor has begun to emerge. The preponderance of fish species being caught were the smaller nearshore species. The elements of fast swimming, hard-striking species, such as the larger members of the scombrids, were conspicuous by their small size range (no element was larger than the largest comparative specimen, which weighed 7.7 k (17 lbs). These observations suggested that fishing line strength may have been an important limiting factor in the overall fishing strategy of the prehistoric populations along the Bight.

Modern fishermen have developed, probably by trial and error, various types of fishing line for application to particular environments. They know, for example, that fishing from a rocky shore requires stronger line than from a boat over a sandy bottom. This has little to do with the fish they are seeking but much to do with the fact that the line often snags and considerable line-strength is required to pull it free. Fishermen exploiting the offshore pelagic environment for species such as tuna put away their nearshore fishing tackle and break out the heavy duty equipment. In some cases, however, tunas follow their prey into the nearshore habitats where they encounter fishermen seeking smaller species. The usual result in these rare events is that the fish strikes, the line parts, and the fish escapes leaving a disgruntled fisherman. On the other hand, if the tuna is small enough, an expert can land the powerful fish with light tackle. These incidents became a cause celebre in the fishing magazines and sports periodicals. The evidence from the prehistoric middens of the Southern California Bight, by analogy, suggest a similar scenario.

To test this hypothesis the modern fishing lines utilized by Southern California marine sports fishermen were analyzed. These fishing lines are variable in relation to the type of fish or fish habitat being exploited. The modern day experts on Southern California salt-water fishing recommend the use of fish line ranging from 12- to 50-pound test strength (Cannon 1964:33-105; Davis 1983:1; Miller 1984;

Tre Tryckare 1976:282). A random survey of ten Southern California tackle shops and four charter boat companies disclosed that most marine fishermen who exploit nearshore environments, utilize fishing line ranging from 12- to 25-pound test strength. The average test strength of the most popular fish lines for nearshore fishing is about 20 pounds.

The strength of modern fishing line is determined by the breaking point of the line when subjected to a "dry poundage test." This test measures the amount of weight that a secured piece of dry line can support before breaking. A ten-pound test line, therefore, is one which, if securely fixed at one end, will fail if ten pounds of weight are attached to the unsecured end. This test was perfected for natural-fiber cordage long before modern synthetics appeared. A natural-fiber fishing line which is still used by modern fishermen and tested by the dry poundage test is three-ply linen line (Table 3).

TABLE 3.—*Comparative Strengths of Modern Linen Fishing Line.*

| Ply count | Kilogram Breaking Point | Pound Breaking Point |
|---|---|---|
| 3 | 4.1 | 9 |
| 6 | 8.2 | 18 |
| 9 | 12.3 | 27 |
| 15 | 20.5 | 45 |
| 24 | 32.7 | 72 |
| 39 | 53.2 | 117 |

Modified after Tre Tryckare 1976 (Table 1).

Some fibers increase in strength when wet, and water pressure at various depths will also increase the force necessary to part fishing line. Indian hemp has been alleged to increase in strength when submerged in water (Harrington's notes, quoted in Hudson & Blackburn 1982:166). Although fishing line that may test at a breaking strength of 4.1 kg (9 lbs) in dry air may increase somewhat in strength underwater, part of the line is always exposed to the air making the measurement of wet-strength somewhat irrelevant. There is always dry line at some point between the reel or bail (hand reel such as used by aboriginal peoples and similar to a child's kite string retainer) and where the fish line enters the water. Consequently, this dry section—the weakest point of the line—is the portion for which the dry-poundage test imparts a realistic measure of the line strength. The breaking point of fishing line is calculated by "weakest link" statistics for fibers under tension. This concept is based upon the propagation of a crack located at the most severe defect in the fiber; the fact that less severe defects might exist in the fiber is immaterial.

To determine the traditional materials and methods involved in the manufacture of fishing lines utilized by the prehistoric occupants of the Southern California Bight, an analysis of preserved archaeological and ethnographic

