

UC Merced

Journal of California and Great Basin Anthropology

Title

Evidence for a Prehistoric *Mola mola* Fishery on the Southern California Coast

Permalink

<https://escholarship.org/uc/item/75q9p1gp>

Journal

Journal of California and Great Basin Anthropology, 23(1)

ISSN

0191-3557

Authors

Porcasi, Judith F
Andrews, Sherri L

Publication Date

2001-07-01

Peer reviewed

Evidence for a Prehistoric *Mola mola* Fishery On the Southern California Coast

JUDITH F. PORCASI,

Zooarchaeology Laboratory, Cotsen Institute of Archaeology, University of California,
Los Angeles, CA 90095-1510

SHERRI L. ANDREWS,

ASM Affiliates, Inc., 543 Encinitas Blvd., Suite 114, Encinitas, CA 92024

Numerous previously unidentified bony ossicles recovered from two archaeological sites in the Southern California channel islands (CA-SCLI-43, Eel Point on San Clemente Island and CA-SCAI-17, Little Harbor on Santa Catalina Island), as well as at a Santa Barbara County coastal site, are now known to be remains of the giant ocean sunfish Mola mola (Linnaeus 1758), a creature which can weigh more than 3000 pounds. This compels reevaluation of fish resources and fishing technology available to the earliest inhabitants of the southern archipelago and coast as well as reassessment of certain lines of thought about resource intensification. Although a few cursory and sometimes divergent analyses of fishbone recovered from these sites have been published, our identification of large quantities of Mola elements impacts current understanding of prehistoric resource abundance, fishing technique, and possibly even human health and mortality.

THE GIANT OCEAN SUNFISH

The ocean sunfish (*Mola mola*) is one of two Molidae species found in waters off the Pacific coast of North America (Barnhart 1936; Eschmeyer et al. 1983; Fischer et al. 1995) (Fig. 1). Its Latin name means "mill stone" and refers to its round, disk-like shape as well as to its size. The other species is the smaller slender mola (*Ranzania laevis* [Pennant 1776]). Both are characterized by an unusual flattened shape in which the rear of the body is truncated into a semicircular leathery flap sometimes termed the "clavus" or "pseudocaudal." Another species, *Mola ramsayi*, occurs only in the southern hemisphere.

Molas have disproportionately small, parrot-like beaks and feed primarily on marine invertebrates such as jellyfish. While the slender mola may reach a length of 46 cm (about 2 ft.), the ocean sunfish can attain the astounding length of 305-396 cm (about 10-13 ft.) and weigh in excess of 1500 kg. (about 3300 lbs.). While most specimens collected recently in California weigh only about 45 kg. (100 lbs.) (Eschmeyer et al. 1983), two huge ocean sunfish estimated to weigh a thousand or more pounds each were captured near Santa Catalina Island in the early 1900s (Holder 1912:84-85 and Fig. 39). The Catalina Island Museum displays a photo of western novelist Zane Grey with a 2200-lb. *Mola* he caught in Catalina waters in 1926.

