

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

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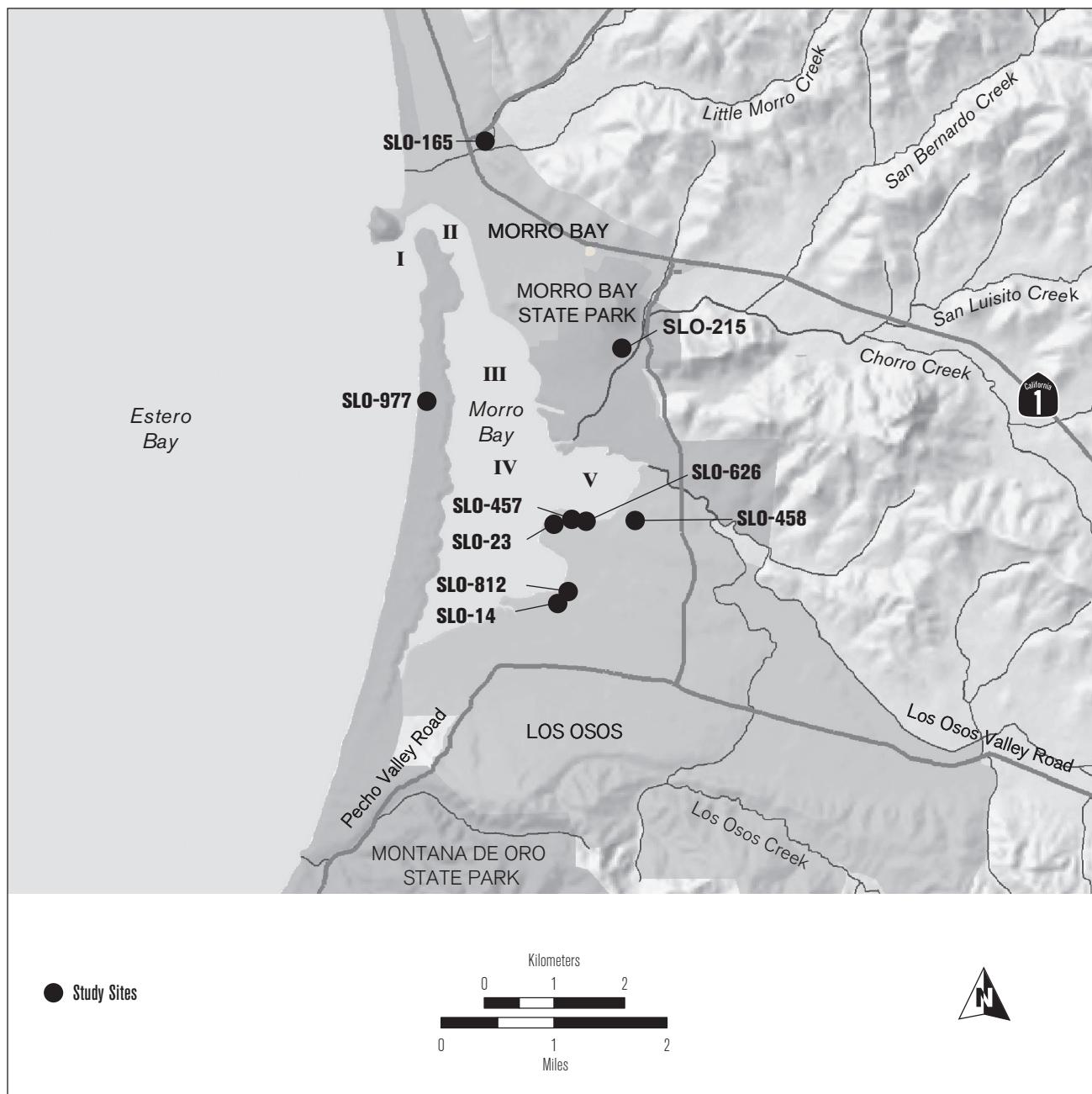
*An 8,000-year sequence of fish remains from Morro Bay, a shallow, 8.1 km.<sup>2</sup> coastal estuary in San Luis Obispo County, has been compiled during recent investigations. The sample, obtained from nine sites and 14 components (total excavation volume=275.86 m.<sup>3</sup>), includes 19,226 fish 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.<sup>3</sup> 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.*

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**I**N 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.<sup>2</sup>) 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              |
|---|--------------------------|
| <i>Elasmobranchiomorpha</i>                   | Sharks, skates, and rays |
| <i>Heterodontus francisci</i>                 | Horn shark               |
| <i>Mustelus californicus</i>                  | Gray smoothhound         |
| <i>Triakis semifasciata</i>                   | Leopard shark            |
| <i>Squatina californica</i>                   | Pacific angel shark      |
| <i>Rhinobatos productus</i>                   | Shovelnose guitarfish    |
| <i>Raja binoculata</i>                        | Big skate                |
| <i>Platyrhinoidis triseriata</i>              | Thornback                |
| <i>Urotrygon halleri</i>                      | Round stingray           |
| <i>Myliobatis californica</i>                 | Bat ray                  |
| <b>Actinopterygii</b>                         |                          |
| <i>Engraulis mordax</i>                       | Northern anchovy         |
| <i>Clupea pallasii</i>                        | Pacific herring          |
| <i>Sardinops sagax</i>                        | Pacific sardine          |
| <i>Oncorhynchus mykiss</i>                    | Rainbow trout, steelhead |
| <i>Porichthys notatus</i>                     | Plainfin midshipman      |
| <i>Atherinops affinis</i>                     | Topsmelt                 |
| <i>Atherinopsis californiensis</i>            | Jacksmelt                |
| <i>Fundulus parvipinnis</i>                   | California killifish     |
| <i>Gasterosteus aculeatus</i>                 | Threespine stickleback   |
| <i>Syngnathus californiensis</i>              | Kelp pipefish            |
| <i>Syngnathus leptorhynchus</i>               | Bay pipefish             |
| <i>Sebastodes auriculatus</i>                 | Brown rockfish           |
| <i>S. dalli</i>                               | Calico rockfish          |
| <i>S. mystinus</i>                            | Blue rockfish            |
| <i>S. paucispinis</i>                         | Boccacio                 |
| <i>S. rastrelliger</i>                        | Grass rockfish           |
| <i>S. serranoides</i>                         | Olive rockfish           |
| <i>Ophiodon elongatus</i>                     | Lingcod                  |
| <i>Oxylebius pictus</i>                       | Painted greenling        |
| <i>Artedius lateralis</i>                     | Smoothhead sculpin       |
| <i>Cottus asper</i>                           | Prickly sculpin          |
| <i>C. gulosus</i>                             | Riffle sculpin           |
| <i>Leptocottus armatus</i>                    | Pacific staghorn sculpin |
| <i>Scorpaenichthys marmoratus</i>             | Cabezon                  |
| <i>Trachurus symmetricus</i>                  | Jack mackerel            |
| <i>Cymatogaster aggregata</i>                 | Shiner perch             |
| <i>Damalichthys vacca (Rhacochilus vacca)</i> | Pile perch               |
| <i>Embiotoca jacksoni</i>                     | Black perch              |
| <i>E. lateralis</i>                           | Striped seaperch         |
| <i>Hyperprosopon argenteum</i>                | Walleye surfperch        |
| <i>Hypsurus caryi</i>                         | Rainbow seaperch         |
| <i>Micrometrus aurora</i>                     | Reef perch               |

