Title

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REPORTS

Revisiting the Fish Remains from CA-SLO-2, Diablo Canyon, San Luis Obispo County, California: Searching for the Elusive Wolf-eel (*Anarrhichthys ocellatus*)

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*John Fitch's (1972) report on CA-SLO-2 is perhaps the single most iconic study of fish remains in California. The site was excavated by Roberta Greenwood in 1968, and Fitch devoted over 900 hours to the analysis of (mostly) otoliths from a single column sample, leaving non-otoliths from the column and other remains from the rest of Greenwood's excavations unexamined. For this study, we analyzed the previously unidentified remains (consisting primarily of vertebrae) and compared the results with those from Fitch's otolith study and Greenwood's 6 mm. excavation units. Not surprisingly, we found additional and smaller fishes in the micromesh samples. Since Fitch's report is the only one in California that we are aware of that has identified remains of the wolf-eel (*Anarrhichthys ocellatus*), we sought to determine if the identification of this species was credible. We conclude that prickleback (*Xiphister *sp.) teeth were misidentified as wolf-eel, and consequently that wolf-eel has yet to be documented as a fish used by Native Californians. This is consistent with the general lack of evidence for the exploitation of large and/or pelagic fishes along the central California coast. Furthermore, all three samples suggest that rockfishes (*Sebastes *spp.) and northern anchovy (*Engraulis mordax*) were consistently important to the Diablo Cove fishers. Other small schooling fishes, including herrings (Clupeidae), night smelt (*Spirinchus starksi*), and New World silversides (Atherinopsidae), were important as well, but comparisons between methods and the use of micromesh samples do not necessarily indicate the relative importance of small versus large fish. Diachronic comparisons from all three samples indicate that fishing increased during the Middle Period. Two of the three data sets suggest that fishing then declined at Diablo Canyon during the Late Period.*

Excavations in 1968 at CA-SLO-2, located at Diablo Canyon in San Luis Obispo County, California (Fig. 1), yielded one of the larger trans-Holocene faunal collections from western North America. The site was originally excavated and described by Greenwood (1972), but limited resources prevented a complete analysis of faunal materials. John Fitch, a fisheries biologist with the California Department of Fish and Game, devoted an inordinate effort to the identification of 12,161 fish elements from one column sample (Fitch 1972), leaving most of the larger vertebrate remains unstudied for more than 35 years (Jones et al. 2008). In addition to 13,517 bird, mammal, and non-avian reptile remains, Jones et

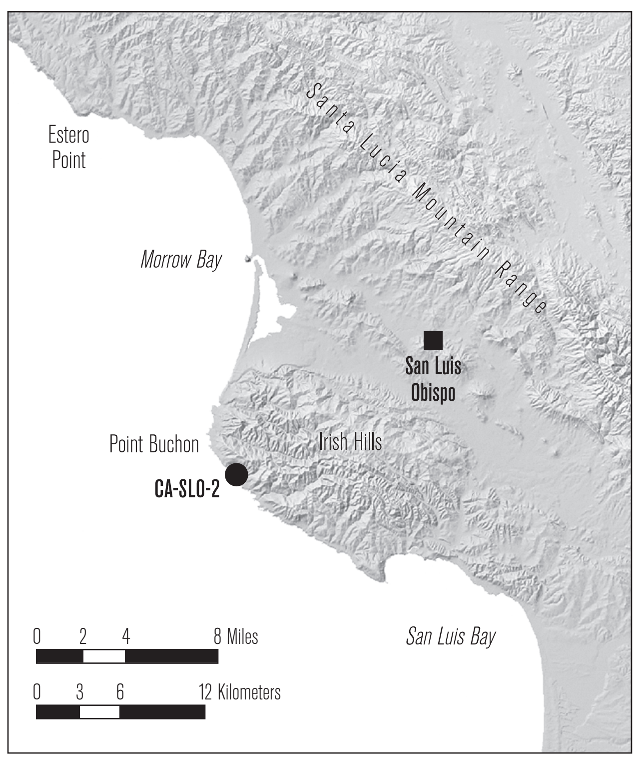

Figure 1. Location of CA-SLO-2.

al. (2008) identified 9,646 fish bones recovered from 30 1 × 2 m. units processed with 1/4 in. [6 mm.] mesh, exclusive of the column sample.

Fitch's iconic study yielded 669 otoliths, 3,166 teeth, 11 scales and dermal denticles, and 8,315 unstudied vertebrae. His identifications benefitted from an independent but parallel survey conducted in 1970 by the California Department of Fish and Game that surveyed the local fishes near Diablo Cove. Fitch spent "just under 900 hours" microscopically examining the materials he recovered from 0.725 m.[3] of matrix that was water-screened through nested 0.5 and 1.0 mm. mesh. He reported a minimum of 40 species belonging to 24 families (Fitch 1972:102; taxonomic names adjusted following Page et al. [2013]). The time spent on the project and the meticulous nature of his evaluation make Fitch's work exemplary not just for the time when it was completed, but for studies of this type in general. The vertebrae that Fitch isolated, but left unstudied, have not been examined in nearly 50 years.

An unusual finding from the Fitch study was his identification of 116 teeth as belonging to wolf-eel (*Anarrhichthys ocellatus*). To our knowledge, this is the only identification of wolf-eel from the California archaeological record (Gobalet 2012:89), despite analyses from the last 50 years of hundreds of thousands of elements from numerous sites spanning the Holocene (e.g., Boone 2012; Gobalet and Jones 1995; Gobalet et al. 2004; Jones et al. 2016a; Joslin 2006, 2010; Rick 2007; Salls 1988; Tushingham and Christiansen 2015; Tushingham et al. 2016). Here we report the results of our analysis of the vertebrae that Fitch did not identify. We approached his collection with two related goals in mind.

Our first goal was to conduct a methodological comparison and characterization of the Diablo Canyon fishing adaptation. The vertebrae reported here provide data for an important comparison between findings derived using three different recovery methods. We sought to compare the results from Fitch's otoliths, our analysis of his previously unidentified vertebrae, and Jones et al.'s (2008) study of all the elements recovered from 6 mm. mesh in terms of the quantity of remains and the diversity of species identified. In this regard, the three reports represent another opportunity to compare micro- versus macro-recovery, an issue that has been addressed repeatedly in the past (e.g., Boone 2012; Jones and Codding 2012; Jones et al. 2016a; Joslin 2012; Moss et al. 2017). The Diablo Cove collection is unusual, however, because it provides for comparison with a sample from extremely small mesh (1 mm. and under).

Using the results from the three studies, we then sought to reconcile the different results in order to characterize the nature of fishing adaptations at Diablo Canyon over time. Rather than assuming that the smallest-mesh sample would necessarily provide a more truthful or accurate assessment of the prehistoric fishery, we attempted to identify patterning that was common to multiple sampling methods. In this regard, it must be recognized that the most important comparisons that can be made for prehistoric fisheries are diachronic ones derived through a single recovery method. Comparisons across methods do not provide any clear or certain assessment of the relative importance of small versus large fishes. Fitch's otolith identifications suggested a continuous incremental increase in fish remains (and fishing) throughout the Diablo Cove sequence, while Jones et al. (2008) suggested a peak in fishing during the Middle Period and a decline thereafter. While neither study demonstrated a definitive qualitative change in fishing, Fitch's results hinted that northern anchovy became more important later in the Holocene. We hoped to resolve these conflicting interpretations utilizing a third set of data.