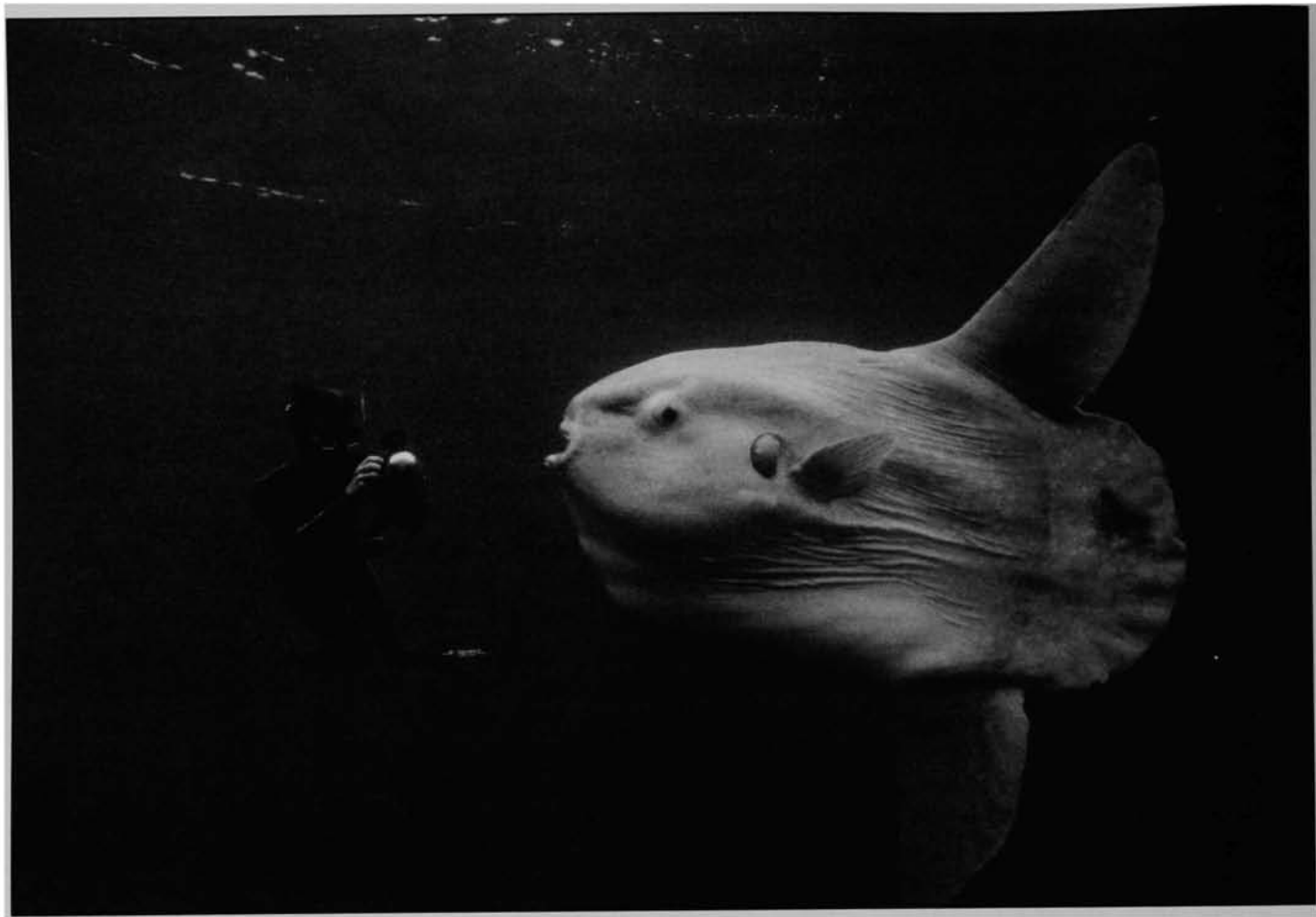


Fig. 1. The ocean sunfish *Mola mola* (A less-than-full-size individual).
(Photo courtesy of Phillip Colla of Oceanlight, Carlsbad, CA.)

Collisions between sunfish and ships have been known to cause damage to even large watercraft. In 1998, a large *Mola mola* was rammed by an oceangoing Australian cement carrier, slowing the ship from 14 to 11 knots and abrading the ship's paint work back to the bare metal (internet communication, Australian Museum, Sydney).

The sunfish is pelagic and is found worldwide in tropical to temperate waters. During warm-water episodes such as *El niño*, the fish can be found as far north as Alaska. Although this fish can navigate deep waters, it is most frequently observed basking at the surface. The slender mola is rare north of Mexico (Eschmeyer et al. 1983:301). The ocean sunfish can be captured with hook and line, spear, gaff, or net. It is extremely docile and can be approached and touched by humans. Although its flesh is gelatinous and

sometimes considered to be poisonous, it is edible and some organs are valued by certain populations as having beneficial properties. The sunfish is known to be infested with numerous parasites. Natural predators of full-size ocean sunfish might be large sharks, large pinnipeds, or killer whales. Juveniles might be taken by any fish-eating species.

THE "INVISIBLE" SUNFISH BONES

Although molas are considered boned fish as distinct from the cartilaginous species, the peculiar osteology of the ocean sunfish has, until now, rendered it nearly invisible in archaeological middens. Like those of the cartilaginous elasmobranchi (sharks and rays), few sunfish elements survive disintegration after death. It is almost a misnomer to think of *Mola mola* elements



Fig. 2. Paper-thin "bones" of a juvenile ocean sunfish curated at the Los Angeles Museum of Natural History.

as bones. As reported by Gregory and Raven (1934), "the most striking characteristic of the skeleton is the great reduction of bony tissue. Ossification is so weak that the material... resembles cartilage. The skeleton, when dry, for the most part shrinks into thin, delicate and fibrous or spongy pieces...." In young individuals, the "bones" are similar to thin tissue paper (Fig. 2). Butchery and cooking would tend to destroy sunfish skeletal elements further. Scientists at the Florida Museum of Natural History describe *Mola mola* bone as an "amazingly papery...reticulate netting of very friable papery strands...a sorry mess" (personal communication S. Scudder 2000).

IDENTIFIABLE ELEMENTS

Because this species has such poorly ossified bone, only two elements survive in an archaeological context. Prior to this paper, the only element identified in archaeological middens has been the beak (see for example Gobalet and Jones 1995:818), which is composed of the lower dentary and the upper premaxilla. These elements are distinctive when recovered intact (Figs. 3A and 3B), but like the other bones of the sunfish, they are quite fragile and easily destroyed by normally occurring taphonomic forces. The resulting small fragments are difficult to identify, even as fishbone. The pictured juvenile premaxilla weighs .7 g and the dentary weighs .5 g.

The elements which we identify here and which



Fig. 3A. External view, juvenile ocean sunfish beak, California Academy of Sciences Specimen No. 209000/242.

have been recovered in substantial quantities at several island sites and at least one coastal locale are the only other resilient bony structures in the fish--densely calcified ossicles which occur in the flattened clavus (Gregory and Raven 1934:145-146; Tyler 1980:378) (Fig. 4). These ossicles are arrayed within the semicircular clavus at the ends of a series of dorsal and anal fin rays as illustrated in the figure accompanying Gregory and Raven (1934).

Archaeologically recovered ossicles are somewhat variable in size and shape and range from 12 mm to more than 7 or 8 cm, presumably depending on age/size of the fish and possibly anatomical position. In terms of general shape,



Fig. 3B. Internal view, juvenile ocean sunfish beak, California Academy of Sciences Specimen No. 209000/242. (Juveniles display prominent internal ridges which diminish over time.)



Fig. 4. Typical sunfish ossicles recovered from a single unit/level provenience at Little Harbor.

most of the ossicles resemble a segment of peeled orange or a dark brown “Brazil nut” (*Bertholletia excelsa*), having the same roughly triangular cross-section. The ossicles are extremely hard and dense and have a grainy surface texture. Many have a sharp keel opposite the curved surface. Some are quite rounded, others are very elongate. Other morphological variations include lateral ridges or “lipping” where the ossicles join adjacent structures, and sometimes a partially perforated groove along the curved surface, again presumably for connection with adjoining structures in the clavus.

Several excavation seasons at Eel Point (CA-SCLI-43, on San Clemente Island) and Little Harbor (CA-SCAI-17, on Santa Catalina Island) have yielded large collections of these ossicles which attest to the presence of this fish in the islanders’ diet. While the mammal, avian, and invertebrate constituents of these collections have been analyzed and published (for example see Raab et al. 1995; Porcasi et al. 2000; Porcasi 1995, 1999; Porcasi and Fujita 2000, etc.), fish remains from these sites have been only partially described (Salls 1988; Arnold et al. 1997; Andrews 2000, etc.). Within the faunal or piscine collections from these sites, however, numerous peculiar “ossicles” remained unidentified. They generally were recognized as bone--sometimes assumed to be fish--but they could not be related to any species. In

some archaeofaunas, the ossicles have been misidentified as mammal, no doubt due to their chunky, hard form.

