Chapter 15

ECOLOGICAL DETERMINANTS REVISITED:
FOOD, FISH, AND DEMOGRAPHY IN CENTRAL CALIFORNIA

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(First) Author’s Forward

Ultimately the paper below is about population pressure, a topic that Bob Bettinger has approached only with caution—more so than most researchers. I first heard Bob allude directly to population pressure as a possible influence in prehistoric human ecology as a young(ish) graduate student when he delivered an evening lecture to the public about his research in the White Mountains.

Adhering to the scholarly ethic of the day, Bob rarely discussed his own research in the classroom, even in a seminar on the Great Basin, so it was only by attending this lecture that I heard about the daunting environment of the White Mountains, and the fact that humans late in the Holocene elected to settle there. The take-home conclusion that night was that there had to have been some type of Malthusian pressure at work to force people to live in such a difficult place—even if the Whites did offer up marmots and mountain sheep as food resources. This seemed like a very firmly grounded interpretation—one that I would learn to appreciate even more six months later when my wife, Debbie, got a position as a Teaching Assistant for Bob’s White Mountain field school. Debbie was (and still is) fascinated by the White Mountain’s natural environment and archaeology, but she also made it clear that the job, for a variety of reasons, had its challenges. Although she did not suffer overmuch the physiological effects of extreme elevation, she said that a small percentage of students did have an especially hard time with altitude sickness. Debbie had been up in the Whites for about a month before I was able to visit. I arrived at the field station about 2:00 in the afternoon on a Friday, happy to see my wife and stunned by the scenery. By about 6:00 PM, however, it became apparent that I was one of that small percentage of the population who cannot handle high elevations, although, not ever having experienced altitude sickness, I didn’t know exactly what was happening to me. What I did
know was that my heart was racing, my whole body ached, and I was terribly nauseous. Bob and Debbie arranged to get me and her down the mountain ASAP, and we spent an uncomfortable night in Bishop.

Twenty-five years later I returned to the Whites with Bob and a film crew who were producing a documentary on California’s past (Becoming California). To make a long story short, my second experience there went much the same way as the first—and on about the same schedule. I spent a pleasant afternoon with Bob and the cameramen continuing touring and filming. By evening I was puking. I spent the next couple of days laying in the truck while Bob and the cameramen continued touring and filming. Suffice it to say, my two experiences thoroughly convinced me of the legitimacy of Bob’s explanation for prehistoric human presence in the White Mountains, and I’ve thought long and hard about the influences of population growth and “pressure” in Native California ever since.

Abstract

Human population levels have long been recognized as critical variables in models of hunter-gatherer prehistory. In California, population has been estimated via a variety of approaches, beginning first with head counts from historic and ethnographic censuses (Kroeber and Cook) and progressing to various archaeological/logical proxies. The latter have often been used to determine the presence/absence of demographic “pressure” and its possible relation to climate, technological, social and political innovation, and/or economic intensification. Some of the earliest and clearest thinking on prehistoric demography was by Martin Baumhoff in his 1963 monograph, Ecological Determinants of Aboriginal California Populations, in which he reconstructed contact-era food availability in northern California focusing on the quantity and distribution of acorns and salmon. Here, we pick up where Baumhoff left off by examining marine fish resources in central California via ethnography, historic catch records, and archaeological fish bone densities to evaluate demography in this region and the likelihood of demographic “pressure.” Findings suggest that the enormous productivity of these fisheries has generally been under-appreciated by archaeologists, and that they were most likely unaffected by 11,000 years of Native exploitation.

Introduction

The food resources of California were bountiful in their variety rather than in their overwhelming abundance...If one supply failed, there were hundreds of others to fall back upon. If a drought withered the corn shoots, if the buffalo unaccountably shifted, or if the salmon failed to run, the very existence of people in other regions was shaken to its foundations. But the manifold distribution of available food in California and the working out of corresponding means of reclaiming them prevented a failure of the acorn crop from producing similar effects. It might produce short rations and racking hunger, but scarcely starvation [Kroeber 1925:524].

Human population levels have long been recognized as critical variables in models of hunter-gatherer prehistory inasmuch as population growth over time can create situations of demographic imbalance that instigate cultural change (cf. Binford 1968; Cohen 1975, 1977; Glassow 1978; but see also Cowgill and Wilsen 1975). Considerations of population size and the potential for population pressure have long histories of scholarly concern in California, beginning with general, qualitative observations by early ethnographers, such as Kroeber’s above, and progressing to attempts at more sophisticated, quantitative assessments by ecologically-minded archaeologists in the 1960s and 70s. From that point onward, population pressure and/or growing populations have been invoked explicitly or implicitly in many models of California prehistory, particularly those involving resource intensification (e.g., Basgall 1987; Broughton 1994, 1997; Broughton et al. 2015; Chartkoff and Chartkoff 1984; Cohen 1981; Fredrickson 1974; Glassow et al. 1988; Hildebrant and McGuire 2002; Morgan 2015). While ethnographers have tended to envision a demographic situation of “affluence” (sensu Cohen 1981) in Native California with respect to the population/resource relationship, archaeologists, examining diachronic trends (e.g., the use of acorns), have tended instead to see situations of “overcrowding.”

Here we build on one of the earliest assessments of Native demography in California: Baumhoff’s (1963) ecological study in which he attempted to determine whether indigenous populations in the North Coast Ranges and the San Joaquin Valley were at or near carrying capacity at the...
time of historic contact by using modern fish and game records and vegetation maps to quantify the amount of food available to people in those areas. Baumhoff focused on three resources: acorns, large game, and salmon. Ultimately, he concluded that the population of northwestern California was below the carrying capacity, while the southern North Coast Ranges had human populations that were at or near their limit, and may have been poised at the brink of some type of “Malthusian adjustment” at the time of contact.

For the current study, we evaluate a region, the coast between San Francisco Bay and the Santa Barbara Channel (Figures 1 and 2), and a resource, marine fisheries, that Baumhoff did not consider, using an approach similar to his. Our goals are also similar, but with the added objective of rethinking certain aspects of fishing in Native California, specifically, its origins, energetics, productivity, and role in regional subsistence models. To accomplish this, we first describe the fisheries in the study area including historic catch records. We then summarize ethnographic information on fishing, archaeological findings of fish and fishing technology, and conclude with a discussion of the productivity of the fish resource and its implications for prehistoric demography in this region. These various lines of evidence indicate that the food potential of marine fisheries along the shoreline of central California has generally been under-appreciated; historic records in particular show that it was simply enormous. Furthermore, some of the technology used to exploit fish
especially nets) was very labor-intensive, but evidence for its use occurs fairly early—before impacts of population growth and/or pressure would be expected in the record. This suggests that fishing along the California coast was more a product of historical tradition rather than demographically-driven intensification, as others have suggested (e.g., Boone 2012; Erlandson 2007).

**Central Coast Fisheries**

Two basic types of fish habitat dominate the central California coast: (1) exposed, mostly rocky shores that front the western edge of the coast and provide habitat for extensive kelp forests, and (2) the estuaries of San Francisco Bay, Elkhorn Slough, and Morro Bay. The latter two systems are considerably smaller than San Francisco Bay, and were not accessible to as many people prehistorically. All three systems are similar, however, in that they provide sheltered settings where freshwater merges with salt, creating a distinctive habitat that supported large numbers of diverse fishes.

The role of San Francisco Bay in the salmon fishery was well known to Baumhoff, of course, since Native fisheries of the Central Valley that he assessed were part of the broader Sacramento/San Joaquin/San Francisco Bay estuarine system. Salmon was commercially fished in the bay as early as 1850 and California Fish and Game began keeping track of the yearly catch in 1874 (Smith and Kato 1979). More complete scientific inventories of bay fisher-
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Rockfishes, halibut, flounder, and sardines were targeted commercially in the mid-20th century when the fishery famously collapsed. Prior to that, Chinese communities harvested them in significant numbers until the staggering productivity of fisheries adjacent to central California shorelines (Tables 1 and 2). In 1926, the County (Port) of San Francisco recorded catches totaling over 18 million pounds of fish with a heavy emphasis on Pacific sardines and sole, but also salmon, rockfish, and Pacific herring. That total grew to over 52 million pounds in 1935, largely based on increased harvest of Pacific sardines. Records from the Monterey region (Monterey and Santa Cruz counties) are equally impressive: a total of over 100 species of fishes. In addition to salmon, the commercial fisheries targeted sturgeon, Pacific herring, northern anchovy, starry flounder, and surfperches.

The presence, importance, and productivity of the smaller estuaries of Elkhorn Slough and Morro Bay were not fully appreciated by Baumhoff or other early anthropologists largely because these systems simply had not yet been studied. The number and diversity of fishes inhabiting their waters were not well-documented until late in the 20th century. The ichthyofauna of Elkhorn Slough was partially described in 1935 (MacGinitie 1935), but a full inventory was not completed until 1972 (Browning 1972; Kukowski 1972). The first biological inventory of Morro Bay was published in 1966 (California Fish and Game 1966). In both cases, the commercial value of these estuarine fisheries was not exploited until the 1940s when the U.S. Army Corps of Engineers converted them into commercial harbors that facilitated large-scale modern fishing operations (Silberstein et al. 2002; Gordon 1974; Krieger 1990). Even with the conversions of these systems into fishing ports, the resulting commercial operations targeted the open waters more than the actual estuaries themselves.

The most recent inventory of Elkhorn Slough fisheries identifies a minimum of 102 species, 82 of which are marine fishes and 16 that use the estuary as a spawning ground (Yoklavich et al. 2002). Only four species are non-natives. Among the most common fishes are surfperches, northern anchovy, leopard sharks, Pacific staghorn sculpin, starry flounder, and bat ray (Yoklavich et al. 2002). At Morro Bay, a total of 66 fish species have been documented (Fierstine et al. 1973). The most common are members of the family, Embiotocidae (black perch and shiner perch), starry flounder, California halibut, northern anchovy, and Pacific staghorn sculpin.

The highly productive open coast fisheries of central California were recognized very early at the Monterey Peninsula where sardines were taken commercially in staggering quantities at least as early as the 1880s, and continued to be harvested in significant numbers until the mid-20th century when the fishery famously collapsed partially due to overfishing. Prior to that, Chinese communities exploited what are believed to have been rockfishes, halibut, flounder, and sardines as early as the 1850s (Lydon 1985). Because of the presence of the deep submarine canyon west of Elkhorn Slough, scientific inventories have recorded over 300 species within Monterey Bay (Kukowski 1972), however many of these were pelagic and were generally out-of-reach for nearshore Native fisher people.

A final note on these fisheries is the degree to which the habitats and fauna, particularly those of the estuaries, have been altered in historic times. Given the relatively recent scientific inventories, much previous writing on the ichthyofaunal archaeological record has emphasized the importance of archaeology for defining the unaltered, pre-contact native biota (Schulz 1979; Schulz and Simons 1973, Gobalet 1990, 1992, 2004).

