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Source: *American Antiquity*, Oct., 2001, Vol. 66, No. 4 (Oct., 2001), pp. 595-613

Published by: Cambridge University Press

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# PALEOCOASTAL MARINE FISHING ON THE PACIFIC COAST OF THE AMERICAS: PERSPECTIVES FROM DAISY CAVE, CALIFORNIA

Torben C. Rick, Jon M. Erlandson, and René L. Vellanoweth

*Analysis of over 27,000 fish bones from strata at Daisy Cave dated between about 11,500 and 8500 cal B.P. suggests that early Channel Islanders fished relatively intensively in a variety of habitats using a number of distinct technologies, including boats and the earliest evidence for hook-and-line fishing on the Pacific Coast of the Americas. The abundance of fish remains and fishing-related artifacts supports dietary reconstructions that suggest fish provided more than 50 percent of the edible meat represented in faunal samples from the early Holocene site strata. The abundance and economic importance of fish at Daisy Cave, unprecedented among early sites along the Pacific Coast of North America, suggest that early maritime capabilities on the Channel Islands were both more advanced and more variable than previously believed. When combined with a survey of fish remains from several other early Pacific Coast sites, these data suggest that early New World peoples effectively used watercraft, captured a diverse array of fish, and exploited a variety of marine habitats and resources.*

*El análisis de más de 27.000 huesos de pescado de Daisy Cave (Cueva de las Margaritas), cuyos estratos datan entre 11.500 y 8.500 cal B.P., sugiere que los primeros habitantes de Channel Islands (Las Islas del Canal), de la costa del Pacifico norteamericano, pescaron con relativa intensidad en una variedad de nichos ecológicos. Además, usaron un amplio número de distintas tecnologías incluyendo el uso de botes, anzuelos y cuerdas. La abundancia de los restos de especies de pescado y de los artefactos relacionados con la pesca han ayudado a la reconstrucción dietética, sugiriendo que el pescado proporcionó más del 50% del alimento, siendo eso representado en las muestras de fauna de este sitio dentro del estrato del Holoceno Temprano. La importancia económica y la plenitud de pescado de Daisy Cave de esta parte de la costa del Pacifico, era sin precedente e indica que la capacidad marítima de los habitantes de los Channel Islands era más avanzada y variable de lo que se creía. Combinado esta información con otros estudios sobre restos de pescado de distintos sitios de la costa del Pacífico de entonce, sugiere que la gente del Nuevo Mundo usó con eficacia la tecnología marítima, capturando una diversidad de pescados y explotando una variedad de recursos marítimos de su medio ambiente.*

Interested in understanding the role of aquatic resources in human subsistence economies, archaeologists have long focused on establishing the antiquity of marine food use (e.g., Erlandson 1994, 2001; Hayden 1981; Jones 1991; Moseley 1975; Osborn 1977; Perlman 1980; Yesner 1980, 1987). Some researchers have argued, for instance, that marine resources were adopted gradually into human diets beginning with littoral foods such as shellfish and only later including more behaviorally complex fauna such as fish and sea mammals (Lyman 1991; Meighan 1965, 1989; Ryder 1969). Related to this is the idea that marine vertebrates generally require more sophisticated technology for their capture and use by humans in the past.

Marine fishing is usually considered to have developed relatively late in human history (see Hayden 1981:525; Klein 1999:454–459), including much of the Pacific Coast of North America where evidence for intensive fishing is thought to be limited to the last several thousand years and to be intimately related to the development of complex maritime societies (Colten 1993; Glassow 1996; Raab et al. 1995). From cultural ecological or optimal foraging perspectives, the relatively late development of intensive marine fishing is often considered to be due to the heavy investment of labor and materials involved in fishing-related technologies such as boats, nets, weirs, etc. Others have questioned the value of marine fishing at all, arguing that

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American Antiquity, 66(4), 2001, pp. 595–613
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it is an unpredictable and risky endeavor that often provides only minimal returns when compared to "optimal" large terrestrial game:

> But fish are different. Some species, especially surface feeders, will give away their presence, but not bottom feeders. And fish cannot be tracked—this is a particular problem in exploiting oceanic fish. The forager can only go to a likely place to find fish, then begin searching randomly. If there are no fish there, the forager could waste quite a bit of time before accepting this as likely [Kelly 1996:209].

A growing body of data demonstrates, however, that many early New World peoples had more eclectic subsistence economies than previously presumed (e.g., Dillehay et al. 1992; Roosevelt et al. 1996; Yesner 1996), including the systematic exploitation of marine fish at several Pacific Coast sites (Erlandson et al. 1999; Keefer et al. 1998; Rick and Erlandson 2000; Sandweiss et al. 1998). Along the southern California Coast, early economies appear to have focused primarily on marine shellfish and plant foods, but a variety of sea mammals, fish, birds, and land mammals were also exploited (Erlandson 1994; Erlandson and Moss 1996; Jones 1991). Nonetheless, some of the earliest sites on the California Coast have produced relatively little evidence of marine fishing (see Erlandson 1994; Fitch 1972; Glassow 1996), and numerous studies have suggested that intensive fishing was limited to the Late Holocene.

New data from Channel Island sites raise questions about the antiquity of intensive fishing capabilities along the California Coast. Vellanoweth and Erlandson (1999) recently demonstrated that some Channel Island groups engaged in relatively intensive marine fishing by at least 5,000 years ago, with fish comprising 47 to 67 percent of the edible meat represented by faunal samples from components dated to about 5,200 and 4,800 years ago, respectively. In this paper, we present data from Daisy Cave on San Miguel Island that extend the antiquity of relatively intensive fishing back another 5,000 years to the very beginning of the Holocene. We examine the nature of early fishing strategies at Daisy Cave by analyzing over 27,000 fish bones recovered from Early Holocene and terminal Pleistocene strata at Daisy Cave, the vast majority of which come from strata dated between about 9700 and 8000 R.Y.B.P. (ca. 10,500 and 8500 cal B.P.). Comparing this assemblage to other faunal and artifactual data from the same strata, we reconstruct the kinds of fish caught and the habitats from which they came, the probable seasons during which fishing occurred, the technologies used to capture fish, and the significance of fishing relative to other subsistence practices. Exploring the broader implications of the Daisy Cave fish remains, we also summarize fish assemblages from other early North and South American Pacific Coast sites. Ultimately, we demonstrate considerable variability in early fishing strategies and maritime lifeways among Pacific Coast peoples, as well as the potential productivity of fishing in nearshore marine environments.

## Environmental Setting and Chronology

Located between 19 and 44 km off the southern California mainland (Figure 1), the northern Channel Islands contain a relatively impoverished terrestrial fauna, with the largest indigenous land mammals being the small island fox and the spotted skunk (Schoenherr et al. 1999). A number of terrestrial plants that abound on the mainland—and were crucial to early Milling Stone peoples of the mainland coast—are also either absent or relatively rare on the islands (Timbrook 1993). For decades, the isolation of the islands, the dearth of terrestrial resources, and the lack of Milling Stone sites contributed to the mistaken belief that the Channel Islands were colonized relatively late in the history of the region (e.g., Olson 1930; Rozaire 1967; Yesner 1987:301). It is now clear, however, that a wealth of marine resources has attracted maritime peoples for at least the last 12,000 years (Erlandson and Moss 1996; Erlandson et al. 1996; Johnson et al. 2000). The Channel Islands have been separated from the mainland throughout the Pleistocene and even at the height of the Last Glacial were at least 6 km offshore, indicating that early Channel Islanders used some form of ocean-going watercraft to reach the islands and probably in subsistence activities as well.