We have now compiled evidence that these ossicles are the remains of the huge ocean sunfish. We feel that the quantity of these elements at the two island sites suggests a vigorous *Mola mola* fishery in the southern islands, particularly at Little Harbor. Such a fishery would have contributed large quantities of marine protein to the human diet and poses new questions as to how such massive fish were captured, transported, and processed by the early island inhabitants. This question is particularly important at the Little Harbor site which occupies a cliff towering some 400 feet above the present-day shore and where the densest concentrations of mola ossicles have been found.

IDENTIFICATION OF THE OSSICLES

Identification of these ossicles as belonging to the *Mola mola* resulted from fortuitous interdisciplinary research of the archaeologist/zoarchaeologist authors with scientists at the Los Angeles County Museum of Natural History. While we were sure the ossicles were fishbone, the species remained a mystery. Several taxa, especially among the sharks, were investigated by dissection and X-ray in hopes of locating the dense ossicles *in situ*. Then the resemblance of the ossicles to fossil specimens of Miocene Molidae was noted. With this clue, we obtained and dissected a recently captured juvenile *Mola mola* and compared the archeological ossicles with incipient ossicles in the clavus of the young fish (Fig. 5). Tyler (1980:376) notes that in juveniles “bony ossicles are just beginning to be evident around the bifurcate distal ends of a few of the more medial rays of the pseudocaudal fin, these ossicles being well developed in adults.”

We also compared the archeological ossicles with an ossicle curated by the California Academy of Sciences (CAS), San Francisco, (Specimen No. 209000/242). Figure 6 shows that the CAS ossicle is identical to a juvenile ossicle recovered from Eel Point in 1999 and had all other features (in juvenile



Fig. 5. Incipient ossicles in clavus of dissected juvenile *Mola mola*

form) of the ossicles recovered from both Eel Point and Little Harbor.

The CAS specimen is from an extremely young, small individual weighing approximately 10 lb. and about 15 inches long (38 cm.) (This is approximately one hundredth the size of a large, fully grown sunfish.) It is 11.7 mm. long, 8.75 mm. high, 7.25 mm. thick and weighs .4 g. The archaeological element is 14 mm. long, 11.2 mm. high, 10 mm. thick and weighs 1.1 g. and probably represents a slightly larger juvenile.

To authenticate our identification, a full-size, adult specimen was needed to confirm that the larger archaeological ossicles derived from large *Mola molas*. Such an adult skeletal specimen was located and examined at the Florida Museum of Natural History, Gainesville (Specimen No. UF

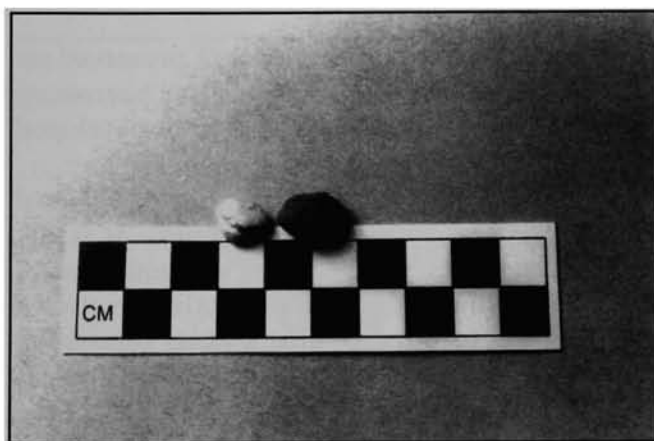


Fig. 6. Comparison of archaeological ossicle from Eel Point (on right) with ossicle curated by the California Academy of Sciences Specimen No. 209000/242.

11883), and some ossicles from that specimen were loaned to the Los Angeles County Museum where we were able to examine them in detail. This fish was 7.5 feet long and weighed several thousand pounds when alive. It was collected in 1961 from the Atlantic coast of Florida. Figure 7 illustrates an ossicle from this specimen. Figures 8 and 9 compare the ossicle with one from Little Harbor. Many ossicles from Little Harbor (Fig. 4) match or exceed the size of the Florida specimen ossicles. Figure 10 presents a *Mola mola* dentary recovered from Eel Point.

As yet we have not determined with any certainty how many ossicles an individual may present and what the size ranges of the ossicles



Fig. 7. Ossicle from Florida Museum of Natural History Specimen No. UF 11883 with portions of surrounding structures which form the lateral lipping (ridges) seen in Fig. 9.

might be. This may be quite variable depending on age and size of the individual fish or on location of the ossicles within the skeleton. However, Fraser-Brunner (1951:110) notes that the mola has eight or nine ossicles.

ARCHAEOLOGICAL REPORTS OF THE OCEAN SUNFISH

While the waters of the southern California coast are a natural habitat of the ocean sunfish, this species is seldom reported in archaeological contexts because of its poor survivability in middens and because the



Fig. 8. Comparison of archaeological ossicle from Little Harbor (on left) with ossicle from Florida Museum of Natural History Specimen No. UF 11883 showing perforated keel edge.

ossicles had never been identified. Only a few notations of this species, based on recovery of one or two fragmentary beaks, have entered the literature. Other than a single specimen (a beak fragment) reported from CA-MNT-234 on the central coast (Gobalet and Jones 1995), all previous reports of archaeological ocean sunfish are based on a few scattered fragments (presumably beaks) from Santa Cruz Island, specifically CA-SCRI-192 (Colten 1992, 1993, 1995; Johnson 1993; Van Slyke 1998). However, several ocean sunfish beak elements are listed in unpublished field data from a 1991 project at Little Harbor prepared by Bleitz and on file at the Catalina Island Museum.

An on-going and as-yet unpublished analysis of faunal remains recently excavated from a Santa Barbara County coastal site (CA-SBa-52/53, the former Aerophysics Site), is now yielding a few ocean sunfish elements. At least eight ossicle fragments and a beak have been recovered from various units at depths ranging from 10 to 140 cm. Six radiocarbon dates from this site range between 6940 and 4840 Cal B.P. (personal communication L. Wilcoxon 2001). One ossicle is derived from a level dated 6720 – 6400 Cal B.P., and several other ossicles are from levels dated between 6940 – 4850 Cal B.P.

