Title
Prehistoric Fisheries of Morro Bay, San Luis Obispo County, California

Journal
Journal of California and Great Basin Anthropology, 36(1)

ISSN
0191-3557

Authors
Jones, Terry L.
Gobalet, Kenneth W.
Mikkelsen, Patricia
et al.

Publication Date
2016

Peer reviewed

Journal of California and Great Basin Anthropology | Vol. 36, No. 1 (2016) | pp. 119–147

Prehistoric Fisheries of Morro Bay, San Luis Obispo County, California

TERRY L. JONES
Department of Social Sciences, California Polytechnic State University,
San Luis Obispo, CA 93407-0329

KENNETH W. GOBALET
Department of Biology, Emeritus, California State University, Bakersfield, CA 93311
Current Address: 625 Wisconsin St. San Francisco, CA 94107

PATRICIA MIKKELSEN
Far Western Anthropological Research Group, Davis, CA 95618

KACEY HADICK
Far Western Anthropological Research Group, Davis, CA 95618

WILLIAM R. HILDEBRANDT
Far Western Anthropological Research Group, Davis, CA 95618

DEBORAH A. JONES
Far Western Anthropological Research Group, Davis, CA 95618

An 8,000-year sequence of fish remains from Morro Bay, a shallow, 8.1 km.^{2} coastal estuary in San Luis Obispo County, has been compiled during recent investigations. The sample, obtained from nine sites and 14 components (total excavation volume = 275.86 m.^{3}), includes 19,226 fish elements recovered via 1/8-inch dry-screening and 718 elements from 1/16-inch water-screened columns. The archaeological findings are generally consistent with species inventories from the 1970s, although northern anchovies are under-represented in the prehistoric record. Remains show a consistent focus on the netting of small schooling fishes in the calm backwaters of the bay. A significant decrease in bat rays is attributed to a shift in seasonality, although overexploitation cannot be ruled out. Remains show only modest changes between 8,000 and 950 cal B.P., but a dramatic spike in NISP/m.^{3} and fish/deer + rabbits during the Middle-Late Transition suggests an increased focus on marine prey during droughts of the Medieval Climatic Anomaly, when Morro Bay apparently served as a refugium. Fishing declined relative to terrestrial resources during the Late Period, when acorns and other plant foods increased in importance.

In recent years the importance of fish, fishing, and fishing-related technologies to coastal hunter-gatherers has been researched and documented extensively in southern California, especially in the Santa Barbara Channel, where as early as 1993 Glassow reported an increase in the relative dietary importance of fish throughout the Holocene (see also Arnold 1992, 1995, 2001, 2004; Erlandson 2001; Gamble 2008; Glassow 1993; Kennett 2005; McKenzie 2007; Pletka 2001; Rick 2007; Rick and Erlandson 2000; Turnbull et al. 2015, among others). This apparent example of fish as a focus of economic intensification in a coastal context provides a comparative datum for the evaluation of prehistoric fisheries elsewhere in coastal California.

One setting where archaeological evidence for fishing has not been synthesized is Morro Bay (Fig. 1), a shallow, 2,000-acre (8.1 km.^{2}) coastal estuary situated on the central California coast in San Luis Obispo County. Occupied by speakers of Northern Chumash at the time of contact, Morro Bay is one of the most isolated

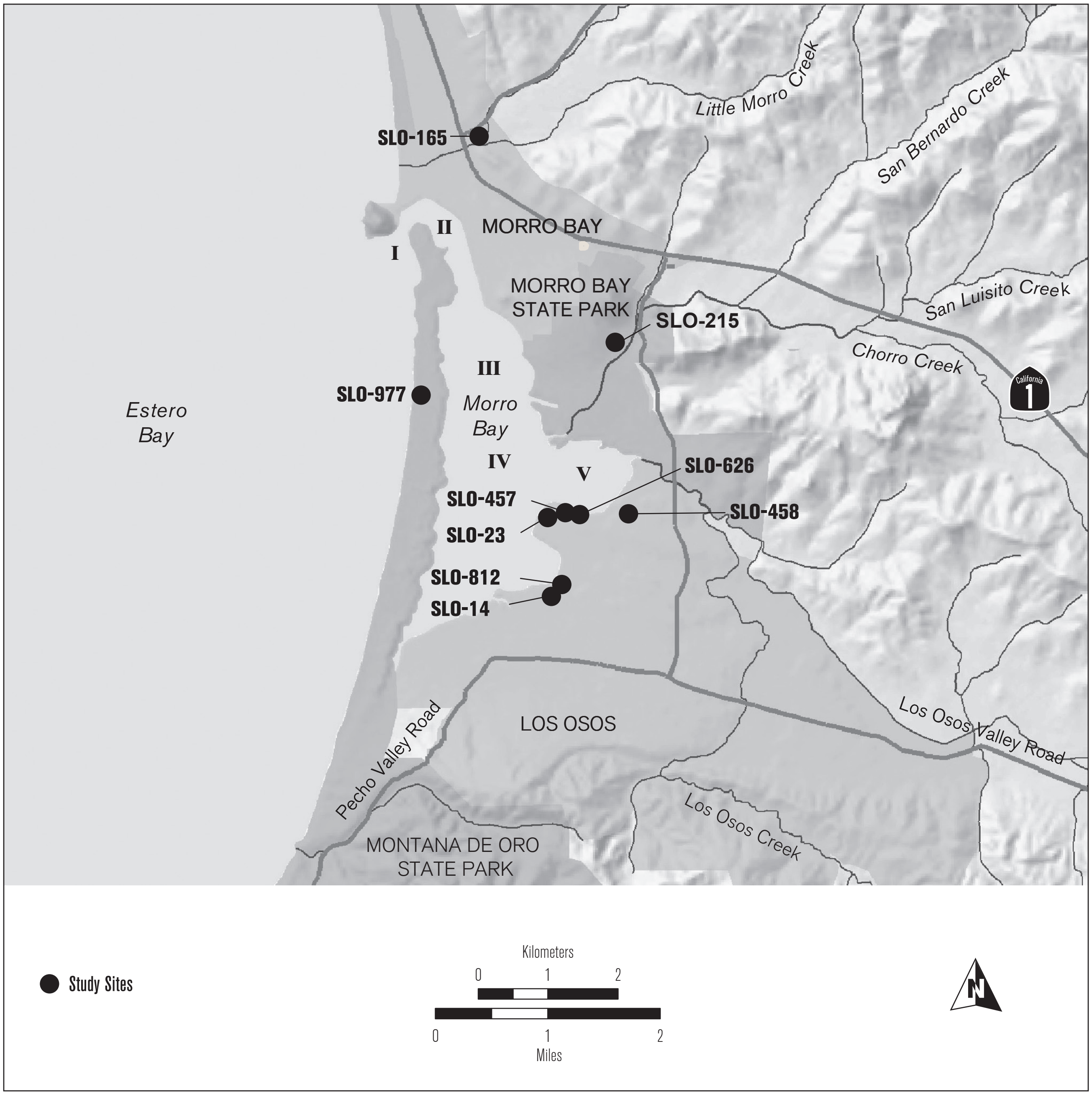

Figure 1. Morro Bay Archaeological Sites with Habitat Zones I-V as defined by Fierstine et al. (1973).

and least-studied estuaries in California. Archaeological investigation of the bay's abundant shoreline sites began only in the 1960s (Clemmer 1962), and the first radiocarbon dates were not obtained until the 1970s (Hoover and Sawyer 1977). Biological inventories of the bay's rich marine and terrestrial fauna also began only in the late 1960s (California Department of Fish and Game 1966; Fierstine et al. 1973; Gerdes et al. 1974; Horn 1980).

While a preliminary cultural chronology was established for the general San Luis Obispo County area by Greenwood (1972), based on findings from Diablo Canyon on the open coast to the south (sometimes referred to as the "Pecho Coast"), data from the Morro Bay estuary have been slower to accumulate. In the last two decades, there have been a number of substantial investigations at Morro Bay (e.g., Bertrando 2000, 2004a;

Jones et al. 1994, 2004; Mikkelsen et al. 2000), highlighted by the recently completed Los Osos Wastewater Project, which yielded substantial artifact and faunal samples from six sites along the southern edge of the bay (Jones et al. 2015). Here we describe the 8,000-year sequence of fish remains from around Morro Bay developed from 14 archaeological components investigated over the last two decades, with particular reliance on findings from Los Osos.

Our objectives in this study were to evaluate the archaeological fish assemblages with respect to possible (1) variations between modern and prehistoric fisheries; (2) a gradual trans-Holocene increase in the importance of fishing as a consequence of human population growth; (3) changes in target species related to new technologies (see Arnold and Bernard 2005; McKenzie 2007) and/or overexploitation (see Broughton 1994, 1997; Salls 1992); and (4) variations in the relative importance of fish with respect to climatic shifts (marine or terrestrial) and/or human population movements. With regard to the latter, it has been proposed that Morro Bay and other coastal settings in San Luis Obispo County served as refugia for human populations during the Medieval Climatic Anomaly (Codding and Jones 2007; Joslin 2010; Mikkelsen et al. 2000). Also, the region seems to have been witness to settlement changes (Bertrando 2006) and a major increase in sites occupied ca. 6,000–5,500 cal B.P., which has been interpreted as a sign of population increase in the mid-Holocene (Jones 1996; Jones et al. 2007; Mikkelsen et al. 2000). The degree to which variations in fishing and/or fish remains might reflect this apparent demographic change has not been systematically evaluated.

SETTING

Environment

Morro Bay is the northern end of a southeastward trending depression that encompasses the Los Osos and San Luis valleys (Cooper 1967:74). It is made up of the drowned mouths of the two primary drainages that enter the bay today—Chorro Creek and Los Osos Creek. In the past, Morro Creek also discharged into the estuary system from the north. Sand dunes surround the bay and form a barrier between the estuary and outer Estero Bay. These dunes represent a series of developmental phases from the late Pleistocene through the Holocene (Orme 1990). Entrance to the bay from the open ocean was significantly improved in the 1940s by construction of breakwaters by the U.S. Army Corp of Engineers. Prior to that, the mouth of Morro Bay was open to surf action, and it was noted in 1769 by members of the Portolá expedition (Brown 2001:487) as being essentially unsuitable for ship portage.

With respect to fishes, the Morro Bay area offers a range of habitat types based on varied substrates and locations relative to the bay's mouth and sources of freshwater. Fierstine et al. (1973) defined five zones within the modern bay (Fig. 1). Zone I was within the present-day harbor created by the construction of breakwaters in the 1940s. Prehistorically, this area was open ocean just outside of the estuary's mouth, distinguished by a coarse sand bottom. Zone II had a mud-sand bottom and was situated just within the mouth of the pre-contact estuary, east of Morro Rock; it was recognized as the most artificial of the bay's habitats. Zone III represented the north-central portion of the bay, away from its mouth, and was described as a transitional area between Zones II and IV, with a mix of developed and natural shoreline. Zone IV was nearly all of the shallow back bay, and was marked by extensive beds of eelgrass (*Zostera* sp.) and a silty-mud bottom. Zone V was the estuarine delta formed by Chorro and Los Osos creeks, the two largest freshwater sources that currently empty into the bay. Salinity in Zone V varied significantly with changing tides.

For the current study, fishes were associated with three broad habitats: (1) *estuarine* (representing Fierstine et al.'s [1973] Zones, III, IV, and V); (2) *estuarine and open coast* (fish that occur both within and outside the embayment); and (3) *sandy and rocky open coast* (Fierstine et al.'s Zones I and II along with the open shoreline north and south of the bay's mouth at Morro Rock).

The nature and distribution of habitats within the bay have changed over time, however. Orme (1990) established that the Morro Bay sand spit is underlain by estuarine deposits (Flandrian estuarine muds) at a depth of 12.5 meters below sea level. An extensive deposit of estuarine muds has also been documented offshore on the surface of the sea floor ca. 2 km. west of the barrier at a depth of ca. 18–25 meters. These deposits indicate that the current estuary was preceded by a larger paleoestuary that extended farther west sometime during the late Pleistocene-early Holocene. Shellfish assemblages indicate that an estuarine environment was established along the shore of Morro Bay by 8,100 cal B.P. when sea level was ca. 18–20 meters below its current position (Masters and Aiello 2007). Shellfish from the Millingstone/Lower Archaic component at CA-SLO-812 suggest a gravelly substrate at the back of the bay where muds and silts had not yet accumulated (Jones et al. 2015). A 7,800–7,000 cal B.P. assemblage from CA-SLO-215, adjacent to the Chorro delta, indicates a reasonably well-established estuarine embayment, with some accumulation of muds and silts suitable for various clams (Jones et al. 2004). Gallagher (1996) and Orme (1990) surmise that between 8,000 and 4,000 cal B.P. the low discontinuous sand barrier that formed the bay was slowly migrating eastward. For the most part, sediment cores do not suggest major changes in bay habitat after 4,000 years ago, with brackish conditions generally prevailing, although sedimentation rates did increase significantly in historic times. Shellfish assemblages show a trend of decreasing oyster frequencies between 8,100 and 2,500 cal B.P. consistent with gradual infilling of the estuary; however, there is some evidence for seismically-induced changes in the bay between 2,500 and 1,500 cal B.P., as detected by Gallagher (1996) in sediment cores and represented (tentatively) by gaps in the radiocarbon record (Jones et al. 2015). Whether the latter influenced the nature and distribution of fish habitats within the bay is unclear, but spatial differentiation in substrata would have, in general, influenced the make-up of fish populations in different portions of the bay, especially in the early through middle Holocene before silts and muds had collected throughout the embayment. Such variation could potentially influence the species make-up of archaeological assemblages.

Fishes

The California Department of Fish and Game identified 66 species of fish (64 natives) within Morro Bay in 1966 which were subsequently confirmed by Fierstine et al. (1973 and Table 1) when they conducted systematic collecting between 1968 and 1970. Their surveys showed that three species—northern anchovy, shiner perch, and black perch—accounted for more than 50% of the fish in

Table 1

FISHES OF MORRO BAY (FROM FIERSTINE ET AL. 1973; TERMINOLOGY FROM PAGE ET AL. 2013)

Taxon	Common Name
Elasmobranchiomorphi	**Sharks, skates, and rays**
Heterodontus francisci	Horn shark
Mustelus californicus	Gray smoothhound
Triakis semifasciata	Leopard shark
Squatina californica	Pacific angel shark
Rhinobatos productus	Shovelnose guitarfish
Raja binoculata	Big skate
Platyrhinoidis triseriata	Thornback
Urobatis halleri	Round stingray
Myliobatis californica	Bat ray
Actinopterygii	**Ray-finned fishes**
Engraulis mordax	Northern anchovy
Clupea pallasii	Pacific herring
Sardinops sagax	Pacific sardine
Oncorhynchus mykiss	Rainbow trout, steelhead
Porichthys notatus	Plainfin midshipman
Atherinops affinis	Topsmelt
Atherinopsis californiensis	Jacksmelt
Fundulus parvipinnis	California killifish
Gasterosteus aculeatus	Threespine stickleback
Syngnathus californiensis	Kelp pipefish
Syngnathus leptorhynchus	Bay pipefish
Sebastes auriculatus	Brown rockfish
S. dalli	Calico rockfish
S. mystinus	Blue rockfish
S. paucispinis	Boccacio
S. rastrellinger	Grass rockfish
S. serranoides	Olive rockfish
Ophiodon elongatus	Lingcod
Oxylebius pictus	Painted greenling
Artedius lateralis	Smoothhead sculpin
Cottus asper	Prickly sculpin
C. gulosus	Riffle sculpin
Leptocottus armatus	Pacific staghorn sculpin
Scorpaenichthys marmoratus	Cabezon
Trachurus symmetricus	Jack mackerel
Cymatogaster aggregata	Shiner perch
Damalichthys vacca (Rhacochilus vacca)	Pile perch
Embiotoca jacksoni	Black perch
E. lateralis	Striped seaperch
Hyperprosopon argenteum	Walleye surfperch
Hypsurus caryi	Rainbow seaperch
Micrometrus aurora	Reef perch

Table 1 *(Continued)*

FISHES OF MORRO BAY (FROM FIERSTINE ET AL. 1973; TERMINOLOGY FROM PAGE ET AL. 2013)

Taxon	Common Name
Actinopterygii *(Continued)*	**Ray-finned fishes** *(Continued)*
M. minimus	Dwarf perch
Phanerodon atripes	Sharpnose seaperch
P. furcatus	White seaperch
Rhacochilus toxotes	Rubberlip seaperch
Cebidichthys violaceus	Monkeyface prickleback
Apodichthys flavidus	Penpoint gunnel
Apodichthys fucorum	Rockweed gunne
Gibbonsia montereyensis	Crevice kelpfish
Heterostichus rostratus	Giant kelpfish
Gobiesox meandricus	Northern clingfish
Rimicola muscarum	Kelp clingfish
Clevelandia ios	Arrow goby
Eucyclogobius newberryi	Tidewater goby
Gillichthys mirabilis	Longjaw mudsucker
Lepidogobius lepidus	Baby goby
Peprilus simillimus	Pacific pompano
Citharichthys stigmaeus	Speckled sanddab
Paralichthys californicus	California halibut
Parophrys vetulus (*Pleuronectes vetulus*)	English sole
Platichthys stellatus	Starry flounder
Pleuronichthys coenosus	C-O sole
P. guttulatus (*Hypsopsetta guttulata*)	Diamond turbot
P. ritteri	Spotted turbot
Psettichthys melanostictus	Sand sole
Symphurus atricaudus	California tonguefish

the bay by number caught. At least 10 species, including black perch, shiner perch, lingcod, Pacific staghorn sculpin, and starry flounder, are year-round residents of the estuary. As many as 30 others are seasonal migrants (Gerdes et al. 1974).