Historic Catch Records

Publications available from California Fish and Game (formerly Division of Fish and Game California) provide quantitative data back to 1926 for commercial fish landings from counties along the California coast, later aggregated into administrative regions. Records from individual ports also exist, but with less accessibility (e.g., some records are only available locally). Of course, the commercial industry exploited fisheries far out to sea using massive, mechanized equipment. Catch records also do not distinguish where exactly fishes were caught in terms of habitat or precise location; they only document the port where the catch was landed. Further, the historic catch record reflects a much broader expanse of ocean than was accessible to Native people. Nonetheless, many of the same species that were exploited commercially were caught in prehistory.

A small sample from the yearly catch records shows the staggering productivity of fisheries adjacent to central California shorelines (Tables 1 and 2). In 1926, the County (Port) of San Francisco recorded catches totaling over 18 million pounds of fish with a heavy emphasis on Pacific sardines and sole, but also salmon, rockfish, and Pacific herring. That total grew to over 52 million pounds in 1935, largely based on increased harvest of Pacific sardines. Records from the Monterey region (Monterey and Santa Cruz counties) are equally impressive: a total of over 386 million pounds in 1935, consisted mostly of Pacific sardines (>376 million pounds), but also rockfishes (>215,000 pounds), northern anchovies (>76,000 pounds), and California halibut (>41,000 pounds).
comparative purposes, even higher catch figures were reported from the Los Angeles Region (including the Northern Channel Islands), where in 1935 the take was over 505 million pounds. In those more southern waters, Pacific sardines were still the most abundant fish reported, but albacore tuna was represented by more than 4 million pounds.

Yearly catch records for Morro Bay that begin after 1946 when the port was opened show variation in quantity and species over time. For the first year recorded, 1947, a total of 264,840 pounds was documented (Table 2), almost all of which was albacore taken from pelagic settings. This was consistent with the heavy exploitation of various tuna in southern California that began in the early 20th century after the decline of sardines (Braje 2016). Catches increased and diversified in the ensuing decades with over 35 million pounds reported in 1958 and 1968, most of which (over 28 million pounds) were Pacific sardines. Pacific chub mackerel were also well represented in the catch from 1958 (over three million pounds), but decreased in subsequent years. During the El Niño years of 1982 and 1983 the catches from Morro Bay show declines from years past, but still were over 7 million pounds per year. There has long been speculation by archaeologists (e.g., Arnold 1992; Simons 1992) that El Niño related declines may have severely impacted Native societies who were dependent on fishing. The Morro Bay catch records suggest that significant quantities of fish were still present in coastal waters even during an extreme El Niño, although it is unknown if fishermen had to range more widely to bring in this catch during those years.

The Ethnography of Fishing in Central California

Baumhoff’s hesitance to evaluate demography in central coastal California was reasonable in light of the incomplete ethnographic record available for those areas circa 1963. Whereas Kroeber and his students recorded a great deal of information on fishing and other subsistence activities among groups like the Yurok, Pomo, and Yokuts in the early decades of the 20th century (see Kroeber and Barrett 1960), nothing comparable was published for the Costanoan, Esselen, coastal Salinan, or northern Chumash in central California. Ethnographic information on those groups, collected mostly by J.P. Harrington, languished in unpublished form for many years so that, until recently, information for central California was limited to early historic observations by Spanish explorers and mis-

sionaries, and highly limited syntheses (Harrington 1942; Mason 1912). In the subsequent decades, much work has been done with Harrington’s notes (Gamble 2008, Klar 1977, 1991; Hudson and Blackburn 1979, 1986; Hudson et al. 1978; Rivers and Jones 1993; Jones et al. 2000), mission records (King 1974, 1984, 1994; Johnson 1988; Milliken 1983; 1986, 1987, 1995, 2002, 2010), historic accounts (Milliken and Johnson 2005; Brown 2001) and other sources (Greenwood 1978; Hester 1978a; Hester 1978b; Levy 1978). Together these records provide for improved understanding of cultures and subsistence regimes of the indigenous peoples living between present-day San Francisco Bay and Point Conception, but they are still a far cry from the type of participant observation that is necessary to develop precise characterizations of the energetics associated with resource use (see for example Bliege-Bird and Bird 1997) and/or the exact ecological situation of communities vis-à-vis their resource base. For this reason, archaeology has long been recognized as a needed supplement to the central California ethnographic record, limitations notwithstanding (see Breschini and Haversat 1980, 1994).

The more recently published ethnographic and historic accounts make it clear that fishing was extremely important in the Santa Barbara Channel where sewn-plank canoes were used in tandem with bone and shell hooks, nets, spears, and harpoons (Gamble 2008; Hudson et al.1978). Because so much has been written about fishing adaptation in the Santa Barbara Channel in the last few decades, we limit our efforts here to the ethnography of the area between Point Conception and San Francisco Bay inhabited at contact by the Northern Chumash, Salinan, Esselen, and Costanoan/Ohline-speaking peoples. However, some archaeological evidence from the Channel area is included for the purposes of comparison.

Fish and fishing are mentioned infrequently in the earliest accounts of encounters between the Spanish and Native central Californians, but the descriptions are often woefully lacking in details. One of the earliest observations was by the seafarer, Sebastian Cermeño in 1595, probably in the vicinity of Avila Beach:

There were observed on the shore of the sea many people on top of some bluffs, where they had many settlements….. I anchored in front of these settlements and I saw how the Indians had
### Table 1: Select historic catch records for 1926, 1935, and 1947 between San Francisco Bay and Los Angeles.

<table>
<thead>
<tr>
<th>Common Name*</th>
<th>Historic Taxonomic Designation</th>
<th>San Francisco County*</th>
<th>Santa Cruz County</th>
<th>Monterey Co.</th>
<th>San Luis Obispo/Santa Barbara Counties**</th>
<th>Los Angeles Co. a</th>
<th>Los Angeles Co. b</th>
<th>Los Angeles Co. c</th>
<th>Los Angeles Co. d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albacore</td>
<td><em>Scomber japonicus</em></td>
<td>0</td>
<td>0</td>
<td>372,795</td>
<td>120</td>
<td>119,999</td>
<td>683,442</td>
<td>1,272,140</td>
<td>363</td>
</tr>
<tr>
<td>Anchovies</td>
<td><em>Engraulis mordax</em></td>
<td>3,400</td>
<td>74,550</td>
<td>390,173</td>
<td>0</td>
<td>48,560</td>
<td>76,355</td>
<td>13,493,816</td>
<td>-</td>
</tr>
<tr>
<td>California halibut</td>
<td><em>Trachurusulus</em></td>
<td>92,490</td>
<td>18,462</td>
<td>3,812</td>
<td>3,926</td>
<td>9,534</td>
<td>41,892</td>
<td>135,378</td>
<td>228,263</td>
</tr>
<tr>
<td>Herring</td>
<td><em>Clupea pallasi</em></td>
<td>421,544</td>
<td>792,090</td>
<td>602,257</td>
<td>0</td>
<td>0</td>
<td>47,280</td>
<td>923,224</td>
<td>290</td>
</tr>
<tr>
<td>Perch***</td>
<td><em>Erimiacis</em></td>
<td>55,443</td>
<td>132,324</td>
<td>69,328</td>
<td>8,742</td>
<td>4,581</td>
<td>39,389</td>
<td>49,349</td>
<td>16,282</td>
</tr>
<tr>
<td>Rockfish</td>
<td><em>Sebastes</em></td>
<td>886,788</td>
<td>886,374</td>
<td>211,305</td>
<td>1,007,364</td>
<td>1,299,954</td>
<td>215,359</td>
<td>1,321,275</td>
<td>87,288</td>
</tr>
<tr>
<td>Salmon</td>
<td><em>Onocorynchus spp.</em></td>
<td>936,330</td>
<td>1,053,787</td>
<td>1,485,657</td>
<td>12,253</td>
<td>39,520</td>
<td>219,700</td>
<td>738,469</td>
<td>0</td>
</tr>
<tr>
<td>Sardines</td>
<td><em>Sardina albacore</em></td>
<td>7,046,615</td>
<td>36,792,639</td>
<td>626,228</td>
<td>1,300</td>
<td>155,100,307</td>
<td>376,150,587</td>
<td>36,773,318</td>
<td>0</td>
</tr>
<tr>
<td>Sole</td>
<td><em>Parophrys ferox</em></td>
<td>6,078,453</td>
<td>8,515,218</td>
<td>3,598,738</td>
<td>2,090,654</td>
<td>179,896</td>
<td>135,789</td>
<td>421,756</td>
<td>87,288</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>2,587,984</td>
<td>3,872,895</td>
<td>1,925,945</td>
<td>975,004</td>
<td>1,605,681</td>
<td>8,776,303</td>
<td>18,386,181</td>
<td>315,776</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>18,120,983</td>
<td>52,140,274</td>
<td>9,350,385</td>
<td>4,101,871</td>
<td>156,868,39</td>
<td>386,388,031</td>
<td>75,916,777</td>
<td>735,571</td>
</tr>
</tbody>
</table>

*Also includes San Mateo Co.
**Also includes Santa Barbara and Ventura Counties
***Includes non-natives; What are “Perch?”
****Includes Santa Cruz County
a. Common names are not consistent with current usage
b. Includes all San Francisco Bay counties
c. Primarily mackerel and other tuna
d. Includes fish from Mexico landed at Los Angeles
e. Includes Northern Channel Islands

SOURCES: California Division of Fish and Game (1929), (1937), (1949)
on shore many balsas made of tule, which are like reeds, or as otherwise called, tule. The balsas were made like canoes, and with these they go fishing…..shortly one came down from the bluff, and taking a balsa, got into it and came on board the launch, where we made much of him and gave him some pieces of cotton… soon others came and we gave them to understand by signs that they should bring us something to eat, as we had no food…. They went ashore and brought some bitter acorns and mush in some dishes made of straw….They use the bow and arrow, and their food consists of bitter acorns and fish [Translation by H. R. Wagner 1924:16].

The Portola expeditions of 1769-71 recorded next to nothing about actual fishing practices, but the entourage was often given fish by Native people, and accounts frequently mention tributes of fish to leaders, particularly the famous, Buchon (or the Goitre), a paramount who had authority over multiple northern Chumash communities as in this account:

Late in the day some fourteen heathens came from the aforesaid village, bringing about sixteen fresh fish of very good size, saying their Chief Goitre had told them that if we should spend the night here they would bring us food in the early morning [in Brown 2001:713].

Further north, a member of the Anza expedition recorded these comments at Mission San Carlos in 1776:

The Indians of this mission… are mostly fishermen, and their catch, very diverse and of good quality, is plentiful. Besides an abundance of sardine, easy to harvest because the schools are so large, they also take excellent salmon, which enter the rivers to spawn. I am told that as far inland as San Antonio Mission the Indians harvest this fish from the Monterey River (in Guerrero 2006:186).