**Table 1 (Continued)****FISHES OF MORRO BAY (FROM FIERSTINE ET AL. 1973;  
TERMINOLOGY FROM PAGE ET AL. 2013)**

| Taxon  | Common Name                          |
|--|--------------------------------------|
| <i>Actinopterygii</i> (Continued)                        | <i>Ray-finned fishes</i> (Continued) |
| <i>M. minimus</i>  | Dwarf perch                          |
| <i>Phanerodon atripectus</i>                             | Sharpnose seaperch                   |
| <i>P. furcatus</i>                                       | White seaperch                       |
| <i>Rhacochilus toxotes</i>                               | Rubberlip seaperch                   |
| <i>Cebidichthys violaceus</i>                            | Monkeyface prickleback               |
| <i>Apodichthys flavidus</i>                              | Penpoint gunnel                      |
| <i>Apodichthys fucorum</i>                               | Rockweed gunne                       |
| <i>Gibbonsia montereyensis</i>                           | Crevice kelpfish                     |
| <i>Heterostichus rostratus</i>                           | Giant kelpfish                       |
| <i>Gobiesox meandricus</i>                               | Northern clingfish                   |
| <i>Rimicola muscarum</i>                                 | Kelp clingfish                       |
| <i>Clevelandia ios</i>                                   | Arrow goby                           |
| <i>Eucyclogobius newberryi</i>                           | Tidewater goby                       |
| <i>Gillichthys mirabilis</i>                             | Longjaw mudsucker                    |
| <i>Lepidogobius lepidus</i>                              | Baby goby                            |
| <i>Peprilus simillimus</i>                               | Pacific pompano                      |
| <i>Citharichthys stigmaeus</i>                           | Speckled sanddab                     |
| <i>Paralichthys californicus</i>                         | California halibut                   |
| <i>Parophrys vetulus</i> ( <i>Pleuronectes vetulus</i> ) | English sole                         |
| <i>Platichthys stellatus</i>                             | Starry flounder                      |
| <i>Pleuronichthys coenosus</i>                           | C-O sole                             |
| <i>P. guttulatus</i> ( <i>Hypsopsetta guttulata</i> )    | Diamond turbot                       |
| <i>P. ritteri</i>  | Spotted turbot                       |
| <i>Psettichthys melanostictus</i>                        | Sand sole                            |
| <i>Syphurus atricaudus</i>                               | 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. <sup>3</sup> ) | Mesh (inch)                         | Temporal Components (Periods)             | Adjacent Fish Habitat(s) <sup>a</sup> | 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<br>Jones et al. (1994)<br>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)<br>Gobalet and Jones (1995)                           |
| <b>Total</b> | <b>275.86</b>                        |                                     |   |                                       |                   |   |

<sup>a</sup>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 *Elasmobrachiomorpha* (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 Sounthor (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 x 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.<sup>3</sup> 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**

