AN ICTHYOARCHAEOLOGICAL STUDY OF DIETARY CHANGE IN THE CALIFORNIA DELTA, CONTRA COSTA COUNTY

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This paper presents the results from a diachronic study of fish remains from two neighboring archaeological mound sites in Contra Costa county, Hotchkiss Mound (CA-CCO-138; 850–450 cal BP) and Simone Mound (CA-CCO-139; 1200–950 cal BP). A previous study (Eerkens and Bartelink, in review) using stable isotope data from individual burials suggested dietary differences between these two sites. This study examines fish remains as a potential source of these dietary differences. Fish remains from shovel probes were identified and quantified. Results indicate that both assemblages are dominated by Sacramento perch (30% and 36%, respectively) and minnows (chub, hitch, pikeminnow; 65% and 57% respectively). Similarities in the ichthyofaunal assemblages suggest that the fish species consumed remained relatively consistent between the Middle and Late Periods, indicating that variation in human bone collagen stable isotope values was not likely driven by differences in the species of fish consumed.

The Sacramento-San Joaquin Delta (or the California Delta) is an expansive inland river delta and estuary system. Although this region has rich biodiversity in mammals and birds, the Delta is especially known for its diverse and unique ichthyofaunal communities, which are composed of freshwater, anadromous, and euryhaline species. Although certain species are present year-round, others are seasonally available, during migration and/or spawning events. Prehistoric hunter gatherers, who occupied the Delta for millennia, took full advantage of the ichthyofaunal resources available to them, as is evident from rich fish collections from midden deposits and settlement locations. This study focuses on how fishing strategies in the Delta changed from the Middle Period (1200–950 cal BP) to Late Period (850–450 cal BP). As indicated by the number of dated site components and burials, this transition is marked by an increase in population size (Milliken and Bennyhoff 1993; Rosenthal et al., 2007), which could have resulted in intensified fishing and the investment of new fishing technologies.

We contrast human bone collagen isotopic data (Eerkens and Bartelink, in review) with the ichthyofaunal assemblages from two mound sites, Hotchkiss Mound (CA-CCO-138; Middle/Late Transition through Late Period) and Simone Mound (CCO-139; Middle Period), to gain new insight into long-term change in prehistoric fisheries. Despite their notoriety, and excellent bone preservation, these sites have had little archaeological analyses conducted on them but show enormous potential for understanding long-term human-environmental interactions in the California Delta.

ENVIRONMENTAL SETTING

The California Delta is formed by the confluence of the Sacramento and San Joaquin Rivers, which then slowly flow into San Francisco Bay over a low elevation gradient. This area once supported enormous populations of migratory waterfowl in extensive freshwater marshes and riparian woodlands (Ricketts, et al. 1999). Grasslands and the fringes of marshes and lakes once supported large populations of pronghorn, mule deer, and tule elk. Vernal pools in seasonally flooded depressions hosted several aquatic invertebrates that are restricted to these habitats and also provided sources of freshwater for humans and large game away from major water courses (Ricketts, et al. 1999).

Around 4–5 million years ago, when the predecessor of the Sierra Nevada Mountains and Coast Range eroded, fish from the ancient Columbia River systems invaded the Sacramento-San Joaquin river

systems (Miller 1965). The large size of the latter, diverse habitats, and isolation from other river systems made it a center for fish speciation. Of the 90 freshwater fish species in the California Delta, 40 are native to the region, and of those, 17 are endemic (Moyle 1972). These drainages are also visited by a number of anadromous species, as well as marine species that can tolerate brackish environments. A combination of damming, agricultural runoffs, invasive sport fish, and climate change has contributed to a dramatic decline in native fish species (Brown and Moyle 2005). Today many native species are in decline (e.g., green sturgeon, splittail, longfin smelt), endangered (e.g., delta smelt, winter-run chinook salmon), extirpated (e.g., coho salmon, Sacramento perch, tidewater goby), or extinct altogether (e.g., thicktail chub).