This account was corroborated by mission padres near Monterey a few years later:

…After two weeks of fish eating, on the Sunday following, leaving the sardines at peace, they went hunting for the nests of sea birds that live in rocks and feed on fish. Serra [1784] quoted in Breschini and Haversat [1994:184].

In the San Francisco Bay area in 1775-76 Pedro Font made the following observation near Carquinez:

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Table 2: Select historic catch records from Morro Bay, San Luis Obispo, California (in pounds).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Albacore</td>
<td>220,439</td>
<td>744,830</td>
<td>1,600,572</td>
<td>270,238</td>
<td>1,899,510</td>
</tr>
<tr>
<td>Pacific Anchovies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13,942</td>
<td>7,184</td>
</tr>
<tr>
<td>California halibut</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>170,307</td>
<td>136,264</td>
</tr>
<tr>
<td>Pacific Herring</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Lingcod</td>
<td>0</td>
<td>110,366</td>
<td>47,881</td>
<td>352,100</td>
<td>99,149</td>
</tr>
<tr>
<td>Jack Mackerel</td>
<td>0</td>
<td>3,060,254</td>
<td>279,520</td>
<td>5,461</td>
<td>1,544</td>
</tr>
<tr>
<td>Surf Perches</td>
<td>0</td>
<td>26,590</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rockfishes</td>
<td>0</td>
<td>2,505,049</td>
<td>1,350,149</td>
<td>5,198,222</td>
<td>3,324,254</td>
</tr>
<tr>
<td>Salmon</td>
<td>0</td>
<td>61,602</td>
<td>26,669</td>
<td>116,736</td>
<td>116,605</td>
</tr>
<tr>
<td>Pacific Sardines</td>
<td>0</td>
<td>28,387,600</td>
<td>28,387,600</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sole</td>
<td>0</td>
<td>105,003</td>
<td>116,808</td>
<td>857,111</td>
<td>1,226,938</td>
</tr>
<tr>
<td>White seabass</td>
<td>0</td>
<td>73,354</td>
<td>0</td>
<td>1,426</td>
<td>3,449</td>
</tr>
<tr>
<td>Other</td>
<td>44,401</td>
<td>179,165</td>
<td>407,797</td>
<td>605,010</td>
<td>1,258,987</td>
</tr>
<tr>
<td>Total</td>
<td>264,840</td>
<td>35,253,813</td>
<td>35,253,813</td>
<td>7,590,578</td>
<td>8,073,884</td>
</tr>
</tbody>
</table>

* El Niño year.

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…we made signs to them that they should go and get us some fish with the two hooks I gave them. They clearly understood us, but they brought us nothing and showed very little appreciation for the hooks, because their method of fishing is with nets [Font [1776] in Bolton 1933: 365].

And, near Suisun Bay, Font noted:

We saw there some launches very well made of tule, with their prows or points somewhat elevated. They had been anchored near the shore with some stones for anchors, and in the middle of the water some Indians were fishing in one, for in all this gulf of the Puerto Dulce the Indians enjoy plenty of excellent fish, among them being very fine salmon in abundance [Font [1776] in Bolton 1933:371].

Also near Suisun Bay, the following account was recorded that almost certainly describes the capture of a sturgeon (Hylkema 2007:15):

We saw there some launches very well made of tule, with their prows or points somewhat elevated. They had been anchored near the shore with some stones for anchors, and in the middle of the water some Indians were fishing in one, for in all this gulf of the Puerto Dulce the Indians enjoy plenty of excellent fish, among them being very fine salmon in abundance. I saw that they were fishing with nets and that they anchored the launch with some very slim poles....Among other fish which they caught the Indians who were fishing pulled out two very large ones, about two varas long, and their method of catching them was this; as soon as they felt from the pull made by the fish that it was in the net, which was tied to the two poles, they began gradually to raise one of the poles, and as soon as the fish and the net came into sight, without taking it from the water they gave the fish many blows on the head. Once I counted fifteen blows in succession, and in another case twenty-odd. Now that it was dead and had lost its strength they took it from the net and put it inside the launch... I was not able to determine whether or not they were those called tolos, although from their form they appeared to be those, for they had a very large head, little eyes, small mouth like a tube which they puffed out and sucked in, the body having no scales, thick skin, and some spots like little stars and other figures, caused by some little bones which they had between skin and flesh. The flesh was very white, savory, and without spines and the bones were soft and spongy, like tendons....But before delivering it they took the spawn from the stomach and intestine like a pocket, and right there on the spot they ate the spawn raw and put what was left over in the intestine [Font [1776] in Bolton 1933:371-373].

Also at Suisun Bay the Anza expedition made the following observation in 1776:

that since the mouth of the bay the most abundant fish is salmon--deep red, tender, and large. Of the ones we have seen none was less than five hands [in Guerrero 2006:197].

Together the ethnographic accounts document that fishing was accomplished with hook and line, tule balsa canoes, and especially nets. Only a handful of exploited species are mentioned-- mostly sardines and salmon. Although the residents in the vicinity of Mission San Carlos were described as fishermen, for most of the rest of central California there is nothing to suggest that fishing was the primary means of subsistence. Indeed, one account from San Francisco Bay suggests a certain ambivalence:

This stream appears to have some fish for we saw there some small mojaras, and some nets with which the Indians fish; but I think it all amounts to very little, for I noticed that the Indians who live around the estuary and the port are not fishermen, for in their villages are seen only piles of shells of mussels which must be what they fish and eat most of [Font [1776] in Bolton 1933:355].

On the one hand, fish are mentioned repeatedly as a food across central California, but the above quote also seems consistent with people who were not fishing specialists. However, Spanish accounts clearly and consistently describe abundant fisheries.
Fish and Fishing in Archaeological Models

Considerations of the relative importance of fish and fishing in California archaeology are fairly recent. Although not emphasized by Kroeber or the other early ethnographers, the seasonal abundance of salmon in northwestern California clearly facilitated permanent settlements along the rivers, supported by sophisticated, labor intensive aquatic technologies (dug-out canoes, weirs, harpoons). Early explanations for the emergence of the sedentary, intensive salmon economies in Northwestern California were largely cultural-historical/linguistic, assuming that the Algic and Athabaskan-speaking groups brought the adaptation with them in a southward migration, relatively late in time (Whistler 1979; Moratto 1984). Alternatively, Hildebrandt and Hayes (1993) attributed the emergence of this sedentary, storage-dependent adaptation to climate cooling beginning ca. 2800 BP which reduced the diversity and abundance of resources in upland settings, and forced people to increase their reliance on riverine resources such as salmon. Subsequently, Tushingham (2009) re-argued the case for a linguistic group migration as the underlying cause of salmon-intensification in northern California.

In more recent decades, the importance of marine fish has been emphasized in southern California, particularly in models focused on the Channel Islands and Santa Barbara mainland (e.g., Arnold 1992; Erlandson et al. 2007; Glassow 1993; Kennett 2005; Rick 2007, among others), most of which build upon ethnographic accounts that describe Chumash use of sewn-plank canoes in a fishing-centric, maritime economy (Gamble 2008). Glassow (1993) showed that over a 7,000-year span, Santa Cruz Island exhibited a general increase in fish remains (and relative decrease in shellfish) that ultimately culminated in a “spectacular” increase in the dietary importance of fish after ca. 800 BP. Population growth was suggested to be the main cause underlying the increased pursuit of the more difficult-to-acquire fish over time along with possible effects from climate change. Erlandson et al. (2007) referred to the Island pattern as “fishing up the food chain.” Similar patterning was seen on San Clemente Island where Salls (1988, 1992) argued for a 10,000-year process of intensification in which an increasing reliance on fish was accompanied by overexploitation and species replacements.

Subsequent studies especially from the Northern Channel Islands have continued to document a dramatic rise in fish remains and fishing equipment during the late Holocene. Kennett (2005) reported an increase in quantity and types of fish through the Holocene with exponential increases in fish bone density after 1300 BP which he associated with increasing diet breadth and intensified subsistence, also related to human-induced degradation of intertidal habitats. Following earlier arguments (e.g., Glassow 1993), Kennett (2005) also associated increased fishing with more permanent settlements. Rick (2007) documented huge numbers of fish remains in Late Period middens on San Miguel Island. Kennett and Kennett (2000) attributed the late Holocene developments to changes in sea surface temperatures that caused drought, reduced terrestrial productivity, and intensified fishing. Even more recent studies continue to show modest increases in fishing during the early Holocene on the Channel Islands, and a pronounced ramp up between 2600 and 200 cal BP (Guisel et al. 2015).

Arnold (1992) also focused on fishing as an important component in her model of emergent Chumash complexity, but she placed more theoretical emphasis on the technology used to capture fish (the sewn-plank canoe), and the labor organized to construct it (under the direction of elites), than the underlying value of fish as a subsistence resource. She suggested that the intensive Chumash maritime economy, including island-mainland trade, craft specialization, sedentism, and exploitation of pelagic fish (albacore, yellowfin, and bluefin tuna) emerged rather abruptly ca. 1500 BP in response to climatic crisis. Middens in the Chumash area do show remains of pelagic fish remains (Bernard 2004), but the quantities are minute (Jones and Klar 2009).

In central California intensification models have generally focused on acorns (Basgall 1987) and terrestrial game (Broughton 1994a, 1999, 2004), arguing for the emergence of labor-intensive economies at the onset of the Middle Period, ca. 2450 BP or slightly earlier (Hildebrand and McGuire 2002). However, Broughton (1994b) made a case for overexploitation of salmon in the Sacramento River and a subsequent increase in smaller-bodied fishes late in time. He argued that Native fishpeople affected a diminution in sturgeon due to overfishing in San Francisco Bay (Broughton 1999). Most recently, Broughton et al. (2015) argued on the basis of findings from 23 sites that sturgeon populations were depressed.
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through time due to human population pressure and overexploitation in the San Francisco Bay area.

An important synthetic model focused specifically on fishing in central California was developed by Boone (2012) who evaluated fisheries in the Monterey Bay area via te-nets of human behavioral ecology. She found evidence for exploitation of a wide variety of fishes from multiple habitats including rocky shores and the Elkhorn Slough estuary between 8000 and 3500 cal BP, and noted high frequencies of mass captured fish such as anchovies, sur-perches, and silversides (caught with nets) as well as species (sardines) that would have been caught by boat. She recognized that the use of relatively labor-intensive tech-niques employed in mass capture (boats and nets) seemed to be too early to be a product of population pressure and/or intensification, and instead, most likely reflected the legacy of a coastal migration route into California. Her model further predicts that variation through time in species in the Monterey Bay area would reflect changes in sea surface temperatures.