One additional aspect of the fishing adaptation that we sought to evaluate was the apparent absence of large pelagic fishes in the Diablo Cove sites. Whereas the occurrence of remains of deep water fishes is often touted as evidence for pelagic fishing in the Santa Barbara Channel (e.g., Arnold and Bernard 2005; Bernard 2001, 2004), this resource does not seem to have been exploited on the central coast. Allen and Pondella (2006) identify 19 large fishes as open ocean pelagic species that—with the exception of yellowtail jack and Pacific bonito—are only rarely found in waters over the continental shelf or come inshore. Our working hypothesis regarding these large pelagic fishes was that they were not sought by native fishers along the central coast of California, which is consistent with the notion that this fishery was under-exploited prehistorically (Jones et al. 2016b). Interestingly, this stands in contrast to a recent study from the coast of Chile that provides concrete evidence for the exploitation of pelagic species as early as 7,900 cal B.P. (Béarez et al. 2016).

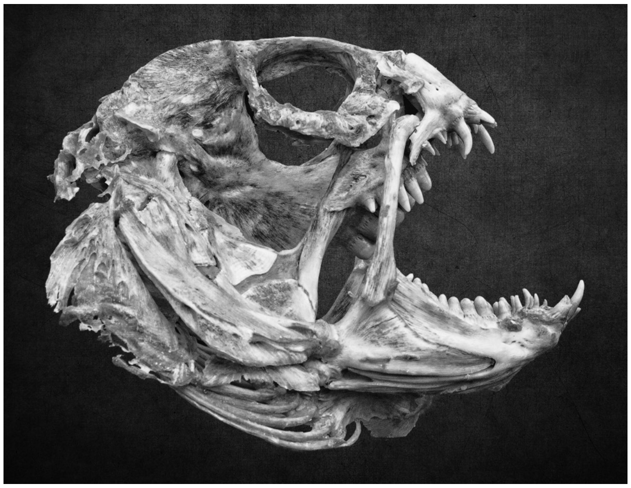

Figure 2. Skull of wolf-eel (*Anarrhichthys ocellatus*) 12 cm. high.

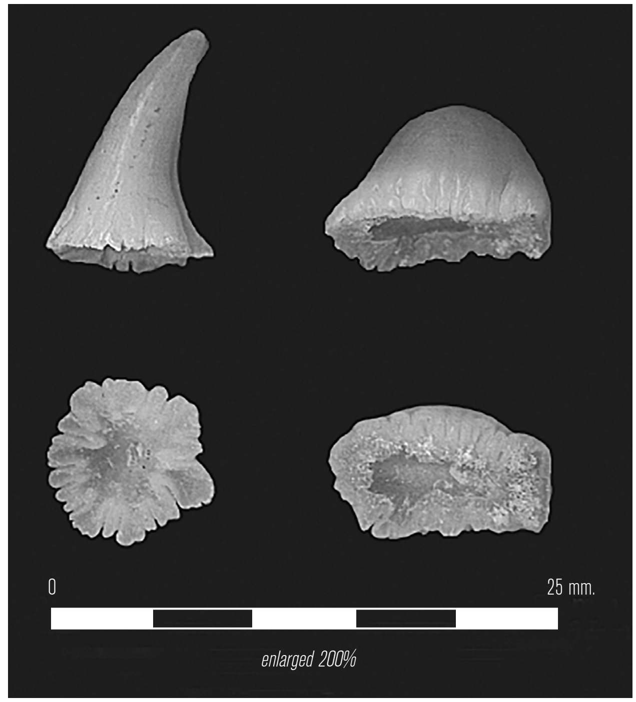

Figure 3. Wolf-eel teeth.

Our second and perhaps most tangible goal was to determine whether wolf-eel was represented among the vertebrae and teeth from any of the CA-SLO-2 samples, in order to confirm or reject Fitch's assignment of 116 teeth to that species. Today the wolf-eel is common from central California northward (Love 2011:367). Wolf-eel remains have been reported from sites in Alaska (Moss 2015), Washington State, and British Columbia (Crockford et al. 1997; Kopperl 2007; Orchard 2007; Wigen 1995), and from a site sampled in the 1970s on the Kamchatka Peninsula of Russia (Michael A. Etnier, personal communication March 27, 2017). Wolf-eel in Washington State was apparently reserved for consumption by Makah shamans (Swan 1868 in Love 2011:468).

For native fishers, the wolf-eel was a potentially large target (reaching 240 cm. in total length), was accessible from shallow water, and was edible (Love 2011; Mecklenburg et al. 2002). Furthermore, it should be relatively easy to identify archaeologically because of its large, distinctive caniniform (over 1.5 cm. long) or molariform (to 1.0 cm. high) teeth (Figs. 2 and 3). The massive teeth and jaws are used to crush the shell of their prey, which includes sea urchins, crabs, clams, sand dollars, snails, and barnacles (Love 2011:468).

METHODS

Fitch (1972)

Greenwood excavated a 50 × 50 cm. column specifically to provide Fitch with a sample to examine for fish remains (Fitch 1972:101). The column was excavated in 10 cm. increments to the base of the midden deposit at a depth of 3 m. At Fitch's request, Greenwood processed the samples through 1/4-inch (6 mm.) mesh, and removed all materials larger than 6 mm. The sediments that passed through the 6 mm. mesh were delivered to Fitch. A mistake in labeling, however, eliminated the 240–250 cm. sample. Fitch then processed each sample with water and bleach through nested 1.0 and 0.5 mm. mesh sieves. Thus, the starting point for the Fitch study was 29 samples, each representing 0.025 m.^{3} of recovery volume containing materials between 0.5 and 6 mm. in size. As noted above, Fitch spent approximately 900 hours sorting fish remains from the residues. He examined all of the materials from the 1.0 mm. mesh but sampled 25 spoonfuls of material from the 0.5 mm. mesh residue of each level. His published findings do not discriminate between remains recovered from the 0.5 mm. versus the 1.0 mm. mesh, hence his sample represents findings from a mix of both mesh sizes. Here we acknowledge this shortcoming, but treat the study as essentially representing recovery with 1.0 mm. mesh.

Fitch did not specifically identify the reference collection he used to compare with the archaeological remains, but he did describe the methods used to inventory the

Diablo Cove fishes by California Department of Fish and Game divers in 1970. The inventory resulted in an extensive collection of fishes, and we can reasonably assume that Fitch extracted otoliths and jaw parts in order to create a reference collection. Fitch also had at his disposal an extensive set of previously-prepared reference specimens, since he had already completed analyses of archaeological remains from sites at Corona Del Mar (Fitch 1967) and Ventura (Fitch 1969). However, it is clear that Fitch was focused almost entirely on otoliths as species-diagnostic elements, having published on their value in "linking the past with the present" as early as 1957 (Fitch 1957). For the CA-SLO-2 study, he identified 665 of 669 otoliths to at least genus level and illustrated many examples with photographs. He apparently also had reference teeth and jaw fragments at his disposal, since he identified 653 of 3,170 such remains from the column sample to at least genus level. However, the large number of teeth and jaw elements (2,517) classified simply as "unidentified teleost," suggests either Fitch's disinterest in or mistrust of the diagnostic utility of such elements. This same opinion seems to have carried over to vertebrae. Fitch recovered 8,315 vertebrae, including ten identified only as "elasmobranch."

Jones et al. (2008)

Jones et al. (2008) reported the results of identifications of 9,646 fish bones as part of a broader study in which they examined all of the faunal remains from Greenwood's 1968 excavation of CA-SLO-2. The fish bones were recovered from 1 × 2 m. units and had not been previously analyzed. In the area of Greenwood's investigations, the site extended to a maximum depth of 3.4 m., although some other areas of the deposit were shallower. A total of 30 1 × 2 m. units was excavated in 10-cm. levels and dry-processed through 6 mm. mesh in the field. Greenwood (1972:5) reported a total recovery volume of 109 m^3, but data from only 98.9 m^3 were available for the 2008 study due to the collection's attrition during its time in storage. The analytical sample included all fish remains (vertebrae, jaws and teeth, otoliths, and scales) recovered from the excavation units processed with 6 mm. mesh. The majority of the collection consisted of vertebrae.