| Trinomial     | Period                     | Temporal Component              |           | Dominant Fish            |       |      |           |             |                    | No. Species                          | Margalef Index | Recip Berger-Parker Index |       |
|---------------|----------------------------|---------------------------------|-----------|--------------------------|-------|------|-----------|-------------|--------------------|--------------------------------------|----------------|---------------------------|-------|
|               |                            | Exca. Volume (m. <sup>3</sup> ) | Fish NISP | Name                     | N     | %    | NISP Deer | NISP Rabbit | Fish/Deer + Rabbit | Fish NISP/m <sup>3</sup> / Component |                |                           |       |
| 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.<sup>3</sup>; 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<br>290 ± 35 (Cal B.P.) | Median Probability (Cal B.P.) | Reference                  |
|------------|-------------|---------------------|--------------------|-----------------------------|--------------------------|---|-------------------------------|----------------------------|
| CA-SLO-14  | Beta-342991 | NO/E0               | 120-130            | <i>Tresus nuttallii</i>     | 2,650 ± 30 BP            | 2,047-1,917   | 1,984                         | Jones et al. (2015)        |
| CA-SLO-14  | Beta-342992 | NO/E0               | 170-180            | <i>Macoma</i> spp.          | 2,660 ± 30 BP            | 2,059-1,927   | 1,996                         | Jones et al. (2015)        |
| CA-SLO-14  | Beta-327293 | EU-1                | 20-30              | <i>Tresus nuttallii</i>     | 2,660 ± 30 BP            | 2,059-1,927   | 1,996                         | Laurie and Pulcheon (2012) |
| CA-SLO-14  | Beta-327294 | EU-1                | 80-90              | <i>Tresus nuttallii</i>     | 2,600 ± 30 BP            | 1,982-1,865   | 1,925                         | Laurie and Pulcheon (2012) |
| CA-SLO-14  | WSU-4069    | —                   | 30-45              | <i>Neverita lewisii</i>     | 4,050 ± 175 BP           | 3,917-3,464   | 3,706                         | Dills (1990)               |
| CA-SLO-14  | WSU-4070    | —                   | 30-45              | <i>Neverita lewisii</i>     | 5,060 ± 160 BP           | 4,846-4,255   | 5,046                         | Dills (1990)               |
| CA-SLO-23  | Beta-202570 | S4/E0,<br>Feature 1 | 20-40              | <i>Haliotis rufescens</i>   | 890 ± 90                 | 334-101   | 229                           | Jones et al. (2015)        |
| CA-SLO-23  | Beta-202571 | S4/E0               | 40-50              | <i>Haliotis cracherodii</i> | 1,060 ± 70               | 472-328   | 401                           | Jones et al. (2015)        |
| CA-SLO-23  | Beta-202572 | S4/E0               | 60-70              | <i>Tivela stultorum</i>     | 4,540 ± 70               | 4,449-4,233   | 4,351                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-202573 | S4/E0               | 100-110            | <i>Tivela stultorum</i>     | 4,750 ± 70               | 4,773-4,550   | 4,642                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-327757 | NO/E12              | 40-50              | <i>Neverita lewisii</i>     | 3,810 ± 30               | 3,457-3,349   | 3,407                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-327736 | NO/E12              | 60-70              | <i>Saxidomus nuttallii</i>  | 4,380 ± 30               | 4,217-4,068   | 4,135                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-327737 | NO/E12              | 130-140            | <i>Tresus nuttallii</i>     | 3,840 ± 30               | 3,492-3,373   | 3,439                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-327756 | NO/E0               | 40-50              | <i>Saxidomus nuttallii</i>  | 4,560 ± 30               | 4,442-4,297   | 4,383                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-327735 | NO/E0               | 80-90              | <i>Leukoma staminea</i>     | 3,840 ± 30               | 3,492-3,373   | 3,439                         | Jones et al. (2015)        |
| CA-SLO-23  | Beta-379946 | N9.2/W6             | 10-20              | <i>Ostrea lurida</i>        | 1,380 ± 80               | 718-563   | 654                           | Jones et al. (2015)        |
| CA-SLO-23  | Beta-379947 | Feature 5           | 69                 | <i>Leukoma staminea</i>     | 940 ± 30                 | 361-253   | 300                           | Jones et al. (2015)        |
| CA-SLO-23  | Beta-379948 | Feature 6           | 169                | <i>Saxidomus nuttallii</i>  | 4,410 ± 30               | 4,243-4,092   | 4,180                         | Jones et al. (2015)        |
| CA-SLO-165 | Beta-058185 | CT-2                | 30-40              | <i>Tresus nuttallii</i>     | 4,740 ± 80               | 4,735-4,523<br>4,771-474                              | 4,628                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058186 | CT-2                | 70-80              | <i>Saxidomus nuttallii</i>  | 3,500 ± 70               | 3,133-2,913   | 3,018                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058187 | CT-2                | 120-130            | <i>Saxidomus nuttallii</i>  | 4,770 ± 90               | 4,798-4,551   | 4,660                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058188 | CT-2                | 130-140            | <i>Macoma</i> sp.           | 7,910 ± 90               | 8,171-7,972   | 8,083                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058189 | CT-6                | 60-70              | <i>Saxidomus nuttallii</i>  | 1,560 ± 70               | 895-737   | 815                           | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058190 | CT-6                | 80-90              | <i>Tresus nuttallii</i>     | 1,280 ± 80               | 640-516   | 580                           | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058191 | CT-9                | 20-30              | <i>Tivela stultorum</i>     | 5,260 ± 80               | 5,448-5,213   | 5,312                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058192 | CT-9                | 60-70              | <i>Saxidomus nuttallii</i>  | 4,810 ± 90               | 4,825-4,581   | 4,704                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058193 | CT-9                | 100-110            | <i>Saxidomus nuttallii</i>  | 4,970 ± 80               | 5,033-4,810   | 4,927                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058194 | CT-10               | 180-190            | <i>Saxidomus nuttallii</i>  | 4,700 ± 80               | 4,694-4,439   | 4,579                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-058195 | CT-10               | 220-230            | <i>Saxidomus nuttallii</i>  | 7,530 ± 90               | 7,799-7,607   | 7,710                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-096187 | S41/E12             | 160-180            | <i>Saxidomus nuttallii</i>  | 5,020 ± 80               | 5,079-4,840<br>5,111-5,098                            | 4,991                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-100105 | N2/E10              | 130-140            | <i>Neverita lewisii</i>     | 4,970 ± 80               | 5,033-4,810   | 4,927                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-100106 | N14/E9              | 90-100             | <i>Saxidomus nuttallii</i>  | 5,450 ± 80               | 5,614-5,429   | 5,515                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-100107 | N2/E1               | 160-170            | <i>Tivela stultorum</i>     | 5,440 ± 80               | 5,605-5,418   | 5,505                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-100108 | S41/E12             | 220-230,<br>Bur 4? | <i>Tivela stultorum</i>     | 5,350 ± 80               | 5,490-5,308   | 5,413                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-103840 | N2/E9               | 60-70              | <i>Tresus nuttallii</i>     | 1,800 ± 90               | 1,166-960   | 1,066                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-103841 | N21/E8              | 50-60              | <i>Balanus</i> sp.          | 5,410 ± 80               | 5,366-5,362<br>5,578-5,389                            | 5,476                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-103842 | S41/D12             | 100-110            | <i>Saxidomus nuttallii</i>  | 5,010 ± 70               | 5,057-4,836   | 4,973                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-103843 | S101/E5             | 40-50              | <i>Neverita lewisii</i>     | 4,040 ± 70               | 3,794-3,585   | 3,683                         | Mikkelsen et al. (2000)    |
| CA-SLO-165 | Beta-103844 | S35.5/W2            | 60-70              | <i>Saxidomus nuttallii</i>  | 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<br>290 ± 35 (Cal B.P.) | Median Probability (Cal B.P.) | Reference               |
|------------|-------------|-----------|---------------------|---------------------------|--------------------------|---|-------------------------------|-------------------------|
| CA-SLO-165 | Beta-103845 | N4/W8     | 40-50               | <i>Tivela stultorum</i>   | 5,500 ± 70               | 5,643-4,745   | 5,570                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-103846 | N2/E1     | 90-100              | <i>Tivela stultorum</i>   | 5,480 ± 70               | 5,625-5,462   | 5,547                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-104334 | S101/E5   | 110-120             | <i>Leukoma staminea</i>   | 7,020 ± 90               | 7,358-7,163   | 7,257                         |                         |
| CA-SLO-165 | Beta-104335 | S36.5/W2  | 110-120             | <i>Neverita lewisi</i>    | 5,060 ± 80               | 5,139-4,912<br>5,194-5,148                            | 5,043                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-104336 | CT-7      | 150-160             | <i>Tivela stultorum</i>   | 5,490 ± 80               | 5,646-5,460   | 5,558                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-104337 | CT-3      | 98                  | <i>Tivela stultorum</i>   | 5,480 ± 70               | 5,625-5,462   | 5,547                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-109160 | CT-8      | 140-150             | <i>Olivella</i> G6 bead   | 2,920 ± 50               | 2,215-2,209<br>2,402-2,240                            | 2,316                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | Beta-109161 | S41/E12   | 150-160,<br>Feat. 3 | <i>Olivella</i> 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<br>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<br>3,492-3,488<br>3,551-3,534             | 3,464                         | Mikkelsen et al. (2000) |
| CA-SLO-165 | UCI-138     | 10W       | 150-160             | <i>Tivela stultorum</i>   | 2,680 ± 130              | 2,191-1,857   | 2,028                         | Breschini et al. (1996) |
| CA-SLO-165 | UCI-139     | P1        | 20-40               | <i>Tivela stultorum</i>   | 4,385 ± 75               | 4,260-4,008   | 4,144                         | Breschini et al. (1996) |
| CA-SLO-165 | UCI-140     | P1        | 60-80               | <i>Tivela stultorum</i>   | 5,115 ± 75               | 5,255-5,010   | 5,112                         | Breschini et al. (1996) |
| CA-SLO-165 | UCI-141     | SB2       |                     | <i>Panopea generosa</i>   | 4,385 ± 75               | 4,260-4,008   | 4,144                         | Breschini et al. (1996) |
| CA-SLO-165 | UCI-142     | 10        | 130-140             | <i>Tivela stultorum</i>   | 5,530 ± 80               | 5,703-5,507   | 5,605                         | Breschini et al. (1996) |
| CA-SLO-165 | UCI-143     | 10        | 180-190             | <i>Tivela stultorum</i>   | 1,790 ± 60               | 1,133-969   | 1,055                         | Breschini et al. (1996) |
| CA-SLO-165 | WSU-4035    | —         | Surface             | <i>Neverita lewissi</i>   | 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             | <i>Tresus nuttalli</i>    | 6,855 ± 50               | 7,170-6,990   | 7,080                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83198   | 2         | 150-160             | <i>Leukoma staminea</i>   | 7,405 ± 40               | 7,630-7,560   | 7,595                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83191   | 3         | 10-20               | <i>Saxidomus nuttalli</i> | 1,630 ± 40               | 930-830   | 880                           | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83192   | 3         | 30-40               | <i>Neverita lewissi</i>   | 7,590 ± 40               | 7,800-7,680   | 7,740                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83193   | 3         | 60-70               | <i>Saxidomus nuttalli</i> | 6,940 ± 40               | 7,240-7,150   | 7,195                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83194   | 3         | 80-90               | <i>Tresus nuttalli</i>    | 6,820 ± 45               | 7,140-6,950   | 7,045                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83195   | 3 Feat. 1 | 90-100              | <i>Tresus nuttalli</i>    | 7,005 ± 40               | 7,290-7,200   | 7,245                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83196   | 3 Feat. 1 | 90-100              | <i>Saxidomus nuttalli</i> | 6,820 ± 50               | 7,150-6,950   | 7,050                         | Jones et al. (2004)     |
| CA-SLO-215 | UCR-83210   | 2         | 160-170             | <i>Leukoma staminea</i>   | 6,825 ± 40               | 7,140-6,970   | 7,055                         | Jones et al. (2004)     |
| CA-SLO-457 | Beta-342993 | NO/W2.5   | 20-30               | <i>Tresus nuttalli</i>    | 1,570 ± 30               | 887-776   | 825                           | Jones et al. (2015)     |
| CA-SLO-457 | Beta-342994 | NO/W2.5   | 60-70               | <i>Ostrea lurida</i>      | 1,510 ± 30               | 811-698   | 763                           | Jones et al. (2015)     |
| CA-SLO-457 | Beta-342996 | N2/E0     | 30-40               | <i>Tresus nuttalli</i>    | 1,510 ± 30               | 811-698   | 763                           | Jones et al. (2015)     |
| CA-SLO-457 | Beta-342995 | N2/E0     | 70-80               | <i>Saxidomus nuttalli</i> | 1,600 ± 30               | 905-799   | 851                           | Jones et al. (2015)     |
| CA-SLO-458 | Beta-202574 | S2/E0     | 60-70               | <i>Saxidomus nuttalli</i> | 4,920 ± 70               | 4,978-4,771   | 4,858                         | Jones et al. (2015)     |
| CA-SLO-458 | Beta-202575 | S0/E0     | 60-82               | <i>Saxidomus nuttalli</i> | 5,010 ± 40               | 5,021-4,864   | 4,956                         | Jones et al. (2015)     |
| CA-SLO-458 | Beta-379949 | TU1       | 30-40               | <i>Tresus nuttalli</i>    | 1,160 ± 30               | 524-459   | 492                           | Jones et al. (2015)     |
| CA-SLO-626 | Beta-327738 | N16/E0    | 30-40               | <i>Saxidomus nuttalli</i> | 1,410 ± 30               | 714-639   | 676                           | Jones et al. (2015)     |
| CA-SLO-626 | Beta-327739 | N18/E0    | 80-90               | <i>Macoma</i> sp.         | 1,180 ± 30               | 536-471   | 506                           | Jones et al. (2015)     |
| CA-SLO-626 | Beta-327740 | S6/E0     | 50-60               | <i>Saxidomus nuttalli</i> | 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<br>290 ± 35 (Cal B.P.) | Median Probability (Cal B.P.) | Reference           |
|------------|-------------|-------|-------------|-------------------------------|--------------------------|---|-------------------------------|---------------------|
| CA-SLO-812 | Beta-202576 | NO/EO | 30-40       | <i>Clinocardium nuttallii</i> | 2,560 ± 50               | 1,958-1,806   | 1,880                         | Jones et al. (2015) |
| CA-SLO-812 | Beta-202577 | NO/EO | 50-60       | <i>Haliotis rufescens</i>     | 2,850 ± 50               | 2,303-2,155   | 2,227                         | Jones et al. (2015) |
| CA-SLO-812 | Beta-204808 | NO/EO | 80-90       | <i>Saxidomus nuttalli</i>     | 4,370 ± 80               | 4,239-3,980   | 4,123                         | Jones et al. (2015) |
| CA-SLO-812 | Beta-202578 | NO/EO | 100-110     | <i>Leukoma staminea</i>       | 7,740 ± 110              | 8,021-7,780   | 7,908                         | Jones et al. (2015) |
| CA-SLO-812 | Beta-202579 | NO/EO | 140-150     | <i>Saxidomus nuttalli</i>     | 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 Archaic 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.<sup>3</sup>), Early (excavation volume = 37.2 m.<sup>3</sup>), and Middle (1.20 m.<sup>3</sup>) 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.<sup>2</sup> 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.<sup>3</sup> 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.<sup>3</sup> 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.<sup>3</sup> The total number of bones in the sample was 11,581, of which 4,393 could only be identified as Actinopterygii.<sup>1</sup> 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.<sup>3</sup> 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.<sup>3</sup>) 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.<sup>3</sup> 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.<sup>3</sup> 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.<sup>3</sup> 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.<sup>3</sup> 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.<sup>3</sup>, 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.<sup>3</sup> (Table 7). For these components, we have summarized the relative proportions of species, density of fish bones within the deposits (NISP/m.<sup>3</sup>), 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 (*Sebastodes* spp.), with fewer than 2% of the remains. Lacking any blind testing, we are not confident that species of *Sebastodes* 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 *Sebastodes* 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