The marine environment of the Channel Islands is exceptionally productive, with the upwelling of nutrient-rich waters supporting unusually large populations of pinnipeds, cetaceans, seabirds, shellfish, and hundreds of species of fish (Love 1996:19). San Miguel Island, like the other northern Channel Islands, provides ready access to a diverse array of marine habitats from deep water to shallow water zones, including highly productive kelp forests especially rich in fish populations (Glassow and Wilcoxon

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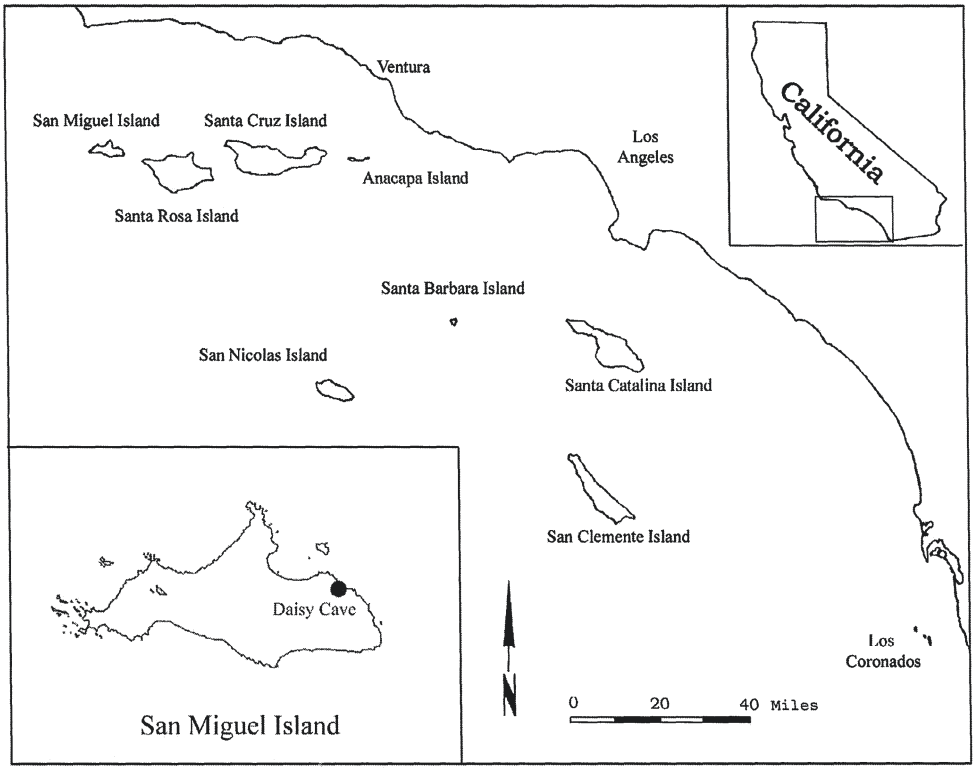


**Figure 1. Daisy Cave and the Southern California Coast.**

1988); rocky, sandy, or mosaic reef and nearshore zones; and a variety of intertidal habitats, including extensive rocky coastlines where fish can be caught from shore.

While the overall configuration and productivity of Channel Island marine habitats has changed dramatically since the end of the Last Glacial, archaeological assemblages spanning the Holocene suggest that a similar suite of marine resources has been available for human harvest throughout this time. During the Early Holocene, rapidly rising sea levels flooded many former coastal lowlands and canyons, leading to the formation of numerous estuaries along much of the mainland coast of the Santa Barbara Channel (Erlandson 1994). There is only limited evidence for estuary formation on the Channel Islands, however, where rocky shorelines appear to have dominated throughout the Holocene.

Because the sea floor drops off relatively rapidly offshore, Daisy Cave appears to have remained within a few hundred meters of the San Miguel Island shoreline throughout the past 12,000 years (Erlandson et al. 1996:357), and the structure of local marine habitats may have been similar to modern conditions. Daisy Cave is a multicomponent archaeological site situated just above a rocky, surf-swept portion of the northeast coast of San Miguel Island. The site consists of a narrow fissure approximately 11 m deep and 1.5 to 3 m wide, with an outer rockshelter approximately 4 x 5 m wide, and a shell midden on the slope in front of the shelter. Stratified archaeological deposits are located in all three areas, and prior to erosion covered an area over 200 $m^2$. The coastline in the site vicinity is dominated by a rugged, rocky shore with numerous intertidal or nearshore fissures, rocky ledges and overhangs, kelp beds, and patches of sandy substrate. Because of the steep offshore topography, a variety of benthic zones would have been within close range of the site for maritime fishing peoples.

Two primary occupational strata (E and F) at Daisy Cave have been dated to the early Holocene and one stratum (G) to the terminal Pleistocene (Table 1). Calendar age ranges suggest that Stratum E was deposited between about 8480 and 9270 cal B.P., Stratum F between about 8980 and 10,290 cal B.P., and Stratum G at approximately 11,600 cal B.P. (Erlandson et al. 1996). The early strata at Daisy

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Table 1. A Radiocarbon Chronology for Early Holocene Components from Daisy Cave.

| Provenience | Lab Number | Material Dated | Uncorrected $^{14}C$ Age | $^{13}C/^{12}C$ Adjusted | Calendar Age Range (cal BP)[a] |
|---|---|---|---|---|---|
| Col. E6, Str. E1 | CAMS-8866 | Charred twig | — | 7810 ± 60 | 8480 (8590) 8640 |
| Col. E6, Str. E1 | CAMS-14379 | CA mussel | — | 8380 ± 60 | 8530 (8610) 8750 |
| Col. E6, Str. E1 | CAMS-14380 | CA mussel | — | 8400 ± 60 | 8560 (8630) 8820 |
| Col. E6, Str. E1 | CAMS-14360 | CA mussel | — | 8440 ± 80 | 8580 (8710) 8870 |
| Col. E6, Str. E1 | Beta-15621 | Black abalone | 8030 ± 100 | 8460 ± 100 | 8590 (8760) 8890 |
| Col. E6, Str. E1 | CAMS-14361 | CA mussel | — | 8500 ± 80 | 8640 (8820) 8900 |
| Col. E6, Str. E4 | Beta-15622 | Black abalone | — | 8730 ± 120 | 8880 (8960) 9270 |
| Col. E6, Str. E4 | CAMS-8865 | Charred twig | — | 8040 ± 60 | 8790 (9000) 9030 |
| Col. E6, Str. F1 | Beta-16523 | CA mussel | 8470 ± 120 | 8900 ± 120 | 8980 (9050) 9420 |
| Col. E6, Str. F1 | CAMS-8867 | Charred twig | -- | 8600 ± 60 | 9530 (9550) 9600 |
| Col. E6, Str. F3 | Beta-49948 | CA mussel | 8940 ± 90 | 9360 ± 90 | 9590 (9810) 9920 |
| Col. E6, Str. F3 | CAMS-8863 | Charred twig | — | 8810 ± 80 | 9700 (9860) 10,150 |
| Col. E6, Str. F/G | CAMS-33375 | Marine shell | — | 9620 ± 70 | 9840 (10,120) 10,290 |
| Col. E6, Str. G | Beta-52360 | Black turban | 10,180 ± 70 | 10,600 ± 70 | 10,860 (11,120) 11,620 |
| Col. E6, Str. G | Beta-14660 | Red abalone | 10,260 ± 90 | 10,700 ± 90 | 10,880 (11,500) 11,900 |
| Col. E6, Str. G | CAMS-9094 | Wood charcoal | — | 10,390 ± 130 | 11,950 (12,330) 12,780 |

[a]All dates were calibrated using Calib 4.3 (Stuiver and Reimer 1993, 2000) and one sigma age ranges are presented. A ΔR of 225 ± 35 years was used for all shell samples, and $^{13}C/^{12}C$ ratios were either determined by the radiocarbon labs, or an average of +430 years was applied (Erlandson 1988).

Cave appear to represent a series of short-term occupations over a period of about 3,000 years, with a gap of over 1,000 years between the earliest relatively ephemeral occupation and a series of more intensive early Holocene occupations. The early occupations of Daisy Cave correspond with Moratto's (1984:108–109) Paleocoastal Tradition, characterized by a diversified coastal subsistence base and relative dearth of milling equipment. Fish remains are also found in middle and late Holocene site strata, but these have yet to be completely analyzed.

## Sampling and Analytical Methods

All taxonomic identifications in this study were performed by T. Rick using comparative collections at the Departments of Anthropology at the University of Oregon and University of California, Santa Barbara. The fish remains were identified to the most specific taxon possible, including identifications to order, family, genus, and species following the nomenclature, seasonality, and habitat information of Eschmeyer et al. (1983), Love (1996), and Miller and Lea (1972). Following Gobalet (1997:320), our approach to the identification process is conservative, with most identifications made to family or genus. A suite of 26 different elements were identified, but dense elements including the angular, dentary, maxilla, parasphenoid, premaxilla, quadrate, vertebra, and vomer, were among the most commonly identified elements (see Rick 1999). The following elements were also identified, but most were present in minor amounts: basioccipital, ceratohyal, epihyal, frontal, hyomandibular, interopercle, opercle, palatine, parietal, pharyngeal, post-cleithrum, post-temporal, preopercle, radial, scapula, supracleithrum, supraoccipital, and urohyal. Many of the fragmentary specimens could be typed by element, but had features indicative of two or sometimes three different taxa of fish, often from entirely different families. Taking a conservative approach, these ambiguous elements were identified as undifferentiated teleost or elasmobranch and excluded from further identification. Many of the problems encountered during analysis stem from a lack of multiple comparative specimens, or ambiguities associated with the preservation of some archaeological specimens. We did not identify beyond family or genus, except when a perfect match could be made.