ARCHAEOLOGY AND THE MORRO BAY FISH-BONE SAMPLE

Overviews of archaeological research completed in the Morro Bay area are available from Bertrando (2006), T. Jones et al. (1994), Mikkelsen et al. (2000), and D. Jones et al. (2015). Several hundred prehistoric archaeological sites have been recorded in the vicinity of the bay, and no fewer than 49 of these have been subjected to more intensive investigation, including excavation and/or radiocarbon dating. Despite this seemingly lengthy and substantive research history, most of the archaeological investigations in the Morro Bay area have been limited to relatively small samples, often with inadequate chronological controls. Sites that have produced substantive fish-bone assemblages from temporally controlled contexts are far fewer. For the current study we rely on findings from nine sites, described below (Table 2).

In evaluating the assemblages from Morro Bay, it was imperative that methods of recovery and reporting were taken into consideration, since it has been

Table 2

MORRO BAY STUDY SITES

Trinomial	Excavation Volume (m.^{3})	Mesh (inch)	Temporal Components (Periods)	Adjacent Fish Habitat(s)[a]	Fish Bone Analyst	Reference
CA-SLO-14	21.49	1/8 dry, 1/16 wet	Middle	IV	Gobalet	Jones et al. (2015)
CA-SLO-23	92.39	1/8 dry, 1/16 wet	Early, Late	IV, V	Gobalet	Jones et al. (2015)
CA-SLO-165	72.90	1/4 dry, 1/8 dry, 1/8 wet, 1/16 wet	Millingstone/Lower Archaic, Early, Middle	I, II	Gobalet	Salls et al. 1989 Jones et al. (1994) Mikkelsen et al. (2000)
CA-SLO-215	5.00	1/8 dry	Millingstone/Lower Archaic	IV	Gobalet	Jones et al. (2004)
CA-SLO-457	27.70	1/8 dry, 1/16 wet	Middle-Late Transition	IV, V	Gobalet	Jones et al. (2015)
CA-SLO-458	19.56	1/8 dry, 1/16 wet	Early	IV, V	Gobalet	Jones et al. (2015)
CA-SLO-626	24.54	1/8 dry, 1/16 wet	Late	IV, V	Gobalet	Jones et al. (2015)
CA-SLO-812	11.28	1/8 dry, 1/16 wet	Millingstone/Lower Archaic, Early, Middle	IV	Gobalet	Jones et al. (2015)
CA-SLO-977	1.00	1/8 dry	Early	I, III	Gobalet	Dallas (1992) Gobalet and Jones (1995)
Total	**275.86**					

[a]Following Fierstine et al. (1973)

recognized for decades (e.g., Casteel 1972; Gobalet 2005; Thomas 1969; Zohar and Belmaker 2005) that different screen apertures and processing procedures (wet versus dry) can yield dramatically varied results. All of the samples recovered from these sites were obtained with the same two sets of field and laboratory methods: (1) dry-screening through 3 mm. (1/8-inch) mesh with initial sorting by technicians in the field; and (2) smaller column samples processed with water through 1/16-inch mesh in the laboratory.

With respect to quantifying the actual fish data, findings were summarized exclusively by number of identified specimens (NISP). For the purposes of the current paper, we defined "identified" as specimens assigned to at least a family, except for the taxon Pleuronectiformes. Specimens that could be classified only as Elasmobrachiomorphi (sharks, skates, rays) or Actinoptergii (ray-finned fishes) were excluded from our evaluation.

Also of key importance in the evaluation of faunal assemblages is inter-analyst variation. Gobalet (2001) showed that four highly experienced analysts identified and quantified the same set of fish remains differently. Therefore, for the current study, all of the fish-bone remains were identified by a single analyst, Gobalet. Findings from one of the first fish-bone studies from the area by Salls et al. (1989) were excluded from the current synthesis because the taxonomic categories used were simply too different from those of Gobalet. This is not meant to imply that Gobalet's identifications are necessarily more accurate, but quantified comparisons can only be completed when specimens have been assigned to the same or similar taxonomic categories.

A final important factor in successful identification is for analysts to have extensive skeletal reference collections at their disposal. All of the findings described here were identified using a reference collection formerly housed at the Department of Biology, California State University, Bakersfield, but recently donated to the California Academy of Sciences by Gobalet.

Based on these methodological criteria, the sample available from Morro Bay consists of 19,226 fish bones that have been identified to a meaningful taxon and recovered via 1/8-inch dry-screening, and an additional 718 bones recovered from nine column samples processed with water and 1/16-inch screen. The 1/8-inch remains represent 14 temporal components from nine sites, while the 1/16-inch remains were recovered from six sites and represent nine temporal components (Table 3).

The total volume excavated from the nine sites was 275.86 cubic meters. As described in more detail below, components were bracketed chronologically based on 82 radiocarbon dates (Table 4). For these, age estimations (corrected for isotopic fractionization) provided by the laboratories were calibrated using the Calib 7.1 calibration program with a Delta R value of 290+/–35, as proposed by Ingram and Southon (1996). Sites were ascribed to cultural periods following Jones et al. (2007):

Millingstone/Lower Archaic (10,000–5,500 cal B.P.)
Early (5,500–2,600 cal B.P.)
Middle (2,600–950 cal B.P.)
Middle/Late Transition (950–700 cal B.P.)
Late (700–200 cal B.P.)

CA-SLO-14

First recorded by Arnold Pilling in 1947, CA-SLO-14 is a dense estuarine shell midden with extensive disturbance. In 1989, Sawyer completed site monitoring for construction and also obtained the first radiocarbon determinations. Laurie and Pulcheon (2012) reported findings from a monitoring and data recovery investigation that included a 1 × 2 m. unit excavated to 120 cm. They obtained two additional radiocarbon dates, but few fish bones. Excavation by Far Western Anthropological Research Group for the Los Osos Wastewater Project in 2005 showed that the site ranges from 1–2 m. in depth and that it contains a full range of cultural materials, including estuarine and open-coast shellfish, flaked stone tools and debitage, ground stone, and mammal, bird, and fish bone (Jones et al. 2015). A sample of 21.49 $m.^3$ was excavated from the deposit in 2005, and additional radiocarbon dates were obtained, bringing the total number of available radiocarbon determinations to six (Table 4). While the radiocarbon determinations obtained by Sawyer indicate that the site was witness to some occupation during the Early Period, dates and diagnostic artifacts from the Los Osos Wastewater excavations indicate a single Middle Period component in the area investigated in 2005 dating to ca. 2,200–1,900 cal B.P. (Table 4). The fish-bone sample reported here was recovered from that component. This

Table 3

SUMMARY OF FISH BONE ASSEMBLAGES, MORRO BAY TEMPORAL COMPONENTS, 1/8-INCH SCREEN

	Temporal Component			Dominant Fish									
Trinomial	Period	Exca. Volume (m.^{3})	Fish NISP	Name	N	%	NISP Deer	NISP Rabbit	Fish/Deer +Rabbit	Fish NISP/m^3/ Component	No. Species	Margalef Index	Recip Berger-Parker Index
SLO-23	Late	10.50	3,907	Surfperches	1,626	41.6	46	158	19.15	372.0	36	4.354	2.403
SLO-626	Late	11.70	837	Surfperches	351	41.9	1	188	4.43	71.5	31	4.458	2.386
Subtotal/mean		22.20	4,744				47	346	12.07	213.6	42	4.844	2.403
SLO-457	Middle-Late Transition	5.20	7,041	Surfperches	4,161	59.1	4	47	138.10	1,354.0	37	4.063	1.694
SLO-14	Middle	21.40	2,294	Silversides	985	42.9	12	439	5.08	107.2	32	4.006	2.331
SLO-165	Middle	1.20	25	Surfperches	8	32.0	1	0	25.00	20.8	8	2.175	3.125
SLO-812	Middle	3.94	107	Silversides	25	23.4	4	37	2.53	27.2	14	4.812	4.291
Subtotal/mean		26.54	2,426				17	476	5.09	91.4	36	4.491	2.398
SLO-23	Early	27.56	2,916	Surfperches	1,259	43.2	13	82	32.94	113.5	41	5.014	2.320
SLO-165	Early	37.20	588	Surfperches	169	28.7	56	117	3.58	16.7	27	4.077	3.484
SLO-458	Early	9.30	31	Silversides	12	38.7	0	8	4.00	3.44	8	2.023	2.666
SLO-812	Early	2.40	142	Surfperches	51	35.9	16	35	3.17	67.5	12	2.222	2.785
SLO-977	Early	1.00	218	Pacific staghorn sculpin	55	25.2	–	–	0.00	226.0	16	3.136	3.968
Subtotal/mean		77.46	3,895				85	242	11.90	50.3	47	5.564	2.610
SLO-165	Millingstone/ Lower Archaic	3.50	404	Surfperches	197	25.4	2	5	9.57	4.9	16	3.568	2.053
SLO-215	Millingstone/ Lower Archaic	4.40	603	Surfperches	406	67.3	7	135	4.24	137.0	27	4.060	1.458
SLO-812	Millingstone/ Lower Archaic	4.80	113	Herrings	29	25.7	12	57	1.63	27.3	16	3.073	3.906
Subtotal/mean		12.70	1,120				21	197	5.13	88.2	29	3.988	2.506
Grand total		**144.10**	**19,226**										

site is situated in the backwaters of the bay adjacent to Fierstine et al.'s (1973) Zone IV.

CA-SLO-23

CA-SLO-23 was also first recorded in 1947 by Arnold Pilling, who identified it as a shell scatter in the community of Baywood Park measuring about 130 × 110 m. Since then, the site has been subject to multiple small testing projects, including work by Betrando (1996), Hampson and Breschini (1986), Sawyer (1986), and Parker (2003), among others. The testing projects produced four radiocarbon determinations but minimal fish bone. Field investigations for the Los Osos Wastewater Project were conducted by Far Western between 2003 and 2013. While preliminary efforts were limited to surface inspections and minor subsurface probing, substantive testing/data recovery excavations were completed in 2004, 2005, and 2013, and were focused on the densest shell midden deposit in the northern portion of the site, where three long trenches were excavated by hand. Total recovery volume from the deposit was 92.4 m.^{3}; however, the field strategy included a mixed recovery plan so that fish bones were not collected from all excavation units. Nine additional

Table 4

RADIOCARBON DATES FROM MORRO BAY STUDY SITES

Site	Lab No.	Unit	Depth (cm.)	Sample Composition	Conventional Radiocarbon	One Sigma Reservoir Correction 290 ± 35 (Cal B.P.)	Median Probability (Cal B.P.)	Reference
CA-SLO-14	Beta-342991	N0/E0	120–130	*Tresus nuttallii*	2,650 ± 30 BP	2,047–1,917	1,984	Jones et al. (2015)
CA-SLO-14	Beta-342992	N0/E0	170–180	*Macoma* spp.	2,660 ± 30 BP	2,059–1,927	1,996	Jones et al. (2015)
CA-SLO-14	Beta-327293	EU-1	20–30	*Tresus nuttallii*	2,660 ± 30 BP	2,059–1,927	1,996	Laurie and Pulcheon (2012)
CA-SLO-14	Beta-327294	EU-1	80–90	*Tresus nuttallii*	2,600 ± 30 BP	1,982–1,865	1,925	Laurie and Pulcheon (2012)
CA-SLO-14	WSU-4069	–	30–45	*Neverita lewisii*	4,050 ± 175 BP	3,917–3,464	3,706	Dills (1990)
CA-SLO-14	WSU-4070	–	30–45	*Neverita lewisii*	5,060 ± 160 BP	4846–4255	5,046	Dills (1990)
CA-SLO-23	Beta-202570	S4/E0, Feature 1	20–40	*Haliotis rufescens*	890 ± 90	334–101	229	Jones et al. (2015)
CA-SLO-23	Beta-202571	S4/E0	40–50	*Haliotis cracherodii*	1,060 ± 70	472–328	401	Jones et al. (2015)
CA-SLO-23	Beta-202572	S4/E0	60–70	*Tivela stultorum*	4,540 ± 70	4,449–4,233	4,351	Jones et al. (2015)
CA-SLO-23	Beta-202573	S4/E0	100–110	*Tivela stultorum*	4,750 ± 70	4,773–4,550	4,642	Jones et al. (2015)
CA-SLO-23	Beta-327757	N0/E12	40–50	*Neverita lewisii*	3,810 ± 30	3,457–3,349	3,407	Jones et al. (2015)
CA-SLO-23	Beta-327736	N0/E12	60–70	*Saxidomus nuttalli*	4,380 ± 30	4,217–4,068	4,135	Jones et al. (2015)
CA-SLO-23	Beta-327737	N0/E12	130–140	*Tresus nuttallii*	3,840 ± 30	3,492–3,373	3,439	Jones et al. (2015)
CA-SLO-23	Beta-327756	N0/E0	40–50	*Saxidomus nuttallii*	4,560 ± 30	4,442–4,297	4,383	Jones et al. (2015)
CA-SLO-23	Beta-327735	N0/E0	80–90	*Leukoma staminea*	3,840 ± 30	3,492–3,373	3,439	Jones et al. (2015)
CA-SLO-23	Beta-379946	N9.2/W6	10–20	*Ostrea lurida*	1,380 ± 80	718–563	654	Jones et al. (2015)
CA-SLO-23	Beta-379947	Feature 5	69	*Leukoma staminea*	940 ± 30	361–253	300	Jones et al. (2015)
CA-SLO-23	Beta-379948	Feature 6	169	*Saxidomus nuttalli*	4,410 ± 30	4,243–4,092	4,180	Jones et al. (2015)
CA-SLO-165	Beta-058185	CT-2	30–40	*Tresus nuttallii*	4,740 ± 80	4,735–4,523 4,771–474	4,628	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058186	CT-2	70–80	*Saxidomus nuttallii*	3,500 ± 70	3,133–2,913	3,018	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058187	CT-2	120–130	*Saxidomus nuttallii*	4,770 ± 90	4,798–4,551	4,660	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058188	CT-2	130–140	*Macoma* sp.	7,910 ± 90	8,171–7,972	8,083	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058189	CT-6	60–70	*Saxidomus nuttallii*	1,560 ± 70	895–737	815	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058190	CT-6	80–90	*Tresus nuttallii*	1,280 ± 80	640–516	580	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058191	CT-9	20–30	*Tivela stultorum*	5,260 ± 80	5,448–5,213	5,312	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058192	CT-9	60–70	*Saxidomus nuttallii*	4,810 ± 90	4,825–4,581	4,704	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058193	CT-9	100–110	*Saxidomus nuttallii*	4,970 ± 80	5,033–4,810	4,927	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058194	CT-10	180–190	*Saxidomus nuttallii*	4,700 ± 80	4,694–4,439	4,579	Mikkelsen et al. (2000)
CA-SLO-165	Beta-058195	CT-10	220–230	*Saxidomus nuttallii*	7,530 ± 90	7,799–7,607	7,710	Mikkelsen et al. (2000)
CA-SLO-165	Beta-096187	S41/E12	160–180	*Saxidomus nuttallii*	5,020 ± 80	5,079–4,840 5,111–5,098	4,991	Mikkelsen et al. (2000)
CA-SLO-165	Beta-100105	N2/E10	130–140	*Neverita lewisii*	4,970 ± 80	5,033–4,810	4,927	Mikkelsen et al. (2000)
CA-SLO-165	Beta-100106	N14/E9	90–100	*Saxidomus nuttallii*	5,450 ± 80	5,614–5,429	5,515	Mikkelsen et al. (2000)
CA-SLO-165	Beta-100107	N2/E1	160–170	*Tivela stultorum*	5440 ± 80	5,605–5,418	5,505	Mikkelsen et al. (2000)
CA-SLO-165	Beta-100108	S41/E12	220–230, Bur 4?	*Tivela stultorum*	5,350 ± 80	5,490–5,308	5,413	Mikkelsen et al. (2000) Mikkelsen et al. (2000)
CA-SLO-165	Beta-103840	N2/E9	60–70	*Tresus nuttalli*	1,800 ± 90	1,166–960	1,066	Mikkelsen et al. (2000)
CA-SLO-165	Beta-103841	N21/E8	50–60	*Balanus* sp.	5,410 ± 80	5,366–5,362 5,578–5,389	5,476	Mikkelsen et al. (2000)
CA-SLO-165	Beta-103842	S41/D12	100–110	*Saxidomus nuttallii*	5,010 ± 70	5,057–4,836	4,973	Mikkelsen et al. (2000)
CA-SLO-165	Beta-103843	S101/E5	40–50	*Neverita lewisii*	4,040 ± 70	3,794–3,585	3,683	Mikkelsen et al. (2000)
CA-SLO-165	Beta-103844	S35.5/W2	60–70	*Saxidomus nuttalli*	4,700 ± 80	4,694–4,439	4,579	Mikkelsen et al. (2000)