| Taxon                              | Common Name                     | Millingstone/Lower Archaic |         |         |       |       |        | Early   |         |         |         |       |       | Total | %     |
|------------------------------------|---------------------------------|----------------------------|---------|---------|-------|-------|--------|---------|---------|---------|---------|-------|-------|-------|-------|
|                                    |                                 | SLO-165                    | SLO-215 | SLO-812 | Total | %     | SLO-23 | SLO-165 | SLO-458 | SLO-812 | SLO-977 | Total | %     |       |       |
| <b>Elasmobranchiomorpha</b>        | <b>Sharks, skates, and rays</b> |                            |         |         |       |       |        |         |         |         |         |       |       |       |       |
| <i>Heterodontus francisci</i>      | Horn shark                      | 0                          | 0       | 0       | 0     | 0.00  | 1      | 1       | 1       | 0       | 0       | 3     | 0.08  | 3     | 0.06  |
| <i>Isurus oxyrinchus</i>           | 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  |
| <i>Squatina californica</i>        | Pacific angel shark             | 0                          | 2       | 0       | 2     | 0.18  | 9      | 1       | 0       | 2       | 4       | 16    | 0.41  | 18    | 0.36  |
| <i>Rhinobatos productus</i>        | 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  |
| <i>Platyrrhinoidis triseriata</i>  | Thornback                       | 0                          | 1       | 2       | 3     | 0.27  | 23     | 1       | 0       | 0       | 9       | 33    | 0.85  | 36    | 0.72  |
| <i>Myliobatis californica</i>      | 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 |
| <b>Actinopterygii</b>              | <b>Ray-finned fishes</b>        |                            |         |         |       |       |        |         |         |         |         |       |       |       |       |
| <i>Engraulis mordax</i>            | 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 |
| <i>Clupea pallasii</i>             | Pacific herring                 | 0                          | 0       | 1       | 1     | 0.09  | 3      | 0       | 0       | 0       | 0       | 3     | 0.08  | 4     | 0.08  |
| <i>Sardinops sagax</i>             | Pacific sardine                 | 0                          | 2       | 1       | 3     | 0.27  | 3      | 2       | 2       | 0       | 0       | 7     | 0.18  | 10    | 0.19  |
| <i>Merluccius productus</i>        | Pacific hake                    | 0                          | 0       | 0       | 0     | 0.00  | 3      | 15      | 0       | 0       | 15      | 33    | 0.85  | 33    | 0.66  |
| <i>Microgadus proximus</i>         | Pacific tomcod                  | 0                          | 0       | 0       | 0     | 0.00  | 0      | 1       | 0       | 0       | 0       | 1     | 0.03  | 1     | 0.02  |
| <i>Porichthys notatus</i>          | Plainfin midshipman             | 0                          | 5       | 0       | 5     | 0.45  | 0      | 8       | 0       | 0       | 1       | 9     | 0.23  | 14    | 0.28  |
| <i>Porichthys</i> 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 |
| <i>Atherinops affinis</i>          | Topsmelt                        | 0                          | 0       | 0       | 0     | 0.00  | 1      | 3       | 0       | 0       | 0       | 4     | 0.10  | 4     | 0.08  |
| <i>Atherinopsis californiensis</i> | Jacksmelt                       | 0                          | 0       | 0       | 0     | 0.00  | 5      | 0       | 0       | 0       | 25      | 30    | 0.77  | 30    | 0.59  |
| <i>Leuresthes tenuis</i>           | California grunion              | 0                          | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  | 1     | 0.02  |
| Sebastidae                         | Rockfishes                      | 5                          | 8       | 1       | 14    | 1.25  | 179    | 5       | 3       | 2       | 1       | 190   | 4.88  | 204   | 4.07  |
| <i>Hexagrammos</i> sp.             | Greenlings                      | 0                          | 1       | 0       | 1     | 0.09  | 0      | 1       | 0       | 1       | 0       | 2     | 0.05  | 3     | 0.06  |
| <i>Ophiodon elongatus</i>          | 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  |
| <i>Clinocottus analis</i>          | Mosshead sculpin                | 0                          | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Icelinus</i> sp.                |                                 | 0                          | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  | 1     | 0.02  |
| <i>Leptocottus armatus</i>         | Pacific staghorn sculpin        | 1                          | 3       | 1       | 5     | 0.45  | 42     | 1       | 0       | 1       | 55      | 99    | 2.54  | 104   | 2.07  |
| <i>Scorpaenichthys marmoratus</i>  | Cabezon                         | 6                          | 25      | 1       | 32    | 2.86  | 43     | 6       | 0       | 2       | 1       | 52    | 1.34  | 84    | 1.67  |
| <i>Trachurus symmetricus</i>       | 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 |
| <i>Amphisticus rhodterus</i>       | Redtail surfperch               | 0                          | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Amphistichus</i> spp.           |                                 | 0                          | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Cymatogaster aggregata</i>      | Shiner perch                    | 0                          | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Damalichthys vacca</i>          | Pile perch                      | 0                          | 30      | 1       | 31    | 2.77  | 38     | 0       | 0       | 0       | 2       | 40    | 0.10  | 71    | 1.42  |
| <i>Embiotoca jacksoni</i>          | Black perch                     | 0                          | 0       | 0       | 0     | 0.00  | 8      | 0       | 0       | 0       | 0       | 8     | 0.21  | 8     | 0.16  |
| <i>E. lateralis</i>                | Striped seaperch                | 0                          | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  | 1     | 0.02  |
| <i>Embiotoca</i> sp.               | Black or striped seaperch       | 0                          | 1       | 0       | 1     | 0.09  | 16     | 3       | 0       | 0       | 0       | 19    | 0.49  | 20    | 0.39  |
| <i>Hyperprosopon argenteum</i>     | 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