Nearly all other discussions of central coast fishing in-voke climate change of one type or another as a cause of underlying variation. Most of these focus on the late Holocene, particularly the droughts of the Medieval Climatic Anomaly (MCA) or Middle-Late Transition, ca. 1200-650 cal BP. Jones (2003) suggested there was a peak in fishing along the Big Sur coast during this time in re-sponse to decreased terrestrial productivity. Joslin (2010) found support for this in the San Simeon area. Jones et al. (2017) reported an order-of-magnitude spike in fish re-mains at Morro Bay which they attributed to the droughts of the MCA. Boone (2012) found taxonomic support for warmer seas during the MCA in the Monterey Bay area in the form of higher frequencies of sardines.

**Energetics of Fishing**

Models proposed especially by Kennett (2005) and Boone (2012) consider fish and fishing within frameworks of op-timal foraging and/or central place foraging. The caloric values of common central coast fishes were summarized by Boone (2012: 375-376) who showed that these fishes are good sources of protein, provided modest amounts of fat, but offered virtually no carbohydrates. The best sources of fat were small schooling fishes: sardines, herring, and anchovies. Data on the energetics associated with the pursuit of fish are poor for California, and can only be approximated using estimates primarily from the Merriam Islands (Bleige-Bird and Bird 1997) and experiment. The latter has been done by McKenzie (2007) who conducted experiments with shell fishhooks and bone gorges in a variety of nearshore environments, from which he reported a maximum return rate of 198 calories/hour for rockfish and cabezon. This figure is ex-tremely low, and, if taken at face value, would make fish the lowest-ranked marine resource in central California (Table 3), but this low value almost certainly reflects re-duced contemporary nearshore fish populations and lack of cultural knowledge. Returns from the Merriam Islands show fairly high yields from certain forms of net-fishing (Table 3) which may more closely approximate the di-etary potential of California nearshore fisheries.

The energetic yield from net-fishing, however, needs also to take into account the inordinate amount of labor re-quired to produce and maintain nets. Lindström (1996) presented an exceptionally thorough analysis of the fish available in the Truckee River of eastern California and the potential costs and caloric values associated with dif-ferent types of indigenous capture strategies. She con-cluded with 25 different potential return rates, with a startlingly wide range. Mass capture employing gill nets, bag, dip, or lift nets, or baskets produced some returns that put fish as the top-ranked resource of all foods in the western Great Basin, but other methods ranked fish near the bottom. Lindström (1996), did not incorporate the costs associated with equipment production into the return yields, but she did note the extraordinary amount of time needed to produce nets:

...an average gill net size of 100 feet long by 4 1/2 feet wide, with a cordage diameter of 1/16 inch and mesh sizes of 1/2 inch, 1 inch, 1 1/2 inches, 2 inches, and 4 inches was selected. The total cordage required to make 1 gill net of these di-mensions can literally be measured in miles. A gill net made with 4-inch mesh requires 3,343 feet of cordage. The same net made with 1/2-inch mesh requires 34,634 feet, or over 6 1/2 miles of cord-age! The former larger mesh net takes a total of about 213 hours to manufacture, where the latter smaller mesh net takes 2,220 hours, over 10 times the labor involvement to make the same sized net. Working an average of 6 hours a day, the former net takes 1 person about 36 days to complete, the latter takes 370 days to finish. These figures do not
include the time and materials required to manufacture gill net accessories, such as floats, spreading sticks and net weights [Lindström 1996:303].

**The Archaeological Record of Fish and Fishing**

Here we evaluate the archaeological record of fish and fishing from the area between San Francisco Bay and the Santa Barbara Channel. The history of research in this area has been summarized by Jones et al. (2007), Glassow et al. (2007), and Milliken et al. (2007). Calibrated radiocarbon dates attest to an 11,000-year record of human occupation; fluted projectile points suggest the possibility of earlier occupation as far back as ca 13,000 cal BP (Waters and Stafford 2007; Erlandson et al. 2007). Occupation of the Channel Islands is slightly older ca, 12,500-12,000 cal BP (Erlandson et al 2011). Here we attempt to define qualitative and quantitative patterns in fishing over time through this region by calculating NISP/m^3/century for 93 temporal components between Point Conception and San Francisco Bay and 12 components from the Santa Barbara Channel. To generate these values we first divided component NISP by recovery volume, and then divided that value by the number of centuries of occupation represented by a component based on calibrated radiocarbon dates. The ultimate objective of the calculations was to identify possible diachronic patterns in the volumetric density of fish remains.

Of course, a huge issue in evaluating relative frequencies of fish remains and taxonomic variation is recovery method—specifically mesh size. This issue has been discussed ad nauseam (e.g., Bertrando and McKenzie 2012; Boone 2012; Casteel 1972; Gobalet and Jones 2018; Gordon 1993; James 1997; Jones and Coddington 2012; Stahl 1996; Wake 2012; Zohar and Belmaker 2005; among numerous others). Such studies have repeatedly established that smaller mesh sizes yield greater numbers of fish bone, and typically greater numbers of smaller fish species. Bertrando and McKenzie (2012) also pointed out that netted fish typically become more numerous in smaller mesh studies. Jones and Coddington (2012) emphasized, that for

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Inclusive Taxa</th>
<th>Inclusive Species</th>
<th>Method of Capture</th>
<th>Low</th>
<th>Midpoint</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine mammal</td>
<td>Ringed Seal, Bearded Seal</td>
<td><em>Phoca hispida, Erignathus barbatus</em></td>
<td>Encounter</td>
<td>10550</td>
<td>18115</td>
<td>25680</td>
</tr>
<tr>
<td>Fish</td>
<td>Small saltwater fish</td>
<td>Mixed</td>
<td>Cast/ Drag Net</td>
<td>3806</td>
<td>4936</td>
<td>6065</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Canadian goose</td>
<td><em>Branta canadensis</em></td>
<td>Canoe</td>
<td>3206</td>
<td>3646</td>
<td>4086</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Canadian goose</td>
<td><em>Branta canadensis</em></td>
<td>Blind</td>
<td>3460</td>
<td>3460</td>
<td>3460</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Canadian goose, Elder duck</td>
<td><em>Branta canadensis</em></td>
<td>Encounter</td>
<td>1720</td>
<td>3440</td>
<td>5160</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>Ducks</td>
<td><em>Anas sp.</em></td>
<td>Encounter</td>
<td>1975</td>
<td>2342</td>
<td>2709</td>
</tr>
<tr>
<td>Shellfish</td>
<td>Red abalone</td>
<td><em>Haliotis rufescens</em></td>
<td>Encounter</td>
<td>135</td>
<td>1174</td>
<td>2213</td>
</tr>
<tr>
<td>Fish</td>
<td>Small saltwater fish</td>
<td>Mixed</td>
<td>Spear/ Harpoon</td>
<td>600</td>
<td>1100</td>
<td>1600</td>
</tr>
<tr>
<td>Fish</td>
<td>Small to large saltwater fish</td>
<td>Mixed</td>
<td>Handline</td>
<td>400</td>
<td>650</td>
<td>900</td>
</tr>
<tr>
<td>Fish*</td>
<td>Rockfishes, Cabezon</td>
<td><em>Sebastes, Scorpaenicthys</em></td>
<td>Hook</td>
<td>28</td>
<td>118</td>
<td>198</td>
</tr>
<tr>
<td>Shellfish</td>
<td>Cabezon</td>
<td>California mussel</td>
<td><em>Mytilus californianus</em></td>
<td>Stripping/Plucking</td>
<td>214</td>
<td>404</td>
</tr>
</tbody>
</table>

SOURCES: Merriam Islanders from Bliege Bird and Bird (1997); Jones and Coddington (2019); McKenzie (2007:56)
purposes of comparison, it is critical to rely on a single mesh aperture. Accordingly, for the current paper, we emphasize archaeological findings from 1/8 inch (3 mm) mesh. However, Jones et al. (2016) also found that there were significant discrepancies between findings from water-screening versus dry-screening. Thus, the data sets discussed below are mostly derived from 1/8 inch (3 mm) dry screening although some wet-screened data were included in order to boost the overall sample size for some regions and time periods. Those samples recovered from anything other than 3 mm dry-screening are noted.

Estuaries

San Francisco Bay. Owing to wide variation in sample size and recovery methods, generalizing about archaeo-fish remains from the San Francisco Bay area is challenging. Twenty-five temporal components summarized here cover the period between 9500 and ca. 250 cal BP (Table 4), and show both temporal and spatial variation. The earliest Lower Archaic components (9500-5050 cal BP) exhibit only freshwater fishes which is consistent with the status of the bay vis a vis sea level rise prior to the mid-Holocene when saltwater habitat was probably limited to areas west of and near San Francisco. Of note, neither of the earliest components produced substantial numbers of sturgeon.

Dated estuarine shellfish remains indicate that the San Francisco Bay was established by ca. 5000 cal BP (Ingram 1998), defined archaeologically as the onset of the Early Period1. Seven Early Period components, representing different areas within the bay, produced fish remains exhibiting a wide range of dominant species including small schooling taxa likely caught with small-mesh nets (New World silversides and herrings) and single sites dominated by sturgeon or bat ray. Sites in the southern bay show greater frequencies of fishes that inhabit sloughs and muddy shoals as well as freshwater fishes, whereas anadromous fish seem more abundant in the deeper, north bay (Marin County). Importantly, herrings which seem to be the best indicators of net fishing (Bertrand and McKenzie 2012) dominate components in both the Early and Late periods.

Volumetric frequencies of fish bones are very low from the Early through Middle periods. For dry-screened samples, these range between 3 and 91 NISP/m³/century. Including wet-screened samples, the highest pre-1300 cal BP value is 210 NISP/m³/century from CCO-309. Both wet and dry-screen samples show increased values for the Middle-Late-Transition and Late periods suggesting an increase in fishing. However, regional variation is significant since species dominating Late Period components include small schooling fishes as well as larger anadromous species (salmon, steelhead, and sturgeon).

Given that the ethnographic record emphasizes netting of fishes (including sturgeon), the diachronic and spatial variation seems most consistent with a minor increase in netted fish from the Middle-Late Transition onward rather than a systematic species-specific program of targeted fishing. Nets sampled the species present in different areas of the bay from the Early Period onward, although there may have been some seasonally-focused fishing to effectively exploit salmon. Nonetheless, there is nothing to suggest that inhabitants of the bay ever focused on salmon to the degree that Native Californians along the Klamath River did. The pattern argued for by Broughton et al. (2015) for depression of top-ranked sturgeon, followed by a focus on second-ranked bat rays is also not apparent in the methodologically-controlled sample assembled here, and seems a product of his reliance on larger mesh samples. Of the 25 components examined for the current study, only three are dominated by sturgeon, two Early and one Late. Eight components are dominated by relatively small schooling fishes like herrings, New World silversides, and surfperches. Instead, we argue that the modest fishing with nets described ethnographically was the same pattern throughout the sequence, and that species like salmon, that could have been more intensively harvested, simply were not. As noted above, artifact inventories from the bay show grooved stones (interpreted as net weights) from the Early Period on (Elsasser 1978:27), corroborating the importance of nets, although bone hooks occur throughout the sequence as well.