RECOVERY OF SUNFISH OSSICLES FROM THE ISLAND SITES

Notable quantities of ocean sunfish ossicles have now been identified in curated fishbone collections from the Eel Point and Little Harbor sites.

The Eel Point Ossicles

San Clemente Island is the southernmost and fourth largest (148 sq km) of the California Channel Islands. It is 61 km due west of San Diego on the mainland. The other two southern islands, Santa Catalina and San Nicolas, are approximately 39 and 97 km distant from San Clemente, respectively.



Fig. 9. Comparison of archaeological ossicle from Little Harbor (on right) with ossicle from Florida Museum of Natural History Specimen No. UF 11883 showing lateral lipping and grainy structure.

Stratigraphy is extraordinarily well preserved on San Clemente because there are no burrowing animals and most of the island is an undeveloped military preserve.

Eel Point is a rocky headland jutting seaward from the western coast of the island. It is the landward terminus of Eel Ridge, a prominence of Miocene sedimentary rock projecting westward from the island directly into a deep submarine canyon (Eel Ridge Canyon) (Ridlon 1972:1831-1834). This canyon forms the only break in the offshore terrace of the island and may have played an important role in bringing pelagic species nearshore where they might be readily captured

(P. Porcasi et al. 1999).

The site itself is an expansive knoll capping intact cultural deposits often 300 to 500 cm thick. Previous research has demonstrated that this site was occupied by maritime-adapted people from about 9000 to 500 years B.P. (McKusick and Warren 1959; Axford 1978, 1984; Armstrong 1985; Aycock 1983; Meighan 1984, 1986; Raab and Yatsko 1992; Salls 1988, 1990, 1991; Porcasi et al. 2000).

In 1994, 1996, and 1999, this site was excavated by California State University, Northridge (CSUN) in conjunction with the Navy's Office of Natural Resources. The project was designed to develop a detailed chronological structure of the site and a carefully controlled sample of artifacts and faunal materials. Twenty-one test units were excavated to sterile (total volume about 45.5 m³), the majority in natural strata. All material was screened through 1/8-inch screen. Forty-nine radiocarbon dates now provide a temporal framework ranging between 6440 cal B.C. and cal AD 1400 (Porcasi et al. 2000).

The three project years at Eel Point have yielded substantial fishbone collections. The 1994 collection of about 10.7 kg. of fishbone¹ yielded 24 mola ossicle fragments and two largely complete beak fragments. The 1996 collection of about 14.8 kg. of fishbone yielded 11 ossicle fragments. The 1999 fishbone collection of about 6.8 kg. of fishbone yielded 40 ossicle fragments. Table 1 presents these specimens in a chronological context. To accomplish this chronological

background, the Holocene is divided into five periods: Early (8000-5000 B.C.), undated intervening Early/Middle, Middle (5000-1500 B.C.), undated intervening Middle/Late, and Late (1500 B.C.-A.D. 1400). The undated intervening periods derive from strata for which no radiocarbon evidence is directly available, but their stratigraphic position between dated layers allows for relative temporal placement. The undisturbed stratigraphy of this site permits this. Most of the 77 *Mola mola* specimens from Eel Point are found in Late Holocene context, but a few are found in Middle and even Early/Middle levels. Small numbers of ossicles are now being recognized at other San Clemente Island sites, including some on the upper plateau of the island (Byrd and Andrews, 2002).

The Little Harbor Ossicles

Santa Catalina Island is located 42 km southwest of Los Angeles Harbor and is the second largest of the California Channel Islands, the largest of the southern group. It is 34 km. long and 13 km. wide at its maximum, and is nearly bisected by a narrow isthmus less than 1 km. wide. The Little Harbor site tops a gently sloped headland towering hundreds of feet above a narrow embayment on the seaward coast of the island. Like Eel Point, Little Harbor is favored by a deep submarine trench, the Catalina Canyon, which thrusts directly into the embayment at the base of the cliff (P. Porcasi et al. 1999).

Little Harbor contains an extremely dense, dark ashy midden 20 to 30 cm. below the present surface. This transitions into a clay basal stratum at approximately 65 cm. below the surface. The midden contains abundant bone and shell as well as numerous artifacts.

Three excavation projects at this site produced consistently large accumulations of fishbone. In 1953-55, a UCLA field school excavated 19 5-foot-square units on the upper knoll of the site (26 cubic yards of matrix) (Meighan 1959). However, this matrix was not screened and excavators relied on

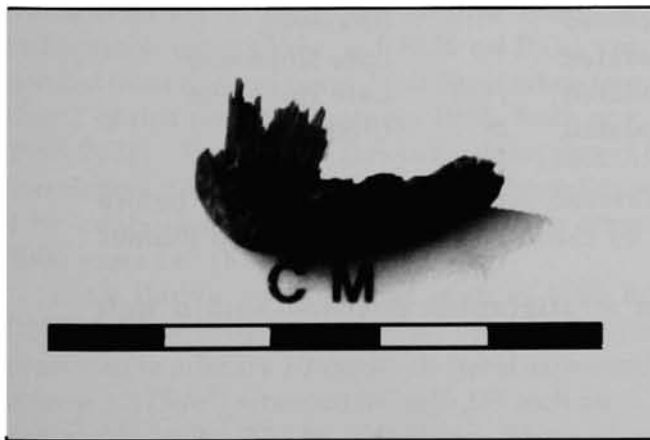


Fig. 10. *Mola mola* dentary recovered in 1994 from Eel Point Site.

¹NOTE

Eel Point fishbone weights are based on field laboratory curation and may change somewhat when these collections are fully analyzed.