Several of the identified categories deserve further explanation, and we highlight aspects of our decision making for the purposes of potential replication (Driver 1992). Specimens identified to the family Atherinidae (silversides), include jacksmelt, topsmelt, and possibly grunion, while Clupeidae includes sardine and herring. Remains identified to the Cottidae (sculpin) family are probably small sculpins such as Pacific staghorn sculpin and threadfin sculpin. Specimens identified as Engraulidae could be several types

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of anchovies (deepbody, northern, etc.), and those identified as Clinidae may be several different types of kelpfish. Remains identified to the family Stichaeidae could be monkeyface eel, or other types of prickleback. Finally, remains from the family Triakidae could be smoothhounds, leopard sharks, or possibly small soupfin sharks. Specific identifications were not made in these instances due to interspecific similarities in the physical appearance of elements, or a lack of comparative specimens. Any taxa denoted with a question mark are tentatively identified due to a lack of comparative materials or poor preservation of the specimen.

To determine the significance of each of the fish taxa, we used a variety of measures: number of identified specimens (NISP), minimum number of individuals (MNI), and bone weights. Each of these methods pose some problems (see Casteel 1976; Grayson 1984; Klein and Cruz-Uribe 1984), but together offer a variety of measures of the relative importance of faunal classes rather than merely discussing their presence or absence. NISP is the count of whole and fragmentary elements for each individual taxon, while the MNI values are derived from this estimate (Wheeler and Jones 1989). Due to the excellent preservation at Daisy Cave, and the relatively large size of the sample, several cranial elements were used in calculating MNI. Most commonly, these included relatively robust cranial elements such as premaxillae, maxillae, dentaries, vomers, parasphenoids, and quadrates, but fragile elements such as frontals, supraoccipitals, and palatines were also used. Many of these elements may have been from the same individual fish, a factor that was considered when calculating MNI. When cranial elements were not abundant, the number of vertebrae identified in the sample was divided by an average number of vertebrae for a given species, genus, or family.

Using all three measures together, we strive to provide the most thorough estimate possible of the importance of various fish taxa at Daisy Cave. To compare the general dietary significance of marine fish versus other faunal classes, we used the weight method to estimate the approximate meat yields represented by the faunal remains recovered in each stratum (see Colten 1993; Erlandson 1994; Glassow and Wilcoxon 1988). While the weight method also suffers from a variety of analytical problems, these are minimized at a site like Daisy Cave where stratigraphic integrity and faunal preservation are exceptional. Nonetheless, our meat weight estimates should not be treated as absolute values, but rather as general approximations, which when used in concert with other zooarchaeological measures (i.e., NISP, MNI, etc.) offer an important analytical tool for understanding the economic importance of various fauna. We also present standardized density values for both fish bone weight and NISP, to complement our dietary reconstructions. Finally, our seasonality and habitat inferences are based on modern biological data, but are assumed to have been similar during the early Holocene (see Wheeler and Jones 1989).

## Fish Remains from Daisy Cave

A total of 27,430 (1.8 kg) fish bones from Daisy Cave were analyzed, including 2,088 (.47 kg) identifiable specimens from Stratum E and F. The assemblage came from six units excavated between 1986 and 1998: a 1-x-.75 m unit (98-E6), a 1- x-.5 m unit (E7), a .5-x-.5 m unit (C5/6), a .8- x-.5 m unit (D5/6), a 1-x-.5 m unit (D6), and a .5- x-.2 m column (E6) (Tables 2–4). Except for Unit E7, which was located on the slope below the rockshelter, all the units were excavated along the dripline of the shelter, where stratigraphic integrity and faunal preservation were exceptional. All excavated sediments were screened over 1/8-inch mesh. Although 1/8-inch screens can cause significant biases in fish assemblages from the California Coast, the exceptional preservation of the Daisy Cave fauna, along with the dearth of very small fish (clupeids, etc.) prone to underrepresentation, suggest that our samples are relatively representative. All six units had excellent faunal preservation, with the best preservation in Column E6, Unit 98-E6, and Unit C5/6. All deposits were excavated stratigraphically, but stratigraphic variation was minimal in Unit E7, so all the materials from the early Holocene levels in that unit have been lumped together. High resolution changes in the distribution of various fish are inferred from the five control units with finely stratified shell midden deposits.

### *Taphonomy*

The preservation of faunal remains at Daisy Cave is generally outstanding, especially compared to most mainland assemblages where stratigraphic mixing, chemical weathering, and fragmentation are major

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Table 2. NISP, Weight (g), and MNI of Fish Identified from Unit E7 at Daisy Cave.

| Taxon | NISP | %NISP[a] | Wt. | %Wt. | MNI | %MNI |
|---|---|---|---|---|---|---|
| Clupeidae (sardine/herring) | 8 | 3.3 | .08 | .2 | 1 | 5.3 |
| Cottidae (sculpin) | 6 | 2.5 | .14 | .3 | 1 | 5.3 |
| *Scorpaenichthys marmoratus* (cabezon) | 30 | 12.6 | 16.22 | 31.5 | 3 | 15.8 |
| Embiotocidae (surfperch) | 124 | 51.9 | 9.38 | 18.2 | 5 | 26.3 |
| Hexagrammidae (greenling) | 3 | 1.3 | .07 | .1 | 1 | 5.3 |
| *Ophiodon elongatus* (ling cod) | 1 | .4 | .49 | 1.0 | 1 | 5.3 |
| Labridae | | | | | | |
| *Semicossyphus pulcher* (sheephead) | 20 | 8.3 | 16.45 | 32.0 | 2 | 1.5 |
| Pleuronectiformes (flatfish) | 1 | .4 | .01 | .1 | 1 | 5.3 |
| Scorpaenidae (scorpionfishes, thornyheads, etc.) | 1 | .4 | .34 | .7 | — | — |
| *Sebastes sp.* (rockfish) | 44 | 18.4 | 8.15 | 15.8 | 3 | 15.8 |
| Stichaeidae (prickleback) | 1 | .4 | .14 | .2 | 1 | 5.3 |
| Teleost undifferentiated | 2944 | — | 126.37 | — | — | — |
| Teleost total | 3183 | — | 177.84 | — | 19 | — |

[a]Percentages are based on fish identified to family, genus, and species.

problems. Inside the dripline of the rockshelter, where most of our sample is derived from, preservation was especially good, with extremely fragile faunal and botanical specimens preserved with limited evidence for crushing or compaction. During excavation, for instance, articulated mussel valves were commonly encountered, along with articulated vertebral columns or other elements of fish, and even occasional sections of articulated fish scales. Significantly, the density of fish remains is closely correlated with that of other classes of cultural materials, including artifacts, charcoal, shellfish, and other faunal remains. Nonetheless, we carefully evaluated the origin of the fish remains before making inferences about human behavior.

Several researchers have suggested, for instance, that clupeids and other small fish may have been introduced into California shell middens incidentally as stomach contents of sea mammals (e.g., Fitch 1969). Others question this idea due to the lack of evidence for formal digestive modification on clupeid remains, ethnohistoric evidence of clupeid fishing, and the presence of such fish at interior sites located far from the coast (Erlandson 1994:103–104; Gobalet 1992; Johnson 1982:12–12; Landberg 1975; Rick and Erlandson 2000). Butler and Schroeder (1998) reported little difference in the effects of human vs. animal (coyote) digestion on fish bones, moreover, suggesting that differentiating between small fish remains consumed by humans vs. other mammals may be problematic. Although we examined the fish bones for any sign of digestion (i.e., staining, pitting, or deformation; see Butler and Schroeder 1998:958–961), no clear evidence for such alterations was identified. A small percentage of the specimens had been deformed, but it remains unclear if this was from digestion, boiling or cooking, or post-depositional processes (i.e., trampling). Butcher marks are also sometimes identified on fish elements (Colley 1990:216–217; Wheeler and Jones 1989:65–66), but except for limited evidence of burning, our analysis revealed no unequivocal signs of butchering or processing.