Faunal identifications were made through direct comparison with museum-curated specimens. Gobalet prepared most of the fish skeletons used for our identifications. At the time of the 2008 study these materials were housed at the Department of Biology, California State University, Bakersfield. They were subsequently donated to and now reside in the Ichthyology Department of the California Academy of Sciences (CAS), Golden Gate Park, San Francisco, CA.[1] All specimens were identified to the most discrete taxonomic level possible on the basis of diagnostic features. Attempts were made to identify all potentially diagnostic elements. Identifications were made by Jereme Gaeta, who was trained by Gobalet.[2]

Current Study

Materials from the Fitch study have been housed at the San Luis Obispo County Archaeological Society Curation Facility since their original reporting. One of us (Gobalet) borrowed the previously unanalyzed vertebrae from the facility in 2014. Seven of the 29 original samples were missing (listed in cm.): 30–40, 50–60, 70–80, 90–100, 100–110, 120–130, and 180–190. That left 22 samples representing 0.55 m^3 of recovery volume and a total of 4,222 vertebrae available for identification. As discussed above, the 22 samples had been passed through 1/4-inch (6 mm.) mesh, and all remains larger than 6 mm. were removed; therefore, these samples included vertebrae between 0.5 and 6 mm. in size. Gobalet completed the identifications of all vertebrae. The reference skeletons used for our identifications were the same ones employed in the 2008 study. No effort was made to re-evaluate Fitch's otolith identifications. Given Fitch's experience with that element and his extensive set of reference specimens, there is every reason to believe they were accurate.[2] All specimens were identified to the most discrete taxon possible on the basis of diagnostic features.

While the current study was focused on identifying and quantifying the previously unanalyzed vertebrae, Gobalet also reviewed the teeth and jaw fragments from Fitch's study, since it was those remains that reportedly included wolf-eel. In keeping with the standards of the day, Fitch did not separate or label the otoliths, teeth, or dermal denticles by taxon, so there was no way of knowing his precise designation for any given specimen. In light of this, Gobalet carefully scanned several thousand teeth and jaw elements in the remaining collection looking for elements representing wolf-eel. He did not closely review the entire collection, re-analyze all the elements, or re-quantify, but instead focused on the samples that Fitch had indicated contained wolf-eel teeth.

Available comparative skeletons of wolf-eel are from large individuals, while the teeth that Fitch recovered were from small individuals. To make certain that appropriately-sized individual fish were examined, Gobalet studied the following preserved wolf-eel specimens at the California Academy of Sciences (total length in parentheses): CAS 21954 (430 mm.), CAS 6065 (465 mm.), CAS 21356 (495 mm.), and CAS 213657 (under 400 mm.). In addition, Rick Feeney of the Natural History Museum of Los Angeles County (NHMLA) provided photos of the teeth of a small wolf-eel specimen.

Taxonomic Considerations

Scientific terminology has evolved and changed slightly since Fitch's study was carried out. Here we use scientific and common names (Table 1) that follow the standards of the American Fisheries Society (Page et al. 2013). Kells et al. (2016) and Love (2011) were helpful in establishing which fishes' ranges included Diablo Cove.

Differences of opinion about the accuracy of identifications to a species within some genera based on otoliths and vertebrae are more problematic. Based on otoliths, Fitch was able to distinguish five species of rockfish (*Sebastes* spp.).[3] Gobalet is not confident that the vertebrae of rockfishes are diagnostic beyond the genus. We therefore identified rockfish vertebrae only to *Sebastes* spp. Furthermore, we did not distinguish between Pacific herring and Pacific sardine vertebrae that lacked their neural and hemal spines and cranial-caudal projections, due to their similarity in appearance. The same is true of the vertebrae of the three atherinopsids (jacksmelt, topsmelt, and grunion), multiple species of surfperches, hound sharks, and within the genera *Hexagrammos*, *Clinocottus*, *Icelinus*, *Oligocottus*, *Xiphister*, and *Gibbsonia*.

Revised Chronology

For diachronic comparisons we relied on the vertically-defined temporal components reported by Jones et al. (2008), which were based on 33 corrected and calibrated radiocarbon determinations—with one exception. Because of criticism by Hildebrandt et al. (2010), Jones and Codding (2018) recently modified component definitions at CA-SLO-2, retaining the Middle (2,800–950

Table 1

LIST OF SCIENTIFIC AND COMMON NAMES OF FISHES GENERALLY USED IN THIS PAPER FOLLOWING PAGE ET AL. (2013)

Common Name	Taxon
Cartilaginous Fishes	Elasmobranchiomorphi
Horn Shark	*Heterodontus francisci*
Bigeye Threasher	*Alopias superciliosus*
Common Thresher Shark	*A. vulpinus*
White Shark	*Carcharodon carcharias*
Mackerel Sharks	Lamnidae
Shortfin Mako	*Isurus oxyrinchus*
Salmon Shark	*Lamna ditropis*
Hound Sharks	Triakidae
Soupfish Shark (Tope)	*Galeorhinus galeus*
Gray Smoothhound	*Mustelus californicus*
Leopard Shark	*Triakis semifasciata*
Blue Shark	*Prionace glauca*
Smooth Hammerhead	*Sphyrna zygaena*
Spiny Dogfish	*Squalus suckleyi*
Pacific Angel Shark	*Squatina californica*
Skates and Rays	Rajiformes
Shovelnose Guitarfish	*Rhinobatos productus*
Big Skate	*Beringraja binoculata*
California Skate	*B. inornata*
Longnose Skate	*B. rhina*
Starry Skate	*B. stellulata*
Thornback	*Platyrhinoidis triseriata*
Bat Ray	*Myliobatis californica*
Ray-Finned Fishes	**Actinopterygii**
California Moray	*Gymnothorax mordax*
Northern Anchovy	*Engraulis mordax*
Herrings	Clupeidae
Pacific Herring	*Clupea pallasii*
Pacific Sardine	*Sardinops sagax*
Night Smelt	*Spirinchus starksi*
Opah	*Lampris guttatus*
Pacific Hake	*Merluccius productus*
Spotted Cusk-eel	*Chilara taylori*
Plainfin Midshipman	*Porichthys notatus*
New World Silversides	Atherinopsidae
Topsmelt	*Atherinops affinis*
Jacksmelt	*Atherinopsis californiensis*
California Grunion	*Leuresthers tenuis*
Smallhead Flyingfish	*Cheilopogon pinnatibarbatus*
Scorpionfishes	Scorpaenidae
15 local rockfishes	*Sebastes* sp.