Table 1
CHRONOLOGICAL CONTEXT OF MOLA FRAGMENTS FROM EEL POINT

<u>Unit(Level)</u>	<u>Fragments</u>	<u>C14 Date^a</u>	<u>Presumptive Date^b</u>
A(2)	1	Undated	Late Holocene
A(5B)	1	Undated	Middle Holocene
C(2A)	1	Undated	Late Holocene
C(3B)	1	Undated	Late Holocene
C(6)	1	5919	Middle Holocene
2N/35E(2)	1	Undated	Late Holocene
2N/35E(3)	2	944	Late Holocene
2N/35E(4)	1	1851	Late Holocene
2N/35E(5)	4	1935	Late Holocene
2N/35E(6)	3	1967	Late Holocene
2N/35E(7)	1	2566	Late Holocene
2N/35E Feat.1	1	Undated	Late Holocene
24.5S/77E(5C)	1	Undated	Late Holocene
24.5S/77E(6)	5	Undated	Late Holocene
24.5S/77E(8)	2	1709	Late Holocene
F(1)	1	Undated	Late Holocene
G(1A)	1	Undated	Late Holocene
G(5)	1	Undated	Middle Holocene
26N/20/21E(8)	1	Undated	Middle Holocene
31N/11/12E(6)	4	Undated	Middle/Late
31N/11/12E(7)	1	Undated	Middle/Late
31N/11/12E(8)	1	Undated	Middle Holocene
31N/11/12E(10)	1	Undated	Early/Middle
26N/19E(2)	1	Undated	Late Holocene
29N/14E(2)	2	Undated	Late Holocene
30N/14E(2)	23	Undated	Late Holocene
30N/14E(wall)	2	Undated	Unknown
31N/13E(2B)	2	Undated	Late Holocene
31N/14E(2)	9	Undated	Late Holocene
31N/14E(5)	1	Undated	Unknown

^a Cal B.P. One-sigma mean of dendrocalibrated age of sample in years before present (present = A.D. 1950), calibrated by *Calib rev. 4.1* (Stuiver and Reimer 1993).

^b Relative temporal placement based on stratigraphic position within unit intervening with dated levels.

meticulous visual recovery of cultural materials. Meighan reported "innumerable" fish bones from this project (1959:xx), but other than this statement the fishbone was not described.

Five distinct depositions (Layers) were identified by Meighan. Layer 4 was the dense cultural midden which produced the rich collection of artifacts and faunal remains. A single Middle Holocene radiocarbon date (uncorrected) of 3880 ± 250 B.P. was obtained from charcoal samples collected from the base of Layer 4. This date has now been dendrocalibrated and corrected by Calib 3.0 (Stuiver and Reimer 1993) as 2384 cal B.C. However, this date remains problematic since the charcoal sample was derived from three different portions of the basal midden between 50 and 60 cm deep (Raab et al. 1995:294).

In 1973, a UCLA field school again excavated this site. Matrix from 31 units was screened through 1/8-inch screen (Nelson Leonard III, principal investigator, personal communication 1997). Most units were downslope and west of the earlier project area, dispersed throughout the seaward-projecting cliff. The units were excavated to varying depths and were recorded in both arbitrary 10-cm levels and four observed cultural depositions termed Natural Levels (NL). A total of 22.48 m³ of matrix yielded about 8.53 kg. of fishbone.

Leonard's Natural Level 2 is the primary cultural midden corresponding to Layer 4 described by Meighan. One Late Holocene date (cal A.D. 1022) was derived from the uppermost Natural Level 1, and two Middle Holocene radiocarbon dates (3591 and 3336 cal B.C.) were derived from Natural Level 2 (all dates taken from Unit 1 of this project [Kaufman 1976; Raab et al. 1995:293]). The Middle Holocene dates support correlation of Natural Level 2 with Meighan's Layer 4 by establishing the date of this level as about 5000 years B.P. (Kaufman 1976).

Little Harbor was explored again in 1991 by CSUN. This project consisted of three units excavated in arbitrary 10-cm levels (total excavated volume 1.475 m³) screened through 1/8-inch mesh. This yielded some 2.77 kg. of fishbone. These units were centrally located at the site and produced a higher frequency of fishbone per cubic meter than

did the more widely dispersed units in the 1973 excavation.

Six additional radiocarbon dates were obtained from various levels of the three units, including the basal level of the deepest unit. On the basis of these dates, along with the earlier published dates, Raab et al. (1995:293) established a chronology for this site and a series of five cultural components spanning the Holocene. The richest of these is Component 2, which corresponds with Layer 4 (Meighan 1959:386) and Natural Level 2 identified during the 1973 excavation. Based on the average of six radiocarbon assays, a date of 3316 ± 30 cal B.C. (or about 5300 B.P.) was established for Component 2. The majority of the Little Harbor midden is established as Component 2. A newly obtained radiocarbon date of Cal B.P. 3690 – 3450 (AMS corrected, Beta-155793) derived from marine mammal bone recovered from NL 3 (Unit 24, 50-60 cm), however, is inverse with respect to the NL 2 dates noted above and what might be assumed to be earlier dates for NL 3.

Little Harbor has produced many hundreds of *Mola mola* ossicles, primarily from the Middle Holocene component. The 1973 project yielded 1300 ossicles, 69% of which derived from Natural Level 2. Some ossicles (166) (12.8%) were also found in Natural Level 3, and a lesser quantity of ossicles (62) (4.8%) was found in Natural Level 4, both of which precede Component 2 in time.

Several large concentrations of ossicles were found. Some 96 ossicles were found in one 10-cm. level, and 87 and 81 ossicles were recovered from separate 10-cm-levels of other units (1-x-2-m. units). Overall, the density of ossicles is about 58 ossicles per m³.

The 1991 three-unit project (less than 1.5 m³ excavated matrix) produced 137 mola fragments, or about 92 mola specimens per m³. There are also several concentrations of mola elements at about 40 cm depth. For example, one level (.05 m³) produced 19 mola specimens, or 380 specimens per m³. Another level (.10 m³) produced 34 ossicles or 340 per m³. One of these concentrations is from the provenience which produced the earliest known radiocarbon date from this site (5704 cal B.C.), as well as a date of 3172 cal B.C. (Raab et al. 1995:295). However, the Early

Holocene date of 5704 cal B.C. is considered provisional since it was derived from a possible hearth located below the primary cultural midden in a culturally sterile stratum producing no artifacts or faunal material. Table 2 presents the Little Harbor ossicles from the 1973 and 1991 projects in chronological context, using the same timeframe as established for Eel Point.