Table 4 *(Continued)*

RADIOCARBON DATES FROM MORRO BAY STUDY SITES

Site	Lab No.	Unit	Depth (cm.)	Sample Composition	Conventional Radiocarbon	One Sigma Reservoir Correction 290 ± 35 (Cal B.P.)	Median Probability (Cal B.P.)	Reference
CA-SLO-165	Beta-103845	N4/W8	40–50	*Tivela stultorum*	5,500 ± 70	5,643–4,745	5,570	Mikkelsen et al. (2000)
CA-SLO-165	Beta-103846	N2/E1	90–100	*Tivela stultorum*	5,480 ± 70	5,625–5,462	5,547	Mikkelsen et al. (2000)
CA-SLO-165	Beta-104334	S101/E5	110–120	*Leukoma staminea*	7,020 ± 90	7,358–7,163	7,257	
CA-SLO-165	Beta-104335	S36.5/W2	110–120	*Neverita lewisii*	5,060 ± 80	5,139–4,912 5,194–5,148	5,043	Mikkelsen et al. (2000)
CA-SLO-165	Beta-104336	CT-7	150–160	*Tivela stultorum*	5,490 ± 80	5,646–5,460	5,558	Mikkelsen et al. (2000)
CA-SLO-165	Beta-104337	CT-3	98	*Tivela stultorum*	5,480 ± 70	5,625–5,462	5,547	Mikkelsen et al. (2000)
CA-SLO-165	Beta-109160	CT-8	140–150	*Olivella* G6 bead	2,920 ± 50	2,215–2,209 2,402–2,240	2,316	Mikkelsen et al. (2000)
CA-SLO-165	Beta-109161	S41/E12	150–160, Feat. 3	*Olivella* G2 bead	2,710 ± 60	2,145–1,957	2,062	Mikkelsen et al. (2000)
CA-SLO-165	Beta-117079	N10/E9	90–110	Charcoal-Acorn Shell	1,170 ± 80	1,034–983 1,179–1,045	1,099	Mikkelsen et al. (2000)
CA-SLO-165	Beta-118009	S41/E12	150–160	Charcoal-Acorn Shell	3,240 ± 40	3,484–3,399 3,492–3,488 3,551–3,534	3,464	Mikkelsen et al. (2000)
CA-SLO-165	UCI-138	10W	150–160	*Tivela stultorum*	2,680 ± 130	2,191–1,857	2,028	Breschini et al. (1996)
CA-SLO-165	UCI-139	P1	20–40	*Tivela stultorum*	4,385 ± 75	4,260–4,008	4,144	Breschini et al. (1996)
CA-SLO-165	UCI-140	P1	60–80	*Tivela stultorum*	5,115 ± 75	5,255–5,010	5,112	Breschini et al. (1996)
CA-SLO-165	UCI-141	SB2		*Panopea generosa*	4,385 + 75	4,260–4,008	4,144	Breschini et al. (1996)
CA-SLO-165	UCI-142	10	130–140	*Tivela stultorum*	5,530 ± 80	5,703–5,507	5,605	Breschini et al. (1996)
CA-SLO-165	UCI-143	10	180–190	*Tivela stultorum*	1,790 ± 60	1,133–969	1,055	Breschini et al. (1996)
CA-SLO-165	WSU-4035	–	Surface	*Neverita lewissi*	5,340 ± 100	5,529–5,295	5,399	Breschini et al. (1996)
CA-SLO-215	Beta-130359	3	86–90	Shell-Marine	6,790 ± 80	7,140–6,880	6,750	Jones et al. (2004)
CA-SLO-215	Beta-130360	3	150–160	Shell-Marine	6,790 ± 60	7,090–6,900	6,995	Jones et al. (2004)
CA-SLO-215	UCR-83197	2	110–120	*Tresus nuttalli*	6,855 ± 50	7,170–6,990	7,080	Jones et al. (2004)
CA-SLO-215	UCR-83198	2	150–160	*Leukoma staminea*	7,405 ± 40	7,630–7,560	7,595	Jones et al. (2004)
CA-SLO-215	UCR-83191	3	10–20	*Saxidomus nuttalli*	1,630 ± 40	930–830	880	Jones et al. (2004)
CA-SLO-215	UCR-83192	3	30–40	*Neverita lewissi*	7,590 ± 40	7,800–7,680	7,740	Jones et al. (2004)
CA-SLO-215	UCR-83193	3	60–70	*Saxidomus nuttalli*	6,940 ± 40	7,240–7,150	7,195	Jones et al. (2004)
CA-SLO-215	UCR-83194	3	80–90	*Tresus nuttalli*	6,820 ± 45	7,140–6,950	7,045	Jones et al. (2004)
CA-SLO-215	UCR-83195	3 Feat. 1	90–100	*Tresus nuttalli*	7,005 ± 40	7,290–7,200	7,245	Jones et al. (2004)
CA-SLO-215	UCR-83196	3 Feat. 1	90–100	*Saxidomus nuttalli*	6,820 ± 50	7,150–6,950	7,050	Jones et al. (2004)
CA-SLO-215	UCR-83210	2	160–170	*Leukoma staminea*	6,825 ± 40	7,140–6,970	7,055	Jones et al. (2004)
CA-SLO-457	Beta-342993	N0/W2.5	20–30	*Tresus nuttallii*	1,570 ± 30	887–776	825	Jones et al. (2015)
CA-SLO-457	Beta-342994	N0/W2.5	60–70	*Ostrea lurida*	1,510 ± 30	811–698	763	Jones et al. (2015)
CA-SLO-457	Beta-342996	N2/E0	30–40	*Tresus nuttallii*	1,510 ± 30	811–698	763	Jones et al. (2015)
CA-SLO-457	Beta-342995	N2/E0	70–80	*Saxidomus nuttalli*	1,600 ± 30	905–799	851	Jones et al. (2015)
CA-SLO-458	Beta-202574	S2/E0	60–70	*Saxidomus nuttalli*	4,920 ± 70	4,978–4,771	4,858	Jones et al. (2015)
CA-SLO-458	Beta-202575	S0/E0	60–82	Saxidomus nuttalli	5,010 ± 40	5,021–4,864	4,956	Jones et al. (2015)
CA-SLO-458	Beta-379949	TU1	30–40	*Tresus nuttallii*	1,160 ± 30	524–459	492	Jones et al. (2015)
CA-SLO-626	Beta-327738	N16/E0	30–40	*Saxidomus nuttalli*	1,410 ± 30	714–639	676	Jones et al. (2015)
CA-SLO-626	Beta-327739	N18/E0	80–90	*Macoma* sp.	1,180 ± 30	536–471	506	Jones et al. (2015)
CA-SLO-626	Beta-327740	S6/E0	50–60	*Saxidomus nuttalli*	1,190 ± 30	543–476	513	Jones et al. (2015)

Table 4 *(Continued)*

RADIOCARBON DATES FROM MORRO BAY STUDY SITES

Site	Lab No.	Unit	Depth (cm.)	Sample Composition	Conventional Radiocarbon	One Sigma Reservoir Correction 290 ± 35 (Cal B.P.)	Median Probability (Cal B.P.)	Reference
CA-SLO-812	Beta-202576	NO/EO	30–40	*Clinocardium nuttallii*	2,560 ± 50	1,958–1,806	1,880	Jones et al. (2015)
CA-SLO-812	Beta-202577	NO/EO	50–60	*Haliotis rufescens*	2,850 ± 50	2,303–2,155	2,227	Jones et al. (2015)
CA-SLO-812	Beta-204808	NO/EO	80–90	*Saxidomus nuttalli*	4,370 ± 80	4,239–3,980	4,123	Jones et al. (2015)
CA-SLO-812	Beta-202578	NO/EO	100–110	*Leukoma staminea*	7,740 ± 110	8,021–7,780	7,908	Jones et al. (2015)
CA-SLO-812	Beta-202579	NO/EO	140–150	*Saxidomus nuttalli*	7,300 ± 60	7,559–7,442	7,503	Jones et al. (2015)

radiocarbon dates were obtained, bringing the total for the site to 13. The dates, and an extensive collection of temporally-significant beads and projectile points, show that the lower levels of the site are dominated by materials representing the Early Period, and that the upper levels harbor a Late Period component. The total number of fish bones recovered from the site as a whole was 31,075. Analytical samples drawn from that total are listed in Table 3. This site is situated adjacent to Fierstine et al.'s (1973) Zones IV and V.

CA-SLO-165

Prior to the recent work at CA-SLO-23, the most significant findings from the Morro Bay area were from CA-SLO-165, an extremely large, deep midden situated near the mouth of Morro Creek. The site has been investigated by a number of researchers over the years, including Gibson (1983), Jones et al. (1994), Singer and Atwood (1987), Carson and Farrell (2000), Gobalet (2001), and Bertrando (2004b), but Mikkelsen et al. (2000) produced the most important synthesis. An extensive suite of 38 radiocarbon dates shows a prolonged and complex history of site use beginning ca. 8,070 cal B.P. and extending to ca. 600 cal B.P., but the majority of the radiocarbon dates (n = 22) and associated residues date to the Early Period. Modest components indicate occupation during the Millingstone/Lower Archaic (6,500 – 3,500 B.C.), Middle, Middle-Late Transition, and Late periods, but the site is clearly dominated by Early Period materials. Radiocarbon dates suggest an occupational hiatus of over 1,500 years between the earliest site use ca. 6,070 – 5,700 B.P. during the Millingstone/Lower Achaic Period and the beginning of the most intensive site use at the onset of the Early Period ca. 3,600 B.P. We include fish-bone data from the Millingstone/Lower Archaic (excavation volume = 4.4 m.^{3}), Early (excavation volume = 37.2 m.^{3}), and Middle (1.20 m.^{3}) Period components. This is the only site in the current study situated adjacent to Fierstine et al.'s (1973) Zone II.

CA-SLO-215

CA-SLO-215 is an extensive shell midden occupying an area of approximately 27,280 m.^{2} within Morro Bay State Park. Initially recorded by Hoover and Fleming (1976), the site was more thoroughly documented by Woodward et al. (1986). It is marked by slightly darkened midden soil within the natural sedimentological context of a stabilized sand dune. The most abundant surface constituents were fragments of estuarine clam and cockle shells, with occasional pieces of Monterey chert debitage, and fire-altered rock. Excavation showed that the shell remains extended to a depth of 1.7 m. below surface. A total of 5 m.^{3} of deposit was excavated from the site by California State Parks archaeologists in 1999 and 2000. Eleven radiocarbon dates show that CA-SLO-215 is dominated by materials dating to the Millingstone/Lower Archaic Period, ca. 7,800 – 6,750 cal B.P. Minor occupation during the Middle-Late Transition is evident in the uppermost site levels, but the site appears to be marked primarily by a single temporal component dating to 7,800 – 6,750 cal B.P. This is the only site in the current study situated immediately adjacent to Fierstine et al.'s (1973) Zone V, the Chorro delta area. It was also situated in close proximity to Zone III

CA-SLO-457

CA-SLO-457 was first recorded in Los Osos by Dills (1969), who noted it simply as a concentration of shells. The site is now recognized as a dense, black estuarine shell midden with flaked stone debitage, formal tools, ground stone, mammal and bird bone, abundant shell remains, and fish bone. Excavation showed the site to be relatively shallow, extending only 60 to 90 cm. below the surface. Testing/data recovery excavations were undertaken at CA-SLO-457 by Far Western in 2005 for the Los Osos Wastewater Project when a series of hand-excavated units was completed for a total recovery volume of 27.70 m.^{3} The total number of fish bones recovered from this excavation was 37,645. However, a sampling strategy was employed for fish bone analysis, with bones identified from a recovery volume of 5.2 m.^{3} The total number of bones in the sample was 11,581, of which 4,393 could only be identified as Actinopterygii.[1] Four radiocarbon dates indicate that the excavation sample represents a single Middle-Late Period Transition component, ca. 1,000–700 cal B.P. This site is situated adjacent to Fierstine et al.'s (1973) Zones IV and V.

CA-SLO-458

Situated on a stabilized dunal ridge overlooking the southeast margins of the estuary in Baywood Park, CA-SLO-458 is a variable-density shell midden covering an estimated area of 300 × 300 m. The upper portion of the deposit consists of a dark, shell-rich midden that has been cut into and bisected by road construction, with further impacts from home construction and utilities. Far Western investigations were initiated in 2003, with subsurface excavations totaling 19.56 m.^{3} completed in 2004 and 2013. Three radiocarbon dates indicate two temporal components: an Early Period occupation represented in three near-contiguous backhoe trenches, and a second more recent component represented by a small sample of materials from a test unit placed on the west side of 10th Street near the crest of the hill. This more recent component contains intermingled materials dating to both the Middle-Late Transition and Late periods. By far the bulk of the excavation sample (17.56 m.^{3}) recovered from CA-SLO-458 was associated with the Early Period occupation. This site is situated adjacent to Fierstine et al.'s (1973) Zones IV and V.