Erlandson and Moss (2001) have argued that a variety of birds and other animals can deposit faunal remains in archaeological sites, particularly caves. A variety of birds including cormorants, pelicans, hawks, oyster catchers, sea gulls, and crows inhabit the Daisy Cave area today. In 1991, numerous cormorant nests were found in and around the cave itself, attesting to intensive use of the site area by sea birds in some years. In addition, Holocene or late Pleistocene strata at Daisy Cave have also produced the remains of bald eagle, California condor, owls, and other birds (Guthrie 1980) known to prey on or scavenge fish remains (Broughton 2000; Erlandson and Moss 2001). With such a wide array of fish-eating or scavenging birds represented in the area, we carefully considered the possibility that some of the fish remains were deposited by sea birds rather than humans.

Several lines of evidence suggest, however, that the vast majority of fish remains were brought to Daisy Cave and consumed by people. First, the presence of numerous bone gorges and abundant cordage that may have been used in nets (Connolly et al.

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Table 3. Fish Remains from Stratum E.

| Taxon | Unit 98E6 | | Column E6 | | Unit C5/6 | | Unit D5/6 | | Unit D6 | | Total | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | %Wt.[a] | NISP | %NISP | MNI | %MNI |
| *Teleost* | | | | | | | | | | | | | | | | |
| Atherinidae (silversides) | — | — | 0.01 | 1 | — | — | — | — | — | — | 0.01 | <0.1 | 1 | 0.1 | 1 | 0.6 |
| Clinidae (kelpfish) | — | — | 0.04 | 2 | — | — | — | — | 0.09 | 2 | 0.13 | <0.1 | 4 | 0.2 | 4 | 2.2 |
| Clupeidae (herring, sardine) | 0.06 | 6 | 0.05 | 4 | 0.01 | 1 | — | — | 0.18 | 17 | 0.30 | <0.1 | 28 | 1.7 | 7 | 3.9 |
| Cottidae (sculpin) | 0.04 | 3 | 0.12 | 12 | 0.11 | 1 | — | — | 0.06 | 6 | 0.33 | <0.1 | 22 | 1.3 | 10 | 5.6 |
| *Scorpaenichthys marmoratus* (cabezon) | 23.45 | 38 | 8.45 | 20 | 29.14 | 49 | 20.0 | 37 | 30.24 | 59 | 111.28 | 28.7 | 203 | 12.4 | 25 | 14.0 |
| Embiotocidae (surfperch) | 15.83 | 171 | 8.33 | 106 | 12.92 | 106 | 13.67 | 91 | 39.35 | 432 | 90.10 | 23.3 | 906 | 55.5 | 50 | 28.1 |
| *Damalichthys vacca* (pile perch) | — | — | — | — | — | — | — | — | 3.03 | 2 | 3.03 | 0.8 | 2 | 0.1 | 1 | 0.6 |
| Engraulidae? (anchovy) | — | — | 0.01 | 1 | — | — | — | — | — | — | 0.01 | <0.1 | 1 | 0.1 | 1 | 0.6 |
| Hexagrammidae (greenling) | 0.03 | 1 | 0.01 | 2 | — | — | — | — | 0.27 | 16 | 0.31 | <0.1 | 19 | 1.2 | 5 | 2.8 |
| *Ophiodon elongatus* (lingcod) | — | — | 0.46 | 3 | 1.6 | 6 | 2.09 | 3 | 2.49 | 5 | 6.64 | 1.7 | 17 | 1.0 | 6 | 3.4 |
| Labridae (senorita or wrasse) | — | — | 0.01 | 1 | — | — | 0.07 | 2 | 0.09 | 2 | 0.17 | <0.1 | 5 | 0.3 | 3 | 1.7 |
| *Semicossyphus pulcher* (California sheephead) | 43.26 | 31 | 6.04 | 15 | 15.72 | 16 | 10.89 | 13 | 29.29 | 51 | 105.20 | 27.2 | 126 | 7.7 | 25 | 14.0 |
| Pleuronectiformes (flatfishes) | 0.03 | 1 | 0.02 | 1 | 0.03 | 1 | — | — | 0.13 | 3 | 0.21 | <0.1 | 6 | 0.4 | 5 | 2.8 |
| Scorpaenidae | 3.38 | 13 | — | — | — | — | — | — | — | — | 3.38 | 0.9 | 13 | 0.8 | — | — |
| *Sebastes* spp. (rockfish) | 10.04 | 48 | 6.75 | 28 | 9.17 | 29 | 17.48 | 57 | 20.92 | 105 | 64.36 | 16.6 | 267 | 16.4 | 29 | 16.3 |
| Stichaeidae (prickleback) | — | — | — | — | 0.33 | 1 | — | — | 0.18 | 1 | 0.51 | <0.1 | 2 | 0.1 | 2 | 1.1 |
| Teleost undifferentiated | 195.33 | 3248 | 110.38 | 4752 | 133.80 | 1851 | 194.43 | 2043 | 446.24 | 8846 | 1080.18 | — | 20,740 | — | — | — |
| Subtotal | 291.45 | 3560 | 140.68 | 4948 | 202.83 | 2061 | 258.63 | 2246 | 572.56 | 9547 | 1466.15 | — | 22,362 | — | 174 | — |
| *Elasmobranch* | | | | | | | | | | | | | | | | |
| Squatinidae | | | | | | | | | | | | | | | | |
| *Squatina californica* (angel shark) | 1.01 | 1 | — | — | — | — | — | — | — | — | 1.01 | 0.3 | 1 | 0.1 | 1 | 0.6 |
| Triakidae (smoothhounds, soupfin, etc.) | 0.07 | 6 | — | — | — | — | 0.31 | 2 | — | — | 0.38 | 0.1 | 8 | 0.5 | 3 | 1.7 |
| Subtotal | 1.08 | 7 | — | — | — | — | 0.31 | 2 | — | — | 1.39 | — | 9 | — | 4 | — |
| Total | 292.53 | 3567 | 140.68 | 4948 | 202.83 | 2061 | 258.94 | 2248 | 572.56 | 9547 | 1467.54 | | 22,371 | — | 178 | — |

[a]Percentages are based on specimens identified to family, genus, and species.

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Table 4. Fish Remains from Stratum F.

| Taxon | Unit 98E6 | | Column E6 | | Unit C5/6 | | Unit D5/6 | | Unit D6 | | Total | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | NISP | Wt. | %Wt.[a] | NISP | %NISP | MNI | %MNI |
| *Teleost* | | | | | | | | | | | | | | | | |
| Clinidae (kelpfish) | 0.07 | 2 | — | — | — | — | — | — | — | — | 0.07 | 0.2 | 2 | 0.9 | 1 | 1.8 |
| Clupeidae (herring, sardine) | 0.02 | 2 | 0.16 | 17 | — | — | — | — | 0.02 | 2 | 0.20 | 0.6 | 21 | 9.5 | 4 | 7.3 |
| Cottidae (sculpin) | — | — | 0.04 | 1 | 0.01 | 1 | — | — | — | — | 0.05 | 0.2 | 2 | 0.9 | 2 | 3.6 |
| *Scorpaenichthys marmoratus* (cabezon) | 3.39 | 6 | 0.45 | 1 | 0.25 | 1 | — | — | 0.22 | 1 | 4.31 | 13.8 | 9 | 4.1 | 5 | 9.1 |
| Embiotocidae (surfperch) | 1.28 | 14 | 0.33 | 8 | 0.57 | 7 | 0.92 | 6 | 3.71 | 60 | 6.81 | 21.9 | 95 | 43.2 | 13 | 23.6 |
| Hexagrammidae (greenling) | — | — | — | — | — | — | — | — | 0.02 | 1 | 0.02 | 0.1 | 1 | 0.5 | 1 | 1.8 |
| *Ophiodon elongatus* (lingcod) | — | — | — | — | 2.47 | 4 | — | — | — | — | 2.47 | 7.9 | 4 | 1.8 | 1 | 1.8 |
| Labridae (senorita or wrasse) | — | — | — | — | — | — | — | — | 0.07 | 4 | 0.07 | 0.2 | 4 | 1.8 | 2 | 3.6 |
| *Semicossyphus pulcher* (California sheephead) | 7.42 | 18 | 0.25 | 1 | 0.93 | 2 | 1.45 | 2 | 0.5 | 4 | 10.55 | 33.9 | 27 | 12.3 | 8 | 14.5 |
| Pleuronectiformes (flatfishes) | 0.07 | 2 | 0.06 | 1 | 0.1 | 2 | — | — | — | — | 0.23 | 0.7 | 5 | 2.3 | 3 | 5.5 |
| Scorpaenidae | | | | | | | | | | | | | | | | |
| *Sebastes* spp. (rockfish) | 2.03 | 26 | 1.22 | 7 | 0.84 | 4 | 1.08 | 3 | 1.06 | 7 | 6.23 | 20.0 | 47 | 21.4 | 12 | 21.8 |
| Stichaeidae (pricklebacks) | — | — | — | — | — | — | — | — | 0.05 | 1 | 0.05 | 0.2 | 1 | 0.5 | 1 | 1.8 |
| Teleost undifferentiated | 20.44 | 316 | 8.50 | 516 | 6.06 | 85 | 5.98 | 108 | 28.4 | 631 | 69.38 | — | 1656 | — | — | — |
| Subtotal | 34.72 | 386 | 11.01 | 552 | 11.23 | 106 | 9.43 | 119 | 34.05 | 711 | 100.44 | — | 1874 | — | 53 | — |
| *Elasmobranch* | | | | | | | | | | | | | | | | |
| Elasmobranch undifferentiated | 0.08 | 1 | — | — | — | — | 0.01 | 1 | — | — | 0.09 | 0.3 | 2 | 0.9 | 2 | 3.6 |
| Subtotal | 0.08 | 1 | — | — | — | — | 0.01 | 1 | — | — | 0.09 | — | 2 | — | 2 | — |
| Total | 34.8 | 387 | 11.01 | 552 | 11.23 | 106 | 9.44 | 120 | 34.05 | 711 | 100.53 | — | 1876 | — | 55 | — |