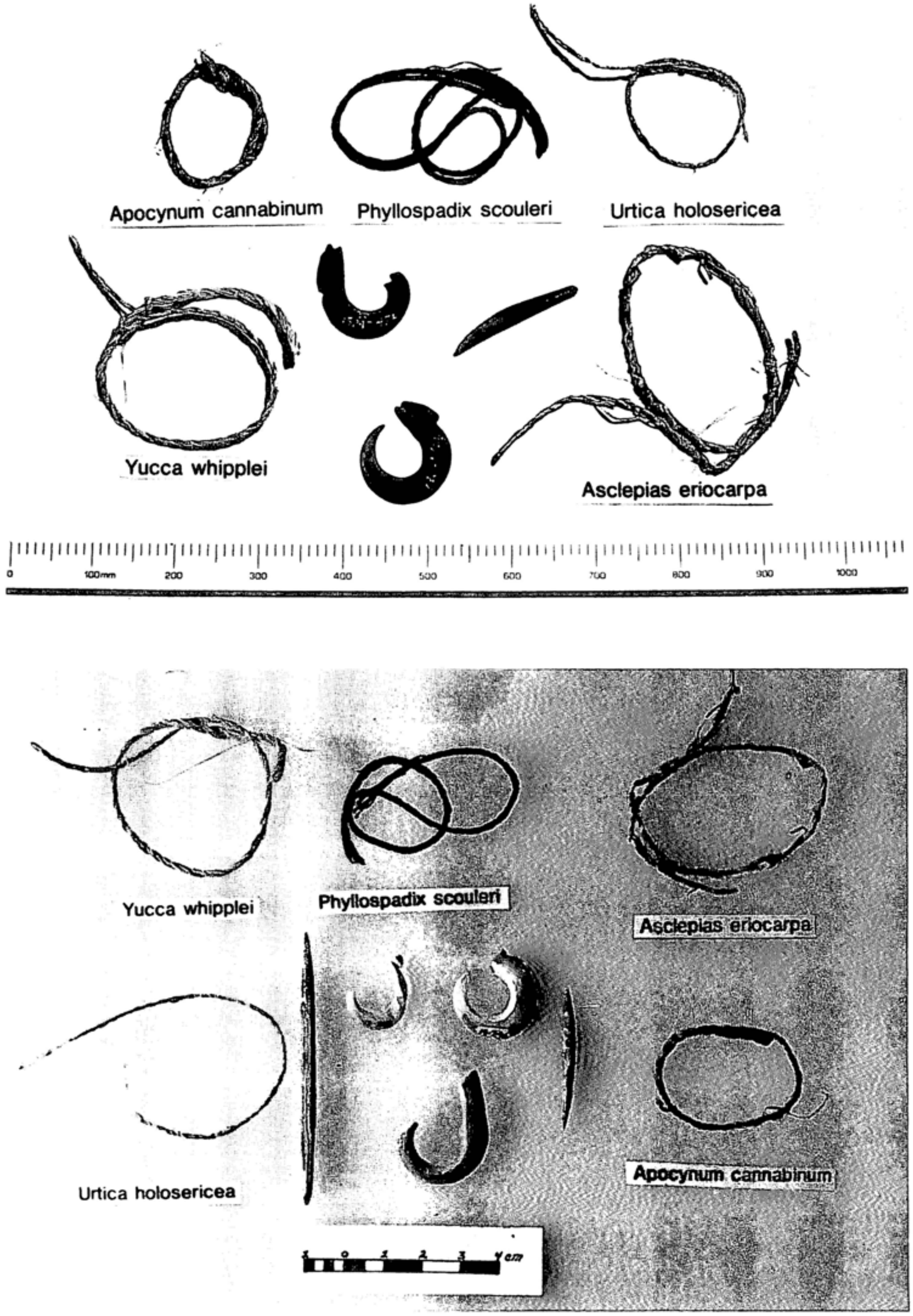


FIG. 3. Fishing cordage made from various plants and used in the strength tests. The single-piece shell fishhooks and gorges are types from the Southern California Bight and are pictured here for comparison with the lines.

cordage was conducted. Due to preservation factors few archaeological specimens were available. Comparative collections of both prehistoric and ethnographic lines from Southern California, are small. The entire collections of cordage available at the Southwest Museum, The Santa Barbara Museum of Natural History, and the Natural History Museum of Los Angeles County were examined. The number of strands, twining, and when possible the number of fibers in each strand were recorded for later replication using fresh materials. Ethnographic accounts of cordage manufacture were also considered.

Following this preliminary survey, several native plants were collected and processed into cordage. Two and three-ply cordage were made in the traditional method described by Hoover (1974). The cordage was probably not as finely made as that manufactured by an experienced prehistoric Indian, yet it did appear to match the museum material (Fig. 3). The six plant materials tested in these experiments included: Indian hemp, dogbane or *(Apocynum cannabinum)*, collected from San Clemente at San Mateo Creek, Orange County, California; Nettle *(Urtica holosericea)*, from the same location; Milkweed *(Asclepias eriocarpa)*, collected in the Santa Monica Mountains, Los Angeles County, California; Yucca *(Yucca whipplei)*, collected from Malibu, Los Angeles County, California; Surf grass *(Phyllospadix scouleri)*, collected from the north end of San Clemente Island; and Round shaft human hair (same as California Indians).