| Taxon   | Common Name                    | Millingsone/Lower Archaic |         |         |       |        | Early  |         |         |         |         | Total | %     |
|---|--------------------------------|---------------------------|---------|---------|-------|--------|--------|---------|---------|---------|---------|-------|-------|
|   |                                | SLO-165                   | SLO-215 | SLO-812 | Total | %      | SLO-23 | SLO-165 | SLO-458 | SLO-812 | SLO-977 | Total | %     |
| <i>Micrometrus minimus</i>                                  | Dwarf perch                    | 0                         | 0       | 0       | 0     | 0.00   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Phanerodon furcatus</i>                                  | White seaperch                 | 0                         | 1       | 0       | 1     | 0.09   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| <i>Rhacochilus taxates</i>                                  | Rubberlip seaperch             | 0                         | 0       | 0       | 0     | 0.00   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| <i>Oxyjulis californica</i>                                 | Señorita                       | 0                         | 0       | 0       | 0     | 0.00   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| Stichaeidae   | Pricklebacks                   | 0                         | 2       | 1       | 3     | 0.27   | 6      | 0       | 0       | 0       | 0       | 6     | 0.15  |
| <i>Cebidichthys violaceus</i>                               | Monkeyface prickleback         | 0                         | 1       | 0       | 1     | 0.09   | 4      | 3       | 0       | 0       | 0       | 7     | 0.18  |
| <i>Xiphister</i> spp.                                       | Rock or black prickleback      | 0                         | 0       | 0       | 0     | 0.00   | 1      | 3       | 0       | 0       | 0       | 4     | 0.10  |
| Clinidae  | Kelp blennies                  | 0                         | 4       | 0       | 4     | 0.36   | 15     | 0       | 0       | 0       | 0       | 15    | 0.39  |
| <i>Gibbonsia</i> sp.  | Kelp fish                      | 0                         | 0       | 0       | 0     | 0.00   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Heterostichus rostratus</i>                              | Giant kelpfish                 | 0                         | 13      | 1       | 14    | 1.25   | 75     | 0       | 1       | 3       | 0       | 79    | 2.03  |
| Gobiidae  | Gobies                         | 0                         | 0       | 0       | 0     | 0.00   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Gillichthys mirabilis</i>                                | Longjaw mudsucker              | 0                         | 1       | 0       | 1     | 0.09   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| <i>Sphyraena argentea</i>                                   | Pacific barracuda              | 0                         | 1       | 0       | 1     | 0.09   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Scomber japonicus</i>                                    | Pacific chub mackerel          | 0                         | 0       | 0       | 0     | 0.00   | 4      | 0       | 0       | 0       | 0       | 4     | 0.10  |
| Pleuronectiformes   | Righteye and lefteye flounders | 0                         | 5       | 0       | 5     | 0.45   | 13     | 1       | 0       | 0       | 0       | 14    | 0.36  |
| <i>Citharichthys</i> sp.                                    | Sanddabs                       | 0                         | 0       | 0       | 0     | 0.00   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Paralichthys californicus</i>                            | California halibut             | 0                         | 0       | 0       | 0     | 0.00   | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  |
| <i>Eopsetta jordani</i>                                     | Petrale sole                   | 0                         | 0       | 0       | 0     | 0.00   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| <i>Parophrys vetulus</i><br>( <i>Pleuronectes vetulus</i> ) | English sole                   | 0                         | 0       | 0       | 0     | 0.00   | 1      | 0       | 0       | 0       | 0       | 1     | 0.03  |
| <i>Platichthys stellatus</i>                                | Starry flounder                | 0                         | 2       | 0       | 2     | 0.18   | 2      | 1       | 0       | 0       | 0       | 3     | 0.08  |
| <b>Subtotal</b>   |                                | 309                       | 557     | 83      | 949   | 84.76  | 2,691  | 273     | 30      | 109     | 144     | 3,247 | 82.49 |
| <b>Grand total</b>  |                                | 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 pricklyback, 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

| Taxon                              | Common Name                     | Middle Period |         |         |       |       | Middle-Late |       | Late   |         |       |       |
|------------------------------------|---------------------------------|---------------|---------|---------|-------|-------|-------------|-------|--------|---------|-------|-------|
|                                    |                                 | SLO-14        | SLO-165 | SLO-812 | Total | %     | SLO-457     | %     | SLO-23 | SLO-626 | Total | %     |
| <b>Elasmobranchiomorpha</b>        | <b>Sharks, skates, and rays</b> |               |         |         |       |       |             |       |        |         |       |       |
| <i>Heterodontus francisci</i>      | Horn shark                      | 4             | 0       | 0       | 4     | 0.16  | 27          | 0.38  | 6      | 1       | 7     | 0.18  |
| <i>Isurus oxyrinchus</i>           | 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  |
| <i>Squatina californica</i>        | Pacific angel shark             | 9             | 0       | 1       | 10    | 0.41  | 34          | 0.48  | 7      | 0       | 7     | 0.15  |
| <i>Rhinobatos productus</i>        | 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  |
| <i>Platyrrhinoidis triseriata</i>  | Thornback                       | 0             | 0       | 2       | 2     | 0.08  | 34          | 0.48  | 29     | 5       | 34    | 0.72  |
| <i>Myliobatis californica</i>      | 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  |
| <b>Actinopterygii</b>              | <b>Ray-finned fishes</b>        |               |         |         |       |       |             |       |        |         |       |       |
| <i>Engraulis mordax</i>            | 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 |
| <i>Clupea pallasii</i>             | Pacific herring                 | 0             | 0       | 0       | 0     | 0.00  | 4           | 0.06  | 6      | 0       | 6     | 0.13  |
| <i>Sardinops sagax</i>             | Pacific sardine                 | 63            | 0       | 0       | 63    | 2.59  | 24          | 0.34  | 19     | 3       | 22    | 0.46  |
| <i>Merluccius productus</i>        | Pacific hake                    | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Microgadus proximus</i>         | Pacific tomcod                  | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Porichthys notatus</i>          | Plainfin midshipman             | 0             | 1       | 0       | 1     | 0.04  | 0           | 0.00  | 2      | 2       | 4     | 0.08  |
| <i>Porichthys</i> 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 |
| <i>Atherinops affinis</i>          | Topsmelt                        | 2             | 0       | 0       | 2     | 0.08  | 4           | 0.06  | 0      | 0       | 0     | 0.00  |
| <i>Atherinopsis californiensis</i> | Jacksmelt                       | 0             | 0       | 0       | 0     | 0.00  | 1           | 0.01  | 0      | 0       | 0     | 0.00  |
| <i>Leuresthes tenuis</i>           | California grunion              | 0             | 0       | 0       | 0     | 0.00  | 1           | 0.01  | 1      | 0       | 1     | 0.02  |
| Sebastidae                         | 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  |
| <i>Clinocottus analis</i>          | Mosshead sculpin                | 2             | 0       | 0       | 2     | 0.08  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Icelinus</i> sp.                |                                 | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Leptocottus armatus</i>         | Pacific staghorn sculpin        | 9             | 1       | 0       | 10    | 0.41  | 38          | 0.54  | 39     | 12      | 51    | 1.08  |
| <i>Scorpaenichthys marmoratus</i>  | Cabezon                         | 88            | 0       | 4       | 92    | 3.79  | 18          | 0.26  | 56     | 7       | 63    | 1.33  |
| <i>Trachurus symmetricus</i>       | 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 |
| <i>Amphisticus rhoderatus</i>      | Redtail surfperch               | 1             | 0       | 0       | 1     | 0.04  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Amphistichus</i> spp.           |                                 | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Cymatogaster aggregata</i>      | Shiner perch                    | 0             | 0       | 0       | 0     | 0.00  | 2           | 0.03  | 0      | 1       | 1     | 0.02  |
| <i>Damalichthys vacca</i>          | Pile perch                      | 10            | 0       | 1       | 11    | 0.45  | 174         | 2.47  | 90     | 4       | 94    | 1.98  |
| <i>Embiotoca jacksoni</i>          | Black perch                     | 1             | 0       | 0       | 1     | 0.04  | 14          | 0.19  | 12     | 2       | 14    | 0.29  |
| <i>E. lateralis</i>                | Striped seaperch                | 2             | 0       | 0       | 2     | 0.08  | 3           | 0.04  | 5      | 2       | 7     | 0.15  |
| <i>Embiotoca</i> sp.               | Black or striped surfperch      | 4             | 0       | 0       | 4     | 0.16  | 163         | 2.32  | 47     | 5       | 52    | 1.09  |
| <i>Hyperprosopon argenteum</i>     | Walleye surfperch               | 0             | 0       | 0       | 0     | 0.00  | 2           | 0.03  | 1      | 0       | 1     | 0.02  |
| <i>Micrometrus minimus</i>         | Dwarf perch                     | 0             | 0       | 0       | 0     | 0.00  | 2           | 0.03  | 0      | 1       | 1     | 0.02  |
| <i>Phanerodon furcatus</i>         | White seaperch                  | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Rhacochilus toxotes</i>         | Rubberlip seaperch              | 0             | 0       | 0       | 0     | 0.00  | 3           | 0.04  | 0      | 0       | 0     | 0.00  |
| <i>Oxyjulis californica</i>        | Señorita                        | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 3      | 1       | 4     | 0.08  |
| Stichaeidae                        | Picklebacks                     | 2             | 0       | 1       | 3     | 0.12  | 0           | 0.00  | 5      | 1       | 6     | 0.13  |
| <i>Cebidichthys violaceus</i>      | Monkeyface pickleback           | 13            | 0       | 0       | 13    | 0.54  | 2           | 0.03  | 2      | 0       | 2     | 0.04  |
| <i>Xiphister</i> spp.              | Rock or kelp picklebak          | 10            | 0       | 0       | 10    | 0.41  | 6           | 0.09  | 1      | 1       | 2     | 0.04  |