Table 1 (*Continued*)

LIST OF SCIENTIFIC AND COMMON NAMES OF FISHES GENERALLY USED IN THIS PAPER FOLLOWING PAGE ET AL. (2013)

Common Name	Taxon
Greenlings	Hexagrammidae
Kelp or Rock Greenling	*Hexagrammos* sp.
Lingcod	*Ophiodon elongatus*
Sculpins	Cottidae
Coralline Sculpin	*Artedius corallinus*
Padded Sculpin	*A. fenestralis*
Scalyhead Sculpin	*A. harringtoni*
Smoothhead Sculpin	*A. lateralis*
Bonyhead Sculpin	*A. notospilotus*
Woolly Sculpin	*Clinocottus analis*
Calico Sculpin	*C. embryum*
Mosshead sculpin	*C. gobiceps*
Bald Sculpin	*C. recalvus*
Bull Sculpin	*Enophrys taurinua*
Brown Irish Lord	*Hemilepidotus spinosus*
Pacific Staghorn Sculpin	*Leptocottus armatus*
Tidepool Sculpin	*Oligocottus maculosus*
Saddleback Sculpin	*O. rimensis*
Fluffy Sculpin	*O. snyderi*
Cabezon	*Scorpaenichthys marmoratus*
3 local basses	Paralabrax sp.
Kelp Bass	*Paralabrax clathratus*
Barred Sand Bass	*Paralabrax nebulifer*
Ocean Whitefish	*Caulolatus princeps*
Yellowtail Jack	*Seriola lalandi*
Jack Mackerel	*Trachurus symmetricus*
Dolphinfish (Dorado or Mahi Mahi)	*Coryphaena hippurus*
Drums and Croakers	Sciaenidae
White Seabass	*Atractoscion nobilis*
White Croaker	*Genyonemus lineatus*
Queenfish	*Seriphus politus*
Opaleye	*Girella nigricans*
Surfperches	Embiotocidae
Barred Surfperch	*Amphisticus argenteus*
Calico Surfperch	*A. koelzi*
Redtail Surfperch	*A.rhodoterus*
Kelp Perch	*Brachyistius frenatus*
Shiner Perch	*Cymatogaster aggregata*
Pile Perch	*Damalichthys vacca*
Black Perch	*Embiotoca jacksoni*
Striped Seaperch	*E. lateralis*
Walleye Surfperch	*Hyperprosopon argenteum*
Reef Perch	*Micrometrus aurora*

Table 1 (*Continued*)

LIST OF SCIENTIFIC AND COMMON NAMES OF FISHES GENERALLY USED IN THIS PAPER FOLLOWING PAGE ET AL. (2013)

Common Name	Taxon
Rubberlip Seaperch	*Rhacochilus toxotes*
Blacksmith	*Chromis punctipinnis*
Garibaldi	*Hypsypops rubicundus*
Wrasses	Labridae
Señorita	*Oxyjulis californica*
California sheephead	*Semicossyphus pulcher*
Pricklebacks	Stichaeidae
High Cockscomb	*Anoplarchus purpurescens*
Monkeyface Prickleback	*Cebidichthys violaceus*
Crisscross Prickleback	*Plagiogrammus hopkinsii*
Black or Rock Prickleback	*Xiphister* sp.
Penpoint Gunnel	*Apodichthys flavidus*
Wolf-eel	*Anarrhichthys ocellatus*
Kelp Blennies	Clinidae
Spotted Kelpfish	*Gibbsonsia elegans*
Striped Kelpfish	*G. metzi*
Crevice Kelpfish	*G. montereyensis*
Northern Clingfish	*Gobiesox meandricus*
Pacific Barracuda	*Sphyraena argentea*
Mackerels	Scombridae
Skipjack Tuna	*Katsuwonus pelamis*
Pacific Bonito	*Sarda chiliensis*
Pacific Chub Mackerel	*Scomber japonicus*
Albacore	*Thunnus alalunga*
Yellowfin Tuna	*T. albacares*
Bigeye Tuna	*T. obesus*
Pacific Bluefin Tuna	*T. orientalis*
Swordfish	*Xiphias gladius*
Striped Marlin	*Kajikia audax*
Pacific Sanddab	*Citharichthys sordidus*
Speckled Sanddab	*C. stigmaeus*
Longfin Sanddab	*C. xanthostigma*
Arrowtooth Flounder	*Atherestes stomias*
Starry Flounder	*Platichthus stellatus*
Ocean Sunfish	*Mola mola*

cal B.P., 70–200 cm.) and Late periods (550–200 cal B.P., 0–70 cm.) as originally defined, but revising the levels associated with the middle and early Holocene as follows: Initial Early Period, 5,700–5,000 cal B.P., 200–230 cm., and Millingstone/Lower Archaic (10,300–5,700 cal B.P., 230–340 cm.; Table 2).

Table 2

TEMPORAL COMPONENT SUMMARY FOR FISH BONE ANALYSIS FROM CA-SLO-2

Depth (cm.)	Geologic Age	Cultural Period	Radiocarbon Dates (N)	Calendric Age (calibrated B.P.)	Excavation Volume (m.^{3}) Fitch (1972) column sample	Excavation Volume (m.^{3}) Fitch (1972) Column Sample Minus Missing Levels (2017)	Excavation Volume (m.^{3}) Jones et al. (2008)
0–70	Late Holocene	Late Period	3	550–200	0.175	0.125	29.0
70–200	Late Holocene	Middle Period	11	2,800–950	0.325	0.200	49.5
200–230	Middle Holocene	Initial Early	7	5,700–5,000	0.075	0.075	15.0
230–340[a]	Early Holocene	Millingstone/Lower Archaic	13	10,300–5,700	0.125[b]	0.150	5.4
			33		0.700	0.550	98.9

[a] Fitch column extended only to 300 cm.
[b] The 240–250 cm. level was missing for Fitch's study.

RESULTS

During the current study, 4,014 vertebrae were assigned to at least a family, and 208 to the general category of ray-finned fishes (Table 3). Thirty species in 20 families are represented among the vertebrae, with a diversity score of 3.473. Overall, the sample is dominated by northern anchovies (27.2%, Tables 4 and 5) although the two earlier temporal components (Millingstone/Lower Archaic and Initial Early) are dominated by rock or black prickleback (25.7% and 27.1% respectively). The volumetric density of remains from the overall sample was 7,676.4 NISP/m.^{3} while the highest volumetric density for any temporal component was in the Middle Period (12,330 NISP/m.^{3}).

Methodological Comparison

Comparison between the samples shows expected variation. As has been recognized for decades, 6 mm. mesh screens do not retain the remains of diminutive species (see Boone 2012; Butler 1993; Casteel 1972; Fitch 1967; Gobalet 1989; Gordon 1993; James 1997; Jones and Codding 2012; Jones et al. 2016a; Thomas 1969). While the greatest number of fish bones (N=6,070) was identified from the large excavation volume recovered by Greenwood using 6 mm. mesh, that sample produced the lowest number of species (n=23) with the lowest diversity (2.525), and the lowest volumetric density (61.4 NISP/m.^{3}). Rockfishes and cabezon, both of which reach a substantial size, accounted for 81.8% of the sample (Table 6). Northern anchovy, which were abundant among the vertebrae analyzed for the current study, were absent. Greenwood's 6 mm. unit sample also showed the highest volumetric density of remains in the Middle Period component (77.9/m.^{3}). In comparison, among the otoliths, Fitch found 40 species (Table 7) in 24 families and with the highest diversity (n=5.995). These remains were dominated by rockfishes (33%), followed by northern anchovy (26.3%) and night smelt (14.2%). The latter were absent from the 6 mm. remains reported by Jones et al. (2008). The otolith study had a moderate volumetric density of remains (955.7 NISP/m.^{3}) with the highest value (1,148.6 NISP/m.^{3}) being associated with the Late Period component.