These vegetable fiber cords were tested for their dry-pound strengths at the University of California, Los Angeles, Materials Testing Laboratory. An Instrom Universal Testing Machine, Model TTCL MI-6, was utilized to measure cordage-strength. The vegetable fiber lines were tested in a dry condition and most proved to have failure rates measuring within the range of modern dry fishing line (Table 4). The average modern nearshore fisherman uses 12- to 20-pound test line as an overall utility line. It performs well for surf casting, pier fishing, and casting light baits for small to moderate-sized fish such as barracuda, bass, bonito, and halibut, in other words, nearshore fishing (Davis 1983).

Table 4 discloses that most of the dry plant fiber cordage tested well within the strengths required for fishing the nearshore community of species. Line which would have been strong enough to hold a large game fish did not exist in the sample tested. The weakest cordage was made from surfgrass *(Phyllospadix scouleri)*, and the strongest from yucca and human hair. The surf grass requires at least seven fibers in a two strand cord to be effective. This matches the material recovered from the Nursery Site (SCII-1215) on San Clemente Island (Salls 1988). The surf-grass fibers are very thick. When seven or more fibers are utilized, a heavy cord resembling a small rope rather than a fishing line is the result. When one uses two single strands of surf grass (single fibers), it closely resembles Northwest Coastal Indian net fiber; however, its strength is only about two pounds.

The tests on human hair are somewhat deceptive. Although registering breaking strengths of up to 22.5 lbs (Table 3), the strands did not really break but stretched several inches after reaching the high point on the graph. The hair fibers within each strand then, unlike plant fibers, begin to slip past one another until a splice is reached—the cordage then separated. These strands are very tough and with increased twist pitch during the stretching, human hair twine is able to withstand higher weight-loads over greater durations of time. Although ethnographic accounts suggest that human hair was used as fishline, no archaeological samples were available for this study.

TABLE 4.—*Aboriginal Fishing Line strength Experiment*

| Sample | Material | # Ply | Cord Diameter | Dry Pound Strength |
|---|---|---|---|---|
| 1 | *Apocynum cannabium* | 2 | 1.60mm | 11.9 |
| 2 | *Apocynum cannabium* | 2 | 1.62mm | 12.9 |
| 3 | *Apocynum cannabium* | 2 | 1.62mm | 17.0 |
| 4 | *Apocynum cannabium* | 2 | 1.11mm | 8.4 |
| 5 | *Apocynum cannabium* | 2 | 1.60mm | 11.4 |
| 6 | *Apocynum cannabium* | 3 | 1.94mm | 12.5 |
| 7 | *Apocynum cannabium* | 3 | 1.74mm | 16.6 |
| 8 | *Asclepias eriocarpa* | 2 | 1.90mm | 17.0 |
| 9 | *Asclepias eriocarpa* | 2 | 1.70mm | 10.7 |
| 10 | *Asclepias eriocarpa* | 2 | 1.81mm | 8.3 |
| 11 | *Aslcepias eriocarpa* | 2 | 1.41mm | 4.9 |
| 12 | *Asclepias eriocarpa* | 2 | 1.40mm | 6.1 |
| 13 | *Utica holosericea* | 2 | 1.10mm | 11.0 |
| 14 | *Utica holosericea* | 2 | 1.00mm | 6.5 |
| 15 | *Utica holosericea* | 2 | 1.20mm | 6.4 |
| 16 | *Utica holosericea* | 2 | 0.60mm | 3.9 |
| 17 | *Utica holosericea* | 3 | 2.10mm | 13.8 |
| 18 | *Utica holosericea* | 3 | 2.03mm | 17.7 |
| 19 | *Yucca whipplei* | 2 | 1.73mm | 17.8 |
| 20 | *Yucca whipplei* | 2 | 1.41mm | 8.2 |
| 21 | *Yucca whipplei* | 2 | 1.60mm | 22.0 |
| 22 | *Yucca whipplei* | 2 | 2.03 | 13.2 |
| 23 | *Yucca whipplei* | 2 | 1.70mm | 9.8 |
| 23 | *Yucca whipplei* | 3 | 1.99mm | 21.3 |
| 25 | *Yucca whipplei* | 3 | 2.20mm | 27.7 |
| 26 | Human | 2 | 1.23mm | 9.2 |
| 27 | (round shaft) hair | 2 | 1.50mm | 22.5 |