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.<sup>3</sup>—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

| 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  |

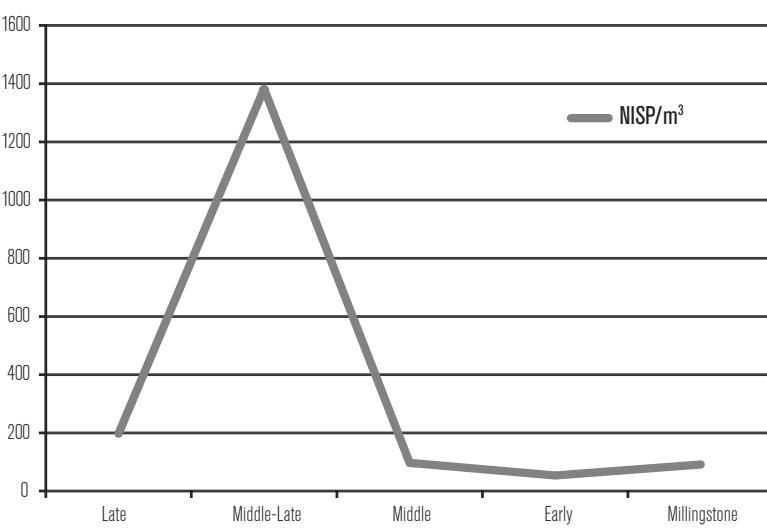


Figure 2. Fish NISP/m<sup>3</sup> 1/8-inch Mesh, Morro Bay Archaeological Sites through Time.

Table 6 (Continued)

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

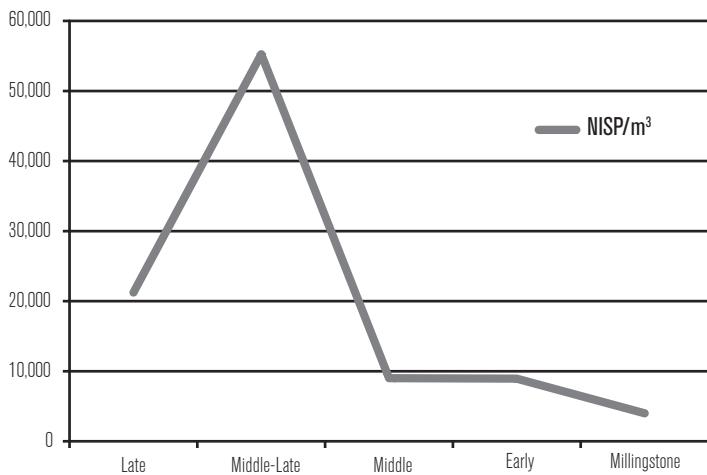
| Taxon   | Common Name                    | Middle Period |         |         |       |       | Middle-Late |       | Late   |         |       |       |
|---|--------------------------------|---------------|---------|---------|-------|-------|-------------|-------|--------|---------|-------|-------|
|   |                                | 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  |
| <i>Gibbonsia</i> sp.  | Kelpfish                       | 1             | 0       | 0       | 1     | 0.04  | 0           | 0.00  | 0      | 1       | 1     | 0.02  |
| <i>Heterostichus rostratus</i>                              | 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  |
| <i>Gillichthys mirabilis</i>                                | Longjaw mudsucker              | 2             | 0       | 0       | 2     | 0.08  | 14          | 0.19  | 5      | 1       | 6     | 0.13  |
| <i>Sphyraena argentea</i>                                   | Pacific barracuda              | 0             | 0       | 0       | 0     | 0.00  | 1           | 0.01  | 0      | 0       | 0     | 0.00  |
| <i>Scomber japonicus</i>                                    | 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  |
| <i>Citharichthys</i> sp.                                    | Sanddabs                       | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 1       | 1     | 0.02  |
| <i>Paralichthys californicus</i>                            | California halibut             | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 1      | 0       | 1     | 0.02  |
| <i>Eopsetta jordani</i>                                     | Petrale sole                   | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 1      | 0       | 1     | 0.02  |
| <i>Parophrys vetulus</i><br>( <i>Pleuronectes vetulus</i> ) | English sole                   | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Platichthys stellatus</i>                                | 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

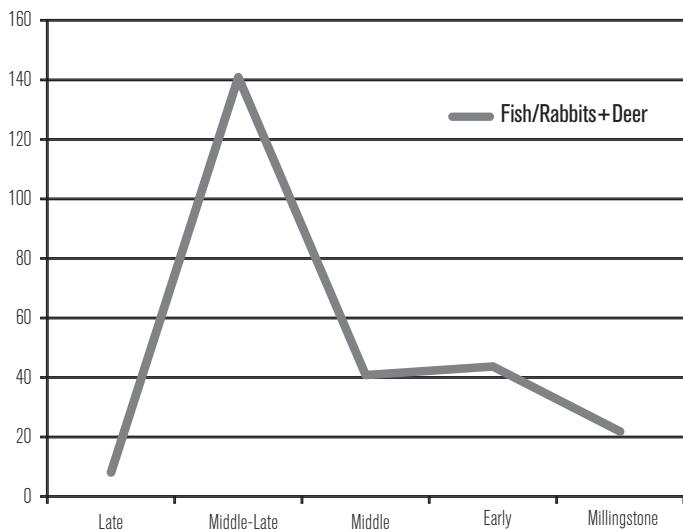
| Taxon                             | Common Name                | Millstone |        |         | Early  |         |       | Middle |         |        |       |       |
|-----------------------------------|----------------------------|-----------|--------|---------|--------|---------|-------|--------|---------|--------|-------|-------|
|                                   |                            | SLO-812   | %      | SLO-812 | SLO-23 | SLO-458 | Total | %      | SLO-812 | SLO-14 | Total | %     |
| Elasmobranchiomorpha              | Sharks, skates, and rays   |           |        |         |        |         |       |        |         |        |       |       |
| <i>Myliobatis californica</i>     | Bat ray                    | 3         | 7.50   | 2       | 0      | 0       | 2     | 1.24   | 3       | 0      | 3     | 2.38  |
| <i>Platyrrhinoidis triseriata</i> | Thornback                  | 0         | 0      | 0       | 1      | 0       | 1     | 0.62   | 0       | 0      | 0     | 0     |
| <i>Rhinobatos productus</i>       | 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          |           |        |         |        |         |       |        |         |        |       |       |
| <i>Engraulis mordax</i>           | 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  |
| <i>Clupea pallasii</i>            | Pacific herring            | 0         | 0      | 0       | 0      | 0       | 0     | 0      | 0       | 2      | 2     | 1.59  |
| <i>Sardinops sagax</i>            | 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 |
| <i>Leptocottus armatus</i>        | Pacific staghorn sculpin   | 4         | 10.00  | 11      | 6      | 1       | 18    | 11.18  | 0       | 0      | 0     | 0.00  |
| <i>Scorpaenichthys marmoratus</i> | 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 |
| <i>Damalichthys vacca</i>         | Pile perch                 | 2         | 5.00   | 2       | 3      | 0       | 5     | 3.11   | 3       | 0      | 3     | 2.38  |
| <i>Heterostichus rostratus</i>    | 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 <sup>3</sup> ) |                            | 0.010     |        | 0.010   | 0.004  | 0.004   | 0.018 |        | 0.010   | 0.004  | 0.014 |       |
| NISP/m <sup>3</sup>               |                            | 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         |
| <b>14,211</b> | <b>100.01</b> | <b>5,015</b>       | <b>19,226</b> | <b>100.02</b> |