ISSUES INTRODUCED BY A *MOLA MOLA* FISHERY

Subsistence Resources

The presence of the huge ocean sunfish in the island middens is evidence of a marine harvest much richer than previously reasoned. Although the island middens are thick with marine mammal, invertebrate, bird, and fish remains, the inclusion of an easily captured species which could weigh 1000 kg. or more greatly increases subsistence potential. Especially during the Middle Holocene when use of marine resources climaxed at both island sites, a great deal more fish protein would have been available, as evidenced by the archaeologically recovered sunfish ossicles.

Recent thinking has proposed that fishing became more important in coastal peoples' diet over time as populations of mammals were diminished by hunting and as the human population grew (see for example Glassow 1993;

Colten 1993, 1995; Raab 2000; Raab et al. 1998; Broughton 1997). Yet, as an anachronism, the huge Mola was apparently being exploited as early as the Middle Holocene, possibly even before that time. The reason for this may be found within the tenets of optimal foraging theory. The mola presents a completely different set of cost vs. benefit factors than fishing for the typically smaller, sub-surface species that make up most coastal faunal assemblages. Unlike those species, the molas are very big, involve surface capture, and probably only the simplest capture technique. In other words, they present a big benefit at small cost. In addition, the great size of these fish might have made them competitively large, highly ranked "meat packages" akin to large terrestrial and marine mammals in optimal foraging terms. However, the role, if any, of the mola in intensification scenarios is yet to be defined.

Dissection of our juvenile specimen revealed that relative to its overall size, the ocean sunfish produces little actual muscle tissue. Below its coarse, denticle-covered skin is a nearly rigid layer of dense tissue with a texture like thick styrofoam.

Only a thin layer of muscle tissue is found within the flattened disc-like body. Most of the body consists of enormous viscera. It is likely that the nearly rigid skin and firm tissue underneath lend more support to the body than does the skeleton. The dense tissue and even the rough

Table 2

CHRONOLOGICAL CONTEXT FOR MOLA FRAGMENTS FROM LITTLE HARBOR

NL	Fragments	Component	Fragments	C14 ^a	Period
1	180	5	57	A.D. 1022	Late
1		4		A.D. 657	
--		3	26	2384 B.C.	(Late/Middle)
2	892	2	26	3316 B.C.	Middle
3	166	--	28	1740-1500 B.C. ^d	Middle
4	62 ^c	--		--	(Early/Middle)
--		1		5704 B.C. ^b	Early

^aFrom Porcasi and Fujita 2000:552; Raab et al. 1995.

^bProvisional date per Raab et al. 1995.

^cThese specimens are placed between the Early and Middle periods on the basis of stratigraphic position rather than actual dates.

^dBeta-155793.

skin may have been rendered usable in some manner by the prehistoric people, possibly for oil, fat, or abrasive material. When cooked, the flesh becomes fairly firm.

Fishing Technology

The manner in which islanders may have captured so large a fish remains an archaeological mystery. However, the fish is docile and relatively slow-swimming, and frequently basks on the surface. It will take a baited hook or can be gaffed or netted. Any of these methods might have been used. However, it is unknown if the primitive fish gorge or the bone or shell fish hooks commonly found on the islands would be sufficient to capture such a fish. Strong cordage would also be needed. There is no direct evidence of netting at the island sites. Lithic projectile points which might have been used in a spear-fishing technique are found at both Little Harbor and Eel Point. At present the technique for landing a full-size sunfish with prehistoric equipment can only be imagined. Stable watercraft would be a necessity.

Seasonality

The ocean sunfish inhabits fairly warm tropical to temperate waters. Its presence in large numbers along the California coast would be greatest during the summer or during frequent but brief warm water climatological episodes or longer warm water fluctuations known to have occurred during the Holocene. Kennett (1998:123) has recorded a series of extensive warm water periods occurring throughout the Holocene, with an especially pronounced warm water period (reaching a maximum of about 15 degrees C) during the Middle Holocene (ca 4500-4000 years B.P.). This might explain the increased presence of the ocean sunfish in certain strata of the Middle Holocene middens at both Eel Point and Little Harbor. Furthermore, the presence of the sunfish in the California Bight during this warm water period agrees with Raab et al. (1995) that elevated water temperature does not induce large-scale ecological disaster, but rather presents a modified ecology in which warm water species replace those requiring lower temperatures.

Human Health and Mortality

Although the addition of ocean sunfish to the islanders' menu of exploited fish species would have brought additional quantities of marine protein into the diet, this species might also have been responsible for illness and possible mortality among the island people. If not killed by thorough cooking prior to being eaten, the parasites borne by this fish are likely to be transferred to humans where they could cause serious debilitating disease and death. Whether or not this scenario occurred is entirely speculative at this point.

A *Mola mola* Effigy

Appreciation of the Mola in the prehistoric island lifeway may be indicated by a Mola effigy pendant (Fig. 11) curated at the American Museum of Natural History in New York. It is realistically fashioned of polished abalone shell: the distinctive dorsal and anal fins and flattened clavus of the mola are well modeled, and the large eye and round gill opening are displayed. Although it lacks good provenience, this ornament is recorded as a constituent of the collection assembled by Mr. James Terry of Hartford, Connecticut, the museum's first Curator of Anthropology between 1891 and 1894. This collection, which contained some 15,000 specimens from the Channel Islands and the adjacent mainland counties, was gathered by Terry from several local collectors during the late 1800s and purchased by the museum in 1891 (Nelson 1936). Few items in the Terry collection have detailed provenience.