| | | | | |
|---|---|---|---|---|
| 28 | | 2 | 1.20mm | 8.0 |
| 29 | | 2 | 1.60mm | 15.0 |
| 30 | *Phyllospadix scouteri* | 2 | 2.13mm | 13.6 |
| 31 | *Phyllospadix scouteri* | 2 | 0.90mm | 5.4 |
| 32 | *Phyllospadix scouteri* | 2 | 1.20mm | 0.0 |
| 33 | *Phyllospadix scouteri* | 2 | 1.11mm | 0.0 |
| 34 | *Phyllospadix scouteri* | 2 | 1.00mm | 4.6 |
| 35 | *Phyllospadix scouteri* | 3 | 1.20mm | 7.6 |
| 36 | *Phyllospadix scouteri* | 3 | 1.42mm | 2.6 |
| 37 | *Phyllospadix scouteri* | 3 | 2.20mm | 9.1 |

## ADDITIONAL LIMITING FACTORS

Usually Scombridae (albacore, skipjack, bluefin, and yellowfin tuna) migrations occur well to the west (1,000-500 miles) of the outer Channel Islands. The occasional nature of their presence in coastal archaeological sites is a result of short term climate and water temperature variations (Clemens 1961:39). Site Catchment theory would suggest that the manufacture and transport of heavy lines in the rare chance of encountering the larger scombrids would be an inefficient use of energy. The Scombridae (tunas) move north in the summer months staying well seaward from cold, murky coastal areas (Clemens 1961:9). Exceptions to these migratory patterns do occur. The largest blue fin tuna *(Thunnus thynnus)* ever recorded in these waters was caught in November 1988 (Hillinger 1988). A school of exceptionally large blue fin tuna were encountered by the commerical tuna fleet approximately 8 km (5 mi) south of Santa Rosa Island. These fish were difficult to catch even with the modern equipment of the commercial boats (Clemens 1961:2).

This difficulty in catching the larger scombrids is suggested as another possible explanation for the general paucity of their elements in the archaeological middens of the Southern California Bight. The coastal sites at Rincon Point (SBa-1) and Mescalitan Island (SBa-46) are within canoe distance from Santa Rosa Island, but few scombrids were identified in a recent analysis (Richard Huddleston 1988, personal communication). At Mescalitan Island only three or four medium sized elements, probably albacore *(Thunnus alalunga)*, were present out of approximately 100,000 recovered elements. Huddleston found that nearshore species such as white croaker *(Genoyonemus lineatus)*, grunion *(Leuresthes tenuis)*, topsmelt *(Atherinops affins)*, white seabass *(Atractoscion nobilis)*, and white surfperch *(Phanerodon furcatus)*, made up the preponderance of the elements.

Rincon Point, on the other hand, revealed that some spearing of open-channel sharks and swordfish occurred but the elements from nearshore species such as white croaker and anchovies *(Engraulis mordax)* were the most abundant elements (Huddleston & Barker 1978:Table 1). Croakers (Sciaenidae) are common surf fishes which are easily taken with nets. Nets are also the only efficient means of harvesting anchovies which are often seen in the forewave area and around the kelp beds. There were no medium sized scombroids recovered from Rincon Point and it appeared that large fish were not an important element in the fishing strategy (Huddleston & Barker 1978:23).

The large pelagic tunas would have been extremely difficult if not impossible for aboriginal fishermen to catch or even harpoon. Even smaller species of the scombrids can be hazardous to fishermen in small boats. Tre Tryckare (1976:285) in his outstanding monograph, *The Lore of Sportsfishing,* warns that fishing for tuna from small boats is not recommended because fish weighing as little as 23 kg (50 lbs) can still pull a man overboard. Holder (1910:50-72) vividly describes similar hazards of tuna fishing from small skiffs around the Southern California Channel Islands. These examples were of fishermen using rods and reels which absorb much of the impact of such hard-striking fish. One can only imagine the impact on a hand held line or one tied to the gunwale of a plank canoe.