Fitch's study was the only one to identify the following: spotted cusk-eel, brown Irish lord, jack mackerel, queenfish, kelp perch, shiner perch, striped seaperch, walleye surfperch, reef perch, criss-cross prickleback, arrowtooth flounder, and five species of rockfishes. Among the teeth and dermal denticles, Fitch (1972) was the only one to report the following as well: gray smoothhound, leopard shark, blue shark, spiny dogfish, a skate, Pacific angel shark, wolf-eel, and starry flounder. Using otoliths, Fitch identified to species fishes that could only be identified to family with vertebrae. This illustrates the value of having a very skilled and experienced individual working with a familiar collection. Jones et al. (2008) was the only study to find shovelnose guitarfish, yellowtail jack, a barred, calico, or redtail surfperch, rubberlip surfperch, Pacific barracuda, ocean sunfish, and a member of the mackerel family. The presence of these species can be attributed to the much larger excavation volume and sample size (n=6,070) with 6 mm. mesh. Our current examination of Fitch's vertebrae was the only

Table 3

SUMMARY OF FISH VERTEBRAE RECOVERED FROM CA-SLO-2

	Depth (cm.)																			
Common Name	0–10	10–20	20–30	30–40 missing	40–50	50–60 missing	60–70	70–80	80–90	90–100, 100–110 tag "removed"	110–120	120–130 otoliths only	130–140	140–150	150–160	160–170	170–180 missing	180–190 missing	190–200	200–210
Cartilaginous Fishes	1																		1	
Hound Sharks																				
Gray Smoothhound																				
Leopard Shark																				
Blue Shark																				
Spiny Dogfish																				
Pacific Angel Shark																				
Skates and Rays																				
Shovelnose Guitarfish																				
Beringraja sp.; 4 poss. Skates																				
Thornback											1									
Bat Ray			1						1		1									
Northern Anchovy	13	14	56				153		159		159		137	30	46	24	46		32	10
Herrings	6	20	20		3		78		92		95		53	23	7	10	14		2	3
Pacific Herring																				
Pacific Sardine	1	2	4		3		8		9		4		7	1	2				1	
Night Smelt	3	4	14		1		38		32		59		46	15	28	19	34		27	5
Pacific Hake							1							1	2					
Spotted Cusk-eel																				
Plainfin Midshipman													1	2	4	4	10		2	2
New World Silversides	2	3	7		1		28		39		58		37	12	21	7	11		6	
Topsmelt			1						2					1						
Jacksmelt																				
California Grunion							2													
Rockfishes, 15 local	7	22	25		3		74		81		61		41	6	7	4	11			1
Greenlings																				1
Kelp or Rock Greenling	1		4		1		3		1		10			1	3	3	4			
Lingcod																				
Sculpins													2						1	
Artedius sp; 6 poss. sculpins					1				1											
Clinocottus sp.; 3 poss. sculpins							5				2		1		4	1				
Bull Sculpin																				
Brown Irish Lord																				
Pacific Staghorn Sculpin													1			1				
Oligocottus sp.; 3 poss. sculpins											1						1			
Cabezon		3	1						7		3		6		1	4	1			
Yellowtail Jack																				
Jack Mackerel																				
Drums and Croakers																				

210–220	220–230	230–240	240–250 missing also by Fitch	250–260	260–270	270–280	280–290	290–300	Total	Fitch (1972) Otoliths	Fitch (1972) Teeth, derm denticles	Jones et al. (2008) 6mm. mesh
				1					**3**			6
												62
											3	
											3	
											1	
											15	
											3	1
												5
												4
											8	
									1			
	1			1					**5**		2	2
38	21	42		51	20	17	17	6	**1,091**	176		
4	5	7		6	5	1	1	3	**458**			10
					1				**1**			
	2	2		1	1		1		**49**	9		1
11	11	22		12	9	2	4	1	**397**	95		
									4	4		25
										1		
4	1	3		4	8	3	5	2	**55**	33		17
7	2	3		6	17	12	10	2	**291**	4		1
									4	12		
				1					**1**			
									2	1		
4	2	4		4		3	1		**361**	221		2,788
						1			**2**			
				1					**32**			44
										2	1	200
		2		1	2	2			**10**			
1	2								**5**			
				1		1			**15**			
	1								**1**			
										1		
		1		2	2		1		**8**	6		
									2			
1	1				1		1		**30**	9		2,176
												1
										1		
					4				**4**			

one to document thornback, Pacific herring, jacksmelt, bull sculpin, blacksmith, high cockscomb, penpoint gunnel, striped kelpfish, a sanddab, and up to nine additional sculpins in the genera *Artedius*, *Clinocottus*, and *Oligocottus*. Most of these are diminutive species whose bones would not be retained in 6 mm. mesh.

Characterizing the Diablo Adaptation Over Time: The Relative Importance of Small Fishes

The three samples vary in the degree to which they shed light on the nature of the Diablo Canyon fishing adaptation, especially with regard to the significance of small fishes.

The large sample from 6 mm. mesh suggests that relatively large fish (rockfish and cabezon) were the primary targets of the Diablo Canyon fishers. The technological evidence available from CA-SLO-2 in the form of circular shell fishhooks (Greenwood 1972:43) seems to support that interpretation, because the majority of the hooks have a fairly large diameter (>2 cm.) and they appear in the archaeological record during the Middle Period, when the remains of rockfishes increase significantly.

Over four thousand vertebrae were found in the 1.0 mm. mesh samples, and 48.5% of these are from fishes that only attain a small maximum size: northern anchovy, herrings, and night smelt (Table 4). Otoliths from these fishes comprise 41.8% of the sample recovered by Fitch, but only 10 otoliths (herrings) were recovered from the 6 mm. mesh remains reported by Jones et al. (2008). There was considerable correspondence between the vertebrae and the otoliths of northern anchovy; these fishes were represented by 27.2% of the vertebrae and 26.3% of the otoliths in the two separate studies. The same was true of night smelt, with 9.9% of the vertebrae and 14.2% of the otoliths. Though those small fishes are consistently represented in the small fraction materials, 11.4% of the vertebrae and only 0.2% of the otoliths are from herrings, leaving us to wonder what happened to most of the herring heads, the portion of the skeleton containing the otoliths?

Northern anchovy are small schooling fishes that are typically found beyond the outer fringes of kelp forests on rocky coasts like that present at Diablo Cove (Fitch 1972:108). They were almost certainly caught with nets employed from watercraft for offshore access.

Table 3 (*Continued*)

SUMMARY OF FISH VERTEBRAE RECOVERED FROM CA-SLO-2

	Depth (cm.)																			
Common Name	0–10	10–20	20–30	30–40 missing	40–50	50–60 missing	60–70	70–80	80–90	90–100, 100–110 tag "removed"	110–120	120–130 otoliths only	130–140	140–150	150–160	160–170	170–180 missing	180–190 missing	190–200	200–210
White Croaker																				
Queenfish																				
Surfperches		4	11		2		13		17		26		24	10	13	3	12		7	
Amphistichus sp.; 3 poss. Surfperches																				
Kelp Perch																				
Shiner Perch																				
Pile Perch																				
Black Perch or Striped Seaperch																				
Striped Seaperch																				
Walleye Surfperch																				
Reef Perch																				
Rubberlip Seaperch																				
Blacksmith																				
Señorita		2	8				26		23		25		15	1			2		2	
Pricklebacks									10		6		5	4			4			
High Cockscomb		1							2		1						1			
Monkeyface Prickleback	1	2					1		8				1				4			1
Crisscross Prickleback																				
Black or Rock Prickleback	5	22	33		2		47		41		66		76	42	55	37	44		31	13
Penpoint Gunnel							1		1		2		2							
Wolf-eel																				
Kelp Blennies		1																		
Gibbsonia sp. 3 poss. Kelpfish			5				6		1		2		4	2	2				1	
Striped Kelpfish						1														
Northern Clingfish	1	1					2		2		4	1	3		3	1	4		2	
Pacific Barracuda																				
Scombridae; 9 poss. Mackerel or Tuna																				
Citharichthys sp., 3 poss. sanddabs																				
Arrowtooth Flounder																				
Starry Flounder																				
Ocean Sunfish																				
Ray-Finned Fishes	3	12	6				21		26		26		17	7	5	6	14		3	5
Total	**44**	**113**	**196**		**17**		**507**		**555**		**612**		**479**	**158**	**203**	**124**	**217**		**118**	**41**
# of Vertebrae reported by Fitch (1972)	44	116	188		553		512		563		619		480	190	205	126	220		120	31