CA-SLO-626

CA-SLO-626 was initially investigated in a series of modest testing projects in the 1980s (Gibson 1984a, 1984b; Singer 1985) that yielded neither fish remains nor radiocarbon determinations. Subsurface testing/data recovery was undertaken by Far Western in 2005, and additional data recovery was completed in 2013, for a total recovery volume of 24.54 m.^{3} Three radiocarbon dates were obtained from depths between 30 and 90 cm. The oldest date has a two sigma range of 850 to 650 cal B.P, which suggests the Middle-Late Transition Period, but the two other dates indicate the Late Period. Temporally diagnostic beads were dominated by Late Period types, particularly K1 (n=22), K3 (n=1), and clam disks (n=2), from a total of 35 specimens for the site as a whole. Together, the radiocarbon determinations and beads indicate that while the site was witness to some modest occupation during the Middle-Late Transition Period, it is dominated by a Late Period component dating ca. 750–500 cal B.P. As at SLO-457, a sampling strategy was employed at this site for fish bone analysis, so a recovery volume of 11.7 m.^{3} is associated with an NISP of 858 for the Late Period component. This site is situated adjacent to Fierstine et al.'s (1973) Zones IV and V.

CA-SLO-812

CA-SLO-812 is a deep estuarine shell midden in Los Osos, on the southern edge of the Morro Bay estuary. It covers an area of 220 × 100 m. and contains abundant estuarine and some open coast shellfish remains, shell beads, projectile points, bifaces, ground stone artifacts, and bird, mammal, reptile, and fish bones. The site was first tested by Gibson (1977), who identified two possible house floors. It was investigated by Far Western in 2004 for an early version of the wastewater project. Further data recovery was anticipated but project plans were eventually changed to avoid the site, and no further hand excavation was completed. The total recovery from the 2004 investigation was 11.38 m.^{3} Radiocarbon dates from the base of the deposit (100–180 cm.) mark a Millingstone/Lower Archaic component dating to ca. 8,000–7,500 cal B.P.; intermediate site levels (70–100 cm.) represent an Early Period component, ca. 4,300–3,900 cal B.P.; and that the uppermost levels (0–70 cm.) mark an early Middle Period occupation dating to 2,200–1,900 cal B.P. This site is situated adjacent to Fierstine et al.'s (1973) Zone IV.

CA-SLO-977

CA-SLO-977 is situated on the Morro Bay sandspit, and site inhabitants would have had ready access to both the

Morro Bay estuary and the open waters of Estero Bay. The site was subjected to a subsurface testing program by Dallas (1992). This unusual deposit yielded chunks of asphaltum and asphaltum-stained tools, along with shell and fish bone samples. Three radiocarbon dates place this site in the Early Period. Fish bones were analyzed from a recovery volume of 1 m.^{3} This site would have provided access to Fierstine et al.'s (1973) Zones I and III.

RESULTS AND DISCUSSION

Fishes from the 14 archaeological components represent all habitats within the bay and cover the period between 8,000 and 300 cal B.P. The only under-represented time period is that of the last two centuries of prehistory and the immediate post-contact era (ca. 400–200 cal B.P.); none of the investigated archaeological sites can be linked with an ethnographic village name. Two sites in the area that yielded dates and/or assemblages consistent with the centuries before and after contact—CA-SLO-216 (Hoover and Sawyer 1977) and CA-SLO-1800/H (Price et al. 1997)—did not produce abundant fish remains. The total recovery volume represented by the primary 1/8-inch-mesh fish-bone sample for the nine sites evaluated is 144.1 m.^{3}, containing a NISP of 19,226 from temporally controlled contexts (Tables 5 and 6). The 1/16-inch wet-screen sample includes 718 bones from 0.054 m.^{3} (Table 7). For these components, we have summarized the relative proportions of species, density of fish bones within the deposits (NISP/m.^{3}), and diversity of the fish-bone assemblages (Margalef and Berger-Parker diversity indices). Also, the combined numbers of the two primary terrestrial species (deer and rabbits) were compared with fish bones as potential indices of the relative importance of fish versus terrestrial game (see Table 3).

Historical Ecology

In general, the archaeological fish remains exhibit considerable overlap with those recorded in the 1973 survey of Morro Bay by Fierstine et al. (1973; Table 1). Among the sharks and rays, the round stingray is the most noteworthy species missing from the archaeological remains, and it has not been definitively identified at any archaeological site north of San Diego County (Gobalet et al. 2004), but their spines might be confused with those from bat rays.

Numerous other species missing from the archaeological remains are generally tiny (<7.5 cm. total length), or small (<30 cm. total length), have very delicate skeletons that do not preserve, or have a combination of these traits. The diminutive fishes listed in Table 1 (found by Fierstine et al. in Morro Bay in 1973) include California killifish, threespine stickleback, pipefishes, several sculpins, northern clingfish, kelp clingfish, gunnels, several gobies, and Pacific pompano. To our knowledge, several of these have never been reported in the remains from any California archaeological site (California killifish, kelp clingfish, arrow goby, tidewater goby, or bay goby) or only at a single locality (Pacific pompano at CA-SBA-3806, and pipefish from CA-MRN-327; Gobalet, unpublished data).

Our ability to identify only four genera of pleuronectiforms, where Fierstine et al. (1973) identified seven genera with nine species, is not surprising because these fishes are typically listed only as Pleuronectiformes in archaeological reports (e.g., Gobalet et al. 2004). Noteworthy here as well is the modest representation of rockfishes (*Sebastes* spp.), with fewer than 2% of the remains. Lacking any blind testing, we are not confident that species of *Sebastes* can be discriminated on the basis of individual bones or otoliths (see Gobalet et al. 2004; Love 2011; Turnbull et al. 2015:362). As a consequence, we cannot state whether the *Sebastes* identified by Gobalet were taken from outside the bay or from the Morro Bay estuary. Rockfishes are perhaps the "signature" large fishes of the central coast (Gobalet 2000; Gobalet et al. 2004) and are quite abundant at well-studied sites like CA-SLO-2 (Fitch 1972; Jones et al. 2008) on the Pecho Coast. There were no steelhead remains in our samples.

Certain aspects of the archaeological collections suggest that the Native American fishery in general was a selective one. Foremost are the abundant herrings (Pacific sardine and/or Pacific herring) and New World silversides (topsmelt, jacksmelt, and/or California grunion) in the archaeological sample. With the exception of the California grunion, these fishes were caught by Fierstine et al. (1973) but in surprisingly small numbers. Collectively, the herrings and New World silversides constitute 31.2% of the archaeological sample. Additionally, Fierstine et al. (1973) caught 11 species of surfperches in Morro Bay representing 37% of their entire take, with shiner perch and black perch

Table 5

FISH REMAINS FROM MORRO BAY COMPONENTS, MILLINGSTONE/LOWER ARCHAIC AND EARLY PERIODS

		Millingstone/Lower Archaic					Early								
Taxon	**Common Name**	**SLO-165**	**SLO-215**	**SLO-812**	**Total**	**%**	**SLO-23**	**SLO-165**	**SLO-458**	**SLO-812**	**SLO-977**	**Total**	**%**	**Total**	**%**
Elasmobranchiomorphi	**Sharks, skates, and rays**														
Heterodontus francisci	Horn shark	0	0	0	0	0.00	1	1	1	0	0	3	0.08	3	0.06
Isurus oxyrinchus	Shortfin mako	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Triakidae	Requiem sharks	45	12	9	66	5.89	114	146	0	9	18	287	7.37	353	6.99
Squatina californica	Pacific angel shark	0	2	0	2	0.18	9	1	0	2	4	16	0.41	18	0.36
Rhinobatos productus	Shovelnose guitarfish	0	1	3	4	0.36	30	34	0	4	27	95	2.44	99	1.97
Rajidae	Skates	0	0	0	0	0.00	2	3	0	0	5	10	0.26	10	0.19
Platyrhinoidis triseriata	Thornback	0	1	2	3	0.27	23	1	0	0	9	33	0.85	36	0.72
Myliobatis californica	Bat ray	50	30	16	96	8.57	46	129	0	18	11	204	5.24	300	5.98
Subtotal		95	46	30	171	15.27	225	315	1	33	74	648	16.64	819	16.33
Actinopterygii	**Ray-finned fishes**														
Engraulis mordax	Northern anchovy	1	0	0	1	0.09	0	4	0	0	0	4	0.10	5	0.09
Clupeidae	Herrings	80	8	29	117	10.45	514	19	2	15	4	554	14.22	671	13.38
Clupea pallasii	Pacific herring	0	0	1	1	0.09	3	0	0	0	0	3	0.08	4	0.08
Sardinops sagax	Pacific sardine	0	2	1	3	0.27	3	2	2	0	0	7	0.18	10	0.19
Merluccius productus	Pacific hake	0	0	0	0	0.00	3	15	0	0	15	33	0.85	33	0.66
Microgadus proximus	Pacific tomcod	0	0	0	0	0.00	0	1	0	0	0	1	0.03	1	0.02
Porichthys notatus	Plainfin midshipman	0	5	0	5	0.45	0	8	0	0	1	9	0.23	14	0.28
Porichthys sp.	Midshipman	0	0	0	0	0.00	2	0	0	0	0	2	0.05	2	0.04
Atherinopsidae (Atherinidae)	New World silversides	197	32	22	251	22.41	429	17	12	34	36	528	13.56	779	15.53
Atherinops affinis	Topsmelt	0	0	0	0	0.00	1	3	0	0	0	4	0.10	4	0.08
Atherinopsis californiensis	Jacksmelt	0	0	0	0	0.00	5	0	0	0	25	30	0.77	30	0.59
Leuresthes tenuis	California grunion	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Sebastes spp.	Rockfishes	5	8	1	14	1.25	179	5	3	2	1	190	4.88	204	4.07
Hexagrammos sp.	Greenlings	0	1	0	1	0.09	0	1	0	1	0	2	0.05	3	0.06
Ophiodon elongatus	Lingcod	2	5	0	7	0.62	15	8	0	0	0	23	0.59	30	0.59
Cottidae	Sculpin family	0	1	0	1	0.09	0	3	1	0	0	4	0.10	5	0.09
Clinocottus analis	Mosshead sculpin	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Icelinus sp.		0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Leptocottus armatus	Pacific staghorn sculpin	1	3	1	5	0.45	42	1	0	1	55	99	2.54	104	2.07
Scorpaenichthys marmoratus	Cabezon	6	25	1	32	2.86	43	6	0	2	1	52	1.34	84	1.67
Trachurus symmetricus	Jack Mackerel	0	0	0	0	0.00	2	0	0	0	0	2	0.05	2	0.04
Sciaenidae	Drums and croakers	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Embiotocidae	Surfperches	17	406	24	447	39.91	1,259	169	9	51	4	1,492	38.31	1,939	38.66
Amphisticus rhodterus	Redtail surfperch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Amphistichus spp.		0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Cymatogaster aggregata	Shiner perch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Damalichthys vacca	Pile perch	0	30	1	31	2.77	38	0	0	0	2	40	0.10	71	1.42
Embiotoca jacksoni	Black perch	0	0	0	0	0.00	8	0	0	0	0	8	0.21	8	0.16
E. lateralis	Striped seaperch	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Embiotoca sp.	Black or striped seaperch	0	1	0	1	0.09	16	3	0	0	0	19	0.49	20	0.39
Hyperprosopon argenteum	Walleye surfperch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00

Table 5 *(Continued)*

FISH REMAINS FROM MORRO BAY COMPONENTS, MILLINGSTONE/LOWER ARCHAIC AND EARLY PERIODS

		Millingstone/Lower Archaic					Early								
Taxon	Common Name	SLO-165	SLO-215	SLO-812	Total	%	SLO-23	SLO-165	SLO-458	SLO-812	SLO-977	Total	%	Total	%
Micrometrus minimus	Dwarf perch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Phanerodon furcatus	White seaperch	0	1	0	1	0.09	1	0	0	0	0	1	0.03	2	0.04
Rhacochilus toxotes	Rubberlip seaperch	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Oxyjulis californica	Señorita	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Stichaeidae	Pricklebacks	0	2	1	3	0.27	6	0	0	0	0	6	0.15	9	0.18
Cebidichthys violaceus	Monkeyface prickleback	0	1	0	1	0.09	4	3	0	0	0	7	0.18	8	0.16
Xiphister spp.	Rock or black prickleback	0	0	0	0	0.00	1	3	0	0	0	4	0.10	4	0.08
Clinidae	Kelp blennies	0	4	0	4	0.36	15	0	0	0	0	15	0.39	19	0.38
Gibbonsia sp.	Kelp fish	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Heterostichus rostratus	Giant kelpfish	0	13	1	14	1.25	75	0	1	3	0	79	2.03	93	1.85
Gobiidae	Gobies	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Gillichthys mirabilis	Longjaw mudsucker	0	1	0	1	0.09	1	0	0	0	0	1	0.03	2	0.04
Sphyraena argentea	Pacific barracuda	0	1	0	1	0.09	0	0	0	0	0	0	0.00	1	0.02
Scomber japonicus	Pacific chub mackerel	0	0	0	0	0.00	4	0	0	0	0	4	0.10	4	0.08
Pleuronectiformes	Righteye and lefteye flounders	0	5	0	5	0.45	13	1	0	0	0	14	0.36	19	0.38
Citharichthys sp.	Sanddabs	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Paralichthys californicus	California halibut	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Eopsetta jordani	Petrale sole	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Parophrys vetulus (*Pleuronectes vetulus*)	English sole	0	0	0	0	0.00	1	0	0	0	0	1	0.03	1	0.02
Platichthys stellatus	Starry flounder	0	2	0	2	0.18	2	1	0	0	0	3	0.08	5	0.09
Subtotal		309	557	83	949	84.76	2,691	273	30	109	144	3,247	82.49	4,196	83.60
Grand total		**404**	**603**	**113**	**1,120**	**100.03**	**2,916**	**588**	**31**	**142**	**218**	**3,895**	**99.13**	**5,015**	**99.93**

representing about 60% of all the surfperches. The abundance of surfperches in the archaeological record (42.7%) exceeds that illustrated by Fierstine et al. (1973), and also may reflect a targeted fishery. Shiner perch reach 20 cm. in total length, and black perch reach 39 cm. (Love 2011). The shiner perch remains are small and probably overlooked because the vertebrae of all embiotocids are extremely difficult to differentiate and are usually identified only to the family Embiotocidae (Gobalet et al. 2004). We attributed four tiny lower pharygeals to shiner perch, and untold numbers of vertebrae could have been from them as well. We attributed nearly 300 elements to *Embiotoca*, the genus of striped seaperch and black perch, the most abundant surfperch found by Fierstine et al. (1973). This is compelling evidence that, in general, *Embiotoca* were the native-fishery targeted species within Morro Bay from its mouth to its southern end prior to historic modification. Other species that further indicate an overall emphasis on fish within the estuary include the longjaw mudsucker recovered from three of the Los Osos sites. Longjaw mudsuckers could have been taken from the Los Osos Creek estuary, the only region where Fierstine et al. (1973:Zone V) recorded them. The abundant Pacific staghorn sculpins (representing about 1% of the archaeological sample) and shiner perch are tolerant of fresh water and would thrive in euryhaline conditions (Moyle 2002:362, 428) like those present in the delta of Los Osos Creek. We consider this convincing evidence that this calm backwater of the Morro Bay estuary was extensively netted for fishes. A previous study by Bertrando and McKenzie (2011) concluded the same thing for the late Holocene, based on metric studies of surfperch vertebrae.