One must also consider the possible impact of Scombrid poisoning. There exists in the flesh of most fishes a chemical constituent known as histidine. When this constituent is acted upon by bacteria, it apparently changes into a histamine-like substance called saurine, which can produce a severe allergy-like illness in humans. Saurine is especially prone to develop in Scombrid fishes that are left to stand without refrigeration or out in the sun for several hours (Halstead 1952:112). The resulting toxic effect, known as *Scombrid Poisoning,* is most characteristic of the meats from the tunas such as skipjack, bonito, mackerel, albacore, and others. This may be the fundamental reason that many of these species, especially those which require long transportation durations from distant fishing locations, are so rare in the Southern California maritime sites.

## PROBLEMS IN INTERPRETING PREHISTORIC FISHERIES

Most of the early archaeological investigations into Southern California prehistoric fisheries were hampered by the lack of expertise into fish faunal identification so that the fish fauna were not thoroughly analyzed (Woodward 1929:43; Roeder 1986:2). The implementation of more recent and advanced archaeological methods such as column stampling, flotation, properly identified fish comparative collections, otolith analysis, and computer modeling has greatly improved the collection and identification of fish faunal samples (Fitch 1967:191; 1969:56). The application of these new techniques on faunal assemblages often provide results which conflict with the ethnographic or historic information on subsistence practices (Classen 1986:31; Lightfoot & Cerrato 1988:142; Salls 1988:441-442). Finally, they sometimes conflict with paleoenvironmental reconstructions based on invertebrate marine fauna or pollen analysis (Salls 1988:43-57).

*Ethnographic data.*—It is very difficult to separate Native California Indian fishing traditions from those of the Mexican-Indian immigrants because these traditions have tended to meld into muddled accounts (Timbrook 1987:179). For example, Fernando Librado, a Chumash Indian consultant, described to the early ethnographer John P. Harrington (nd), a fishing strategy for "corbina" wherein a boat was used. The boat was tied in "sea weed" as an anchoring device during the corbina fishery (Harrington nd, in Hudson & Blackburn 1982:207-208). The corbina is a Southern California surf species *(Menticirrhus undulatus)* which lives in Open Coast Sandy Beach (OC) environments usually in the surf zone where they feed on invertebrates. Sea weed (probably kelp) is not found in this environment and corbina are not found in KB habitats. In fact, no plant growth of any kind long enough to tie to a boat exists in the OC surf zone.

When one examines this account it is apparent that the informant is describing a fish native to Mexico—the corvina—not the California species (corbina) as suggested. The corvina (several species of *Cynoscion)* are fished from boats in the Gulf of California as described in Librado's account. The Southern California species *(Menticirrhus undulatus)* is a fish of the surf zone where the fishing method described would be impossible. There are several Mexican fish described by Harrington's consultants as California species. I beieve that these informants were not consciously attempting to deceive the ethnographer, but only describing Mexican strategies that had become hopelessly merged into their oral tradition (Salls in press). It is also possible that a translation error is present because names such as corbina or corvina sound the same in Spanish to the untrained ear.

*Environmental data.*—The absence or presence of certain species in Southern California archaeological sites have been interpreted as indications of climatic (Hubbs 1948; Glassow 1987; Walker & Snethkamp 1984) or sea-level change (Masters 1985). Walker and Snethkamp (1984) suggest that paleoecological variations in water temperatures may have changed marine habitats. This hypothesis is based on the temperature-sensitive marine organisms preserved in laminated deep sea core sediments (Pisias 1978). Pisias' data suggests that ocean temperatures have frequently exceeded the limits of the giant kelp *(Macrocistis pyrifera)*.

> By looking at archaeological deposits laid down during these different time periods, we expect to see variation in exploited subsistence resources. During periods of warm water conditions, we expect to see relatively small proportions of kelp bed fish, sea urchins, and other marine organisms that depend upon well-developed kelp beds. In contrast, species that favor higher water temperatures, such as barracuda and some species of tuna, should increase during periods of warm water (Walker & Snethkamp 1984:7).

There are several factors to be considered when interpreting "deep sea cores." It has been discovered that the dead organisms (thanatocoenoses) used to interpret temperature change may not be representative of the biocoenoses (assemblage of living organisms) in the overlying water column:

> Selective dissolution of thin walled specimens at depth, differential removal of easily transported species by scouring bottom currents, and occasional contamination by exotic species transported over long distances by large-scale ocean currents all contribute elements of uncertainty. Because of these problems sediments over much of the ocean floor are unsuitable for paleoclimatic reconstruction (Bradley 1985:172).