Though northern anchovy are caught using hook and line today, Bertrando and McKenzie (2012) argue that Native Californians lacked the tiny hooks necessary for their capture. Fitch (1972:108) could not accept the likelihood that watercraft were employed in this manner, and argued instead that these and other small fishes reached the site as gut contents of large predatory vertebrates. However, he did not consider the possibility that poisons could have

210–220	220–230	230–240	240–250 missing also by Fitch	250–260	260–270	270–280	280–290	290–300	Total	Fitch (1972) Otoliths	Fitch (1972) Teeth, derm denticles	Jones et al. (2008) 6mm. mesh
										1		3
										1		
10	8	5		11	8	9	10	3	**206**	35	438	227
												1
										1		
										12		
										7	59	13
												4
										9		
										6		
										1		
												2
							1		**1**			
5				1	1	2	3	1	**117**		5	
									29			357
		1							**6**			
									18	5		13
										3		
23	37	42		36	25	24	21	9	**731**	10	1	104
									6			
											116	
					2				**3**			
		2		3			1		**29**			
					1				**2**			
4	2	3			2				**35**	3		
												1
												1
				1					**1**			
										1		
											1	
												1
7	13	3		14	5	8	7		**208**	4	2,517	
119	**109**	**142**		**158**	**114**	**85**	**84**	**27**	4,222			**6,070**
121	111	139		129	118	88	87	27	**4,787**	536	4,251	

been used to stun or kill fish (see Starkey 2014:5). Such poisons could be derived from wild cucumber (*Marah* spp.), soaproot (*Cholorgalum pomeridianum*), buckeye (*Aesulyus californica*), and turkey mullein (*Eremocarpus*

Table 4

PERCENTAGE OF SAMPLES OF DOMINANT FISHES IN THREE SEPARATE STUDIES FROM CA-SLO-2

	Vertebrae This Study		Otoliths Fitch (1972)		6 mm. Remains Jones et al. (2008)	
Fish	**N**	**%**	**N**	**%**	**N**	**%**
Northern Anchovy	1,091	27.2	176	26.3	0	0.00
Herrings	458	11.4	9	1.3	10	0.20
Night Smelt	397	9.9	95	14.2	0	0.00
Plainfin Midshipmen	55	1.4	33	4.9	17	0.30
New World Silversides	291	7.2	4	0.6	1	<0.01
Rockfishes	361	9.0	221	33.0	2,788	45.90
Lingcod	0	0.0	2	0.3	200	3.30
Cabezon	30	0.7	9	1.3	2,176	35.80
Surfperches	206	5.1	44	6.6	225	3.70
Señorita	117	2.9	0	0.0	0	0.00
Black/Rock Prickleback	731	18.2	10	1.5	104	1.70
Other	277	6.9	74	11.1	549	9
Total	**4,014**	**100**	**669**	**100**	**6,070**	**100**

setigerus). Ethnographically, soaproot was reported to have been used for such a purpose by Chumash speakers (Timbrook 2007:56) and other Native California groups (Mead 2003:162). Wild cucumber was used by the Pomo to poison fish in tidepools (Mead 2003:367). Furthermore, if the small fishes were gut contents of predators, the number of elements should reflect this, with corresponding numbers of otoliths and vertebrae. Northern anchovy have 43 to 47 vertebrae, night smelt 60 to 64, and Pacific sardine 48 to 54 (Mechlenburg et al. 2002). Though each individual fish will have two sagittae (otoliths), only 27% of the number of vertebrae to be expected were present from northern anchovy and 13% from night smelt, but twice the number of herring vertebrae were present. This suggests that at least some of the small fishes were targeted for consumption and were not gut contents of predatory mammals, birds, or larger fishes. The artifact record does not provide clear support for the netting of northern anchovies until the Middle Period, when notched stones, likely used as net weights, appear (Greenwood 1972:34). Nonetheless, these fishes are present in significant quantities throughout the CA-SLO-2 sequence represented in two of the three samples (otoliths and the current vertebrae study).

Table 5

SUMMARY OF PREVIOUSLY UNIDENTIFIED FISH VERTEBRAE FROM FITCH'S (1972) 50 x 50 cm. COLUMN SAMPLE (1 mm. MESH)

Cultural Period	Excavation volume (m.^{3})	NISP (vertebra)	N Species	NISP/m.^{3}	Dominant taxon (NISP)	NISP	%	Secondary Taxon	NISP	%	Margolef diversity
Late Period	0.125	877	24	11,896.0	Northern anchovy	236	26.9	Rockfishes	131	14.9	3.394
Middle Period	0.200	2,466	27	12,330.0	Northern anchovy	633	25.7	Rock or black prickleback	392	15.9	3.329
Initial Early	0.075	269	17	3,586.7	Rock or black prickleback	73	27.1	Northern anchovy	69	25.7	2.860
Millingstone/ Lower Archaic	0.150	610	27	4,066.7	Rock or black prickleback	157	25.7	Northern anchovy	153	25.1	4.054
	0.550	4,222	30	7,676.4		1,099	26.0		745	17.6	3.473

Table 6

SUMMARY OF FISH REMAINS FROM GREENWOOD'S (1972) 1 x 2 M UNIT EXCAVATIONS (6 mm. [1/4 INCH] MESH) FROM JONES ET AL. (2008)

Cultural Period	Excavation volume (m.^{3})	NISP	# Species	NISP/m.^{3}	Dominant Fsh	NISP	%	Secondary Fish	NISP	%	Margolef diversity
Late Period	29.0	1,811	15	62.4	Rockfishes	961	53.1	Cabezon	587	32.4	1.866
Middle Period	49.5	3,855	23	77.9	Rockfishes	1,733	44.9	Cabezon	1,372	35.6	2.664
Initial Early	15.0	168	8	11.2	Cabezon	98	58.3	Rockfishes	38	22.6	1.366
Millingstone/ Lower Archaic	5.4	236	15	43.7	Cabezon	119	50.4	Rockfishes	58	24.5	2.562
	98.9	6,070	23	61.4		2,911	47.9		2,055	33.9	2.525

Table 7

SUMMARY OF FITCH'S (1972) ANALYSIS OF OTOLITHS FROM 0.5 x 0.5 COLUMN SAMPLE (1 mm. MESH), CA-SLO-2

Cultural Period	Excavation volume (m.^{3})	NISP (Otoliths)	NISP/m.^{3}	# Species	Dominant Fsh	NISP	%	Secondary Fish	NISP	%	Margolef diversity
Late Period	0.175	201	1,148.6	16	Rockfishes	101	50.2	Northern anchovies	44	21.9	2.828
Middle Period	0.325	357	1,098.5	22	Northern anchovies	104	29.1	Rockfishes	90	25.2	3.573
Initial Early	0.075	38	506.6	9	Northern anchovies	14	36.8	Rockfishes	11	28.9	2.199
Millingstone/ Lower Archaic	0.125	73	584.0	13	Rockfishes	19	26.0	Northern anchovies	14	19.2	2.797
	0.700	669	955.7	40		238	35.6		159	23.8	5.995