PAST ICTHEOARCHAEOLOGICAL STUDIES

Ethnographic and historic accounts suggest that coho (*Oncorhynchus kisutch*) and chinook (*O. tshawytsch*) salmon made up the bulk of the catch from the Native American fisheries in the Central Valley (Yoshiyama 1999). It was estimated that chinook runs numbered up to 300,000 individuals in the San Joaquin River Drainage. Comprehensive zooarchaeological studies of several sites in the Delta, however, do not substantiate this claim (Broughton, 1994; Gobalet et al. 2004). For example, Gobalet et al. (2004) found that ichthyofaunal assemblages of the Central Valley are dominated by local freshwater species, such as Sacramento perch (*Archoplites interruptus*) and minnows (family Cyprinidae), and that salmonids constitute a small proportion of identified fish remains. More closely related to the current study, Gobalet (2016) identified more than 10,000 fish remains from a Late Period site (CCO-647; BP 720–510) east of the modern city of Oakley on the western edge of the San Joaquin Delta, and less than 2 kilometers north of CCO-139 and CCO-139. The CCO-647 assemblage was dominated by freshwater species (n=10343; 98%), and only small numbers of sturgeon (n=171; 2%; *Acipenser* sp.), salmonids (n=15), and starry flounder (n=5; <1%; *Platichthys stellatus*; tolerate brackish waters) were identified. Additionally, the recovery of the marine obligate Pacific hake (n=1; <1%; *Merluccius productus*) suggested trade or transport from the coast.

SITE BACKGROUND

Hotchkiss Mound and Simone Mound are located in Contra Costa County near the town of Oakley (Figure 1). Hotchkiss Mound is a large prehistoric village and burial site situated 6.5 kilometers east of Oakley (Cook and Heizer 1962). Prior to canalization and damming this area consisted of marshy tule-covered swamp. The site sits on a stabilized sand dune several meters high that provided protection from spring river flood waters (Cook and Elsasser 1956). From the surrounding area, elk, river clams, fish, and migratory fowl were readily available. The site was first recorded and excavated by amateur archaeologist E. N. Johnson in 1936, who reported the site to the University of California's Department of Anthropology. It was later excavated by Robert F. Heizer in 1938 where he recovered 110 burials from the northwest portion of the mound. UC Berkeley field schools revisited the site a number of times between 1938 and 1953, resulting in the exposure of several hundred human burials, ritual animal burials, domestic features, as well as large numbers of artifacts and faunal remains. Data from the Hotchkiss Mound played a crucial role in documenting the cultural chronology of Central California. For example, Hotchkiss Mound is considered a type-site for Late Period cultures of Central California (Beardsley 1948, 1954; Bennyhoff 1994 [1968]; Lillard, et al. 1939; Ragir 1972). Also known as the "Augustine Pattern" (Fredrickson 1973), this period is characterized by small projectile points, intensive exploitation of acorns, a proliferation of shell beads and ornaments, and increased population density (Atchley 1994).

Simone Mound is located just east of Hotchkiss Mound, and is in a similar naturally occurring piper sand mound (Busby 2001). The site was first excavated by amateurs in 1939, including E. N. Johnson who reported the presence of several burials, a dance floor and/or house pit floors, and numerous artifacts (Bard and Busby 1978).