Because of the apparent selectivity of the local prehistoric fishers, one would not expect a precise equivalency between the archaeological remains and historic surveys. Still, there is a noticeable discrepancy between the abundance of northern anchovies within the bay in 1973 and the low numbers in the archaeological samples (NISP=9, 0.05% from 1/8-inch mesh; NISP=17, 2.36% from 1/16-inch mesh). Either the local fishers were not harvesting large numbers of anchovies, or the emphasis on 1/8-inch mesh recovery has led to an under-representation of smaller individual fishes like anchovies. With respect to the latter, the low percentage of anchovies in the 1/16-inch sample still falls far short of the frequency of anchovies observed by Fierstine et al. in 1973, suggesting that the dearth of anchovy bones may not be a mere artifact of the recovery method, but could instead reflect an actual absence or low frequency of the anchovies within the bay prehistorically. Such an absence is not an insignificant issue because fisheries biologists have recognized that the western Pacific in historical times experienced large-scale fluctuations between anchovies and sardines, attributed to trends in ocean temperatures, with anchovies dominant during cooler periods and sardines dominant during warmer periods (Chavez et al. 2003). Historic catch records from Morro Bay (which reflect the offshore fishery) show this fluctuation dramatically (California Department of Fish and Game 1976, 2010), and it has been recognized archaeologically in southern California, with fluctuations between the two species dating back 1,850 years (Love 2011:91). The absence of anchovy remains from Morro Bay, between 8,000 and 300 cal B.P., is an intriguing pattern that needs to be further studied.

Some species represented among the archaeological remains suggest that the Native American fishery extended beyond the sandspit to Estero Bay; these include mako shark, Pacific hake, California grunion, greenling, several sculpins, some surfperches, Pacific barracuda, rock or black prickleback, Pacific chub mackerel, and petrale sole.

Spatial and Diachronic Patterns

A few patterns in the archaeological remains speak to modest variations related to the proximity of sites to habitat zones. CA-SLO-977, the only site situated on the Morro sand spit, produced the only assemblage dominated by Pacific staghorn sculpin, a fish that frequents estuarine mudflats (Love 2011:218). This was also the only deposit to yield substantial numbers of jacksmelt (n=25; 11.5%), a schooling pelagic fish that is found near shore in all types of settings, including estuaries (Love 2011:138). Importantly, CA-SLO-977, situated adjacent to both the open coast and the estuary, shows no clear evidence for exploitation of the former, which supports the notion of a general emphasis on estuarine fisheries. Waters adjacent to the sand spit within the bay seem to have provided habitat especially well-suited to Pacific staghorn sculpin and jacksmelt. Other findings show uniformity across habitat zones. In particular, Early Period components from CA-SLO-165 at the mouth of the bay (Zone II), and CA-SLO-812 at the back of the bay (Zones IV and V), are both heavily dominated by surfperches, as is the Millingstone/Lower Archaic component at CA-SLO-215. Such uniformity may be at least partially the result of people employing watercraft to routinely access habitats beyond those immediately adjacent to settlements.

Diachronic patterns are potentially more salient, although when evaluated over time, archaeological remains mostly conform to the synchronic observations above—with some variation. Three families/species dominate the record of both the 1/8-inch and 1/16-inch samples throughout the sequence: surfperches, herrings, and New World silversides. Surfperches include species that can be taken either with nets or (large individuals) with hooks/gorges. Herrings (including sardines) and silversides are small schooling fishes that are much more commonly taken with nets, the former often with the aid of watercraft and the latter from shore (Boone 2012; Gause 2002; Love 2011; Salls 1988). The dominance of silversides and surfperches throughout the record (nearly 50%) suggests that fishing was almost certainly undertaken with nets from the very beginning of the sequence, and that it continued throughout the Holocene. Likewise, Rick and Erlandson (2000) argued for early net use along the Santa Barbara mainland. The emphasis on nets at Morro Bay is supported by an artifact record

Table 6

FISH REMAINS(NISP) FROM DRY-SCREENED COMPONENTS, MIDDLE, MIDDLE-LATE TRANSITION, AND LATE PERIODS

		Middle Period					Middle-Late		Late			
Taxon	**Common Name**	**SLO-14**	**SLO-165**	**SLO-812**	**Total**	**%**	**SLO-457**	**%**	**SLO-23**	**SLO-626**	**Total**	**%**
Elasmobranchiomorphi	**Sharks, skates, and rays**											
Heterodontus francisci	Horn shark	4	0	0	4	0.16	27	0.38	6	1	7	0.18
Isurus oxyrinchus	Shortfin mako	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Triakidae	Requiem sharks	88	0	8	96	3.96	266	3.78	98	4	102	2.15
Squatina californica	Pacific angel shark	9	0	1	10	0.41	34	0.48	7	0	7	0.15
Rhinobatos productus	Shovelnose guitarfish	15	0	5	20	0.82	59	0.84	20	0	20	0.42
Rajidae	Skates	29	0	0	29	1.19	24	0.34	5	0	5	0.11
Platyrhinoidis triseriata	Thornback	0	0	2	2	0.08	34	0.48	29	5	34	0.72
Myliobatis californica	Bat ray	4	1	20	25	1.03	27	0.38	27	7	34	0.72
Subtotal		150	1	36	187	7.71	471	6.68	192	17	209	4.41
Actinopterygii	**Ray-finned fishes**											
Engraulis mordax	Northern anchovy	0	4	0	4	0.16	0	0.00	0	0	0	0.00
Clupeidae	Herrings	474	5	5	484	19.95	384	5.45	855	33	888	18.72
Clupea pallasii	Pacific herring	0	0	0	0	0.00	4	0.06	6	0	6	0.13
Sardinops sagax	Pacific sardine	63	0	0	63	2.59	24	0.34	19	3	22	0.46
Merluccius productus	Pacific hake	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Microgadus proximus	Pacific tomcod	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Porichthys notatus	Plainfin midshipman	0	1	0	1	0.04	0	0.00	2	2	4	0.08
Porichthys sp.	Midshipman	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Atherinopsidae	New World silversides	985	4	25	1,014	41.79	1,296	18.41	309	244	553	11.65
Atherinops affinis	Topsmelt	2	0	0	2	0.08	4	0.06	0	0	0	0.00
Atherinopsis californiensis	Jacksmelt	0	0	0	0	0.00	1	0.01	0	0	0	0.00
Leuresthes tenuis	California grunion	0	0	0	0	0.00	1	0.01	1	0	1	0.02
Sebastes spp.	Rockfishes	63	0	6	69	2.84	44	0.62	388	38	426	8.98
Hexagrammos sp.	Greenlings	25	0	0	25	1.03	1	0.01	7	1	8	0.17
Ophiodon elongatus	Lingcod	13	0	2	15	0.62	0	0.00	3	2	5	0.11
Cottidae	Sculpin family	0	1	0	1	0.04	3	0.04	3	1	4	0.08
Clinocottus analis	Mosshead sculpin	2	0	0	2	0.08	0	0.00	0	0	0	0.00
Icelinus sp.		0	0	0	0	0.00	0	0.00	0	0	0	0.00
Leptocottus armatus	Pacific staghorn sculpin	9	1	0	10	0.41	38	0.54	39	12	51	1.08
Scorpaenichthys marmoratus	Cabezon	88	0	4	92	3.79	18	0.26	56	7	63	1.33
Trachurus symmetricus	Jack mackerel	0	0	0	0	0.00	2	0.03	2	0	2	0.04
Sciaenidae	Drums and croakers	0	0	0	0	0.00	0	0.00	0	1	1	0.02
Embiotocidae	Surfperches	354	8	24	386	15.91	4,161	59.10	1,626	351	1,977	41.67
Amphisticus rhoderatus	Redtail surfperch	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Amphistichus spp.		0	0	0	0	0.00	0	0.00	0	0	0	0.00
Cymatogaster aggregata	Shiner perch	0	0	0	0	0.00	2	0.03	0	1	1	0.02
Damalichthys vacca (*Rhicochilus vacca*)	Pile perch	10	0	1	11	0.45	174	2.47	90	4	94	1.98
Embiotoca jacksoni	Black perch	1	0	0	1	0.04	14	0.19	12	2	14	0.29
E. lateralis	Striped seaperch	2	0	0	2	0.08	3	0.04	5	2	7	0.15
Embiotoca sp.	Black or striped surfpurch	4	0	0	4	0.16	163	2.32	47	5	52	1.09
Hyperprosopon argenteum	Walleye surfperch	0	0	0	0	0.00	2	0.03	1	0	1	0.02
Micrometrus minimus	Dwarf perch	0	0	0	0	0.00	2	0.03	0	1	1	0.02
Phanerodon furcatus	White seaperch	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Rhacochilus toxotes	Rubberlip seaperch	0	0	0	0	0.00	3	0.04	0	0	0	0.00
Oxyjulis californica	Señorita	0	0	0	0	0.00	0	0.00	3	1	4	0.08
Stichaeidae	Pricklebacks	2	0	1	3	0.12	0	0.00	5	1	6	0.13
Cebidichthys violaceus	Monkeyface prickleback	13	0	0	13	0.54	2	0.03	2	0	2	0.04
Xiphister spp.	Rock or kelp pricklebak	10	0	0	10	0.41	6	0.09	1	1	2	0.04

Total	%	Total from Table 5	Grand Total	%
38	0.27	3	41	0.21
1	0.01	0	1	0.01
464	3.27	353	817	4.25
51	0.35	18	69	0.36
99	0.69	99	198	1.03
58	0.41	10	68	0.35
70	0.49	36	106	0.55
86	0.61	300	386	2.01
867	6.10	819	1,686	8.77
4	0.03	5	9	0.05
1,756	12.36	671	2,427	12.62
10	0.07	4	14	0.07
109	0.77	10	119	0.62
0	0.00	33	33	0.17
0	0.00	1	1	0.01
5	0.04	14	19	0.09
0	0.00	2	2	0.01
2,863	20.15	779	3,642	18.94
6	0.04	4	10	0.05
1	0.01	30	31	0.16
2	0.01	1	3	0.02
539	3.79	204	743	3.86
34	0.24	3	37	0.19
20	0.14	30	50	0.26
8	0.06	5	13	0.07
2	0.01	0	2	0.01
0	0.00	1	1	0.01
99	0.69	104	203	1.06
173	1.22	84	257	1.34
4	0.03	2	6	0.03
1	0.01	0	1	0.01
6,524	45.91	1,939	8,463	44.01
1	0.01	0	1	0.01
0	0.00	0	0	0
3	0.02	0	3	0.02
279	1.96	71	350	1.82
29	0.20	8	37	0.19
12	0.08	1	13	0.07
219	1.54	20	239	1.24
3	0.02	0	3	0.02
3	0.02	0	3	0.02
0	0.00	2	2	0.01
3	0.02	1	4	0.02
4	0.03	1	5	0.03
9	0.06	9	18	0.09
17	0.12	8	25	0.13
18	0.13	4	22	0.11

that has produced very few hooks or gorges. Strudwick's (1986) recognition that curved shell hooks were best suited for and most commonly used along open coasts is worth noting here as well.

The importance of sharks, skates, and rays, relative to ray-finned fishes, shows a distinctive trans-Holocene trend, with elasmobranchiomorphs decreasing relative to ray-finned fishes after the Early Period (post 2,600 cal B.P.). However, this decline is driven primarily by bat rays, which decrease linearly through the Holocene, representing 8.6% of the sample in the Millingstone/Lower Archaic Period and less than 1% in the Late Period. There are multiple potential explanations for this trend, including seasonality (bat rays are strictly summer migrants to near shore waters [Love 2011:76]), changing habitat over time, and/or resource depression. With respect to the latter, Broughton et al. (2015) recently speculated that bat rays were among the highest ranked piscine resources in the San Francisco Bay area, which could have made them susceptible to overexploitation. Habitat change is a far less likely explanation, as bat rays have no clear habitat preference. Love (2011:76) states that you will find them "in a wide variety of habitats from intertidal mudflats in estuaries to open surf to kelp beds." While a definitive explanation for the decline in the bat rays remains elusive, we currently favor a change in seasonality since other indicators from sites in the Los Osos area suggest that, over the course of the Holocene, an emphasis on summer fishing gave way to greater emphasis on other seasons (Jones et al. 2015) when bat rays were less abundant. However, overexploitation and resource depression remain viable possibilities as well.

Both the 1/8-inch and 1/16-inch residues show the same diachronic patterning in NISP/m.^{3}—with relatively little change during the Millingstone/Lower Archaic through Middle periods, and a significant increase during the Middle-Late Transition Period, followed by a major decline during the Late Period (Figs. 2 and 3). The ratios of fish to deer plus rabbits show the same pattern (Fig. 4). In general, variation

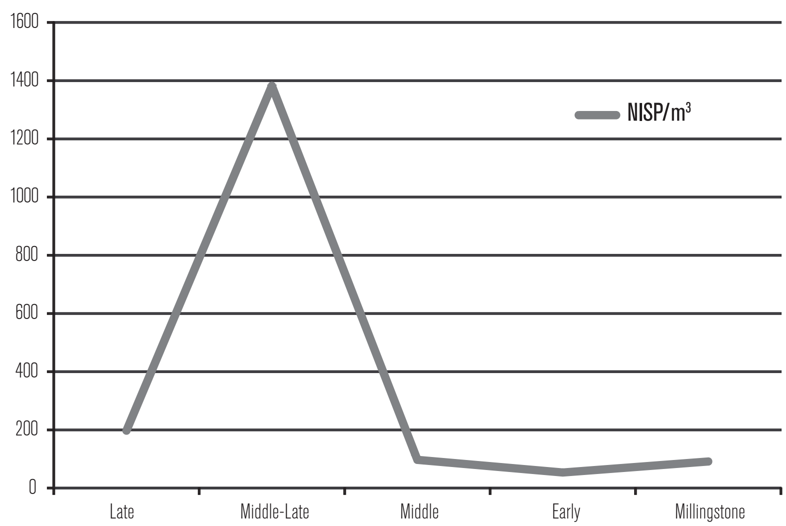

Figure 2. Fish NISP/m^3 1/8-inch Mesh, Morro Bay Archaeological Sites through Time.