Elkhorn Slough and Morro Bay. Methodological variation also complicates the findings from these systems inasmuch as wet-screened values only are available from Elkhorn Slough while only dry-screened values are available from Morro Bay. Nonetheless, certain patterns are fairly clear. First, these systems show substantial volumetric densities of fish bone, particularly at Elkhorn Slough where Breschini and Haversat (1995) documented an Early Period component yielding more than 1,000 NISP/m³/century (see Table 4). Second, components from both
### Table 4: Fish remains from 1/8 inch (3 mm) mesh recovery from Central and south-Central California by temporal component.

<table>
<thead>
<tr>
<th>Trinomial</th>
<th>Temporal Period</th>
<th>Age Span</th>
<th>Excavation volume (m$^3$)</th>
<th>Fish NISP</th>
<th>Fish NISP/m$^3$</th>
<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCO-297**</td>
<td>Late</td>
<td>500-250</td>
<td>6.50</td>
<td>5066</td>
<td>779.4</td>
<td>311.8 Herrings</td>
<td>DeGeorgey (2013)</td>
</tr>
<tr>
<td>MRN-150**</td>
<td>Late</td>
<td>510-480</td>
<td>0.08</td>
<td>20</td>
<td>240.9</td>
<td>803.0 Sturgeon</td>
<td>Wohlgemuth (2013)</td>
</tr>
<tr>
<td>SFR-4 Strat IIa</td>
<td>Late</td>
<td>600-500</td>
<td>6.46</td>
<td>6009</td>
<td>930.2</td>
<td>930.2 Rockfish</td>
<td>Morgan and Dexter (2008)</td>
</tr>
<tr>
<td>SCL-690</td>
<td>Late</td>
<td>800-550</td>
<td>-</td>
<td>19</td>
<td>-</td>
<td>- Minnows</td>
<td>Hylkema (2007)</td>
</tr>
<tr>
<td>CCO-767</td>
<td>Late</td>
<td>920-610</td>
<td>0.80</td>
<td>715</td>
<td>893.8</td>
<td>288.3 Sacramento perch</td>
<td>Wiberg and Clark (2007)</td>
</tr>
<tr>
<td>SFR-4 Strat IIb</td>
<td>M-L-T</td>
<td>1250-700</td>
<td>5.20</td>
<td>1592</td>
<td>306.1</td>
<td>55.6 Surperches</td>
<td>Morgan and Dexter (2008)</td>
</tr>
<tr>
<td>SFR-6**</td>
<td>M-L-T</td>
<td>1300-750</td>
<td>0.55</td>
<td>1826</td>
<td>3320</td>
<td>510.8 Salmon</td>
<td>Jones and Stokes (2002)</td>
</tr>
<tr>
<td>SFR-114</td>
<td>Late Middle, M-L-T</td>
<td>1300-600</td>
<td>2.15</td>
<td>5366</td>
<td>2495.8</td>
<td>356 New World silversides</td>
<td>Byrd et al. (2018)</td>
</tr>
<tr>
<td>MRN-44/HA</td>
<td>Late Middle</td>
<td>1320-900</td>
<td>6.80</td>
<td>2495</td>
<td>366.9</td>
<td>87.4 Salmon</td>
<td>DeGeorgey (2016)</td>
</tr>
<tr>
<td>SFR-4 Strat IIc</td>
<td>Middle</td>
<td>1700-1250</td>
<td>6.00</td>
<td>2475</td>
<td>412.5</td>
<td>91.6 Rockfish</td>
<td>Morgan and Dexter (2008)</td>
</tr>
<tr>
<td>MRN-67 Strat 4</td>
<td>Middle</td>
<td>1900-1700</td>
<td>5.60</td>
<td>974</td>
<td>173.9</td>
<td>86.9 Bat ray</td>
<td>Wohlgemuth this volume; Schwitalla and Powell (2014)</td>
</tr>
<tr>
<td>SCL-677**</td>
<td>Middle</td>
<td>2000-1800</td>
<td>0.61</td>
<td>188</td>
<td>309.7</td>
<td>154.8 New World silversides</td>
<td>Rosenthal (2014)</td>
</tr>
<tr>
<td>SFR-113</td>
<td>Middle</td>
<td>2050-1750</td>
<td>14.05</td>
<td>1083</td>
<td>77.1</td>
<td>25.7 New World silversides</td>
<td>Pastron and Walsh (1988)</td>
</tr>
<tr>
<td>CCO-269</td>
<td>Middle</td>
<td>2700-850</td>
<td>30.60</td>
<td>2023</td>
<td>66.1</td>
<td>3.6 Sturgeon</td>
<td>Holson et al. (2000)</td>
</tr>
</tbody>
</table>

a. Late = 700-180 cal BP; M-L-T = 950-700 cal BP; Middle = 2600-950 cal BP; Early = 5500-2600 cal BP; Lower Archaic = 10,000 - 5500 cal BP

* Volume estimated

** Wet-screened

*** Mixed methods
Table 4 (continued): Fish remains from 1/8 inch (3 mm) mesh recovery from Central and south-Central California by temporal component.

<table>
<thead>
<tr>
<th>Trinomial</th>
<th>Temporal Period</th>
<th>Age Span</th>
<th>Excavation volume (m³)</th>
<th>Fish NISP</th>
<th>Fish NISP/m³ Century</th>
<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRN-44/HB</td>
<td>Middle</td>
<td>2730-1230</td>
<td>1.30</td>
<td>439</td>
<td>337.6</td>
<td>22.5 Salmon</td>
<td>DeGeorgey (2016)</td>
</tr>
<tr>
<td>ALA-309***</td>
<td>Middle</td>
<td>2800-800</td>
<td>90.24</td>
<td>39,393</td>
<td>436.5</td>
<td>21.8 Bat ray</td>
<td>Broughton et al. (2015), Morgan p.c., Gobalet p.c.</td>
</tr>
<tr>
<td>ALA-17</td>
<td>Early and Middle</td>
<td>4000-1600</td>
<td>3.75</td>
<td>223</td>
<td>59.5</td>
<td>4.2 New World silversides</td>
<td>Jones and Darcangelo (2007)</td>
</tr>
<tr>
<td>MRN -67</td>
<td>Early</td>
<td>3200-3000</td>
<td>8.00</td>
<td>984</td>
<td>123.0</td>
<td>61.5 Bat ray</td>
<td>Wohlgemuth this volume; Schwitalla and Powell (2014)</td>
</tr>
<tr>
<td><strong>Strat 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCO-309**</td>
<td>Early</td>
<td>3680-3290</td>
<td>0.09</td>
<td>72</td>
<td>818.2</td>
<td>209.8 Herrings</td>
<td>Price et al. (2006)</td>
</tr>
<tr>
<td>MRN-67</td>
<td>Early</td>
<td>4600-4400</td>
<td>5.60</td>
<td>35</td>
<td>6.3</td>
<td>3.1 Sturgeon</td>
<td>Wohlgemuth this volume; Schwitalla and Powell (2014)</td>
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<td><strong>Strat. 1</strong></td>
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<tr>
<td>SCL-12/H</td>
<td>Early</td>
<td>3300-2400</td>
<td>14.80</td>
<td>838</td>
<td>56.6</td>
<td>6.3 Longjaw mud-sucker</td>
<td>Byrd and Berg (2009)</td>
</tr>
<tr>
<td>CCO-18/548</td>
<td>Early</td>
<td>4000-3100</td>
<td>34.93</td>
<td>1361</td>
<td>38.9</td>
<td>4.3 Sacramento perch</td>
<td>Rosenthal 2010</td>
</tr>
<tr>
<td>CCO-309**</td>
<td>Early</td>
<td>5050-4420</td>
<td>0.05</td>
<td>7</td>
<td>142.9</td>
<td>22.7 Herrings</td>
<td>Price et al. (2006)</td>
</tr>
<tr>
<td><strong>Stratum I</strong></td>
<td></td>
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<tr>
<td>CCO-18/548</td>
<td>Lower Archaic</td>
<td>7100-5000</td>
<td>9.07</td>
<td>15</td>
<td>1.5</td>
<td>0.1 Sacramento perch</td>
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<tr>
<td>P-01-011556</td>
<td>Lower Archaic</td>
<td>9500-8850</td>
<td>0.10</td>
<td>3</td>
<td>30.0</td>
<td>4.6 Sacramento perch</td>
<td>Meyer 2015</td>
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<td><strong>ESTUARY: ELKHORN SLOUGH</strong></td>
<td></td>
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<tr>
<td>MNT-228**</td>
<td>Middle</td>
<td>1590-1260</td>
<td>1.10</td>
<td>3416</td>
<td>3105.5</td>
<td>941.1 New World silversides</td>
<td>Jones et al. (1996)</td>
</tr>
</tbody>
</table>

a. Late = 700-180 cal BP; M-L-T = 950-700 cal BP; Middle = 2600-950 cal BP; Early = 5500-2600 cal BP; Lower Archaic = 10,000 - 5500 cal BP

* Volume estimated

** Wet-screened

*** Mixed methods
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<th>Fish NISP</th>
<th>Fish NISP/m$^3$</th>
<th>Fish NISP/m$^3$/Century</th>
<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNT-234**</td>
<td>Middle</td>
<td>2440-680</td>
<td>0.45</td>
<td>1020</td>
<td>2266.0</td>
<td>696.5</td>
<td>Herrings</td>
<td>Breschini and Haversat (1995)</td>
</tr>
<tr>
<td>MNT-234**</td>
<td>Early</td>
<td>5650-3830</td>
<td>0.46</td>
<td>9592</td>
<td>20,852.0</td>
<td>1032.3</td>
<td>Right-eyed flounders</td>
<td>Breschini and Haversat (1995)</td>
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<tr>
<td>MNT-228**</td>
<td>Lower Archaic</td>
<td>7490-7160</td>
<td>0.80</td>
<td>47</td>
<td>59.0</td>
<td>17.9</td>
<td>Bat ray</td>
<td>Jones et al. (1996)</td>
</tr>
<tr>
<td>MNT-234**</td>
<td>Lower Archaic</td>
<td>7960-5920</td>
<td>1.60</td>
<td>853</td>
<td>533.0</td>
<td>26.3</td>
<td>New World silversides</td>
<td>Breschini and Haversat (1995)</td>
</tr>
</tbody>
</table>