[a]Percentages are based on specimens identified to family, genus, and species.

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1995) in Strata E and F suggest a focus on fishing. The dearth of unequivocal digestive traces on the fish remains in archaeological strata suggests that fish were processed and consumed rather than eaten whole by other animals or humans. Although many birds regurgitate fish vertebrae and otoliths, one would expect at least some of the small fish to show signs of digestion. What appears to have been a bird roost located on a rock shelf inside Daisy Cave contained numerous fish bones, in fact, including hundreds of otoliths from midshipman, cabezon, surfperch, rockfish, etc. (Huddleston 1992). Many of these were heavily digested or weathered, making the assemblage distinct from the archaeological remains.

The presence of medium-sized fish such as sheephead, lingcod, and rockfish also suggests that these fish were caught primarily by humans, though eagles are known to take such animals (Erlandson and Moss 2001). Approximately 10 percent of the fish bone is burned, again suggesting human processing and consumption. There are also relatively few fish bones in the "sterile" layers of Daisy Cave, including strata B and D, which are found between archaeological strata and appear to have accumulated gradually over periods of 2,000 to 3,000 years. Finally, in visiting Daisy Cave annually for most of the past 10 years, Erlandson has closely monitored bird activity at the site and found little evidence of modern fish remains deposited by birds, even after a cormorant nesting colony existed at the site for several years.

*Description of the Assemblage*

Among the more than 27,000 fish bones recovered, at least 252 individuals and 18 different taxa were identified. The vast majority of these were nearshore teleosts, providing over 90 percent of the NISP and weight. Two elasmobranchs were also identified, an angel shark and a smoothhound shark, but the single specimen of each suggests that they were not a significant dietary constituent.

Only a small amount of fish bone was recovered from the terminal Pleistocene Stratum G, including 21 specimens, with a total weight of .5 g from the column sample. Only two specimens (weighing just .03 g) of what appear to be fish bone were identified in Stratum G from Unit 98-E6, and one rockfish atlas vertebra and maxilla fragment were recovered in Column E6. Stratum G is a relatively ephemeral occupational component dominated by marine shellfish remains, which is among the oldest coastal shell middens in the New World (Erlandson et al. 1996). A small assemblage of expedient flaked tools and debitage of both chert and siliceous shale was recovered in Stratum G, but no bone gorges or other clear fishing technologies have been identified.

In Unit E7, surfperch, rockfish, cabezon, and sheephead dominate, accounting for roughly 90 percent of the NISP and 97 percent of the identified teleost weight. These four taxa also contribute roughly 92 percent of the NISP and 96 percent of the weight of the identified taxa in Stratum E for the five other units. Surfperch are the dominant fish category by count for Stratum E in all of the control units, contributing roughly 56 percent of the total NISP for Stratum E. Several smaller fish were also identified in Stratum E, including sculpins, greenling, clupeids, giant kelpfish, small flatfish such as sanddab or flounder, and atherinids. A few elements from lingcod, pricklebacks, and what may be senorita were also identified in the assemblage.

For the most part, similar species of fish were identified in Stratum F, suggesting continuity over the roughly 2,000-year occupation span represented by these two strata. In Stratum F, surfperch, rockfish, cabezon, and sheephead provide approximately 81 percent of the NISP and 90 percent of the weight for the five control units. There appears to be a relatively higher proportion of small fish in Stratum F, with clupeids contributing roughly 10 percent of the NISP, whereas in Stratum E only about 2 percent of the NISP from Column E6 were from clupeids. This may suggest slightly different fishing strategies between the two time periods.

The amount of fish bone varies considerably between the two strata, with the highest count and weight of fish bone in Stratum E, with a NISP of 22,371 and a weight of 1,467.54 g from the five control units. In contrast, only 1,876 specimens weighing just 100.53 grams were identified from Stratum F, suggesting either that the importance of fishing increased through time, human use of the cave became more intense, natural sedimentation rates declined through time, fish bone was deposited elsewhere, or the emphasis of various activities changed through time. Given the higher density of all faunal materials in Stratum E, however, it is probable that the higher density of fish remains in Stratum E is related primarily to more sustained human occupation of the cave. The apparent continuity of identi-

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fied species suggests that while fishing may have intensified, the same general strategies were probably used throughout the occupation. A preliminary analysis of the fish remains from the middle and late Holocene strata at Daisy Cave identified similar species of fish (lingcod, surfperch, rockfish, sheephead, etc.) as were found in the older levels. It is probable that the same basic fishing strategies were used throughout the occupation of Daisy Cave, but the importance of various taxa and fishing techniques undoubtedly varied through time.

All of these lines of evidence suggest that fishing during the early Holocene occupation of Daisy Cave occurred primarily in rocky nearshore and kelp bed habitats. The major taxa, such as sheephead, sculpins, rockfish, and surfperch are all common inhabitants of these environments. The taxa identified in the assemblage are also quite similar to the modern fishes found in San Miguel Island waters today (Engle 1993:478–479). Kelp beds and rocky shores are the most common habitats in the immediate vicinity of Daisy Cave, suggesting considerable continuity in both the structure of local marine habitats and species composition over approximately 10,000 years. The small proportion of flatfish, angel shark, and triakids indicate that some fishing also may have occurred in nearshore sandy or calm water habitats, but these species also venture into rocky areas or kelp beds. An offshore mosaic of rocky and sandy habitats is visible off Daisy Cave today, and it is possible that this also existed during the early Holocene. Based on the identified taxa, fishing could have occurred at any time of the year, but would have been best in seasons other than winter when wave action from storms was less intense.

In addition to the diversity of taxa identified at Daisy Cave, density values for the fish assemblage are also high. Stratum E in Column E6, for example, contained roughly 215,130 fish bones and about 6117 g of fish bone per $m^3$ (4948 bones and 140.68g/.023$m^3$). Similarly, Stratum E of Unit 98-E6 contained roughly 111,469 fish bones and 9142 g of fish bone per $m^3$ (3567 bones and 292.53g/.032 $m^3$). The variation in fish bone densities for these two samples may reflect differential preservation, processing, and intrasite heterogeneity since the number and type of taxa identified in each unit are similar. Density values from Stratum F are significantly lower, with 22,080 fish bones and 440 g of fish bone per $m^3$ from the column sample (552 bones and 11.01g/.025 $m^3$) and 16,125 fish bones and 1450 g of fish bone per $m^3$ in Unit 98-E6 (387 bones and 34.8 g/.024 $m^3$). The discrepancy between Stratum E and F again appears to relate to an overall increase in human use of the cave during the Stratum E occupation.

Our dietary reconstructions for Daisy Cave complement these density values, suggesting that fish were the single largest contributor of meat to the site economy, a pattern that differs from most early Holocene archaeological assemblages from both the mainland coast and the islands of southern California. Edible meat estimates based on the weight method suggest that fish contributed roughly 50–65 percent of the meat represented by faunal remains recovered in the column samples, followed by shellfish with roughly 30–45 percent, and sea mammals and birds are supplemental foods. At most other early Holocene sites, people appear to have focused primarily on shellfish for meat, although they also used an eclectic array of supplemental fauna and fish that sometimes contributed between 10 and 20 percent of the meat represented (Erlandson 1994). The Daisy Cave assemblage suggests that although fishing may have been a secondary subsistence activity at many early Holocene coastal sites, early coastal peoples had the technological capabilities to capture large amounts of fish in productive fishing habitats. Although the abundance of fish bone at Daisy Cave might suggest that the importance of fishing is dramatically underrepresented at some early sites, the dearth of fishing technology and fish remains suggest otherwise. Even if the occupation of Daisy Cave was relatively specialized, our findings emphasize the diversity and variability of the lifeways of early coastal people, a topic we return to in a subsequent section.