Table 6 *(Continued)*

FISH REMAINS(NISP) FROM DRY-SCREENED COMPONENTS, MIDDLE, MIDDLE-LATE TRANSITION, AND LATE PERIODS

		Middle Period					Middle-Late		Late			
Taxon	Common Name	SLO-14	SLO-165	SLO-812	Total	%	SLO-457	%	SLO-23	SLO-626	Total	%
Clinidae	Kelp blennies	0	0	0	0	0.00	0	0.00	52	3	55	1.16
Gibbonsia sp.	Kelpfish	1	0	0	1	0.04	0	0.00	0	1	1	0.02
Heterostichus rostratus	Giant kelpfish	6	0	3	9	0.37	172	2.44	155	99	254	5.35
Gobiidae	Gobies	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Gillichthys mirabilis	Longjaw mudsucker	2	0	0	2	0.08	14	0.19	5	1	6	0.13
Sphyraena argentea	Pacific barracuda	0	0	0	0	0.00	1	0.01	0	0	0	0.00
Scomber japonicus	Pacific chub mackerel	3	0	0	3	0.12	1	0.01	7	0	7	0.15
Pleuronectiformes	Righteye and lefteye flounders	5	0	0	5	0.21	8	0.11	12	2	14	0.29
Citharichthys sp.	Sanddabs	0	0	0	0	0.00	0	0.00	0	1	1	0.02
Paralichthys californicus	California halibut	0	0	0	0	0.00	0	0.00	1	0	1	0.02
Eopsetta jordani	Petrale sole	0	0	0	0	0.00	0	0.00	1	0	1	0.02
Parophrys vetulus (*Pleuronectes vetulus*)	English sole	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Platichthys stellatus	Starry flounder	5	0	0	5	0.21	22	0.31	0	0	0	0.00
Subtotal		2,144	24	71	2,239	92.24	6,570	93.28	3,715	820	4,535	95.56
Grand total		**2,294**	**25**	**107**	**2,426**	**99.95**	**7,041**	**99.96**	**3,907**	**837**	**4,744**	**99.97**

Table 7

FISH REMAINS FROM 1/16TH INCH MESH, COLUMN SAMPLES, MORRO BAY

		Millingstone		Early					Middle			
Taxon	Common Name	SLO-812	%	SLO-812	SLO-23	SLO-458	Total	%	SLO-812	SLO-14	Total	%
Elasmobranchiomorphi	**Sharks, skates, and rays**											
Myliobatis californica	Bat ray	3	7.50	2	0	0	2	1.24	3	0	3	2.38
Platyrhinoidis triseriata	Thornback	0	0	0	1	0	1	0.62	0	0	0	0
Rhinobatos productus	Shovelnose guitarfish	0	0	0	0	0	0	0	0	1	1	0.79
Triakidae	Houndshark	0	0	0	0	0	0	0	0	0	0	0
Actinopterygii	**Ray-finned Fishes**											
Engraulis mordax	Northern Anchovy	1	2.50	5	0	8	13	8.07	0	0	0	0.00
Clupeidae	Herring and sardine family	8	20.00	7	4	13	24	14.90	5	2	7	5.56
Clupea pallasii	Pacific herring	0	0	0	0	0	0	0	0	2	2	1.59
Sardinops sagax	California pilchard	0	0	0	0	1	1	0.62	3	0	3	2.38
Atherinopsidae	New World silversides	17	42.50	20	40	15	75	46.59	57	29	86	68.25
Leptocottus armatus	Pacific staghorn sculpin	4	10.00	11	6	1	18	11.18	0	0	0	0.00
Scorpaenichthys marmoratus	Cabezon	0	0	0	0	0	0	0	0	0	0	0
Embiotocidae	Surfperch family	5	12.50	11	5	6	22	13.66	10	4	14	11.11
Damalichthys vacca	Pile perch	2	5.00	2	3	0	5	3.11	3	0	3	2.38
Heterostichus rostratus	Giant kelpfish	0	0	0	0	0	0	0	2	0	2	1.59
Pleuronectiformes	Flatfishes	0	0	0	0	0	0	0	0	0	0	0
		40	100.00	58	59	44	161	99.99	83	38	121	96.03
Recovery volume (m^3)		0.010		0.010	0.004	0.004	0.018		0.010	0.004	0.014	
NISP/m^3		4,000		5,800	14,750	11,000	8,944		8,700	9,750	9,000	

	Total	%	Total from Table 5	Grand Total	%
	55	0.39	19	74	0.38
	2	0.01	0	2	0.01
	435	3.06	93	528	2.75
	1	0.01	0	1	0.01
	22	0.15	2	24	0.12
	1	0.01	1	2	0.01
	11	0.08	4	15	0.08
	27	0.19	19	46	0.24
	1	0.01	0	1	0.01
	1	0.01	0	1	0.01
	1	0.01	1	2	0.01
	0	0.00	1	1	0.01
	27	0.19	5	32	0.17
	13,344	93.91	4,196	17,540	91.25
	14,211	**100.01**	**5,015**	**19,226**	**100.02**

	Middle-Late		Late					
	SLO-457	%	SLO-23	SLO-626	Total	%	Grand Total	%
	1	0.45	0	0	0	0	9	1.25
	0	0	0	0	0	0	1	0.14
	0	0	0	0	0	0	1	0.14
	9	4.07	2	0	2	1.17	11	1.53
	0	0	0	3	3	1.76	17	2.36
	17	7.69	34	4	38	22.35	94	13.09
	0	0	0	0	0	0	2	0.28
	0	0	0	0	0	0	4	0.56
	135	61.09	53	17	70	41.18	383	53.34
	2	0.90	6	1	7	4.12	31	4.32
	0	0	1	0	1	0.59	1	0.14
	54	24.43	33	12	45	26.47	140	19.49
	2	0.9	0	1	1	0.59	13	1.81
	0	0	0	1	1	0.59	3	0.42
	1	0.45	2	0	2	1.17	3	0.42
	221	99.98	131	39	170	99.99	713	99.29
	0.004		0.004	0.004	0.008		0.054	
	55,250		32,750	9,750	21,250		13,296	

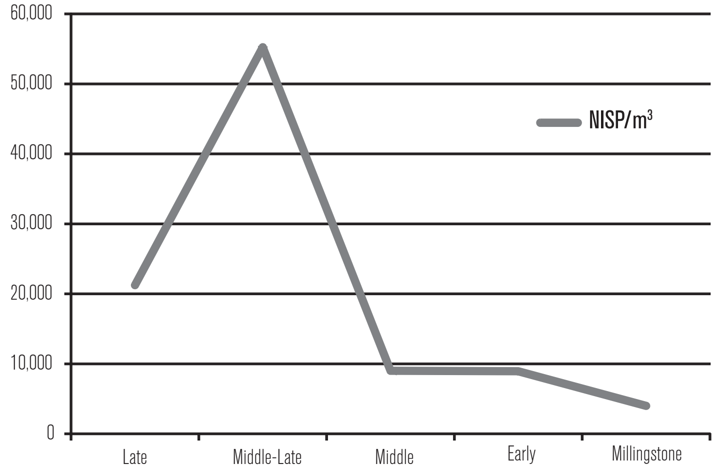

Figure 3. Fish NISP/m³ 1/16-inch Mesh, Morro Bay Archaeological Sites through Time.

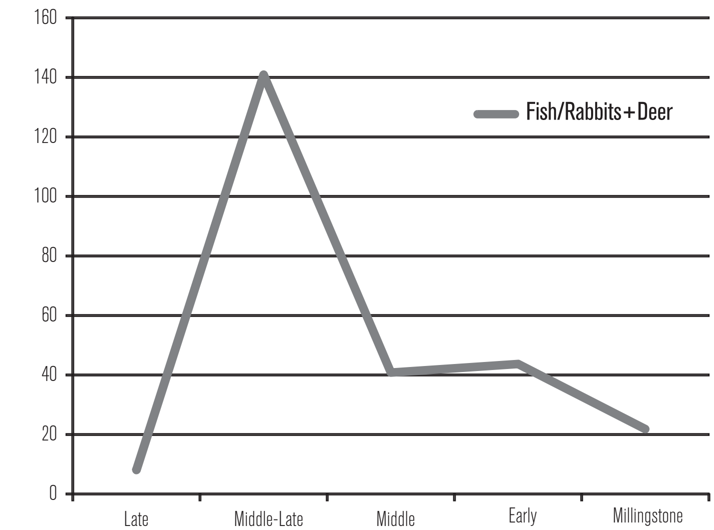

Figure 4. Fish/Deer+Rabbit Bones over time, Morro Bay Archaeological Sites.

across the Millingstone/Early Archaic-Early transition, ca. 6,000–5,500 years B.P., is not as strong as might be expected, based on other studies that document an increase in the number of sites occupied after ca. 5,500 cal B.P. (e.g., Jones et al. 2007) and changes in settlement strategy (Bertrando 2006). The current fish-bone data show a larger number of temporal components for the Early Period than for any other time period, and this pattern stands out even more when all of the dated components in the Morro Bay area are considered (Table 8).

The Millingstone/Early Archaic-Early transition does stand out in relation to fish remains when habitats represented by fishes caught in the southern portion of the bay (Los Osos) are considered. Early Period components from Los Osos show a noticeable increase in fishes from open coastal habitats (Tables 9 and 10), which suggests that foragers were traveling further from residential bases to fish. This is also confirmed by the initial appearance during the Early Period of fishes not found by Fierstine et al (1973) within Morro Bay and that presumably were captured in Estero Bay—Pacific hake, greenling, and rock or black prickleback (see Table 5). Rockfishes also increase significantly across the Millingstone/Lower Archaic-Early Transition, suggesting greater exploitation of the outer waters and possibly an increase in sedentism consistent with the beginning of a more collector-like subsistence strategy, as suggested by Bertrando (2006) on the basis of stone tool assemblages.

Table 8

NUMBER OF MORRO BAY TEMPORAL COMPONENTS OVER TIME

Period	N Components
Late	17
Middle-Late	4
Middle	4
Early	11
Millingstone/Lower Archaic	5
Total	**41**

Table 9

FISH REMAINS FROM MORRO BAY COMPONENTS BY HABITAT, MILLINGSTONE AND EARLY PERIODS

		Millingstone					Early								
Taxon	Common Name	SLO-165	SLO-215	SLO-812	Total	%	SLO-23	SLO-165	SLO-458	SLO-812	SLO-977	Total	%	Total	%
Bays and Estuaries															
Rhinobatos productus	Shovelnose guitarfish	0	1	3	4	0.00	30	34	0	4	27	95	2.33	99	1.88
Platyrhinoidis triseriata	Thornback	0	1	2	3	0.25	23	1	0	0	9	33	0.81	36	0.69
Atherinopsidae (*Atherinidæ*)	New World silversides	197	32	22	251	21.25	429	17	12	34	36	528	12.96	779	14.82
Atherinops affinis	Topsmelt	0	0	0	0	0.00	1	3	0	0	0	4	0.09	4	0.08
Atherinopsis californiensis	Jacksmelt	0	0	0	0	0.00	5	0	0	0	25	30	0.74	30	0.57
Sciaenidae	Drums and croakers	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Gillichthys mirabilis	Longjaw mudsucker	0	1	0	1	0.08	1	0	0	0	0	1	0.02	2	0.04
Citharichthys sp.	Sanddabs	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Paralichthys californicus	California halibut	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Subtotal		197	35	27	259	21.58	489	55	12	38	97	691	16.95	950	18.08
Estuaries and Open Coast															
Rajidae	Skates	0	0	0	0	0.00	2	3	0	0	5	10	0.25	10	0.19
Triakidae	Requiem sharks	45	12	9	66	5.59	114	146	0	9	18	287	7.05	353	6.72
Squatina californica	Pacific angel shark	0	2	0	2	0.17	9	1	0	2	4	16	0.39	18	0.34
Myliobatis californica	Bat ray	50	30	16	96	8.13	46	129	0	18	11	204	5.01	300	5.71
Engraulis mordax	Northern anchovy	1	0	0	1	0.08	0	4	0	0	0	4	0.09	5	0.09
Clupeidae	Herrings	80	8	29	117	9.91	514	19	2	15	4	554	13.60	671	12.77
Clupea pallasii	Pacific herring	0	0	1	1	0.08	3	0	0	0	0	3	0.07	4	0.08
Sardinops sagax	Pacific sardine	0	2	1	3	0.25	3	2	2	0	0	7	0.17	10	0.19
Microgadus proximus	Pacific tomcod	0	0	0	0	0.00	0	1	0	0	0	1	0.02	1	0.02
Porichthys notatus	Plainfin midshipman	0	5	0	5	0.42	0	8	0	0	1	9	0.26	14	0.27
Porichthys sp.	Midshipman	0	0	0	0	0.00	2	0	0	0	0	2	0.05	2	0.04
Ophiodon elongatus	Lingcod	2	5	0	7	0.59	15	8	0	0	0	23	0.55	30	0.57
Cottidae	Sculpin family	0	1	0	1	0.08	0	3	1	0	0	4	0.09	5	0.09
Leptocottus armatus	Pacific staghorn sculpin	1	3	1	5	0.34	42	1	0	1	55	99	2.43	104	1.98

Table 9 *(Continued)*

FISH REMAINS FROM MORRO BAY COMPONENTS BY HABITAT, MILLINGSTONE AND EARLY PERIODS

		Millingstone					Early								
Taxon	Common Name	SLO-165	SLO-215	SLO-812	Total	%	SLO-23	SLO-165	SLO-458	SLO-812	SLO-977	Total	%	Total	%
Embiotocidae	Surfperches	17	406	24	447	37.89	1,259	169	9	51	4	1,492	36.63	1,939	36.90
Amphisticus rhoderatus	Redtail surfperch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Cymatogaster aggregata	Shiner perch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Damalichthys vacca	Pile perch	0	30	1	31	2.54	38	0	0	0	2	40	0.98	71	1.35
Embiotoca jacksoni	Black perch	0	0	0	0	0.00	8	0	0	0	0	8	0.20	8	0.15
Embiotoca sp.	Black or striped seaperch	0	1	0	1	0.08	16	3	0	0	0	19	0.47	20	0.38
Phanerodon furcatus	White seaperch	0	1	0	1	0.08	1	0	0	0	0	1	0.02	2	0.04
Gobiidae	Gobies	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Pleuronectiformes	Righteye and lefteye flounders	0	5	0	5	0.42	13	1	0	0	0	14	0.34	19	0.36
Platichthys stellatus	Starry flounder	0	2	0	2	0.17	2	1	0	0	0	3	0.07	5	0.09
Subtotal		196	513	82	852	66.82	2,087	499	14	96	104	2,800	68.74	3,591	68.33
Open Coast															
Heterodontus francisci	Horn shark	0	0	0	0	0.00	1	1	1	0	0	3	0.07	3	0.06
Isurus oxyrinchus	Shortfin mako	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Merluccius productus	Pacific hake	0	0	0	0	0.00	3	15	0	0	15	33	0.81	33	0.63
Leuresthes tenuis	California grunion	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Sebastes spp.	Rockfishes	5	8	1	14	1.19	179	5	3	2	1	190	4.66	204	3.88
Hexagrammos sp.	Greenlings	0	1	0	1	0.08	0	1	0	1	0	2	0.05	3	0.06
Clinocottus analis	Mosshead sculpin	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Icelinus sp.	Sculpin	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Scorpaenichthys marmoratus	Cabezon	6	25	1	32	2.71	43	6	0	2	1	52	1.28	84	1.59
Trachurus symmetricus	Jack Mackerel	0	0	0	0	0.00	2	0	0	0	0	2	0.04	2	0.04
Embiotoca lateralis	Striped seaperch	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Amphistichus spp.		0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Hyperprosopon argenteum	Walleye surfperch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Micrometrus minimus	Dwarf perch	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Rhacochilus toxotes	Rubberlip seaperch	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Oxyjulis californica	Señorita	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Stichaeidae	Pricklebacks	0	2	1	3	0.25	6	0	0	0	0	6	0.14	9	0.17
Cebidichthys violaceus	Monkeyface prickleback	0	1	0	1	0.08	4	3	0	0	0	7	0.17	8	0.15
Xiphister spp.	Rock or black prickleback	0	0	0	0	0.00	1	3	0	0	0	4	0.09	4	0.07
Clinidae	Kelp blennies	0	4	0	4	0.34	15	0	0	0	0	15	0.37	19	0.36
Gibbonsia sp.	Kelpfish	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0	0.00
Heterostichus rostratus	Giant kelpfish	0	13	1	14	1.19	75	0	1	3	0	79	1.94	93	1.77
Sphyraena argentea	Pacific barracuda	0	1	0	1	0.08	0	0	0	0	0	0	0.00	1	0.02
Scomber japonicus	Pacific chub mackere l	0	0	0	0	0.00	4	0	0	0	0	4	0.09	4	0.08
Eopsetta jordani	Petrale sole	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Parophrys vetulus (*Pleuronectes vetulus*)	English sole	0	0	0	0	0.00	1	0	0	0	0	1	0.02	1	0.02
Subtotal		11	55	4	70	5.92	340	34	5	8	17	404	9.85	474	9.02
Grand total		**404**	**645**	**132**	**1,181**	**99.49**	**3,034**	**620**	**31**	**162**	**226**	**4,073**	**99.91**	**5,254**	**98.59**