Night smelt are small fish whose remains are typically rare in archaeological materials recovered without a fine-screen analysis. They have only been found locally at other sites where mesh smaller than 3 mm. was employed (e.g., CA-SLO-56; Jones 2012). The importance of the true smelt (family Osmeridae) has been well documented in northwestern California (Tushingham and Bencze 2013; Tushingham and Christiansen 2015; Tushingham et al. 2016) and southwestern Oregon (Moss et al. 2017), and the fact that they represent 9.9% and 14.2% respectively of the vertebrae and otoliths from CA-SLO-2 lends support to their likely importance to the coastal Indians of central California (as suggested by Lightfoot and Parrish 2009). Night smelt spawn in the surf zone at night and are typically taken with A-frame nets from shore (Lombard (2016:27). Fitch (1972:110) stated that the CA-SLO-2 otoliths showed signs of digestive action, indicating that they came to the site in the stomachs of larger animals. It is unclear what those signs were and how much such evidence was identified. Still, accepting Fitch's assessment at face value

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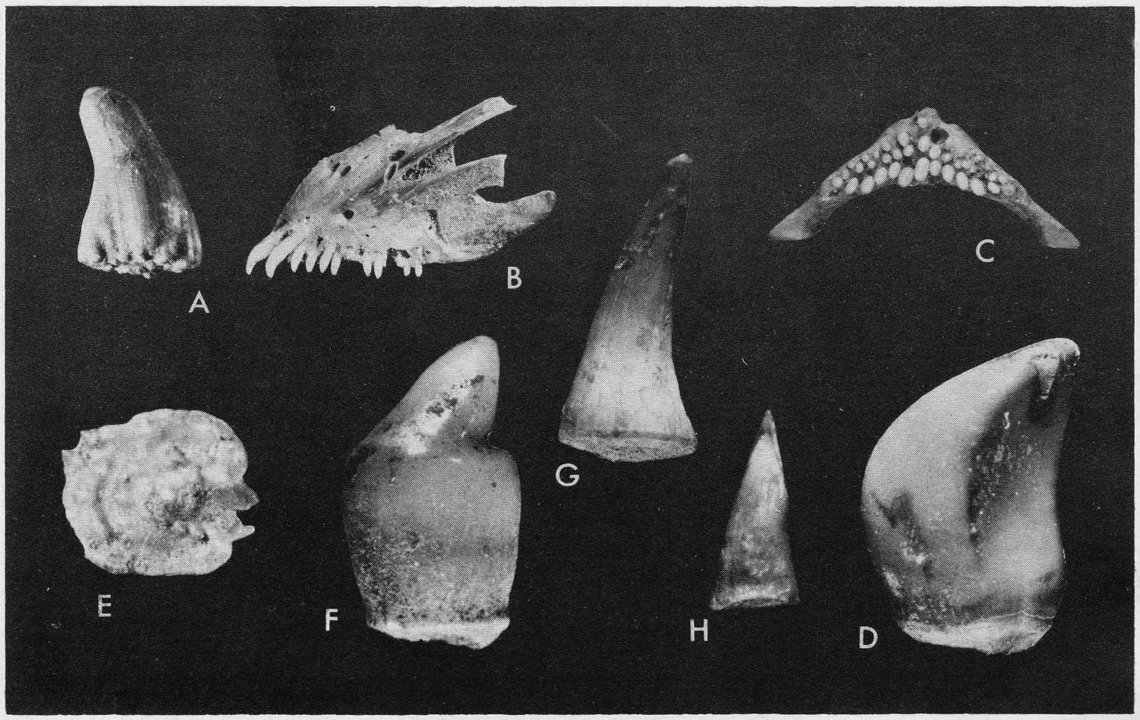

Figure 3. Teleost teeth, a jaw and a scale found in SLO-2. Names of fishes, dimensions of tooth, jaw, or scale, and midden increments are: a) wolf-eel, 2.5 mm high, 280-290 cm; b) senorita upperjaw, 7.8 mm long, 50-60 cm; c) senorita fused pharyngeal, 6.1 mm across, 50-60 cm; d) pile perch pharyngeal tooth, 5.2 mm high, 120-130 cm; e) starry flounder scale, 2.0 mm long, 120-130 cm; f) striped seaperch pharyngeal tooth, 3.4 mm high, 120-130 cm; g) lingcod tooth, 7.5 mm high, 120-130 cm; h) unknown jaw tooth, 2.1 mm high, 130-140 cm.

Figure 4. From Fitch 1972:119. Fitch identified 'A' as wolf-eel tooth.

suggests that some of the remains of this species may have been stomach contents. However, we did not note any digestive corrosion on the vertebrae that we evaluated.

Herrings and New World silversides are also underrepresented in the 6 mm. sample because of their small size, but their relative importance is less clear, since they are represented by only 0.2% and <0.01% respectively of the otoliths. They are represented among the vertebrae in the current study by more substantial percentages: 11.4% and 7.2% respectively.

One curiosity of the archaeological record that we report here is that the large elements reported by Jones et al. (2008) included no plainfin midshipmen following the Middle Period. Fitch's fine-grained evaluation, however, demonstrates that they were present into the Late Period. This illustrates the importance of complementing large-mesh-based studies with more fine-grained ones before conclusions are reached about possible extirpation or limited availability.

Wolf-eel Remains

Despite Fitch reporting the presence of wolf-eel teeth in 21 of 29 excavation levels, neither we nor Jones et al. (2008) identified any wolf-eel vertebrae. An individual wolf-eel contains over 221 vertebrae (Mecklenburg et al. 2002:782), and they are durable. Significantly, Fitch (1972) did not identify any wolf-eel otoliths. Gobalet's review of the teeth and jaw fragments from Fitch's study also revealed no wolf-eel elements. The absence of wolf-eel remains among the vertebrae, the remains previously reported by Jones et al. (2008), the otoliths so thoroughly examined by Fitch, and the re-examination of the teeth and jaws, leads us to conclude that it is highly unlikely that wolf-eel is represented among the CA-SLO-2 remains. Therefore, Fitch likely erred in his identification of teeth assigned to that fish. A tooth illustrated by Fitch (1972; Fig. 4a) that he attributed to wolf-eel supports this conclusion. Our assessment is that the image depicts a black or rock prickleback tooth. We identified the vertebrae of rock or black prickleback in all the levels in which Fitch reported the teeth of wolf-eel. We thus found no evidence for the presence of wolf-eel among the archaeological materials from CA-SLO-2.

SUMMARY AND DISCUSSION

We have compared the results from two previous studies of fish remains from CA-SLO-2—one involving a 1.0 mm. micro-sample focusing on otoliths (Fitch 1972) and the second a 6 mm. macro-sample reported by Jones et al. (2008)—with those from our own analysis of 4,014 previously unanalyzed vertebrae from the same site (also recovered using 1.0 mm. mesh). Not surprisingly, the smaller-mesh recovery method produced more remains overall, more remains of small fishes, and greater species diversity. The macro-sample suggests that relatively large fish (rockfish and cabezon) were the primary targets for Diablo Canyon fishers while the smaller-mesh samples highlight diminutive schooling species: northern anchovies, herrings, night smelt, and New World silversides. In his initial study, Fitch (1972) speculated that the presence of the smallest fishes represented the stomach contents of large predatory vertebrates. We find other explanations for the presence of small fishes in the CA-SLO-2 midden more compelling, but the question of which of the three samples most accurately represents the Diablo Canyon fishing adaptation remains. We do not entirely accept the premise—implicit in some evaluations of the effects/biases of different screen sizes—that smaller mesh somehow results in greater accuracy than can be achieved with large mesh. The findings from CA-SLO-2 involving micro-mesh show that the diminutive species were almost certainly part of the prehistoric fishery, but their importance relative to the larger fishes is by no means clear. The tiny fishes are numerically more abundant, but it obviously takes many smaller fishes to equal the dietary value of a larger rockfish or cabezon. A typical night smelt, for example, weighs ca. 28 grams (Fitch 1972:110), while most adult rockfish exceed 0.9 kg. (Fitch 1972:112).