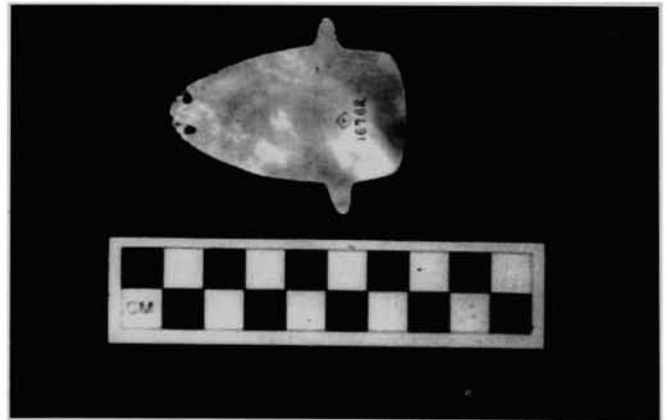


Fig. 11. *Mola* pendant curated by the American Museum of Natural History, New York (Catalog No. 16762).

CONCLUSIONS

This research has identified a previously unrecognized species in the prehistoric fishery of southern California and has demonstrated that this species was both abundant and exploitable. By undetermined technique this species was intensively collected at island and coastal sites, especially during the Middle Holocene. Hopefully this paper will aid archaeologists (especially zooarchaeologists) to develop more detailed analyses and a greater understanding of the early maritime adaptation in this area.

ACKNOWLEDGEMENTS

This research was much aided by Los Angeles County Museum of Natural History Ichthyologist Jeff Seigel and Paleontologist J.D. Stewart. With their help we were able to obtain a juvenile *Mola mola* for dissection and study. We also wish to thank Sylvia Scudder of the Florida Museum of Natural History for her help in locating, examining, and obtaining photographs of the 7.5-foot-long *Mola mola* skeleton in that museum's collection. We also appreciate the loan of the fragmentary juvenile *Mola mola* specimen from the California Academy of Sciences, Berkeley. Phillip Colla of Oceanlight (Carlsbad, CA) generously donated the wonderful underwater *Mola mola* photograph. We thank Larry Wilcoxon of Wilcoxon and Associates and Tom Wake of the Zooarchaeology Laboratory, UCLA Cotsen Institute of Archaeology, for the personal communication regarding *Mola mola* ossicles in the Santa Barbara site collection. Stacey Otte and Jeannine Petersen of the Catalina Island Museum graciously gave us access to the Little Harbor collections and donated a sample for radiocarbon dating. We also thank the willing and efficient help of volunteers Vicki Kahle and Anna Hernandez in quantifying the Little Harbor ossicles. Lisa Thomas discovered the mola pendant in the Terry Collection and provided the photo of that artifact.

REFERENCES

- Andrews, Sherri L.
2000 A Closer Look at the Archaeological Fish Bone Assemblage at the Eel Point Site, San Clemente Island, California. Unpublished masters thesis, Anthropology Department, California State University, Northridge.
- Armstrong, Douglas V.
1985 Archaeology on San Clemente Island, Summer 1985. Ms. on file, Natural Resources Office, Naval Air Station, North Island, San Diego.
- Arnold, Jeanne E., Roger H. Colten, and Scott Pletka
1997 Context of Cultural Change in Insular California. *American Antiquity* 62(2):300-318.
- Axford, L. Michael
1978 Current Archaeological Investigations on San Clemente Island, California. Ms. on file, Natural Resources Office, Naval Air Station, North Island, San Diego.
1984 Four Years of Archeological Investigations on San Clemente Island, California. Ms. on file, Natural Resources Office, Naval Air Station, North Island, San Diego.
- Aycock, Richard D.
1983 An Early Channel Island Site: Excavations at Eel Point, San Clemente Island, California. Ms. on file, Department of Anthropology, University of California, Los Angeles.
- Barnhart, Percy S.
1936 Marine Fishes of Southern California. University of California Press, Berkeley.
- Broughton, Jack M.
1997 Widening Diet Breadth, Declining

- Foraging Efficiency, and Prehistoric Harvest Pressure: Ichthyofaunal Evidence from the Emeryville Shellmound, California. *Antiquity* (71):845-862.
- Byrd, Brian F., and Sherri L. Andrews
2002 Archaeological Testing of Five Sites in the Old Airfield Area, Central San Clemente Island, California. Draft report prepared for the Natural Resources Office, Naval Air Station, North Island, by ASM Affiliates, Inc., Encinitas.
- Colten, Roger H.
1992 Preliminary Analysis of Faunal Remains from Four Sites on Santa Cruz Island. *Proceedings of the Society for California Archaeology* 5:247-297.
1993 Prehistoric Subsistence, Specialization, and Economy in a Southern California Chiefdom. Ph.D. Dissertation, Anthropology Department, University of California, Los Angeles.
1995 Faunal Exploitation During the Middle to Late Period Transition on Santa Cruz Island, California. *Journal of California and Great Basin Anthropology* 17(1):93-120.
- Eschmeyer, William N., Earl S. Herald, and Howard Hammann
1983 *A Field Guide to Pacific Coast Fishes of North America*, Houghton Mifflin Co., Boston.
- Fischer, W., F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter, and V. H. Niem (Eds.)
1995 *Guia Fao Para La Identificacion de Especies Para Los Fines de la Pesca, Pacifico Centro-Oriental, Vol. III Vertebrados*. Organizacion de las Naciones Unidas para la Agricultura y la Alimentacion, Rome.
- Fraser-Brunner, Alan
1951 *The Ocean Sunfishes (Family Molidae)*. *Bulletin of the British Museum (Natural History), Zoology* 1:89-121.
- Glassow, Michael A.
1993 Changes in Subsistence on Marine Resources Through 7,000 Years of Prehistory on Santa Cruz Island. In *Archaeology on the Northern Channel Islands of California: Studies of Subsistence, Economics, and Social Organization*, edited by Michael A. Glassow, pp. 75-94. Coyote Press Archives of California Prehistory 34, Salinas.
- Gobalet, Kenneth W., and Terry L. Jones
1995 Prehistoric Native American Fisheries of the Central California Coast. *Transactions of the American Fisheries Society* 124:813-823.
- Gregory, William K., and Henry C. Raven
1934 Notes on the Anatomy and Relationships of the Ocean Sunfish (*Mola mola*). *Copeia* 4:145-151.
- Holder, Charles F.
1912 *The Fishes of the Pacific Coast*. Dodge Publishing Co., New York.
- Johnson, John R.
1993 Observations on Fish Remains from Five Santa Cruz Island Archaeological Sites. Paper presented for "Analysis of Emergent Complexity in the Prehistoric Channel Islands," NSF Grant BNS 88-12184.
- Kaufman, Thomas S.
1976 Environmental Analysis of the Little Harbor Archaeological Site, Santa Catalina Island, California. Unpublished master's thesis, Department of Anthropology, University of California, Los Angeles.