Unfortunately, the offshore areas of the Southern California Bight comprise one of the unsuitable areas for interpretating ocean core material (Bradley 1985, Fig. 6.2). In addition to the problems of utilizing core samples from such questionable areas as the Santa Barbara Channel (Pisias 1978), archaeologists must realize that the last 8,000 years of time is analyzed from the very top of the deep sea core (core-top sample). Due to bioturbation and other disturbances during core recovery, the upper portion of a core has been considered to be a primary source of error in paleoenvironmental reconstructions (Imbrie & Kipp 1971).

Although climate does fluctuate, and the very conditions described by Walker and Snethkamp have been observed during historical times (Salls 1986, 1988:212), they appear to be very short in duration and are often extremely difficult or impossible to define archaeologically. Interpretation of the piscine remains from the Southern California Bight support the pack rat midden *(Neotoma)* data from the interior of California and Arizona (Spaulding 1985:42; Van Devender & Spaulding 1979:204) in indicating no major climatic change within the last 11,000 years of the Holocene (Table 1).

*Sampling inconsistencies.*—The interpretation of paleoclimates and prehistoric fisheries from the piscine faunal assemblages also presents certain limitations. In general there are four recognized sources of potential sampling bias in a faunal assemblage. First, there are variations in the preservation of bones from element to element as well as from context to context. Therefore the functional content of the site activity area in which the fish bones were deposited strongly affects its preservation. Second, sites are not always effectively sampled nor do researchers always design their investigations to maximize zooarchaeological data (Styles 1981:33). Screen size, for example, can under-represent the smaller species of fish. This bias can sometimes be overcome by using column samples screened through a series of graduated laboratory screens. Third, intra-site variability in function and dispositional patterns is a major problem in regional interpretations of cultural patterns. This can be best controlled by expanded horizontal excavations such as those conducted at the Eel Point (SCII-43) excavations on San Clemente Island and the Shoban Paul Site (LAn-958) in Malibu. These broad horizontal excavations assist in determining a wide variety of functional contents in several parts of a site. Finally, inter-site variability is capable of causing sample bias, since the site's function (temporary camp, village, processing station, etc.) is governed by its resource area and geographic location.

This latter problem can be somewhat overcome by analyzing a large number of sites encompassing every known catchment and settlement pattern. For this study the data from sites analyzed by other investigators was entered into the overall analysis of the prehistoric fishery of the Southern California Bight. The other sampling problems can also be somewhat mitigated by area-wide analysis. The fish assemblages from twenty-one sites analyzed by the author (Table 1) were recovered by the systematic collection of bone through either wet and/or dry screening techniques in order to gain the most reliable sample possible, as well as to maximize the faunal information provided by the sample. This faunal material was further supplemented by wet screen sorting of column samples through a set of graduated laboratory screens.

## INTERPRETATION OF PREHISTORIC FISHERIES FROM FISHHOOKS

Much of the early research on aboriginal fishing on the Southern California Bight concentrated on fishhooks as an indicator of fishing adaptations. Except for some piscine analysis by Tartaglia (1976) fishhook design and use in Southern California was based on evidence from existing cultures (cf. Reinman 1967). Anthropologists and archaeologists utilizing both archaeological and ethnographic evidence have compiled considerable evidence that fishhooks were manufactured for the exploitation of particular environments (Anell 1955; Irwin 1985; Reinman 1967; Stewart 1977). Changes in fishhook morphology from simple gorges to various compound types have also been suggested as evidence for the intensified and diversified exploitation of fish in aboriginal Southern California (Tartaglia 1976).

The recent analysis of 95,668 fish elements and associated changes in fishhook design from 23 Southern California coastal sites ranging in age from 9,775 years B.P. to historic time suggests an additional aspect to fishhook design. Advances or changes in the development of a more sophisticated style of fishhook may not necessarily signify an expanding fishery or specialization, but to the contrary, may indicate a reduction in available resources which necessitated improved procurement methods (Salls 1988).

A fishhook, afterall, is ''any device used on any pliable cord or line for catching fish'' (Kroeber & Barrett 1960:130). Throughout the entire Pacific Basin, the technology of hooking devices has provided a perplexing variety of types. California archaeologists have spent considerable time and effort in determining a functional interpretation for the various fishhooks recovered from coastal sites (cf. Crain 1966; Heizer 1949; Robinson 1942; Strudwick 1985, 1986; Tartaglia 1976). They have diligently sought specific relationships between material, structural, and mechanical principals of various hook designs. This variation has been explained in terms of material, design, handedness, and specialized development for exploiting various fish habitats. It appears, however, that variations in fishhooks are as much due to cultural ideology as they are to any particular mechanical, technological or ecological factors (cf. Binford 1968; Sharer and Ashmore 1979:59).