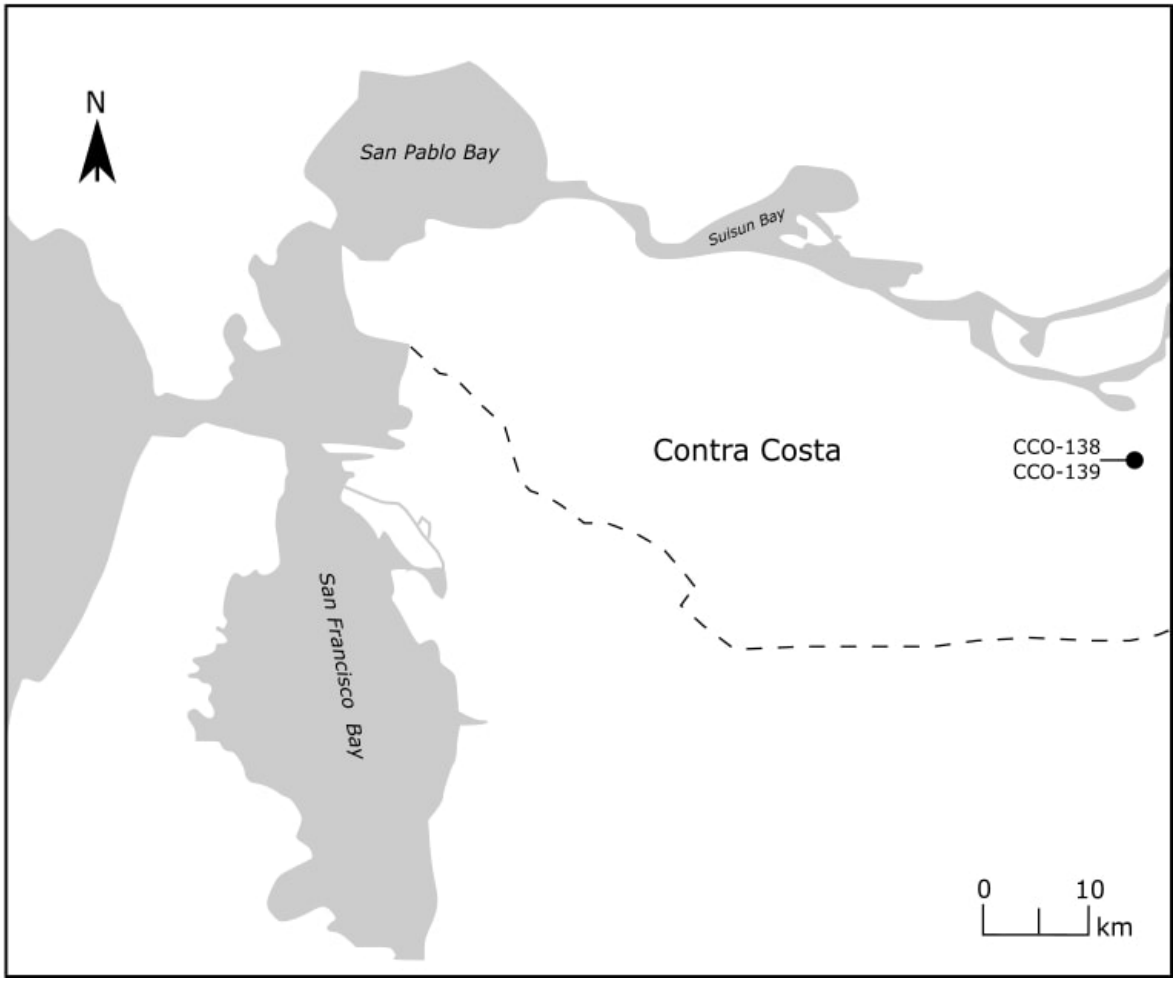


Figure 1. Map of the Bay Area, showing the Location of CA-CCO-138 and CA-CCO-139.

ISOTOPIC AND RADIOCARBON DATA

Radiocarbon and stable isotope data from individual burials at Hotchkiss Mound (n=48) and Simone Mound (n=45) were reported by Eerkens and Bartelink (in review). The interments reveal distinct periods of occupation at the two sites, with the Simone Mound dated 1190–790 cal BP and the Hotchkiss Mound dated to 810–150 cal BP, placing the sites in the Middle Period, and Middle/Late Transition and Late Period, respectively. Isotopic data showed that individuals from Hotchkiss Mound had elevated $\delta^{13}C$ and $\delta^{15}N$ values compared to Simone Mound (Figure 2). This is surprising since the sites are in close proximity to one another, and residents should have had access to similar resources. The isotopic values from Hotchkiss Mound are also distinctive from contemporary individuals living at bayshore sites in the San Francisco Bay Area (for example at the Stege Mound, CCO-297), which on average have higher $\delta^{13}C$ and $\delta^{15}N$ values. Figure 2 also plots $\delta^{13}C$ and $\delta^{15}N$ for individuals from Hotchkiss and Simone Mounds, as well as the Stege Mound, a Late Period site on San Francisco Bay (data from MacKinnon et al. 2015; see DeGeorgey 2016).