**Figure 3. Fish NISP/m<sup>3</sup> 1/16-inch Mesh, Morro Bay Archaeological Sites through Time.**

| Middle-Late |       | Late   |         |        | Grand |        |       |
|-------------|-------|--------|---------|--------|-------|--------|-------|
| SLO-457     | %     | SLO-23 | SLO-626 | Total  | %     | 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 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

**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            |
| <b>Total</b>               | <b>41</b>    |

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 pricklyback (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 9**  
**FISH REMAINS FROM MORRO BAY COMPONENTS BY HABITAT, MILLINGSTONE AND EARLY PERIODS**

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

| Taxon   | Common Name                    | Millingstone |         |         |       |       |        | Early   |         |         |         |       |       | Total | %     |
|---|--------------------------------|--------------|---------|---------|-------|-------|--------|---------|---------|---------|---------|-------|-------|-------|-------|
|   |                                | SLO-165      | SLO-215 | SLO-812 | Total | %     | SLO-23 | SLO-165 | SLO-458 | SLO-812 | SLO-977 | Total | %     |       |       |
| Embiotocidae  | Surfperches                    | 17           | 406     | 24      | 447   | 37.89 | 1,259  | 169     | 9       | 51      | 4       | 1,492 | 36.63 | 1,939 | 36.90 |
| <i>Amphisticus rhoderatus</i>                               | Redtail surfperch              | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Cymatogaster aggregata</i>                               | Shiner perch                   | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Damalichthys vacca</i>                                   | Pile perch                     | 0            | 30      | 1       | 31    | 2.54  | 38     | 0       | 0       | 0       | 2       | 40    | 0.98  | 71    | 1.35  |
| <i>Embiotoca jacksoni</i>                                   | Black perch                    | 0            | 0       | 0       | 0     | 0.00  | 8      | 0       | 0       | 0       | 0       | 8     | 0.20  | 8     | 0.15  |
| <i>Embiotoca</i> sp.  | Black or striped seaperch      | 0            | 1       | 0       | 1     | 0.08  | 16     | 3       | 0       | 0       | 0       | 19    | 0.47  | 20    | 0.38  |
| <i>Phanerodon furcatus</i>                                  | 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  |
| <i>Platichthys stellatus</i>                                | 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 |
| <b>Open Coast</b>   |                                |              |         |         |       |       |        |         |         |         |         |       |       |       |       |
| <i>Heterodontus francisci</i>                               | Horn shark                     | 0            | 0       | 0       | 0     | 0.00  | 1      | 1       | 1       | 0       | 0       | 3     | 0.07  | 3     | 0.06  |
| <i>Isurus oxyrinchus</i>                                    | Shortfin mako                  | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Merluccius productus</i>                                 | Pacific hake                   | 0            | 0       | 0       | 0     | 0.00  | 3      | 15      | 0       | 0       | 15      | 33    | 0.81  | 33    | 0.83  |
| <i>Leuresthes tenuis</i>                                    | California grunion             | 0            | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.02  | 1     | 0.02  |
| <i>Sebastes</i> spp.  | Rockfishes                     | 5            | 8       | 1       | 14    | 1.19  | 179    | 5       | 3       | 2       | 1       | 190   | 4.66  | 204   | 3.88  |
| <i>Hexagrammos</i> sp.                                      | Greenlings                     | 0            | 1       | 0       | 1     | 0.08  | 0      | 1       | 0       | 1       | 0       | 2     | 0.05  | 3     | 0.06  |
| <i>Clinocottus analis</i>                                   | Mosshead sculpin               | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Icelinus</i> sp.   | Sculpin                        | 0            | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.02  | 1     | 0.02  |
| <i>Scorpaenichthys marmoratus</i>                           | Cabezon                        | 6            | 25      | 1       | 32    | 2.71  | 43     | 6       | 0       | 2       | 1       | 52    | 1.28  | 84    | 1.59  |
| <i>Trachurus symmetricus</i>                                | Jack Mackerel                  | 0            | 0       | 0       | 0     | 0.00  | 2      | 0       | 0       | 0       | 0       | 2     | 0.04  | 2     | 0.04  |
| <i>Embiotoca lateralis</i>                                  | Striped seaperch               | 0            | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.02  | 1     | 0.02  |
| <i>Amphistichus</i> spp.                                    |                                | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Hyperprosopon argenteum</i>                              | Walleye surfperch              | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Micrometrus minimus</i>                                  | Dwarf perch                    | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Rhacochilus toxotes</i>                                  | Rubberlip seaperch             | 0            | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.02  | 1     | 0.02  |
| <i>Oxyjulis californica</i>                                 | 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  |
| <i>Cebidichthys violaceus</i>                               | Monkeyface prickleback         | 0            | 1       | 0       | 1     | 0.08  | 4      | 3       | 0       | 0       | 0       | 7     | 0.17  | 8     | 0.15  |
| <i>Xiphister</i> 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  |
| <i>Gibbonsia</i> sp.  | Kelpfish                       | 0            | 0       | 0       | 0     | 0.00  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 0     | 0.00  |
| <i>Heterostichus rostratus</i>                              | Giant kelpfish                 | 0            | 13      | 1       | 14    | 1.19  | 75     | 0       | 1       | 3       | 0       | 79    | 1.94  | 93    | 1.77  |
| <i>Sphyraena argentea</i>                                   | Pacific barracuda              | 0            | 1       | 0       | 1     | 0.08  | 0      | 0       | 0       | 0       | 0       | 0     | 0.00  | 1     | 0.02  |
| <i>Scomber japonicus</i>                                    | Pacific chub mackere l         | 0            | 0       | 0       | 0     | 0.00  | 4      | 0       | 0       | 0       | 0       | 4     | 0.09  | 4     | 0.08  |
| <i>Eopsetta jordani</i>                                     | Petrale sole                   | 0            | 0       | 0       | 0     | 0.00  | 1      | 0       | 0       | 0       | 0       | 1     | 0.02  | 1     | 0.02  |
| <i>Parophrys vetulus</i><br>( <i>Pleuronectes vetulus</i> ) | 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