Modern tackle shops offer a bewildering number of shapes, sizes and types of fishhooks, lures and other fishing equipment, all believed by the designer to be the best for catching a particular fish or fishes. This strongly suggests that esthetics are a major factor in this technology despite the fact that catching fish is the stated objective.

My analysis of the fish remains from the eastern portion of the Southern California Bight disclosed that the familiar gorge type ''fishhook'' did not change significantly from its first appearance in the middle period (Millingstone Horizon) to the Late Prehistoric Period (Table 2). This is especially true of sites located within Bay and Estuary (BE) site catchments where spears and nets could additonally have been utilized. Single-piece shell fishhooks are rare at these sites and have been reported from only two sites south of Point Dume (Salls 1988:312). Both of these generally (BE) sites (San Pedro Harbor and Malibu) had Kelp Bed (KB) and Shallow Rocky Reef (SRRF) habits within the site catchment.

There is evidence that once a basic fishhook design was implemented it was retained through time with only minor stylistic changes (Strudwick 1985:40). For example, a 1,400 year old fishing kit from the Nursery site (SCII-1215) on San Clemente Island contained gorges in addition to composite and single-piece shell fishhooks (Bleitz-Sanburg and Salls in press). The predominate fish species at the Nursery site was the California sheephead *(Semicossyphus pulcher)*. Despite the chronological fishhook sequence on San Clemente Island—from gorges to composite hooks to single-piece shell types—sheephead are the predominate fish in all the San Clemente Island sites from the 9,775 ± 165 years B.P. Eel Point Site to Spanish contact at the Ledge Site (SCII-126). With this in mind, and the fact that hundreds of modern hooks and lures are promoted for use in capturing particular fish, a similar diversity of aboriginal styles probably functioned effectively in hooking a single species. Many archaeologists do not agree with this interpretation.

Functional interpretations have been proposed, for example, that the fish gorge is best designed for pelagic schooling fish (Tartaglia 1976:118), bottom fish (Stewart 1977:45; Irwin 1985:39) or attached to floats or trolling (Reinman 1967:131). This variation in function is not only indicative of gorges but can be found in the interpretation of single-piece shell fishhooks, and composite fishhooks as well. What is important here is to recognize that certain fishhook designs do work more effectively for particular fish species depending on environmental factors present during the fishing operation.

Stewart's (1977:54) excellent description of the use of Halibut hooks in obtaining the Pacific halibut *(Hippoglossus stenolepis)* on the Northwest Coast is an outstanding example of the development of a specialized fishhook. There are two types of halibut on the Pacific Coast, both are members of the order Pleuronectiformes or flatfishes (Eschmeyer, Herald & Hammann 1983:283). The Pacific halibut is the larger of the species and belongs to the family Pleuronectidae, or righteye flounders. This species attains weights to 363 kg (800 lbs) and is found in deep waters from Alaska to Santa Rosa Island. The smaller California halibut *(Paralichthys californicus)* is a member of the lefteye flounder family Bothidae. California halibut weigh up to 33 kg (72 lbs) and range from Washington State to Baja California in nearshore waters. Although the Northwest Coast Indians developed a very efficient fishhook for obtaining the deep-water Pacific halibut, it is important to acknowledge that other types of fishhooks are also efficient in catching this species. Despite close cultural similarities with the Northwest Coast people, fish gorges were used for this species in northwestern California (Kroeber 1976:1; Kroeber & Barrett 1960:89). Perhaps most specialized fishhook designs are in the mind of the fisherman or archaeologist interpreting the artifact and not of particular concern to the fish being sought.

Reinman (1967) and Tartaglia (1976) suggests that fishhook form is a development for special ecological-biological conditions. If this hypothesis is true, then the bone gorge appears to have been the ultimate hook for all conditions in Southern California. The gorge was present in almost every site investigated but does not appear restricted to any particular species fish or ecological area. What strategic value, then, did the Indians acknowledge to justify the time-consuming manufacture of complex shell and composite fishhooks?

This becomes more problematical when one observes that although the species diversity expanded with the introduction of single-piece shell and composite fishhooks, the species clusters remained within the nearshore varieties and did not expand into the open or deeper, outer channel waters. This observation is supported by the ecology of the larger offshore scombrids. These outer channel species of the genera *Thunnus* (albacore, bluefin and yellowfin tuna) and *Euthun-*

*nus pelamis* (skipjack) are found in dense schools where fishermen obtain them in large catches as a result of a single fishing incident. Except for a single site on Santa Catalina Island (Little Harbor, SCal-17), these outer channel fishes are conspicuous by their low numbers or total absence in the archaeological record of sites located within range of periodic offshore tuna fisheries (Table 1). The preponderance of fish elements in these sites are from the solitary nearshore species or from the nearshore pelagic species (Table 1).