ESTUARY: MORRO BAY

| SLO-23    | Late           | 700-250  | 10.50                        | 3907       | 372.0           | 82.7                   | Surfperches               | Jones et al. (2019) |
| SLO-626   | Late           | 700-450  | 11.70                        | 837        | 71.5            | 28.6                   | Surfperches               | Jones et al. (2019) |
| SLO-457   | M-L-T         | 900-700  | 5.20                         | 7041       | 1354.0          | 677.0                  | Surfperches               | Jones et al. (2019) |
| SLO-14    | Middle         | 2050-1850| 18.40                        | 2294       | 124.7           | 62.4                   | New World silversides     | Jones et al. (2019) |
| SLO-812   | Middle         | 2300-1800| 2.90                         | 107        | 36.9            | 7.4                    | New World silversides     | Jones et al. (2019) |
| SLO-23    | Early          | 4800-3350| 14.60                        | 2916       | 199.7           | 13.8                   | Surfperches               | Jones et al. (2019) |
| SLO-165   | Early          | 5700-3400| 37.20                        | 588        | 16.7            | 0.7                    | Surfperches               | Mikkelson et al. (2000) |
| SLO-458   | Early          | 5000-4750| 9.30                         | 31         | 3.4             | 1.4                    | New World silversides     | Jones et al. (2019) |
| SLO-812   | Early          | 4200-4000| 2.40                         | 142        | 67.5            | 33.8                   | New World silversides     | Jones et al. (2019) |
| SLO-977   | Early          | 3900-2800| 1.00                         | 218        | 218             | 19.8                   | Pacific staghorn sculpin  | Dallas (1992) |

a. Late = 700-180 cal BP; M-L-T = 950-700 cal BP; Middle = 2600-950 cal BP; Early = 5500-2600 cal BP; Lower Archaic = 10,000 - 5500 cal BP

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</tr>
</thead>
<tbody>
<tr>
<td>SLO-165</td>
<td>Lower Archaic</td>
<td>8200-7200</td>
<td>3.50</td>
<td>404</td>
<td>115.4</td>
<td>11.5 New World silversides</td>
<td>Mikkelsen et al. (2000)</td>
</tr>
<tr>
<td>SLO-215</td>
<td>Lower Archaic</td>
<td>7800-6880</td>
<td>4.40</td>
<td>603</td>
<td>137.0</td>
<td>13.7 Surfperches</td>
<td>Jones et al. (2019)</td>
</tr>
<tr>
<td>SLO-812</td>
<td>Lower Archaic</td>
<td>8000-7400</td>
<td>4.80</td>
<td>113</td>
<td>27.3</td>
<td>4.6 Herrings</td>
<td>Jones et al. (2019)</td>
</tr>
</tbody>
</table>

OPEN COAST: SAN MATEO/SANTA CRUZ

| SMA-238  | Late            | -        | 2.00                   | 235       | 117.5                | - Rockfish                | Hylkema (1991)          |

OPEN COAST: MONTEREY PENINSULA

| MNT-129**| Late            | 860-470  | 1.40                   | 443       | 316.4                | 81.1 Rockfishes           | Breschini and Haversat (1991) |
| MNT-1485/H**| Late           | 950-280  | 7.20                   | 12,788    | 1776.1               | 115.8 Herrings            | Breschini and Haversat (1992) |
| MNT-1486/H**| Late           | 950-390  | 11.6                   | 8668      | 747.2                | 133.4 Herrings            | Breschini and Haversat (1992) |
| MNT-3**   | M-L-T and Late | 850-300  | 0.09                   | 75        | 852                  | 154.9 Herrings            | Jones (1998)             |
| MNT-125**| Late            | 690-610  | 2.10                   | 38        | 18.1                 | 22.6 Surfperches           | Breschini and Haversat (2003) |
| MNT-834B**| Late            | 550-240  | 2.40                   | 229       | 95.4                 | 30.8 Surfperches           | Breschini and Haversat (2006), Boone (2012) |
| MNT-108** | Early           | 4240-2770| 0.50                   | 3006      | 6012                 | 408.9 Herrings            | Breschini and Haversat (1989) |

OPEN COAST: BIG SUR/SAN SIMEON

| MNT-1277/H| Late/Post-Contact| 550-140  | 5.00                   | 166       | 33.0                 | 8.5 Rockfishes            | Jones (2003)             |

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** Wet-screened
*** Mixed methods
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<th>Fish NISP/m$^3$ Century</th>
<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNT-1227</td>
<td>Late</td>
<td>650-260</td>
<td>3.80</td>
<td>295</td>
<td>77.6</td>
<td>19.9 Rockfishes</td>
<td>Jones (2003)</td>
</tr>
<tr>
<td>MNT-1942</td>
<td>Late</td>
<td>670-140</td>
<td>8.20</td>
<td>277</td>
<td>33.2</td>
<td>6.3 Rockfishes</td>
<td>Wohlgemuth et al. (2002)</td>
</tr>
<tr>
<td>SLO-115**</td>
<td>Late</td>
<td>670-150</td>
<td>1.00</td>
<td>41</td>
<td>41.0</td>
<td>7.9 Rockfish</td>
<td>Joslin (2006)</td>
</tr>
<tr>
<td>MNT-1233</td>
<td>M-L-T</td>
<td>920-520</td>
<td>3.40</td>
<td>425</td>
<td>125.0</td>
<td>31.2 Rockfishes</td>
<td>Jones (2003)</td>
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<tr>
<td>SLO-179</td>
<td>M-L-T</td>
<td>1220-640</td>
<td>8.20</td>
<td>2550</td>
<td>310.9</td>
<td>53.6 Herrings</td>
<td>Waugh (1992)</td>
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<tr>
<td>SLO-2563**</td>
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<td>920-690</td>
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<tr>
<td>MNT-63</td>
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<td>16.9 Rockfishes</td>
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<td>SLO-267</td>
<td>Middle</td>
<td>2400-700</td>
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<td>0.2 Surfperches</td>
<td>Jones and Ferneau (2002)</td>
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<tr>
<td>MNT-73</td>
<td>Early</td>
<td>4250-3650</td>
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<td>2.1 Cabezon</td>
<td>Jones (2003)</td>
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<tr>
<td>MNT-1228</td>
<td>Early</td>
<td>5750-4850</td>
<td>22.00</td>
<td>10</td>
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<td>0.1 Cabezon</td>
<td>Jones (2003)</td>
</tr>
<tr>
<td>SLO-265</td>
<td>Early</td>
<td>5700-5100</td>
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<td>90</td>
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<td>5.4 Surfperches</td>
<td>Hildebrandt et al. (2007)</td>
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<tr>
<td>SLO-1295</td>
<td>Early</td>
<td>5190-2860</td>
<td>1.07</td>
<td>14</td>
<td>13.1</td>
<td>0.6 Cabezon Pricklebacks Kelp Greenling</td>
<td>Joslin (2010)</td>
</tr>
<tr>
<td>SLO-1622**</td>
<td>Early</td>
<td>4700-3760</td>
<td>0.81</td>
<td>92</td>
<td>113.5</td>
<td>12.1 Pricklebacks</td>
<td>Joslin (2010)</td>
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<tr>
<td>SLO-1677**</td>
<td>Early</td>
<td>4910-3640</td>
<td>1.50</td>
<td>299</td>
<td>199.3</td>
<td>15.7 Pricklebacks</td>
<td>Joslin (2010)</td>
</tr>
</tbody>
</table>

a. Late = 700-180 cal BP; M-L-T = 950-700 cal BP; Middle = 2600-950 cal BP; Early = 5500-2600 cal BP; Lower Archaic = 10,000 - 5500 cal BP

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<th>Trinomial</th>
<th>Temporal Period(^a)</th>
<th>Age Span</th>
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<th>Fish NISP</th>
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<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNT-1232/H</td>
<td>Lower Archaic</td>
<td>6350-5850</td>
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<td>39</td>
<td>16.3</td>
<td>3.3 Cabezon</td>
<td>Jones (2003)</td>
</tr>
<tr>
<td>SLO-51/H</td>
<td>Post-Contact</td>
<td>250-180</td>
<td>0.70</td>
<td>4348</td>
<td>6211.4</td>
<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
</tr>
<tr>
<td>SLO-51/H</td>
<td>Late</td>
<td>600-250</td>
<td>4.00</td>
<td>327</td>
<td>81.8</td>
<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
</tr>
<tr>
<td>SLO-1366/H</td>
<td>Late</td>
<td>700-250</td>
<td>1.20</td>
<td>27</td>
<td>22.5</td>
<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
</tr>
<tr>
<td>SLO-9</td>
<td>M-L-T</td>
<td>1000-700</td>
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<td>515</td>
<td>16.9</td>
<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
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<tr>
<td>SLO-5</td>
<td>Middle</td>
<td>1200-950</td>
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<td>22</td>
<td>2.1</td>
<td>Cabezon</td>
<td>Jones and Codding (2019)</td>
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<td>SLO-10</td>
<td>Middle</td>
<td>2700-800</td>
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<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
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<tr>
<td>SLO-497</td>
<td>Early</td>
<td>3200-2300</td>
<td>2.30</td>
<td>35</td>
<td>15.2</td>
<td>Rockfishes</td>
<td>Jones and Codding (2019)</td>
</tr>
</tbody>
</table>

**OPEN COAST: PECHO**

| SLO-56 | Middle | 5.00 | 185 | 37.0 | Herrings | D. Jones (2012) |
| SLO-832 | Lower Archaic | 8.15 | 78 | 9.6 | Surfperches | D. Jones et al. (2002) |
| SLO-1797 | Lower Archaic | 10,000-9500 | 30.20 | 1 | <0.1 | Rockfish | Fitzgerald (2000); Jones et al. (2002) |
| SLO-2337 | Lower Archaic | 6200-6100 | 2.86 | 33 | 4.90 | Surfperches | D. Jones and Mikkelsen (2006) |