Despite the fact that Fitch's samples did not include any elements greater than 6 mm. in size, rockfishes are still represented in meaningful numbers, especially among the otoliths where they are the most numerous elements (33%). That rockfishes dominate both the macro- (>6 mm.) and one of the micro-samples suggests that they may well have been the single most important fish targeted by the inhabitants of CA-SLO-2. With respect to trends over time, all three samples show that the remains of fish increased substantially at the onset of the Middle Period. However, the current analysis of vertebrae and the results from the 6 mm. mesh show that the highest volumetric density of fish remains occurs in the Middle Period component, followed by a decrease in the Late Period component (Tables 5 and 6). This is at odds with Fitch's study which shows the highest volumetric density of otoliths occurs in the Late Period component (Table 7). Since two out of the three analyses suggest a decline during the Late Period, we suggest that that is the more likely pattern. All of the data sets show significant increases at the onset of the Middle Period in the quantities of fish bone present, and it is clear that fishing increased in importance on the Diablo Cove coast at this time. The artifact record that shows shell fishhooks appearing at the same time also supports this conclusion. None of the studies show major species variation over time, but rockfish and northern anchovies represent significant proportions of the remains in at least two of the three analyses. Both of these fishes seem to have been important throughout the sequence, although the artifact record only provides corroborating evidence for the use of nets beginning in the Middle Period.

Teeth attributed by Fitch to wolf-eel were apparently misidentified. This leads us to conclude that remains of the wolf-eel are entirely absent from the archaeological record of California. This absence can almost certainly be explained by the tendency of this fish to create havoc for those attempting to land them. A commercial fisherman at Morro Bay (personal communication to Gobalet, November 29, 2014) stated that he had caught a wolf-eel while fishing for rockfishes, cabezon, and lingcod. He set a line with five hooks on a cable and the wolf-eel took one hook and became tangled in the line and all five hooks. Love (2011:468, citing Carl 1964) relates that a commercial fisherman in British Columbia was painfully bitten on the ankle through his hip-waders by a wolf-eel. This aggressive fish was likely perceived as something to be avoided by some Native Americans. We also wonder how well the bone barbs and shell fishhooks used for line fishing off the California coast would have held up to the robust jaws of the wolf-eel (see Fig. 2).

The absence of wolf-eel from CA-SLO-2 is consistent with the general absence of evidence for the exploitation of very large fishes from pelagic contexts off the central California coast. With the exception of a single blue shark tooth recorded by Fitch, none of the 19 large fishes that Allen and Pondella (2006) identify as open ocean pelagic species (Table 8) are represented among the remains from CA-SLO-2. Clearly, no offshore fishery is represented at CA-SLO-2. Other large fishes that are rare or undocumented from the hundreds of sites summarized by Gobalet and Jones (1995), Gobalet (2000), Gobalet et al. (2004), Jones et al. (2016a) and Turnbull et al. (2015) include the giant sea bass and the open ocean pelagic fishes listed in Table 8. Except for yellowtail jack and Pacific bonito that also come inshore, Allen and Pondella (2006) define this group as only rarely found in waters over the continental shelf. There is no documentation of the exploitation of opah, dolphinfish, smooth hammerhead, or bigeye thresher by the native people in California, although there is now a fairly robust offshore fishery for opah (Love 2011:158). Dolphinfish are found in small schools associated with floating kelp, logs, and other flotsam off shore (Fitch and Lavenberg 1971:57), but juveniles occasionally come into estuaries and harbors and most of those taken today in the waters of southern California are under a year of age (Love 2011:375–376).

Giant sea bass can weigh 256 kg. and reach 226 cm. in length (Love 2011:354, 538). They are rare in the archaeological record and none are known north of Pt. Conception, although they range as far as Humboldt Bay. Canon (1953:248) states that they are caught on the bottom near kelp beds and recommends the use of heavy tackle, 72-pound-test line, and a chain leader—in other words, very robust equipment.

We suggest that the rarity of these massive fishes in the archaeological record is a reflection of the challenging nature of capturing and harvesting them from offshore waters using inadequate gear. We feel that the paucity of an archaeological record for these large fishes suggests that the Native Americans in central California were keenly aware of the problems associated with their capture. From this we infer that the utilization of truly open-ocean environments off central coastal California was minimal, and that the offshore fishery was under-utilized, as has been previously suggested (Jones et al. 2016b).

Table 8

OPEN OCEAN PELAGIC FISHES FROM ALLEN AND PONDELLA (2006:89)

Common Name	Taxon	Cited In	Max. Wt. (kg.)
Bigeye Thresher	*Alopias superciliosus*		364
Common Thresher Shark	*Alopias vulpinus*	B	348
White Shark	*Carcharodon carcharias*	B, C	1,554
Shortfin mako	*Isurus oxyrinchus*	B, C, D	555
Salmon Shark	*Lamna ditropis*	B	220
Soupfin shark (Tope)	*Galeorhinus galeus*	B, C, D	45
Blue Shark	*Prionace glauca*	A, B, D	240
Smooth Hammerhead	*Sphyrna zygaena*		400
Opah	*Lampris guttatus*		270
Yellowtail Jack	*Seriola lalandi*	A, B, C, D	42
Dolphinfish	*Coryphaena hippurus*		46
Skipjack Tuna	*Katsuwonus pelamis*	D	34
Pacific Bonito	*Sarda chiliensis*	B, C	11
Albacore	*Thunnus alalunga*	A, B	41
Yellowfin Tuna	*T. albacares*		182
Bigeye Tuna	*T. obesus*		210
Pacific Bluefin Tuna	*T. orientalis*		555
Swordfish	*Xiphias gladius*	B, C	650
Striped Marlin	*Kajikia audax*		440

Maximum weights are from Love (2011).
Sources A: Gobalet and Jones (1995); B: Gobalet 2000; C: Gobalet et al. (2004), D: Turnbull et al. (2015).

In light of this conclusion, we further suggest that possible archaeological evidence of fishing for large individual fishes needs to be well documented. Most of the remains represented at CA-SLO-2 are from rockfishes and small schooling northern anchovy, night smelt, Pacific sardine or Pacific herring, and New World silversides. While some of the latter would likely have been taken with nets from watercraft, they would not have required travel much beyond the outer edge of kelp forests. Because of the nearly complete absence of pelagic fishes, the archaeological remains from CA-SLO-2 indicate an exclusively near-shore fishery, as Fitch (1972) originally suggested.

NOTES

[1] We did not possess skeletons of all species that were noted in the survey of Diablo Cove (Fitch 1972:120). Excluding rockfishes, we lacked 12 of those species.

[2] Gobalet (2001) documented the variability in an expert evaluation of the same archaeological sample. Both this

evaluation and that reported by Jones et al. (2008) were independent of the study Fitch published 46 years ago. Jereme Gaeta, a coauthor of the 2008 study, was responsible for the fish identifications. At the time he was an undergraduate student who worked in Gobalet's lab. Jones et al. (2016a) stress the importance of using the identifications of a single specialist for consistency. The data presented here and by Jones et al. (2008) used the same diagnostic criteria for designation.

[3]Some concerns have also been raised about the accuracy of rockfish otolith identifications to species (Turnbull et al. 2015:83).

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