- Kennett, Douglas J.
 1998 Behavioral Ecology and the Evolution of Hunter-Gatherer Societies on the Northern Channel Islands, California. Ph.D. Dissertation, Department of Anthropology, University of California, Santa Barbara.
- McKusick, Michael B., and Claude N. Warren
 1959 Introduction to San Clemente Island Archaeology. Annual Report of the University of California Archaeological Survey 1958-1959:107-186.
- Meighan, Clement W.
 1959 The Little Harbor Site, Catalina Island: An Example of Ecological Interpretation in Archaeology. *American Antiquity* 24:383-405.
 1984 Archaeology on San Clemente Island, Summer 1984. Ms. on file, Natural Resources Office, Naval Air Station, North Island, San Diego.
 1986 UCLA Archaeological Research on San Clemente Island, 1986. Ms. on file, Natural Resources Office, Naval Air Station, North Island, San Diego.
- Nelson, Nels C.
 1936 Notes on the Santa Barbara Culture. In *Essays in Anthropology Presented to Alfred L. Kroeber in Celebration of His Sixtieth Birthday*, pp. 199-209, University of California Press, Berkeley.
- Porcasi, Judith F.
 1999 Updating Prehistoric Maritime Subsistence at Little Harbor, Santa Catalina Island, California. *Proceedings of the Fifth California Islands Symposium*. Santa Barbara Museum of Natural History, Santa Barbara.
 1995 Trans-Holocene Marine Mammal Hunting on San Clemente Island, California: Additional Data to Assess a Prehistoric "Tragedy of the Commons" and Declining Mammalian Foraging Efficiency. Unpublished masters thesis. Department of Anthropology, California State University, Northridge.
- Porcasi, Judith F., Terry L. Jones, and L. Mark Raab
 2000 Trans-Holocene Marine Mammal Exploitation on San Clemente Island, California: A Tragedy of the Commons Revisited. *Journal of Anthropological Archaeology* 19:200-220.
- Porcasi, Judith F., and Harumi Fujita
 2000 The Dolphin Hunters: A Specialized Prehistoric Maritime Adaptation in the Southern California Channel Islands and Baja California. *American Antiquity* 65(3):543-566.
- Porcasi, Paul, Judith F. Porcasi, and Collin O'Neill
 1999 Early Holocene Coastlines of the California Bight: The Channel Islands as First Visited by Humans. *Pacific Coast Archaeological Society Quarterly* 35(2/3):1-24.
- Raab, L. Mark
 2000 Intensification, Climatic Stress, and Warfare: Competitive Selection in Late Holocene Coastal Southern California. Paper presented to the 34th Annual Meeting of the Society for California Archaeology, Riverside. Ms. on file, Center for Public Archaeology, California State University, Northridge.
- Raab, L. Mark, Katherine Bradford, Judith F. Porcasi, and William J. Howard
 1995 Return to Little Harbor, Santa Catalina Island, California: A Critique of the Marine Paleotemperature Model. *American Antiquity* 60(2):287-308.

- Raab, L. Mark, and Andrew Yatsko
 1992 Ancient Maritime Adaptations of the California Bight: A Perspective from San Clemente Island. In *Essays on the Maritime Prehistory of California*, edited by Terry L. Jones, pp. 173-193, Publication No., 10, Center for Archaeological Research, University of California, Davis.
- Raab, L. Mark, Judith F. Porcasi, Thomas Garlinghouse, Katherine Bradford, and Andrew Yatsko
 1998 Trans-Holocene Cultural and Biological Impacts on Maritime Resource Intensification on the Southern Channel Islands, California. Paper presented to the 63rd Annual Meeting of the Society for American Archaeology, Seattle. Ms. on file, Center for Public Archaeology, California State University, Northridge.
- Ridlon, James B.
 1972 Pleistocene-Holocene Deformation of the San Clemente Island Crustal Block, California. *Geological Society of America Bulletin* 83:1831-1844.
- Salls, Roy A.
 1988 Prehistoric Fisheries of the California Bight. Ph.D. Dissertation, Department of Anthropology, University of California, Los Angeles.
 1990 The Ancient Mariners: Ten Thousand Years of Marine Exploitation at Eel Point, San Clemente Island, California. *Pacific Coast Archaeological Society Quarterly* 26:61-92.
 1991 Early Holocene Maritime Adaptation at Eel Point, San Clemente Island. In *Hunter-Gatherers of Early Holocene Coastal California*, edited by Jon M. Erlandson and Roger H. Colten. pp. 63-80. Institute of Archaeology, University of California, Los Angeles.
- Stuiver, Minze, and Paula J. Reimer
 1993 Extended ¹⁴C Data Base and Revised Calib 3.0 ¹⁴C Calibration Program. *Radiocarbon* 35:215-230.
 1993 Calib rev. 4.1. *Radiocarbon* 35:215-230.
- Tyler, James C.
 1980 Osteology, Phylogeny, and Higher Classification of the Fishes of the Order Plectognathi (Tetraodontiformes). U.S. Department of Commerce National Ocean and Atmospheric Administration, National Marine Fisheries Service Technical Report NMFS Circular 434.
- Van Slyke, Noel
 1998 A Review of the Analysis of Fish Remains in Chumash Sites. *Pacific Coast Archaeological Society Quarterly*. 34(1):25-58.