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<th>Fish NISP/m³/Century</th>
<th>Dominant species (% NISP)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBA-3404 (Xonxonata)</td>
<td>Late/Post-Contact</td>
<td>650-150</td>
<td>12.40</td>
<td>1135</td>
<td>91.5</td>
<td>18.3</td>
<td>Herrings</td>
<td>Hildebrandt (2004)</td>
</tr>
<tr>
<td>SBA-1037 AU1</td>
<td>Late</td>
<td>470-310</td>
<td>7.68</td>
<td>139</td>
<td>18.1</td>
<td>11.3</td>
<td>Rockfish</td>
<td>Lebow et al. (2005a)</td>
</tr>
<tr>
<td>SBA-530 (AU-1)</td>
<td>Late</td>
<td>760-280</td>
<td>4.22</td>
<td>180</td>
<td>42.7</td>
<td>8.9</td>
<td>Surfperches</td>
<td>Lebow et al. (2007)</td>
</tr>
<tr>
<td>SBA-935</td>
<td>M-L-T/Late</td>
<td>880-550</td>
<td>22.95</td>
<td>8</td>
<td>0.4</td>
<td>0.1</td>
<td>Rockfish</td>
<td>Harro et al. (2000)</td>
</tr>
<tr>
<td>SBA-677</td>
<td>M-L-T</td>
<td>930-660</td>
<td>10.31</td>
<td>150</td>
<td>14.5</td>
<td>5.4</td>
<td>Herrings</td>
<td>Lebow et al. (1998)</td>
</tr>
<tr>
<td>SBA-1010</td>
<td>Middle</td>
<td>2950-1250</td>
<td>5.75</td>
<td>43</td>
<td>7.5</td>
<td>0.4</td>
<td>Herrings</td>
<td>Lebow et al. (2005b)</td>
</tr>
<tr>
<td>SBA-1037 AU2</td>
<td>Early</td>
<td>4050-3800</td>
<td>10.95</td>
<td>2</td>
<td>0.2</td>
<td>&lt;0.1</td>
<td>Rockfish</td>
<td>Lebow et al. (2005a)</td>
</tr>
<tr>
<td>SBA-530 (AU-2)</td>
<td>Early</td>
<td>5290-4990</td>
<td>2.58</td>
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<td>8.5</td>
<td>2.8</td>
<td>Cabezon</td>
<td>Lebow et al. (2007)</td>
</tr>
<tr>
<td>SBA-530 (AU-3)</td>
<td>Lower Archaic/Early</td>
<td>6200-5290</td>
<td>4.13</td>
<td>271</td>
<td>65.6</td>
<td>7.3</td>
<td>Surfperches</td>
<td>Lebow et al. (2007)</td>
</tr>
<tr>
<td>SBA-530 (AU-4)</td>
<td>Lower Archaic</td>
<td>7650-6320</td>
<td>2.48</td>
<td>14</td>
<td>5.6</td>
<td>0.4</td>
<td>Cabezon</td>
<td>Lebow et al. (2007)</td>
</tr>
<tr>
<td>SBA-246B</td>
<td>Lower Archaic</td>
<td>8970-7820</td>
<td>5.67</td>
<td>1</td>
<td>0.2</td>
<td>&lt;0.1</td>
<td>Surfperch</td>
<td>Lebow et al. (2001)</td>
</tr>
<tr>
<td>SBA-530 (AU 6)</td>
<td>Lower Archaic</td>
<td>10,570-8800</td>
<td>6.25</td>
<td>470</td>
<td>75.2</td>
<td>4.2</td>
<td>Surfperches</td>
<td>Lebow et al. (2007)</td>
</tr>
<tr>
<td>SBA-1547</td>
<td>Lower Archaic</td>
<td>10,900-10,600</td>
<td>6.13</td>
<td>49</td>
<td>7.9</td>
<td>2.7</td>
<td>Cabezon</td>
<td>Lebow et al. (2015)</td>
</tr>
</tbody>
</table>

### OPEN COAST: SANTA BARBARA CHANNEL MAINLAND

| SBA-530 | Lower Archaic | 10,570-8800 | 6.25 | 470 | 75.2 | 4.2 | Surfperches | Lebow et al. (2007) |
| SBA-1547 | Lower Archaic | 10,900-10,600 | 6.13 | 49 | 7.9 | 2.7 | Cabezon | Lebow et al. (2015) |

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<th>Temporal Perioda</th>
<th>Age Span One-Sigma Medians (cal BP)</th>
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CHANNEL ISLANDS

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a. Late = 700-180 cal BP; M-L-T = 950-700 cal BP; Middle = 2600-950 cal BP; Early = 5500-2600 cal BP; Lower Archaic = 10,000 - 5500 cal BP

* Volume estimated
** Wet-screened
*** Mixed methods
systems are nearly all dominated by remains of small schooling fishes (New World silversides, herrings, and surfperches), and there is very little spatial variation—much less than at San Francisco Bay. Herrings dominate at least one component as early as 8000 cal BP, suggesting net and watercraft use. Diachronic patterning also varies with San Francisco Bay, especially at Morro Bay, where a peak in fish bone density in the Middle-Late Transition has been associated with droughts of the Medieval Climatic Anomaly (Jones et al. 2017; Stine 1994). This suggests that the fisheries were generally under-utilized, and could have been exploited more heavily whenever some modicum of population pressure presented itself. There is little if anything to suggest that the fish populations themselves were under pressure or were negatively affected by human exploitation, because there is no change in dominant species over time. Furthermore, the high volumetric density of remains from the Early Period at MNT-234 speaks to the amount of fish that could have been caught, but were not, during most periods.

While artifactual evidence for fishing technology is generally lacking from Elkhorn Slough, cobbles with asphaltum lines, interpreted as net weights, are well-represented at Morro Bay from at least the Early Period onward (Figure 3).

Open Coast

San Mateo/Santa Cruz and Monterey Peninsula. The northern stretch of open rocky coast in the current sample shows only three groups that dominate assemblages; rockfish (probably caught by hook and line), and schooling herring and surfperches (amenable to capture with nets). Densities of bones in the samples are generally very modest. Dated components only represent the period between 4240 and 240 cal BP, and diachronic patterning is not entirely clear. Herrings, however, dominate at least one component as early as 4240 cal BP, suggesting use of nets, beach seines, and/or watercraft by that time. The highest value is for the Early Period (409 NISP/m$^3$/century) while the Late Period shows a decreased range between 23 and 155 NISP/m$^3$/century. The high value from MNT-108 speaks to the amount of fish potentially available along this shoreline and/or the ease of capture alluded to in ethnographic accounts.

Whitaker and Byrd (2012) suggested there was an increased reliance on watercraft on the Monterey Peninsula after ca. 950 cal BP, but fish bone density values do not show any increase across this timeline.

Big Sur/San Simeon. Fish bone density values are generally very low along this stretch of rugged coast where access to nearshore fisheries was challenging. Cabezon and rockfish are the dominant species regardless of time, although pricklebacks, which could be caught by hand in tidepools, dominate some assemblages. Herrings are important in only the Middle-Late-Transition component at SLO-179 (Waugh 1992). Findings from the ethnographic Salinan village of Matalcé (Rivers and Jones 1993) show very low fish bone density (8.5 NISP/m$^3$/century). Diachronic patterning matches that of Morro Bay with the highest volumetric densities associated with the Middle-Late-Transition, where they are also associated with medieval droughts (Joslin 2010). The Late Period generally shows a decrease following the Middle-Late-Transition, akin to Morro Bay. Surfperches are common enough to suggest the use of nets and/or seines, but the dominance of rockfish and low frequency of herrings suggests less use of such technology. Surfperches are less clear indicators of net use than herrings (Bertrando and McKenzie 2012).
**Pecho Coast and Pismo Beach.** The open coast of southern San Luis Obispo County shows minimal spatial variability with rockfish and cabezon dominating most assemblages except near Pismo Beach, where an estuary existed in the past (Jones et al. 2002). Fish bone densities are consistently low throughout the entire local sequence—with the exception of the Post-Contact component at SLO-51/H, the ethnographic Chumash village of *Tstyįi* which yielded the single highest value of any site on the mainland: 8873 NISP/m³/century. This shows a substantial increase from the Late Prehistoric Period (23 NISP/m³/century) that has been interpreted as a response to initial Spanish colonialism in which the foraging radius of the village became restricted, thereby encouraging a greater reliance on fish. The importance of the SLO-51/H fish remains cannot be overstated since they demonstrate the degree to which fishing could have been pursued prehistorically—but wasn’t until exigencies were created by the intrusion of Europeans.

Artifacts from the Pecho Coast suggest that bone gorges were employed early, and were later replaced by shell hooks during the Middle Period. Direct evidence for nets is sparse. McKenzie (2007) suggested that the advent of shell hooks was associated with an increase (and more effectiveness) in fishing during the Middle Period. As reasonable as this assertion seems, the regional record does not show the expected increase in fish bone density at the appropriate point in time. Coddington and Jones (2007) argued that advent of the hook led to more individual fishing with hook, line, and sinker rather than group efforts with nets, but this assertion has chronological problems. Radiocarbon dates indicate that hooks were present earlier (Breschini and Haversat 2000).

**Northern Santa Barbara County.** Fish remains from sites north of the Santa Barbara Channel in Santa Barbara County occur in very low densities similar to the Pecho Coast. They also include the oldest fish remains from mainland California (10,900-10,600 cal BP), as reported from SBA-1547, the Sudden Flats Site (Lebow et al. 2015). The remains were dominated by cabezon. While the low density of fish bones at Sudden Flats certainly does not suggest a maritime specialization, it does indicate some involvement with marine resources nearly 11,000 years ago. This stretch of coast shows more variation in species than other rocky shores, with rockfish, herrings, cabezon, and surfperches alternating as the most abundant fishes. The available sample also shows no meaningful trend over time—with nothing akin to the Late Period or Middle-Late-Transition peaks seen in the San Francisco Bay and Morro Bay areas.

The highest density of fish remains in the available sample was from SBA-3404, the ethnographic village of *Xonxonata* (with both Late and Post-Contact components), which yielded 18.3 NISP/m³/century, dominated by herrings. This value is considerably less than the northern Chumash village of *Tstyįi*, but *Xonxonata* is situated considerably further inland (ca 30 km).

Herrings show a rise to the dominant species during the Middle Period, suggesting use of some form of watercraft or beach seines—with the caveat that the overall density of fish bone remained extremely low (0.4 NISP/m³/century). Most scholars (e.g., Glassow 1996) believe that the much-heralded sewn-plank canoe was not employed on the northern Santa Barbara coast, and the low yields of fish bones seem consistent with that view. Tule balsas or some other less complex form of boat was likely used on this coast, albeit sparingly. Again, the appearance of shell hooks during the Middle Period does not seem to have increased production in fishing, nor is there any obvious evidence for an increase in fishing over time.

**Santa Barbara Channel**

The Santa Barbara Channel today is largely an open rocky shoreline, although at least one major estuary was present historically at Goleta Slough. The offshore islands, representing unique insular environments, are also dominated by exposed rocky shorelines with one paleo estuary documented on Santa Rosa Island (Cole and Liu 1994). Identifying well-dated, well-sampled, and adequately reported components from this area was challenging despite a plethora of research interest in recent decades. The sample we report here is no doubt incomplete, but it provides at least some comparative insights into the intensity of fishing in the Channel area relative to the area between San Francisco Bay and Point Conception.

**Mainland.** Unlike regions to the north, herrings show dominance early on the Santa Barbara mainland with high densities (756 NISP/m³/century) as early as 8630 cal BP. Variation in species is also apparent, with white croaker, bat rays, and mackerel dominating components at different times. There is no obvious or clear trend of
increased fishing over time in the sample evaluated here. Rick and Erlandson (2000) argue that the dominant species suggest the use of nets throughout the sequence, which seems reasonable. Sites on the islands suggest that people were using watercraft as early as ca 12,500-12,000 years ago (Erlandson et al. 2011). Advent of the sewn-plank canoe at the end of the Middle Period does not show a coincident increase in fish remains on the mainland—with the caveat that the currently available sample is probably incomplete.