## Fishing-Related Technology

Artifact assemblages from early Holocene sites on the southern California Coast generally lack the diversity later sites contain, particularly with regard to hunting and fishing technology. This may be due to the heavy reliance on shellfish, which generally require little in the way of technology to gather or process. Common artifacts in early mainland sites include manos and metates for seed grinding, flaked hammerstones for making and maintaining such milling equipment, and flake tools, while projectile points, bone tools, and shell beads are much rarer

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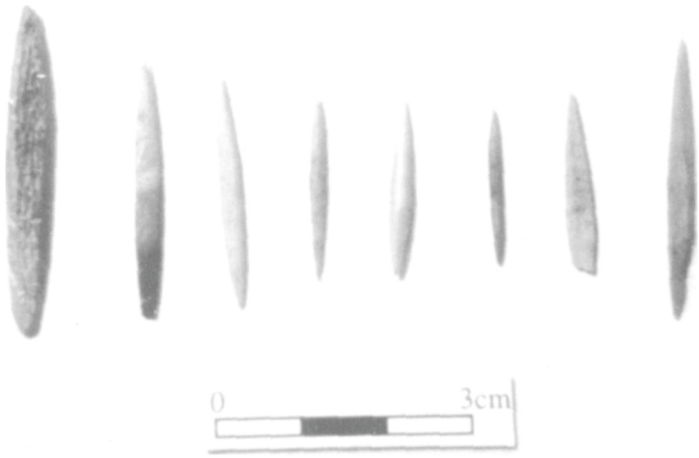


**Figure 2. Selected Bone Fish Gorges from Early Holocene Strata at Daisy Cave.**

(Erlandson 1994:262–266). In early island sites, milling tools are rare or absent, probably because of the limited range of edible plants available. At most early island and mainland sites, evidence for fishing technology is also rare, although possible fragments of gorges have been found in some early mainland sites (Erlandson 1994; Salls 1991). In general, the dearth of evidence for fishing technologies in early sites has been used to argue for the limited importance of fishing or the limited fishing capabilities of early peoples along the southern California Coast.

To determine the earliest types of fishing gear employed along the California Coast, researchers have traditionally relied primarily on biological data and ethnographic accounts (e.g., Fitch 1969, 1972; Salls 1988). There are numerous problems with such approaches, particularly when dealing with early time periods, but when used cautiously this method offers a means to assess the probable fishing gear employed. At Daisy Cave we are fortunate to have a significant assemblage of fishing-related artifacts to complement such reconstructions, including 30 whole or fragmentary bone bipoints (fish gorges) recovered from the Early Holocene levels (Figure 2). As far as we know, these bipoints, found throughout strata E and F, are the earliest known examples of hook-and-line technology documented on the North and South American Pacific Coast. Still undergoing detailed analysis, they appear to have been manufactured from bird, sea mammal, and land mammal bones. Some of the bipoints still retain evidence for scoring or asphaltum where they were tied to a fishing line slightly offset from center. Unlike traditional curved or compound hooks, which generally lodged in the mouth of a fish, bone gorges or "straight hooks" were swallowed whole then lodged in a fish's stomach or throat as the gorge toggled when the fishing line was pulled on. Preliminary analysis of bone-tool-making debitage also suggests that a distinctive "saw and snap" method was used to manufacture bone gorges at the site.

Many of the almost 2,000 pieces of woven seagrass cordage recovered from the early Holocene strata at Daisy Cave may also be related to fishing technologies. Although the precise function of these perishable artifacts is unknown, they have been interpreted as possible fragments of fishing line or nets (Connolly et al. 1995; Norris 1997; Vellanoweth et al. 2001). The types of fish recovered at Daisy Cave support this technological evidence. The abundance of medium-sized kelp-bed and rocky-shore taxa suggest that hook-and-line fishing was probably the prime method of capture. The presence of small fish like clupeids and surfperch suggest that nets were also used, probably dip nets at the least. The small sculpins could have also been caught by hand as they were trapped in small tide pools among the rocks adjacent to the site. Some of the smaller fish may also have served as bait for larger catches. To access the kelp beds, as well as to reach San Miguel Island from the mainland, some form of boat was also required. The presence of humans on the northern

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Channel Islands for at least 12,000 years clearly demonstrates that relatively seaworthy boats were used by the earliest maritime peoples of the area.

## Early Pacific Coast Fishing

In recent years, the number of documented early Pacific Coast sites has grown substantially (see Jones 1991; Lightfoot 1993; Erlandson and Moss 1996). For comparative purposes, we briefly summarize some of the better-known and well-preserved early fish assemblages from the west coasts of North and South America (Table 5). We begin by examining early assemblages from coastal California and southeast Alaska, then discuss fish remains from three early South American sites: Quebrada Jaguay, Quebrada Tacahuay, and Quebrada las Conchas. Ultimately, the 21 sites listed in Table 5 demonstrate widespread fishing capabilities and strategies throughout the North and South American Pacific Coasts, attesting to the importance of fishing during this early time period.

Just around the point from Daisy Cave is a large rockshelter known as Cave of the Chimneys (CA-SMI-603), one of the few early Channel Island assemblages with identified fish remains. From 1997 through 1999 we excavated a 1-x-.5-m-wide unit in natural levels through nearly two meters of stratified shell midden deposits at the site. Our excavations suggest that human occupation of the cave occurred through much of the Holocene, with an early occupation dated between about 7500 and 8400 cal B.P. (Strata 6 and 7; Vellanoweth et al. 2001), just after the early occupation of Daisy Cave appears to have ended. At Cave of the Chimneys, nearly 2,000 fish bones were recovered from the Early Holocene levels, including 1,032 specimens from 0.065 $m^3$ of deposits in Stratum 7 and 909 from .107 $m^3$ of deposits in Stratum 6 (totaling 11,284 NISP/$m^3$ and 619 g/$m^3$). These remains have been identified to at least 11 different types of teleost taxa, but appear to be relatively balanced between three species of fish (surfperch, rockfish, and cabezon). Similar to those from Daisy Cave, the identified fish remains suggest that the early Holocene occupants of Cave of the Chimneys fished primarily in nearshore rocky and kelp-bed habitats. It is probable that gorge and line and dip nets were used to capture and haul in fish. Although only one gorge was recovered from our limited excavations in the early levels, sea grass cordage very similar to the cordage from Daisy Cave was relatively abundant and corroborates the possible use of nets (Vellanoweth et al. 2001). Expedient chipped stone tools were also recovered in Strata 6 and 7, and many of these may have been used to process fish and other resources.

The only other early Channel Island site for which a sizable assemblage of fish bones has been analyzed is CA-SRI-6, a deeply buried 9,300-year-old shell midden located near the mouth of Arlington Canyon on the northwest coast of Santa Rosa Island. Erlandson et al. (1999) screened approximately 121 liters of sediment from sea-cliff exposures at the site and recovered 241 fish bones weighing 16.42 g. Among the 32 identifiable elements, sheephead dominate the assemblage ($n$ = 24), but Clupeiformes ($n$ = 6), and rockfish ($n$ = 2) are also represented. A dietary reconstruction suggests that fish contributed roughly 14 percent of the edible meat represented by this faunal sample, with shellfish (abalones and mussels) contributing approximately 85 percent (Erlandson et al. 1999:262). No artifacts clearly related to fishing were recovered, but behavioral inferences once again suggest that gorge-and-line and net fishing were both used.