Table 10

FISH REMAINS(NISP) FROM MORRO BAY COMPONENTS BY HABITAT, MIDDLE, MIDDLE-LATE TRANSITION, AND LATE PERIODS

		Middle Period					Middle-Late		Late			
Taxon	Common Name	SLO-14	SLO-165	SLO-812	Total	%	SLO-457	%	SLO-23	SLO-626	Total	%
Bays and Estuaries												
Rhinobatos productus	Shovelnose guitarfish	15	0	5	20	0.78	59	0.82	20	0	20	0.41
Platyrhinoidis triseriata	Thornback	0	0	2	2	0.08	34	0.47	29	5	34	0.70
Atherinopsidae	New World silversides	985	4	25	1,014	39.53	1,296	18.03	309	244	553	11.34
Atherinops affinis	Topsmelt	2	0	0	2	0.08	4	0.06	0	0	0	0.00
Atherinopsis californiensis	Jacksmelt	0	0	0	0	0.00	1	0.01	0	0	0	0.00
Sciaenidae	Drums and croakers	0	0	0	0	0.00	0	0.00	0	1	1	0.02
Gillichthys mirabilis	Longjaw mudsucker	2	0	0	2	0.08	14	0.19	5	1	6	0.12
Citharichthys sp.	Sanddabs	0	0	0	0	0.00	0	0.00	0	1	1	0.02
Paralichthys californicus	California halibut	0	0	0	0	0.00	0	0.00	1	0	1	0.02
Subtotal		1,004	4	32	1,040	40.55	1,408	19.58	364	252	616	12.63
Estuaries and Open Coast												
Rajidae	Skates	29	0	0	29	1.13	24	0.33	5	0	5	0.10
Triakidae	Requiem sharks	88	0	8	96	3.73	266	3.70	98	4	102	2.09
Squatina californica	Pacific angel shark	9	0	1	10	0.39	34	0.47	7	0	7	0.14
Myliobatis californica	Bat ray	4	1	20	25	0.97	27	0.38	27	7	34	0.70
Engraulis mordax	Northern anchovy	0	4	0	4	0.16	0	0.00	0	0	0	0.00
Clupeidae	Herrings	474	5	5	484	18.91	384	5.73	855	33	888	18.22
Clupea pallasii	Pacific herring	0	0	0	0	0.00	4	0.06	6	0	6	0.12
Sardinops sagax	Pacific sardine	63	0	0	63	2.45	24	0.33	19	3	22	0.45
Microgadus proximus	Pacific tomcod	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Porichthys notatus	Plainfin midshipman	0	1	0	1	0.04	0	0.00	2	2	4	0.08
Porichthys sp.	Midshipman	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Ophiodon elongatus	Lingcod	13	0	2	15	0.58	0	0.00	3	2	5	0.09
Cottidae	Sculpin family	0	1	0	1	0.04	3	0.04	3	1	4	0.08
Leptocottus armatus	Pacific staghorn sculpin	9	1	0	10	0.39	38	0.52	39	12	51	1.12
Embiotocidae	Surfperches	354	8	24	386	15.18	4,161	57.89	1,626	351	1,977	40.56
Amphisticus rhoderatus	Redtail surfperch	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Cymatogaster aggregata	Shiner perch	0	0	0	0	0.00	2	0.03	0	1	1	0.02
Damalichthys vacca (Rhicochilus vacca)	Pile perch	10	0	1	11	0.43	174	2.42	90	4	94	1.93
Embiotoca jacksoni	Black perch	1	0	0	1	0.04	14	0.19	12	2	14	0.29
Embiotoca sp.	Black or striped surfperch	4	0	0	4	0.16	163	2.27	47	5	52	1.07
Phanerodon furcatus	White seaperch	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Gobiidae	Gobies	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Pleuronectiformes	Righteye and lefteye flounders	5	0	0	5	0.19	8	0.11	12	2	14	0.29
Platichthys stellatus	Starry flounder	5	0	0	5	0.19	22	0.31	0	0	0	0.00
Subtotal		1,070	21	61	1,152	45.06	5,348	74.78	2,851	429	3,410	67.35

Total	%	Total from Table 5	Grand Total	%
99	0.68	99	198	0.99
70	0.48	36	106	0.53
2,863	19.59	779	3,642	18.33
6	0.04	4	10	0.05
1	0.01	30	31	0.16
1	0.01	0	1	0.01
22	0.15	2	24	0.12
1	0.01	0	1	0.01
1	0.01	0	1	0.01
3,064	20.98	950	4,014	20.21
58	0.39	10	68	0.34
464	3.17	353	817	4.11
51	0.35	18	69	0.35
86	0.59	300	386	1.94
4	0.03	5	9	0.05
1,756	12.02	671	2,427	12.22
10	0.07	4	14	0.07
109	0.74	10	119	0.59
0	0.00	1	1	0.01
5	0.03	14	19	0.09
0	0.00	2	2	0.01
20	0.14	30	50	0.25
8	0.05	5	13	0.07
99	0.68	104	203	1.02
6,524	44.61	1,939	8,463	42.66
1	0.01	0	1	0.01
3	0.02	0	3	0.02
279	1.91	71	350	1.76
29	0.19	8	37	0.19
219	1.49	20	239	1.20
0	0.00	2	2	0.01
1	0.01	0	1	0.01
27	0.18	19	46	0.23
27	0.18	5	32	0.16
9,780	66.86	3,591	13,371	67.37

CONCLUSIONS

While the Morro Bay fish remains show a significant decrease in one species (bat rays), the region's sites do not in general indicate any major replacement of species through time. Small schooling fishes, including silversides, herrings, and surfperches (almost certainly caught using nets and simple watercraft), dominate the record throughout the Holocene. This continuity suggests that it is unlikely that these fishes were ever overexploited within the bay prehistorically, as has been proposed for other locations in California (Broughton 1994, 1997, 1999; Broughton et al. 2015; Salls 1992). Furthermore, remains do not exhibit any incremental increase over time. NISP/m^3 values remain relatively low from the Millingstone/Early Archaic through Middle periods (ca. 8,000–950 cal B.P.). The frequency of fish relative to rabbits and deer also stays fairly constant until a major increase in fish remains occurs during the Middle-Late Transition Period.

Fish remains show an unexpectedly minor increase across the Millingstone/Lower Archaic-Early Transition, but increased frequencies of fishes representing more distant habitats are consistent with a shift in settlement strategies during the Early Period, as proposed by Bertrando (2006). The dramatic spike in fish remains and fish/deer+rabbits during the Middle-Late Transition Period can be readily attributed to both an increased focus on marine prey during Medieval Climatic Anomaly droughts, and cool, highly productive sea surface temperatures along the coast at the same time (Kennett and Kennett 2000). Clearly this peak is consistent with the notion that Morro Bay served as a refugium for people during the Medieval Climatic Anomaly, as suggested by Mikkelsen et al. (2000), which in turn is consistent with patterns in the Santa Barbara Channel (Arnold 1992; Kennett 2005; Kennett and Kennett 2000). Following the Middle-Late Transition Period peak, fish remains become less abundant in midden deposits, although values are still higher than any pre-1,000 cal B.P. period. Ratios of fish/rabbits+deer show a decline as well, and in tandem, these trends suggest that fishing became less important relative to terrestrial resources during the Late Period, perhaps signaling the increasing importance of acorns and other plant foods. This deviates somewhat from patterns associated with southern Chumashan speakers in the Santa Barbara Channel, and is more in line with central California, where acorns became the dominant subsistence staple over the last two millennia of prehistory (e.g., Bartelink 2009; Basgall 2004; Bettinger 2015). At a minimum, the Morro Bay fish remains do not support a model of progressive maritime intensification, but instead show very modest variations related to seasonality, climate, and population, and a decline in the importance of fishing coincident with increased reliance on plant foods, particularly the acorn, late in time.

NOTE

[1]"Actinopterygii" is the chosen taxon here because it is more exclusive than "Osteichthyes," which includes not only the ray-finned fishes, but also the lungfishes, coelacanths, bichirs, and their tetrapod descendants (Nelson 2006).

Table 10 *(Continued)*

FISH REMAINS(NISP) FROM MORRO BAY COMPONENTS BY HABITAT, MIDDLE, MIDDLE-LATE TRANSITION, AND LATE PERIODS

		Middle Period					Middle-Late		Late			
Taxon	Common Name	SLO-14	SLO-165	SLO-812	Total	%	SLO-457	%	SLO-23	SLO-626	Total	%
Open Coast												
Heterodontus francisci	Horn shark	4	0	0	4	0.16	27	0.38	6	1	7	0.14
Isurus oxyrinchus	Shortfin mako	1	0	0	1	0.04	0	0.00	0	0	0	0.00
Merluccius productus	Pacific hake	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Leuresthes tenuis	California grunion	0	0	0	0	0.00	1	0.01	1	0	1	0.02
Sebastes spp.	Rockfishes	63	0	6	69	2.68	44	0.61	388	38	426	9.12
Hexagrammos sp.	Greenlings	25	0	0	25	1.01	1	0.01	7	1	8	0.16
Clinocottus analis	Mosshead sculpin	2	0	0	2	0.08	0	0.00	0	0	0	0.00
Icelinus sp.		0	0	0	0	0.00	0	0.00	0	0	0	0.00
Scorpaenichthys marmoratus	Cabezon	88	0	4	92	3.57	18	0.25	56	7	63	1.29
Trachurus symmetricus	Jack mackerel	0	0	0	0	0.00	2	0.03	2	0	2	0.04
Amphistichus spp.		0	0	0	0	0.04	0	0.00	0	0	0	0.00
Embiotoca lateralis	Striped seaperch	2	0	0	2	0.08	3	0.04	5	2	7	0.14
Hyperprosopon argenteum	Walleye surfperch	0	0	0	0	0.00	2	0.03	1	0	1	0.02
Micrometrus minimus	Dwarf perch	0	0	0	0	0.00	2	0.03	0	1	1	0.02
Rhacochilus toxotes	Rubberlip seaperch	0	0	0	0	0.00	3	0.04	0	0	0	0.00
Oxyjulis californica	Señorita	0	0	0	0	0.00	0	0.00	3	1	4	0.08
Stichaeidae	Pricklebacks	2	0	1	3	0.12	0	0.00	5	1	6	0.12
Cebidichthys violaceus	Monkeyface prickleback	13	0	0	13	0.54	2	0.03	2	0	2	0.04
Xiphister spp.	Rock or kelp pricklebak	10	0	0	10	0.39	6	0.08	1	1	2	0.04
Clinidae	Kelp blennies	0	0	0	0	0.00	0	0.00	52	3	55	1.13
Gibbonsia sp.	Kelp fish	1	0	0	1	0.04	0	0.00	0	1	1	0.02
Heterostichus rostratus	Giant kelpfish	6	0	3	9	0.35	172	2.39	155	99	254	5.21
Sphyraena argentea	Pacific barracuda	0	0	0	0	0.00	1	0.01	0	0	0	0.00
Scomber japonicus	Pacific chub mackerel	3	0	0	3	0.12	1	0.01	7	0	7	0.14
Eopsetta jordani	Petrale sole	0	0	0	0	0.00	0	0.00	1	0	1	0.02
Parophrys vetulus (*Pleuronectes vetulus*)	English sole	0	0	0	0	0.00	0	0.00	0	0	0	0.00
Subtotal		220	0	14	234	9.22	285	3.95	692	156	414	17.75
Grand total		**2,411**	**25**	**123**	**2,559**	**100.03**	**7,188**	**99.30**	**4,017**	**857**	**4,874**	**100.40**

Total	%	Total from Table 5	Grand Total	%
38	0.26	3	41	0.21
1	0.01	0	1	0.01
0	0.00	33	33	0.17
2	0.01	1	3	0.02
539	3.68	204	743	3.74
34	0.24	3	37	0.19
2	0.01	0	2	0.01
0	0.00	1	1	0.01
173	1.18	84	257	1.29
4	0.03	2	6	0.03
0	0.00	0	0	0.00
12	0.08	1	13	0.07
3	0.02	0	3	0.02
3	0.02	0	3	0.02
3	0.02	1	4	0.02
4	0.03	1	5	0.03
9	0.06	9	18	0.09
17	0.12	8	25	0.13
18	0.12	4	22	0.07
55	0.38	19	74	0.37
2	0.01	0	2	0.01
435	2.97	93	528	2.65
1	0.01	1	2	0.01
11	0.08	4	15	0.08
1	0.01	1	2	0.01
0	0.00	1	1	0.01
1,367	9.35	474	1,841	9.27
14,621	**100.01**	**5,254**	19,875	100.13

REFERENCES

Arnold, Jeanne E.

1992 Complex Hunter-gatherer-fishers of Prehistoric California: Chiefs, Specialists, and Maritime Adaptations of the Channel Islands. *American Antiquity* 57:60–84.

1995 Transportation Innovation and Social Complexity among Maritime Hunter-gatherer societies. *American Anthropologist* 97:733–747.

Arnold, Jeanne E. (ed.)

2001 *The Origins of a Pacific Coast Chiefdom: The Chumash of the Channel Islands*. Salt Lake City: University of Utah Press.

2004 *Foundations of Chumash Complexity*. Cotsen Institute of Archaeology, University of California, Los Angeles.

Arnold, Jeanne E., and Julienne Bernard

2005 Negotiating the Coasts: Status and the Evolution of Boat Technology in California. *World Archaeology* 37:109–131.

Bartelink, Eric J.

2009 Late Holocene Dietary Change in San Francisco Bay: Stable Isotope Evidence for an Expansion in Diet Breadth. *California Archaeology* 1:227–252.

Basgall, Mark E.

2004 Resource Intensification among Hunter-Gatherers: Acorn Economies in Prehistoric California. In *Prehistoric California: Archaeology and the Myth of Paradise*, L. Mark Raab and Terry L. Jones, eds., pp. 86–98. Salt Lake City:University of Utah Press.

Bertrando, Ethan

1996 *Cultural Resources Significance Testing (Phase 2) of the Renshaw and Shaw Parcel APN: 038-681-022, 616 Santa Lucia, Baywood Park, California*. MS on file at the Central Coast Information Center, University of California, Santa Barbara.

2000 *Phase 3 Cultural Resource Mitigation (Data Recovery), Capping and Monitoring) at SLO-1212, APN: 074-302-016; 020; 021; 022, Los Osos Valley Road, Los Osos CA*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

2004a *Phase 3 Data Recovery and Mitigation of CA-SLO-1795, 1319 Los Osos Valley Road, Los Osos, California*. MS on file at the South Central Archaeological Information Center, Department of Anthropology, University of California, Santa Barbara.

2004b *Data Recovery and Archaeological Monitoring of the Amyx Parcel, 550 Mimosa Street, APN:068-231-015 (CA-SLO-165), Morro Bay California*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

2006 Hunter-gatherers in the Morro Bay Watershed 3650 Years Ago: Settlement, Subsistence, and Technology during an Archaeological Point in Time. *Proceedings of the Society for California Archaeology* 19:211–219.

Bertrando, Ethan, and Dustin K. McKenzie

2011 Identifying Fishing Techniques from the Skeletal Remains of Fish. In *Exploring Methods of Faunal Analysis: Perspectives from California Archaeology*, Michael A. Glassow and Terry L. Joslin, eds., pp. 187–198. Los Angeles: Cotsen Institute Press, University of California, Los Angeles.

Bettinger, Robert L.

2015 *Orderly Anarchy: Sociopolitical Evolution in Aboriginal California*. Berkeley: University of California Press.

Boone, Christie M.

2012 *Integrating Zooarchaeology and Modeling: Trans-Holocene Fishing in Monterey Bay, California*. Ph.D. dissertation, University of California, Santa Cruz.