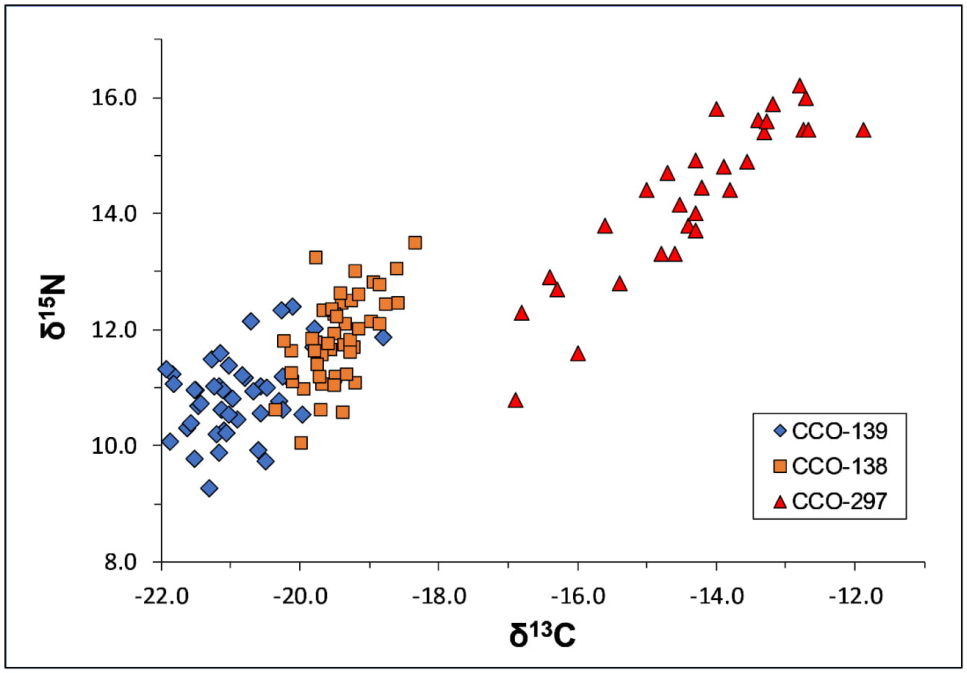


Figure 2. Bivariate Plot of Carbon and Nitrogen Values from Human Burials from CA-CCO-138 (n=48), CA-CCO-139 (n=45), and Bay Area Site CA-CCO-297 (n=30).

Greater consumption of higher trophic level fish or anadromous fish could account for the elevated $\delta^{13}C$ and $\delta^{15}N$ values observed at Hotchkiss Mound relative to Simone Mound, but must have been lower compared to individuals living along the shore of San Francisco Bay at the Stege Mound. Recent research by Talcott et al. (2018) found that freshwater fish of the California Delta have a wide variety of $\delta^{13}C$ and $\delta^{15}N$ values, depending on their diet and life history. Talcott and colleagues found that $\delta^{13}C$ and $\delta^{15}N$ are significantly higher in larger bodied fishes, such as pikeminnow, as well as in anadromous and euryhaline species. It is possible that isotopic differences between human bone collagen from Hotchkiss and Simone Mounds were driven by variation in the types of fish people consumed. If this is the case, we expect the ichthyofauna assemblage at Hotchkiss Mound to have higher proportions of higher trophic-level, anadromous, and/or euryhaline taxa compared to Simone Mound.