Situated immediately across the channel from these three early island sites, two sites on the western Santa Barbara Coast contain evidence for very different fishing strategies. In a small sample (NISP = 356) from CA-SBA-1807, an 8,400–9,000-year-old residential base, at least 18 distinct taxa were identified, including 4 elasmobranchs and 14 teleosts. The assemblage is dominated by fish (surfperch, bat ray, sting ray, shovelnose guitarfish, etc.) that dwell in the calm, sandy habitats of bays and estuaries. The presence of white sea bass, barracuda, rockfish, and yellowtail suggest that other habitats, such as kelp beds, were also exploited. Nearby at CA-SBA-2057, a small, buried 8,300-year-old seasonal camp located about 1 km from the coast, over 3,000 fish bones were analyzed by Rick and Erlandson (2000). Here, at least 15 different taxa were identified, including nine teleosts and six elasmobranchs, but the assemblage is dominated by clupeids, surfperch, elasmobranchs, and flatfish. Similar to CA-SBA-1807, fish were probably obtained primarily from bay and estuarine habitats. Clupeid remains were most abundant in the CA-SBA-2057 assemblage, accounting for 39.2 percent of the edible meat contributed by teleosts and suggesting that the site occupants relied heavily on the use of nets to capture fish. Other methods such

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Table 5. Early Holocene and Terminal Pleistocene Pacific Coast Fish Remains.

| Site | Location | Age[a] | Number of Taxa[b] | Total NISP | Technology | Comments | Reference |
|---|---|---|---|---|---|---|---|
| | | | California | | | | |
| ORA-246 | Crystal Cove, Los Trancos Canyon, Newport | 8370–9240 | 11 taxa: sheephead, croaker, surfperch, mackerel, etc. | 83 | hook and line, etc. | Deposits may be mixed | Mason et al. 1992:74-75 |
| SBA-142 | Glenn Annie Canyon, Goleta | 1260–7930 | 12 taxa: sharks, rays, surfperch, lingcod, kelpfish, jacksmelt, etc. | 155 | hook and line or spears | Deposits are mixed | Colten 1991; Erlandson et al. 1988 |
| SBA-931 | Vandenberg Air Force Base | 8630–10,310 | 6 taxa: surfperch, rockfish, garibaldi, croaker, clupeids | 47 | nets | Deposits may be mixed | Glassow 1991, 1996 |
| SBA-1807 | Western Santa Barbara Coast | 8400–9000 | 18 taxa: surfperch, sharks and rays, yellowtail, etc. | 356 | hook and line, nets | Appears to be a good early context | Erlandson 1994 |
| SBA-2057 | Western Santa Barbara Coast | 8300 | 15 taxa: clupeids, sharks and rays, giant sea bass, etc. | 3080 | nets, hook and line | Good early context | Erlandson 1994; Rick and Erlandson 2000 |
| SCLI-43B | Eel Point, San Clemente Island | 3360–11,230 | 26 taxa: rockfish, sheephead, mackerel, sand bass, etc. | 1581 | spears, hook and line | Early stratum redated to Middle Holocene | Raab 1997; Salls 1991:68-69 |
| SDI-9649 | Allen O. Kelly site, Agua Hedionda Lagoon, San Diego County | 7550–8160 | 15 taxa: clupeids, surfperch, mackerel/tuna, halibut, etc. | 713 | hook and line and nets | Appears to be a good early context | Koerper et al. 1991:48-50 |
| SDI-10965 | Windsong Shores, Agua Hedionda Lagoon, San Diego County | 7680–9010 | 23 taxa: shark, tuna, barracuda, clupeids, halibut, etc. | >3167 | nets, hook and line, etc. | Appears to be a good early context | Gallegos 1991; Gallegos and Carrico 1984; Noah 2000 |
| SLO-2 | Diablo Canyon, San Luis Obispo County | 930–9320 R.Y.B.P. | 25 taxa: midshipman, pricklebacks, surfperch, etc. | >3224 | traps, hook and line, hand | Deposits appear to be mixed | Fitch 1972 |
| SMI-261 | Daisy Cave, San Miguel Island | 8550–12,290 | 18 taxa: rockfish, surfperch, sheephead, cabezon, clupeids, etc. | 27,430 | hook and line, nets, etc. | Finely stratified context | -- |
| SMI-603 | Cave of the Chimneys, San Miguel Island | 7560–8360 | 12 Taxa: mackerel, surfperch, rockfish, sheephead, lingcod, etc. | 1941 | hook and line, nets, etc. | Finely stratified context | Rick 1999 |
| SON-348/H | Duncan's Point Cave, Sonoma County Coast | 7200–9550 | 8 taxa: rockfish, sculpins, greenling, surfperch, pricklebacks | 103 | nets, hook and line | Deposits are probably mixed | Schwaderer 1992 |
| SRI-6 | Arlington Canyon, Santa Rosa Island | 9000 | 3 taxa, rockfish, clupeids, sheephead | 241 | hook and line, spears | Sealed early context | Erlandson et al. 1999; Rick 1999 |
| | | | Northwest coast | | | | |
| CRG-237 | Chuck Lake, Southeast Alaska | 8170–9200 | 7 taxa, flatfish, Pacific cod, rockfish, salmon, herring | 623 | hook and line, etc. | Good early context | Ackerman et al. 1985; Ackerman 1992; Moss 1998 |
| 35DO130 | Tahkenitch Landing, Central Oregon Coast | 7680–8900 | 10 taxa: sculpin, tomcod, herring, surfperch, flatfish, salmon, sturgeon | 628 | hook and line, nets, etc. | Middle Holocene in age? | Minor and Toepel 1986; Moss and Erlandson 1995, 1998 |
| | | | South America | | | | |
| OGSE-80, OGSE-38 | Las Vegas sites, Coastal Ecuador | 6600–10840 R.Y.B.P. | 13 taxa: catfish, drum, shark, snook, jack, tuna, puffer | 287 | hook and line, hand, spear | Appears to be a good early context | Byrd 1976:43-47, 99-101; Stothert 1985 |
| QJ-280 | Quebrada Jaguay, South Coast of Peru | 8120–13,240 | 11 taxa: drum, etc. | 7297 | nets | Good early context | McInnis, 1999:58; Sandweiss et al. 1998 |
| Quebrada Tacahuay | South Coast of Peru | 8660–12,730 | 2 taxa: anchovie and anchovetta | 280 | nets | Good early context | Keefer et al. 1998 |
| Ring Site | South Coast of Peru | 5060–10,600 R.Y.B.P. | 20 taxa: drums, herring, grouper, etc. | 9197 | hook and line, nets | Good early context | Sandweiss et al. 1989:57 |
| Quebrada Las Conchas | North Coast of Chile | 9400–9680 R.Y.B.P. | 24 taxa: corbina or sea bass, etc. | N/A | nets, traps | Good early context | Llagostera 1979, 1992 |

[a]All dates cal B.P. except where noted. All dates are midpoint ranges calibrated with Calib in Table 1 (Stuiver and Reimer 1993, 2000). A $\Delta$ of 225 ± 35 years was used for all California shell samples, and $^{13}C/^{12}C$ ratios were either determined by the radiocarbon labs, or an average of +430 years was applied (Erlandson 1988). A $\Delta$ of 278 ± 50 years was used for the Chuck Lake shell date. Dates containing multiple intercepts were averaged. South American dates are either uncalibrated or were calibrated by the original authors.

[b]In determining the number of taxa present at each site, family identifications were only counted once when a species identification from that family was also present. For example, at Tahkenitch Landing 11 identifications were presented. For the perch family, shiner perch, striped perch, and perch undifferentiated were all identified. Since it is possible that perch undifferentiated may be shiner or striped perch, these were counted as two rather than three taxa, producing a total of 10 rather than 11 taxa.

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as spearing and gorge and line may also have been used, but in much lower frequencies. Although fish appear to have contributed only about 15 percent of the edible meat represented at each site, the dominance of estuarine or bay fish at these sites contrasts sharply with the fish identified at the early island sites and adds to the adaptive diversity of early maritime people along the southern California Coast.

Another early estuarine site in California, CA-SDI-9649, is located about 1.5 km inland from Agua Hedionda Lagoon in San Diego County. Koerper et al. (1991) proposed that CA-SDI-9649 was a residential base spanning the San Dieguito and La Jolla cultural complexes with no signs of a later occupation. Calibration of seven $^{14}C$ dates on marine shell produced ages (at one sigma) between 7550 and 8160 cal B.P., with an average age of ca. 7830 cal B.P. A relatively diverse sample of shellfish and vertebrate remains was recovered from 18 units and a column sample at CA-SDI–9649. Most screening was over 1/4-inch mesh, but three units were screened over 1/8-inch mesh and the column sample was screened over 1/16-inch mesh (Koerper et al. 1991:49). At least 15 fish taxa were identified, including many small nearshore taxa such as surfperch, croakers, grunion, and rockfish, with fishing appearing to have occurred primarily during summer and early fall (Koerper et al. 1991). Undifferentiated mackerel/tuna, white sea bass, and halibut were also identified. The most abundant taxa at CA-SDI-9649 was probably the clupeids, however, with 34 specimens from the fine-mesh screening of the column sample. Correcting for screening bias, Koerper et al. (1991:50) estimated that approximately 66 percent (990 specimens) of the fish remains would have been contributed by clupeids, suggesting that nets were an important part of the fishing technology. Gorges and spearing were probably also employed to capture many of the teleosts and elasmobranchs represented in the assemblage.