| Taxon   | Common Name                    | Middle Period |         |         |       |       | Middle-Late |       | Late   |         |       |       |
|---|--------------------------------|---------------|---------|---------|-------|-------|-------------|-------|--------|---------|-------|-------|
|   |                                | SLO-14        | SLO-165 | SLO-812 | Total | %     | SLO-457     | %     | SLO-23 | SLO-626 | Total | %     |
| <b>Bays and Estuaries</b>                                 |                                |               |         |         |       |       |             |       |        |         |       |       |
| <i>Rhinobatos productus</i>                               | Shovelnose guitarfish          | 15            | 0       | 5       | 20    | 0.78  | 59          | 0.82  | 20     | 0       | 20    | 0.41  |
| <i>Platyrrhinoidis triseriata</i>                         | 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 |
| <i>Atherinops affinis</i>                                 | Topsmelt                       | 2             | 0       | 0       | 2     | 0.08  | 4           | 0.06  | 0      | 0       | 0     | 0.00  |
| <i>Atherinopsis californiensis</i>                        | 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  |
| <i>Gillichthys mirabilis</i>                              | Longjaw mudsucker              | 2             | 0       | 0       | 2     | 0.08  | 14          | 0.19  | 5      | 1       | 6     | 0.12  |
| <i>Citharichthys</i> sp.                                  | Sanddabs                       | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 1       | 1     | 0.02  |
| <i>Paralichthys californicus</i>                          | 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 |
| <b>Estuaries and Open Coast</b>                           |                                |               |         |         |       |       |             |       |        |         |       |       |
| 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  |
| <i>Squatina californica</i>                               | Pacific angel shark            | 9             | 0       | 1       | 10    | 0.39  | 34          | 0.47  | 7      | 0       | 7     | 0.14  |
| <i>Myliobatis californica</i>                             | Bat ray                        | 4             | 1       | 20      | 25    | 0.97  | 27          | 0.38  | 27     | 7       | 34    | 0.70  |
| <i>Engraulis mordax</i>                                   | 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 |
| <i>Clupea pallasi</i>                                     | Pacific herring                | 0             | 0       | 0       | 0     | 0.00  | 4           | 0.06  | 6      | 0       | 6     | 0.12  |
| <i>Sardinops sagax</i>                                    | Pacific sardine                | 63            | 0       | 0       | 63    | 2.45  | 24          | 0.33  | 19     | 3       | 22    | 0.45  |
| <i>Microgadus proximus</i>                                | Pacific tomcod                 | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Porichthys notatus</i>                                 | Plainfin midshipman            | 0             | 1       | 0       | 1     | 0.04  | 0           | 0.00  | 2      | 2       | 4     | 0.08  |
| <i>Porichthys</i> sp.                                     | Midshipman                     | 0             | 0       | 0       | 0     | 0.00  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Ophiodon elongatus</i>                                 | 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  |
| <i>Leptocottus armatus</i>                                | 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 |
| <i>Amphisticus rhoderatus</i>                             | Redtail surfperch              | 1             | 0       | 0       | 1     | 0.04  | 0           | 0.00  | 0      | 0       | 0     | 0.00  |
| <i>Cymatogaster aggregata</i>                             | Shiner perch                   | 0             | 0       | 0       | 0     | 0.00  | 2           | 0.03  | 0      | 1       | 1     | 0.02  |
| <i>Damalichthys vacca</i><br>( <i>Rhicochilus vacca</i> ) | Pile perch                     | 10            | 0       | 1       | 11    | 0.43  | 174         | 2.42  | 90     | 4       | 94    | 1.93  |
| <i>Embiotoca jacksoni</i>                                 | Black perch                    | 1             | 0       | 0       | 1     | 0.04  | 14          | 0.19  | 12     | 2       | 14    | 0.29  |
| <i>Embiotoca</i> sp.                                      | Black or striped surfperch     | 4             | 0       | 0       | 4     | 0.16  | 163         | 2.27  | 47     | 5       | 52    | 1.07  |
| <i>Phanerodon furcatus</i>                                | 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  |
| <i>Platichthys stellatus</i>                              | 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 |

## 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.<sup>3</sup> 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

<sup>1</sup>“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).

| 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 |

Table 10 (Continued)

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

| Taxon   | Common Name             | Middle Period |         |         |       |        | Middle-Late |       | Late   |         |       |        |
|---|-------------------------|---------------|---------|---------|-------|--------|-------------|-------|--------|---------|-------|--------|
|   |                         | SLO-14        | SLO-165 | SLO-812 | Total | %      | SLO-457     | %     | SLO-23 | SLO-626 | Total | %      |
| <b>Open Coast</b>   |                         |               |         |         |       |        |             |       |        |         |       |        |
| <i>Heterodontus francisci</i>                               | Horn shark              | 4             | 0       | 0       | 4     | 0.16   | 27          | 0.38  | 6      | 1       | 7     | 0.14   |
| <i>Isurus oxyrinchus</i>                                    | Shortfin mako           | 1             | 0       | 0       | 1     | 0.04   | 0           | 0.00  | 0      | 0       | 0     | 0.00   |
| <i>Merluccius productus</i>                                 | Pacific hake            | 0             | 0       | 0       | 0     | 0.00   | 0           | 0.00  | 0      | 0       | 0     | 0.00   |
| <i>Leuresthes tenuis</i>                                    | California grunion      | 0             | 0       | 0       | 0     | 0.00   | 1           | 0.01  | 1      | 0       | 1     | 0.02   |
| <i>Sebastes</i> spp.  | Rockfishes              | 63            | 0       | 6       | 69    | 2.68   | 44          | 0.61  | 388    | 38      | 426   | 9.12   |
| <i>Hexagrammos</i> sp.                                      | Greenlings              | 25            | 0       | 0       | 25    | 1.01   | 1           | 0.01  | 7      | 1       | 8     | 0.16   |
| <i>Clinocottus analis</i>                                   | Mosshead sculpin        | 2             | 0       | 0       | 2     | 0.08   | 0           | 0.00  | 0      | 0       | 0     | 0.00   |
| <i>Icelinus</i> sp.   |                         | 0             | 0       | 0       | 0     | 0.00   | 0           | 0.00  | 0      | 0       | 0     | 0.00   |
| <i>Scorpaenichthys marmoratus</i>                           | Cabezon                 | 88            | 0       | 4       | 92    | 3.57   | 18          | 0.25  | 56     | 7       | 63    | 1.29   |
| <i>Trachurus symmetricus</i>                                | Jack mackerel           | 0             | 0       | 0       | 0     | 0.00   | 2           | 0.03  | 2      | 0       | 2     | 0.04   |
| <i>Amphistichus</i> spp.                                    |                         | 0             | 0       | 0       | 0     | 0.04   | 0           | 0.00  | 0      | 0       | 0     | 0.00   |
| <i>Embiotoca lateralis</i>                                  | Striped seaperch        | 2             | 0       | 0       | 2     | 0.08   | 3           | 0.04  | 5      | 2       | 7     | 0.14   |
| <i>Hyperprosopon argenteum</i>                              | Walleye surfperch       | 0             | 0       | 0       | 0     | 0.00   | 2           | 0.03  | 1      | 0       | 1     | 0.02   |
| <i>Micrometrus minimus</i>                                  | Dwarf perch             | 0             | 0       | 0       | 0     | 0.00   | 2           | 0.03  | 0      | 1       | 1     | 0.02   |
| <i>Rhacochilus taxates</i>                                  | Rubberlip seaperch      | 0             | 0       | 0       | 0     | 0.00   | 3           | 0.04  | 0      | 0       | 0     | 0.00   |
| <i>Oxyjulis californica</i>                                 | 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   |
| <i>Cebidichthys violaceus</i>                               | Monkeyface prickleback  | 13            | 0       | 0       | 13    | 0.54   | 2           | 0.03  | 2      | 0       | 2     | 0.04   |
| <i>Xiphister</i> 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   |
| <i>Gibbonsia</i> sp.  | Kelp fish               | 1             | 0       | 0       | 1     | 0.04   | 0           | 0.00  | 0      | 1       | 1     | 0.02   |
| <i>Heterostichus rostratus</i>                              | Giant kelpfish          | 6             | 0       | 3       | 9     | 0.35   | 172         | 2.39  | 155    | 99      | 254   | 5.21   |
| <i>Sphyraena argentea</i>                                   | Pacific barracuda       | 0             | 0       | 0       | 0     | 0.00   | 1           | 0.01  | 0      | 0       | 0     | 0.00   |
| <i>Scomber japonicus</i>                                    | Pacific chub mackerel   | 3             | 0       | 0       | 3     | 0.12   | 1           | 0.01  | 7      | 0       | 7     | 0.14   |
| <i>Eopsetta jordani</i>                                     | Petrale sole            | 0             | 0       | 0       | 0     | 0.00   | 0           | 0.00  | 1      | 0       | 1     | 0.02   |
| <i>Parophrys vetulus</i><br>( <i>Pleuronectes vetulus</i> ) | 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 |

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| 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 |

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