Breschini, G. S., T. Haversat, and J. M. Erlandson

1996 *California Radiocarbon Dates*. Eighth edition. Salinas: Coyote Press.

Broughton, Jack M.

1994 Late Holocene Resource Intensification in the Sacramento River Valley, California: The Vertebrate Evidence. *Journal of Archaeological Science* 21:501–514.

1997 Widening Diet Breadth, Declining Foraging Efficiency, and Prehistoric Harvest Pressure: Ichthyofaunal Evidence from the Emeryville Shellmound, California. *Antiquity* 71:845–862.

1999 Resource Depression and Intensification during the Late Holocene, San Francisco Bay: Evidence from the Emeryville Shellmound Vertebrate Fauna. *University of California Anthropological Records* 32.

Broughton, Jack M., Erik P. Martin, Brian McEneaney, Thomas Wake, and Dwight D. Simons

2015 Late Holocene Anthropogenic Depression of Sturgeon in San Francisco Bay, California. *Journal of California and Great Basin Anthropology* 35:3–27.

Brown, Alan K.

2001 *A Description of Distant Roads: Original Journals of the First Expedition into California, 1769–1770*. San Diego: San Diego State University Press.

California Department of Fish and Game

1966 *Report on the Natural Resources of Morro Bay and Proposal for Comprehensive Area Plan*. Leaflet on file at the California Department of Fish and Game, Sacramento.

1976 Fish Bulletin fish catch statistics available from http://libraries.ucsd.edu/apps/ceofishbull/index.html.

2010 California Commercial Landings for 2000–2010: http://www.dfg.ca.gov/marine/fishing.asp#Commercial.

Carson, Michael, and Nancy Farrell

2000 *Archaeological Test Excavations at a Portion of Site SLO-165, Morro Bay, San Luis Obispo County, California*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Casteel, Richard W.

1972 Some Biases in the Recovery of Archaeological Faunal Remains. *Proceedings of the Prehistoric Society* 38:382–388.

Chavez, Francisco P., John Ryan, Salvador E. Lluch-Cota, and Miguel Niquen

2003 From Anchovies to Sardines and Back: Multidecadal Change in the Pacific Ocean. *Science* 299:217–221.

Clemmer, John S.

1962 *Archaeological Notes on a Chumash House Floor at Morro Bay*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, University of California, Santa Barbara.

Codding, Brian F., and Terry L. Jones

2007 History and Behavioral Ecology during the Middle-Late Transition on the Central California Coast: Findings from the Coon Creek Site (CA-SLO-9), San Luis Obispo County. *Journal of California and Great Basin Anthropology* 27:23–49.

Cooper, William Skinner

1967 Coastal Dunes of California. *Geological Society of America Memoirs* 104. Boulder, Colorado.

Dallas, Herb

1992 Hunters and Gatherers at CA-SLO-977, San Luis Obispo County California. In *Archaeological Investigations of Some Significant Sites on the Central Coast of California*, Herb Dallas Jr. and Gary S. Breschini, eds., pp. 1–37. Salinas, California: Coyote Press.

Dills, Charles

1969 *Archaeological Site Record for CA-SLO-457*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Erlandson, Jon M.

2001 The Archaeology of Aquatic Adaptations: Paradigms for a New Millennium. *Journal of Archaeological Research* 9:287–350.

Fierstine, Harry L., Kurt F. Kline, and Gregory R. Garman

1973 Fishes collected in Morro Bay, California between January 1968 and December 1970. *California Fish and Game* 59:73–88.

Fitch, John

1972 Fish Remains, Primarily Otoliths from CA-SLO-2, Diablo Canyon. In *Years of Prehistory at Diablo Canyon, San Luis Obispo County, California*, Roberta L. Greenwood, ed., pp. 101–120. [*Occasional Papers* 7.] San Luis Obispo, Cal.: San Luis Obispo County Archaeological Society.

Gallagher, Jacqueline

1996 *Late Holocene Evolution of the Chorro Delta, Morro Bay, California*. Ph.D. dissertion, University of California, Los Angeles.

Gamble, Lynn

2008 *The Chumash World at European Contact: Power, Trade, and Feasting among Complex Hunter-Gatherers*. Berkeley: University of California Press.

Gause, Seana L. S.

2002 Ecology and Prey Characteristics of Fish Species found in the vicinity of San Simeon Reef. In *Prehistory at San Simeon Reef: Archaeological Data Recovery at CA-SLO-179 and -267, San Luis Obispo County, California*, Terry L. Jones and Jennifer A. Ferneau, eds. *San Luis Obispo County Archaeological Society Occasional Papers* 16, pp. 409–427.

Gerdes, Gene L., and Bruce M. Browning

1974 *Natural Resources of Morro Bay: Their Status and Future*. [*Coastal Wetland Series* 8.] Sacramento: State of California Department of Fish and Game.

Gibson, Robert O.

1977 *Site Record for CA-SLO-812*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

1983 *Results of Archaeological Subsurface Testing on Portions of CA-SLO-165 Adjacent to Highway 41 Near Morro Bay, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

1984a *Results of Archaeological Subsurface testing at SLO-626 located between 6th Street and 5th Street on the edge of Morro Bay, Baywood Park, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center, University of California, Santa Barbara.

1984b *Results of Archaeological Subsurface Testing at SLO-626, Block 32, lot 8 on Sixth Street, Baywood Park, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center, University of California, Santa Barbara.

Glassow, Michael A.

1993 Changes in Subsistence on Marine Resources through 7,000 Years of Prehistory on Santa Cruz Island. In *Archaeology on the Northern Channel Islands of California*, Michael A. Glassow, ed., pp. 75–90. Salinas: Coyote Press.

Gobalet, Kenneth W.

2000 Has Point Conception been a Marine Zoogeographic Boundary Throughout the Holocene? Evidence from the Archaeological Record. *Bulletin of the Southern California Academy of Sciences* 99:32–44.

2001 A Critique of Faunal Analysis; Inconsistency among Experts in Blind Tests. *Journal of Archaeological Science* 28:377–386.

2005 Comment on "Size Matters: 3-mm. sieves do not increase richness in a fishbone assemblage from Arrawarra I, an Aboriginal Australian shell midden on the mid-north coast of New South Wales, Australia" by Vale and Gargett. *Journal of Archaeological Science* 32:643–645.

Gobalet, Kenneth W., and Terry L. Jones

1995 Prehistoric Native American Fisheries of the Central California coast. *Transactions of the American Fisheries Society* 124:813–823.

Gobalet, Kenneth W., Peter D. Schulz, Thomas A. Wake, and Nelson Siefkin

2004 Archaeological Perspectives on Native American fisheries of California with emphasis on Steelhead and Salmon. *Transactions of the American Fisheries Society* 133:801–833.

Greenwood, Roberta S.

1972 9000 Years of Prehistory at Diablo Canyon, San Luis Obispo County, California. *San Luis Obispo County Archaeological Society Occasional Papers* 7. San Luis Obispo.

Hampson, Paul, and Gary S. Breschini

1986 *Subsurface Archaeological Examination of Two Parcels in Baywood Park, near Los Osos, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center, University of California, Santa Barbara.

Horn, Michael H.

1980 Diet and Seasonal Variation in Abundance and Diversity of Shallow-Water Fish Populations in Morro Bay, California. *Fishery Bulletin* 78:759–770.

Hoover, Robert L., and John Fleming

1976 *Archaeological Site Record for CA-SLO-215*. MS on file at the South Central Coastal Information Center, University of California, Santa Barbara.

Hoover, Robert L., and William B. Sawyer

1977 Los Osos Junior High School Site 4-SLO-214. *San Luis Obispo County Archaeological Society Occasional Papers* 11.

Ingram, B. Lynn, and John R. Southon

1996 Reservoir Ages in Eastern Pacific Coast and Estuarine Waters. *Radiocarbon* 38:573–882.

Jones, Deborah A., Terry L. Jones, Kacey Hadick, William R. Hildebrandt, and Patricia Mikkelsen

2015 Draft Report. *Archaeological Investigations for the Los Osos Wastewater Project, San Luis Obispo County, California*. Report on file at Far Western Anthropological Research Group, Davis, Cal.

Jones, Terry L.

1996 Mortars, Pestles, and Division of Labor in Prehistoric California: A View from Big Sur. *American Antiquity* 6:243–264.

Jones, Terry L., Judith F. Porcasi, Jereme Gaeta, and Brian F. Codding

2008 Diablo Canyon Fauna: A Coarse-Grained Record of Trans-Holocene Foraging from the Central California Mainland Coast. *American Antiquity* 73:289–316.

Jones, Terry L., Kathleen Davis, Glenn Farris, Teresa Fung, Steven D. Grantham, and Betty Rivers

1994 *Toward a Prehistory of Morro Bay: Phase II Archaeological Investigations for the Highway 41 Widening Project, Caltrans Environmental Division, San Luis Obispo*. Report on file at Caltrans, Environmental Division, Sacramento.

Jones, Terry L., Judith F. Porcasi, Kenneth W. Gobalet, and Leroy T. Laurie

2004 CA-SLO-215, A Late Milling Stone Site at Morro Bay, San Luis Obispo County, California. In *Out of the Ice Age: Papers in Honor of Roberta Greenwood*, Ethan Bertrando and Valerie Levulett, eds., pp. 57-70. *San Luis Obispo County Archaeological Society Occasional Papers* 17. San Luis Obispo.

Jones, Terry L., Nathan E. Stevens, Deborah A. Jones, Richard T. Fitzgerald, and Mark G. Hylkema
2007 The Central Coast: A Mid-Latitude Milieu. In *California Prehistory: Colonization, Culture, and Complexity*, Terry L. Jones and Kathryn A. Klar, eds., pp. 125–146. Walnut Creek: Altamira Press.

Joslin, Terry L.
2006 *Late Prehistoric Coastal Adaptations along the San Simeon Reef, San Luis Obispo County, California*. Master's thesis, University of California, Santa Barbara.
2010 *Middle and Late Holocene Hunter-Gather Adaptations to Coastal Ecosystems along the Southern San Simeon Reef, California*. Ph.D. dissertation, University of California, Santa Barbara.

Kennett, Douglas J.
2005 *The Island Chumash, Behavioral Ecology of a Maritime Society*. Berkeley: University of California Press.

Kennett, Douglas J., and James P. Kennett
2000 Competitive and Cooperative Responses to Climate Instability in Coastal Southern California. *American Antiquity* 65:379–395.

Laurie, Leroy, and Andrew Pulcheon
2012 *Archaeological Monitoring and Data Recovery at CA-SLO-14 for the Broderson Avenue Waterline Installation Project, Los Osos, San Luis Obispo County, California*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Love, Milton L.
2011 *Certainly More than You Want to Know about the Fishes of the Pacific Coast: A Postmodern Experience*. Santa Barbara: Really Big Press.

Masters, Patricia M., and Ivano W. Aiello
2007 Postglacial Evolution of Coastal Environments. In *California Prehistory: Colonization, Culture, and Complexity*, Terry L. Jones and Kathryn Klar, eds., pp. 35–52. Walnut Creek: Altamira Press.

Mikkelsen, Patricia, William R. Hildebrandt, and Debbie A. Jones
2000 Prehistoric Adaptations on the Shores of Morro Bay Estuary: Excavations at Site CA-SLO-165, Morro Bay, California. *San Luis Obispo County Archaeological Society Occasional Papers* 14.

McKenzie Dustin
2007 *Experimental Fishing Methods on the Northern Channel Islands: Testing the Relative Productivity of Bone Gorges and Incurving Shell Fishhooks*. Master's thesis, University of California, Santa Barbara.

Moyle, Peter B.
2002 *Inland Fishes of California*. Berkeley: University of California Press.

Nelson, Joseph W.
2006 *Fishes of the World*, 4th ed. New York: Wiley and Sons.

Orme, Anthony R.
1990 The Instability of Holocene Coastal Dunes: The Case of the Morro Dunes, California. In *Coastal Dunes: Form and Process*, K. F. Nordstrom, N. P. Psuty, and R. W. G. Carter, eds., pp. 315–336. New York: Wiley.

Page, L. M., H. Espinosa-Perez, L. T. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrake, R. L. Mayden, and J. S. Nelson
2013 *Common and Scientific Names of Fishes from the United States, Canada, and Mexico*. 7th ed. [*American Fisheries Society Special Publication* 34.] Bethesda, Maryland.

Parker, John
2003 *Cultural Resource Investigation of 1107 Pasadena Drive, Los Osos, APN 038-681-021*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Pilling, Arnold
1947 *Archaeological Site Records for CA-SLO-14 and CA-SLO-23*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Pletka, Scott
2001 The Economics of Island Chumash Fishing Practices. In *The Origins of a Pacific Coast Chiefdom: The Chumash of the Channel Islands*, Jeanne E. Arnold, ed., pp. 221–244. Salt Lake City: University of Utah Press.

Price, Barry A., Sandra Flint, and Kham N. Slater
1997 *Cultural Resources Monitoring and Emergency Excavations for Segment 2 of the Chorro Valley Water Transmission Pipeline Project*. MS on file at the South Central Coast Information Center, University of California, Santa Barbara.

Rick, Torben C.
2007 *The Archaeology and Historical Ecology of Late Holocene San Miguel Island*. Los Angeles: Cotsen Institute of Archaeology, University of California.

Rick, Torben C., and Jon M. Erlandson
2000 Early Holocene Fishing Strategies on the California Coast: Evidence from CA-SBA-2057. *Journal of Archaeological Science* 27:621–633.

Salls, Roy A.
1988 *Prehistoric Fisheries of the California Bight*. PhD. dissertation, University of California, Los Angeles.
1992 Prehistoric Subsistence Change on California's Channel Islands: Environmental or Cultural. In *Essays on the Prehistory of Maritime California*, Terry L. Jones, ed., pp. 157–172. [*Center for Archaeological Research at Davis Publications* 10.] Davis: University of California, Davis.

Salls, Roy A., R. Huddleston, and Dana Bleitz-Sanburg
1989 *The Prehistoric Fishery at Morro Creek CA-SLO-165, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

Sawyer, William B.
1986 *Report of Archaeological Subsurface Testing and Monitoring of Lot 10, Santa Lucia Avenue, Town of El Moro, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

1989 *Archaeological Subsurface Monitoring, Sweet Springs Marsh B MB 72 and Portion of Block 36, Ramona Avenue, Los Osos, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

Singer, Clay A.
1985 *Archaeological Test Report for the Johnston Property, a portion of Site SLO-626 in Baywood Park, Los Osos, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

Singer, Clay A., and J. E. Atwood
1987 *Phase II Archaeological Testing of a Portion of site CA-SLO-165 in the City of Morro Bay, San Luis Obispo County, California*. MS on file at the South Central Coastal Information Center of the California Historical Resources Information System, Department of Anthropology, University of California, Santa Barbara.

Strudwick, Ivan
1986 *Temporal and Areal Considerations Regarding the Prehistoric Circular Fishhook of California*. Master's thesis, California State University, Los Angeles.

Thomas, David H.
1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34:392–401.

Turnbull, J., Kenneth W. Gobalet, Jereme W. Gaeta, and Matthew R. Des Lauriers
2015 The Native American Fishery of Cedros Island, Baja California, and a Comparison with the Fisheries of the Islands of the Southern California Bight. *Journal of California and Great Basin Anthropology* 35:69–86.

Woodward, Jim, Thomas Wheeler, and John Rumming
1986 *Archaeological Site Record for CA-SLO-215 (DPR422G)-Supplemental*. MS on file at the California Department of Recreation, Sacramento.

Zohar, Irit, and Miriam Belmaker
2005 Size Does Matter: Methodological Comments on Sieve Size and Species Richness in Fishbone Assemblages. *Journal of Archaeological Science* 32:635–641.