North of San Francisco Bay, relatively few early Holocene or terminal Pleistocene sites have been found in coastal settings and almost none of these have produced sizeable assemblages of well-dated fish and other faunal remains. An exception comes from an early Holocene occupation at the Chuck Lake site in southeast Alaska (Ackerman et al. 1985; Ackerman 1992:22; Moss 1998:100), where $^{14}C$ dates produced calibrated ages of approximately 8170 and 9200 cal B.P. on charcoal and 8870 cal B.P. on marine shell. No detailed quantitative data are available, but the Chuck Lake assemblage is dominated by bottom-dwelling taxa such as flatfish, Pacific cod, and rockfish, with lesser amounts of salmon and herring also represented. The Tahkenitch Landing site on the Oregon Coast also produced an assemblage of at least 10 fish taxa with associated radiocarbon dates of 7680 and 8900 cal B.P. (Minor and Toepel 1986). Moss and Erlandson (1995, 1998:18) questioned the evidence of human occupation associated with the early Holocene Tahkenitch dates, however, suggesting that these fish remains may have been from the overlying middle Holocene strata. During the middle Holocene, several sites on the Northwest Coast (e.g., Glenrose Cannery and Namu) show an expanded maritime economy, including fish assemblages consisting of salmon, rockfish, flatfish, herring, and other taxa (Matson and Coupland 1995:107–108, 140).

Additional support for the early development of marine fishing capabilities among Pacific Coast peoples comes from three key South American sites. Terminal Pleistocene and early Holocene deposits (ca. 13,240 to 8120 cal B.P.) at Quebrada Jaguay in coastal Peru yielded an assemblage of at least 11 taxa of fish (Sandweiss et al. 1998:1831). Most abundant are drum *(Sciaena deliciosa)* and the similar size of the fish, along with several pieces of knotted cordage inferred to be from nets, led Sandweiss et al. (1998:1830) to conclude that the Quebrada Jaguay fish were captured in nets. This is currently the earliest evidence for net fishing in the New World and suggests a significant understanding of aquatic environments at a very early date. The early use of nets by coastal peoples in Peru is also supported by an assemblage ($n$ = 280) of anchoveta, anchovy, and undifferentiated fish bones recovered from terminal Pleistocene and early Holocene (ca. 12,730 to 8660 cal B.P.) deposits at Quebrada Tacahuay (Keefer et al. 1998). Finally, Llagostera (1979) noted the presence of 24 fish taxa (seven now locally extinct) in early Holocene (ca. 9400 to 9680 R.Y.B.P.) deposits at Quebrada Las Conchas on the north coast of Chile. The presence of *Cynoscion* (corbina or sea bass), which Llagostera (1979:319) argued cannot be caught on a hook and line, suggests that nets were used to catch fish. Small sandstone plummets that may have served as net weights and an abundance of small nearshore bottom-dwelling fish support this contention. Llagostera (1992:87) also argued that

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traps may have been used to catch fish in littoral pools, coves, and lagoons during this time period. The diversity of taxa in the Quebrada Las Conchas assemblage adds to the evidence of extensive fishing by early New World peoples.

## Summary and Conclusions

Fish remains from early Holocene deposits at Daisy Cave demonstrate that at least 18 distinct taxa were obtained from a variety of marine habitats. The early site occupants appear to have fished primarily in kelp beds or rocky shores in the productive waters adjacent to the site, with technologies that included boats, nets, and hook-and-line fishing. Our dietary reconstructions suggest that fish provided between about 50 and 65 percent of the edible meat represented in shell midden samples dated between about 8500 and 10,500 cal B.P. The paleocoastal cave occupants also relied heavily on shellfish, and apparently to a much lesser extent on sea mammals, sea birds, and terrestrial plants and animals.

The fish-bone densities from Daisy Cave are unusually high for early New World coastal sites. The densities for Stratum E by weight (6117 g and 9142 g/m$^3$) are higher than 14 of 27 late Holocene Channel Island samples quantified by Kennett (1998:567). Raab et al. (1995:13–14) and Porcasi et al. (2000:210) present densities by weight for the Eel Point site on San Clemente Island, with the highest densities in deposits dated to after 3300 R.Y.B.P. The highest values they report (6301.1 g/m$^3$ and 5508.0 g/m$^3$, respectively) are similar to values we report for Stratum E at Daisy Cave. It seems clear that fishing was an important part of the subsistence economy at Daisy Cave, comparable to many late Holocene sites in the same region.

Fish remains from other early Holocene shell middens from the southern California mainland coast suggest that paleocoastal people also fished extensively in estuarine habitats, with mainland peoples relying heavily on nets. Paleocoastal people in southern California captured clupeids, surfperch, rockfish, sheephead, flatfish, elasmobranchs, tunas, and other taxa that are essentially the same types of fish captured by late Holocene and ethnographic people in the area, suggesting that broadly similar fishing capabilities were present since at least the early Holocene.

Several other early Pacific Coast sites from North and South America also show an early emphasis on marine fishing, including evidence for the use of nets and other technologies. The extensive reliance on a variety of marine and estuarine resources, and the clear evidence for the use of seaworthy boats in North America, indicates that early Pacific Coast peoples had diverse maritime lifeways comparable to many complex ethnographic groups in the same region. This is not to say that technological and social elaboration did not occur over time, that people were static for thousands of years, or that people did not become more proficient in exploiting marine environments. We argue, however, that many of the technological foundations (seaworthy boats, nets, fishhooks, fish spears, etc.) of maritime societies now appear to have been in place by the earliest well-documented occupations of the Pacific Coast of the Americas (12,000 to 10,000 years ago) and that subsequent developments built on these foundations as population densities expanded and alternative resources such as shellfish were impacted by human predation pressures. In many areas these developments included the intensification of marine fishing efforts, but the timing of such intensification varied widely depending on a variety of factors including the local productivity and accessibility of fish taxa.

Earlier we noted that in developing general theory related to the evolution of aquatic adaptations, some researchers have argued that effective fishing strategies did not develop until relatively late in time (e.g., Klein 1999:454–459; Ryder 1969), or that marine fish are marginal resources compared to land mammals or riverine fish runs because they are unpredictable, require high search costs or technological investments, and frequently yield limited subsistence returns (e.g., Kelly 1996:209, 212). In particular, Kelly (1996:210) argued that net fishing, while capable of yielding high returns, may have been a significant obstacle for early fishers because of the large amount of time required to manufacture and maintain nets.

The data from early Pacific Coast sites raise fundamental questions about the supposedly low productivity of net fishing and marine fishing in general, as well as the late development of effective fishing techniques. Data from Daisy Cave and other early New World coastal sites suggest that marine fish were often highly productive resources exploited from the initial occupation of the coast. Kelp beds, rocky reefs, and estuaries are some of the most productive ecosystems on earth. In many cases, they are

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also relatively predictable marine habitats where fish can be caught in large quantities using hook-and-line, dip nets, spears, and other fishing technologies. Moreover, fish are highly nutritious and digestible sources of meat, protein, and other nutrients. In some cases, at least, it now appears that net fishing and nearshore marine fishing were fundamental and optimal strategies used by some of the earliest Pacific Coast peoples not just to survive, but to thrive.

*Acknowledgements.* We are indebted to Madonna Moss, Mark Raab, and anonymous reviewers for detailed editorial comments that greatly improved this paper. We thank Jim Estes, Mike Glassow, Michael Graham, Jeremy Jackson, John Johnson, Doug Kennett, Rob Losey, Heather McInnis, Anna Noah, Peter Paige, and Robert Steneck for comments on this and other related topics. P. Paige, J. Johnson, and M. Moss helped T. Rick identify portions of the assemblage. M. Glassow and P. Paige graciously provided access to comparative materials at UCSB. Don Morris, Steve Schwartz, Ann Huston, and Ian Williams were instrumental in facilitating our research at CA-SMI-261 and CA-SMI-603, and we thank them for their support and encouragement. Claudia Harris provided the Spanish translation of the abstract. This research was partially supported by NSF grant SBR-9731434, funds from the U.S. Navy, and by the University of Oregon. Finally, we thank Tim Kohler and the editorial staff of *American Antiquity* for assistance in the production of this manuscript.

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*Received September 11, 2000; Accepted November 25, 2000; Revised February 12, 2001.*

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