**Islands.** A limited sample of six components from three islands is used here to illustrate the basic patterns of the insular fishing adaptation. Dominant species vary considerably from island to island, but none of the species in the current sample are small-schooling types that would have required capture by nets. However, the key feature of the island record is the extremely high fish bone density exemplified by SMI-87 (dating 3100-3000 cal BP) that yielded 1910 NISP/m$^3$/century, which is higher than any pre-contact component on the mainland. Middle-Late Transition components from San Miguel Island show even higher values between 7433 and 9438 NISP/m$^3$/century. The latter value is higher than that of any other site in the current study area, including the post-contact occupation at SLO-51/H. This high level of exploitation continued through post-contact times.

Glassow (1993) recognized that fishing generally increased throughout the sequence on the islands. Fishing seems to have been pursued at a high level as early as 3100 cal BP and increased further after that time. Chronological resolution in the current sample is less than perfect, but the greatest increase seems to be associated with the Late Middle or Middle-Late-Transition—as suggested in most generally accepted models of Channel Islands prehistory (e.g., Arnold 1992, 2001; Kennett 2005; Kennett and Kennett 2000). Such models generally associate this increase with initial appearance of the sewn-plank canoe (tomol) replacing earlier craft.

**Summary: Diachronic and Spatial Patterns**

Patterns of fishing across the region between San Francisco Bay and Point Conception show diachronic and spatial variation. The earliest evidence for fishing in this region and immediately adjacent areas comes from site SRI-512W on Santa Rosa Island dating ca 11,900 cal BP (Erlandson et al. 2011), followed on the mainland by SBA-1547 (10,900 cal BP; Lebow et al. 2015), SLO-1797 (10,000 cal BP; Fitzgerald 2000), P-01-011556 (9500 cal BP; Meyer 2015) in the San Francisco Bay Area (Meyer 2015), and SON-348/H (9000 cal BP; Schwaderer 1992; Kennedy 2005), on the open coast north of the bay (Figure 4).

San Francisco Bay shows evidence only for freshwater fishing during the early Holocene, which is a product of the bay’s paleoenvironmental history. When marine fishing began ca. 5000 cal BP, wide spatial variation is apparent. Species likely caught with nets, including herrings and New World silversides, are abundant at some locations early and continued to be exploited during subsequent periods, which implies that nets were always important, as suggested by ethnographic accounts. Sturgeon, salmon, and bat rays are also abundant in some assemblages, but the diachronic patterning argued for by Broughton et al. (2015) (a decrease in sturgeon over time due to overexploitation and resource depression) is not apparent when mesh size used in field recovery is tightly controlled, especially when focusing on 3 mm (1/8 inch) samples. The clearest patterns from the bay are that: (1) fishing increased over time, especially after 1300 cal BP when multiple components show 300-930 NISP/m$^3$/century, and (2) dominant species vary across the estuary. People caught what was locally available and did not transport it great distances. The five Late Period components used for the current study (see Table 4) all show different dominant species. This seems more consistent with localized use of nets and/or seines which essentially sampled the spatial concentrations of different species at locations within the bay.

South of San Francisco Bay and north of the Santa Barbara Channel, patterns are different. The smaller estuaries at Elkhorn Slough and Morro Bay exhibit very little variation, with New World silversides, herrings, and surfperches dominating as early as 8000 cal BP and continuing to do so through the Holocene. Fishing did not increase at the small estuaries over time, but instead, high NISP/m$^3$/century values from the Early, Middle, and Middle-Late Transition, are followed by lower ones during the Late Period. The Monterey Peninsula has one Early Period component (MNT-108, dating ca. 4200 cal BP) dominated by herrings, but the open rocky coasts of Big Sur, Pecho, and northern Santa Barbara County show less evidence for reliance on nets or boats, with components consistently dominated by rockfish and...
cabezon (hook and line species). Herrings dominate a few components along the open coast by the Middle Period or Middle-Late Transition. Most of the open coast sites show low fish bone densities throughout the sequence, but densities were consistently lower during the Late Period than earlier, suggesting that the fish resource was under-utilized leading up to the time of historic contact.

Patterns in the Santa Barbara Channel distinguish themselves from the rest of the study area, and further illuminate the ultimate food potential of the fish resource. At least one mainland site on the Channel shows herrings as the dominant species as early as 8630 cal BP. More importantly, fish bone densities on the islands are higher than any pre-contact component on the mainland by as early as 3100 cal BP. By at least the Middle-Late-Transition, island sites show fish bone densities greater than 7000 NISP/m$^3$/century.

**Discussion: Fish, Nets, Subsistence, and Demography**

Cook (1978) estimated that the human population for the area between San Francisco and Morro bays was 26,000 people at the time of historic contact, including communities up to 100 km inland who would not have had access to or relied upon marine fisheries. Conservatively, perhaps 20,000 people could be considered coastal residents. A sampling of historic catch records from San Francisco alone shows a range between 18 and 52 million pounds of fish per year, and from Monterey between 75 and 386 million pounds. For the year 1935, the combined yield from San Francisco and Monterey was 438 million pounds; for the year 1947, the combined catch from San Francisco, Monterey, and Morro Bay was 85 million pounds. If Native coastal residents each consumed one pound of fish per day per year, that would equate to 7.3 million pounds of fish for the entire region, which is obviously well below even the lowest historic catches.
Of course, as noted above, the modern records represent yields from a much larger catchment than was accessible prehistorically, as well as the use of mechanized equipment. Nonetheless, they suggest there were far more fish available to central coast Native people than were ever harvested.

Modern catch records from the Port of Los Angeles, which include fish caught around the Channel Islands, are the highest from anywhere on the coast (506 million pounds in 1935), which suggests these may have been the richest fisheries of California. However, the catch from the port of Monterey in 1935 (386 million pounds), suggests a near-equal level of abundance. While the high archaeological fish bone densities from the Channel Islands can be at least partially attributed to the richness of the adjacent fisheries, the waters off the Monterey coast were nearly as bountiful yet the archaeological values are considerably lower, suggesting that the resource was under-exploited prehistorically.

While fishing increased over time in the San Francisco Bay area, the opposite was the case along nearly the entire mainland between Monterey and Point Conception, where high archaeological fish bone densities early in time give way to lower ones later. Especially compelling are diachronic trends from Morro Bay where there was a major, but temporary surge in fishing during the Medieval Climatic Anomaly (MCA). When droughts of the MCA abated, fishing declined (Jones et al. 2016, 2017), but there is little to suggest that the food value of the fishing resource changed—it simply was no longer exploited.

Importantly, the diachronic decrease over time is the opposite of what would be expected of assemblages that were heavily biased by destructive taphonomic processes. Faunal analysts are quick to attribute any absence or decline in bone profiles to the likely ravages of taphonomy (see for example, Fagan 2017), but such biases ultimately need to be supported with evidence or evaluated on a site-by-site basis. Here, we suggest that the preservation climate in most central California coastal shell middens was in general, fairly benign (agents of bioturbation notwithstanding), and that the overall diachronic decrease, along with the recovery of large numbers of tiny fish bones from sites like SLO-2 (Fitch 1972), negate arguments that the observed patterns are taphonomically driven.

Findings from the ethnoarchaeographic Chumash village of Tsytywei on the Pecho Coast (CA-SLO-51/H) are also highly informative relative to the subsistence potential of the fish resource as reflected by fish bone density. This site harbored a pre-contact (600-250 cal BP) component, and a post-contact (250-180 cal BP) component. While the pre-contact component yielded a modest 23 NISP/m²/century, the post-contact component showed a staggering increase to over 8,000 NISP/m²/century. This shift is interpreted as a reflection of increased reliance on the local fishery as inhabitants of the village sought to avoid contact with the Spanish, reducing their terrestrial foraging area to concentrate on the immediate shoreline (Jones and Codding 2019; Jones et al. 2017). This pattern suggests strongly that the full food potential of fish was untapped prior to contact.

The indigenous people of central California, however, could not have survived entirely on fish nor was fish necessarily a preferred or highly-ranked resource. Bettinger (2015:232) states that fish can be problematic nutritionally, although he explicitly notes that fat-rich herrings are an exception. Pacific herrings and Pacific sardines are among the most abundant fish represented in historic catches and the archaeological record (see Tables 1 and 2). Still, fish would need to be complemented by some form of carbohydrates—which certainly were not lacking in central California either. Balancing fish nutritionally with carbohydrates would not have been a major challenge.

In terms of a more detailed energetic evaluation, the central California fish resource had little if any back-end costs since storage was unnecessary; fish were available in substantial quantities year-round. Estimates of the post-encounter caloric yields from fish suggest that netted fish have values intermediate between sea mammals and shellfish (Table 3)—with the caveat that such values are crude estimates that do not incorporate any actual California ethnographic data. Regardless, the key aspects of net fishing that affects its potential caloric value are the front-end costs, specifically production of nets. From this, it could be surmised that netting fish was always a lower-ranked subsistence pursuit that was engaged in later in time as a result of population pressure and economic intensification. However, nets and/or seines seem to have been used very early along the California coast, while the demographic situation does not suggest that Native populations were at or near carrying capacity given the
massive size of the fishery in the eastern Pacific. Multiple lines of archaeological and historic evidence suggest there were far more fish available in the waters offshore central California than were ever exploited prehistorically. Netting fish was an effective but not necessarily efficient means for acquiring a substantial quantity of food. Still, it seems untenable to attribute use of nets to incremental population growth or pressure given that nets were used very early. Catching fish by net seems more of an historical tradition that was imported into California from the Old World by people who had already developed a distinctive coastal adaptation that they continued to employ through the Holocene as a method for feeding growing numbers of people, but not necessarily with decreasing efficiency or any effects on the fisheries themselves. Population pressure may only have come into play when there were perturbations in the terrestrial environment such as the Medieval Climatic Anomaly during which fish provided a valuable food source that could be heavily relied upon by those fortunate enough to reside near the shore. If population pressure contributed to the adoption of acorns in Native California as is generally assumed (e.g., Basgall 1987), that pressure would not have emanated from the coast, and indeed coastal populations were probably always less involved with acorns. The stereotype of Native Californians as acorn specialists is probably accurate for the interior, including the Central Valley and Sierra Nevada Range, but less so for San Francisco Bay, central coast and Santa Barbara Channel, for whom we have a poor ethnoarchaeological record. Instead, these groups were masters of diversity who dabbled in acorns, dabbled in fishing, but were still living below the carrying capacity of the environment, owing to the enormous productivity of fisheries in the eastern Pacific.

Notes

1 Subdivisions of Kroeber’s (1939) culture areas of North America.

2 There is considerable imprecision between common names included in historic records and contemporary biological nomenclature.

3 Time periods employed here are: Millingstone/Lower Archaic 10,000-5500 cal BP, Early 5500-2600 cal BP, Middle 2600-950 cal BP, Middle/Late Transition 950-700 cal BP, Late 700-180 cal BP.

Acknowledgments

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