The elements of the larger scombrids, indicative of the offshore environment, actually decreased in middens containing single-piece shell and composite fishhooks when compared to earlier middens containing only the simple gorge (Figure 2). The Little Harbor site, for example, had the highest concentration of skipjack, albacore and Carangid (yellowtail) elements of any site within this analysis. These species accounted for 71 percent of the 1,657 elements present at the site. The gorge was the type of fishhook being utilized (Salls 1988:406-413). The Little Harbor site has an adjusted radiocarbon date of $3680 \pm 250$ years B.P.

It appears that there is another possible explanation for the development of specialized fishhooks in Southern California beyond the special ecological-biological condition hypothesis. I propose that population pressures requiring larger catches stipulated improved fishing methods. This is partially based on the observation of early sites where the fish gorge was used. The aboriginal populations of these sites exploited habitats with particular clusters of fishes (Fig. 2). One site may have several species from a particular habitat with another site having only a small percent of these fish but adding some other species from the cluster to round out the catch. When one views the evidence of fishing from these early sites it becomes apparent that the same species clusters were available from their respective habitats (Allen 1985) as are present in modern marine habitats. The fish remains, however, indicate that only a small proportion of the available fish species within a particular habitat were being caught. During the Intermediate and Late Prehistoric periods (after the appearance of the single-piece and composite fishhooks) a more complete exploitation of the particular habitat occurs (Fig. 2).

The technological advance in the development of single-piece shell fishhooks may have resulted from the dilemma that bone gorges must be swallowed by the fish and become lodged in the viscera before the fish can be landed. One gorge per fish would be required unless the fisherman intended to cut open each fish prior to fishing again. The single-piece fishhook and the composite fishhook, however, are more easily removed from the fish's mouth therefore saving time for actual fishing as well as reducing the number of hooks needed at any one time by the fisherman. this would improve the overall quantity of the catch with respect to the amount of time spent in fishing. The development of more advanced fishhooks to better exploit the existing habitat is not inconsistent with the needs of an increasing population.

## SUMMARY

Despite advances in fishhook technology and potential availability for the exploitation of a wider range of marine habitats, nearshore fishes dominated the prehistoric Southern California coastal middens over the last 10,000 years. This biased exploitation suggests that there may have been conditions which limited the marine resource base. Geographic factors such as distance, wind and climate restricted watercraft utilization. Biological limiting factors such as pelagic fish migration patterns and fish poisoning placed temporal confines on the fishery.

The greater exploitation of a fishery is determined by the degree of technical complexity and versatility of fishing peoples. The diversity of piscine remains from the Southern California Bight indicate that certain fish species continued to be abundantly harvested despite major technological advances in fishhook design. In spite of the introduction of different style fishhooks, the species that were caught by hook and line at the archaeological sites investigated are generally the smaller nearshore varieties. The nearshore habitats appear to have been the preferred fisheries throughout the aboriginal exploitation of the Bight. When present, such open water species as the Scombrids are usually small in size with their bone elements about the same size as the largest elements of the nearshore species such as halibut *(Paralichthys californicus)* and sheephead *(Semicossyphus pulcher)*. The increase in species diversity as well as an overall increase in fish remains concurrent with the development of various fishhook types, suggest that the advancements in technology increased the quality and quanity of the catch from already existing fisheries. Population growth may have been the reason that the more efficient technology was implemented to better exploit a diminishing resource. Expansion into the offshore pelagic tuna fishery was prevented by the limiting factors previously discussed.

The hypothsis proposed here is that the strength of the fishing line made from native fiber plants was a major limiting factor for prehistoric Southern California Bight fishery. To test this hypothesis fishing line of *Apocynum cannabinum, Asclepias eriocarpa, Urtica holosericea, Yucca whipplei,* and human hair, made in a fashion similar to that recovered from archaeological contexts, was tested to discover its maximum dry-strength. The results reveal that native plant fiber fishing line would have been limited to catching fish generally in the 10-20 pound size range. The archaeological record reveals that aboriginal fishermen consistently utilized fish of this size range from nearshore habitats. It does not seem likely that natural fiber line would have held the larger, hard-striking scombrid species common to off-shore locations.

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