METHODS

To examine the ichthyofauna assemblage from the two sites, 14 one-liter soils samples were collected from the surface of the two sites (CCO-138: n=10; CCO-139: n=4). These soil samples were processed for macrofaunal and macroflora remains through machine flotation, and subsequently sorted by undergraduate interns. Samples were rich in faunal remains, including fish, bird, and mammal, as well as lithic debitage. Identification of fish remains was undertaken using the Peter D. Schultz Osteoichthyology collection housed at the University of California, Davis. Comparative manuals and online resources were also consulted. Species level identification was undertaken following guidelines provided by Gobalet et al. (2004) and Casteel (1972). Terms and quantification methods follow Lyman (2008); for example, NISP is the Number of Identified Specimens; taxonomic "richness" is a measure of the number of non-overlapping taxa.

RESULTS

Of the sorted ichthyofaunal remains, all specimens (n=2816) were identified as ray-finned fish (class Actinopterygii), while cartilaginous fish (class Chondrichthyes) were absent. Of the total, 39 percent (n=1110) of specimens were identified to family or to a lower taxonomic level (Table 1). In sum, 10 taxa were identified, including seven freshwater taxa, one anadromous taxa, and two possible anadromous taxa.

Cyprinids

The most common taxa identified were cyprinids (CCO-138=65%, CCO-139=57%). Cyprinids or true minnows, are a freshwater family represented in the California Delta by eight species. The typical native North American minnow is a small, scaled, unspecialized fish. These species have a dark elongated body, silvery in color, and while the mouth always lacks teeth, pharyngeal teeth (throat teeth) are well developed (Moyle 1972). Most minnows are schooling fish. Cyprinids are extremely difficult to distinguish osteologically, especially from vertebrae alone, which tend to preserve best in archaeological contexts. Identification was taken past family level, when possible, using the pharyngeal teeth, and the basioccipital (Casteel 1972; Gobalet, et al. 2004). Three species were identified, including Sacramento pikeminnow (*Ptychocheilus grandis*), thicktail chub (*Gila crassicauda*), and hitch (*Lavinia exilicauda*).

Twelve specimens were identified as Sacramento pikeminnow. Sacramento pikeminnow are readily identifiable compared to other cyprinids due to their size. They are the largest species of cyprinid in California, with a maximum recorded length of 115 centimeters. Sacramento pikeminnow are piscivorous and likely occupied the top trophic level prior to the introduction of largemouth bass (*Micropterus salmoides*; Moyle 1972). Sacramento pikeminnow are typically found in large intermittent and permanent streams of the Sierra Nevada foothills and prefer deep, well-shaded, sand- or rock-bottomed pools.

Nine specimens were identified as thicktail chub. Thicktail chub are heavy-bodied fish with short, deep, and thick caudal peduncles. They are now extinct in the California Delta, and little is known about their life history and ecology. They were originally abundant in lowland lakes, sloughs, slow moving stretches of river, and occasionally in the surface waters of San Francisco Bay.

Five specimens were identified as hitch. Hitch prefer slow moving sloughs, stretches of river, and ponds, and are associated with sandy-bottomed pools, with moderate growth of aquatic vegetation (Moyle and Nichols 1973). They feed mostly on invertebrates and phytoplankton.

Sacramento Perch

Sacramento perch were the second most abundant taxa (CCO-138=30%, CCO-139=36%). Sacramento Perch are a small bodied freshwater fish and are the only native sunfish (family Centrarchidae) in California. Although they were once abundant in the Sacramento-San Joaquin River systems, they are now extinct from the region and only found in a few scattered ponds and reservoirs (to which they were introduced). The Sacramento perch's native habitat is in sluggish, heavily vegetated waters of sloughs and lakes (Brown and Moyle 2005; Moyle 1972).

Sturgeon

Thirty-four specimens were identified as sturgeon. These large demersal fish are represented by two anadromous species from the San Joaquin Valley. Due to their large size, most identified specimens were fragmentary and could not be identified to element, however, one complete lateral scute was identified as belonging to white sturgeon (*A. transmontanus*; Gobalet, et al. 2004). White sturgeon spend most of their lives in estuaries but move into freshwater to spawn in the winter and fall (Moyle 1972).

Table 1. Number of Identified Specimens of Actinopterygii (ray-finned fish) from CA-CCO-138 and CA-CCO-139.

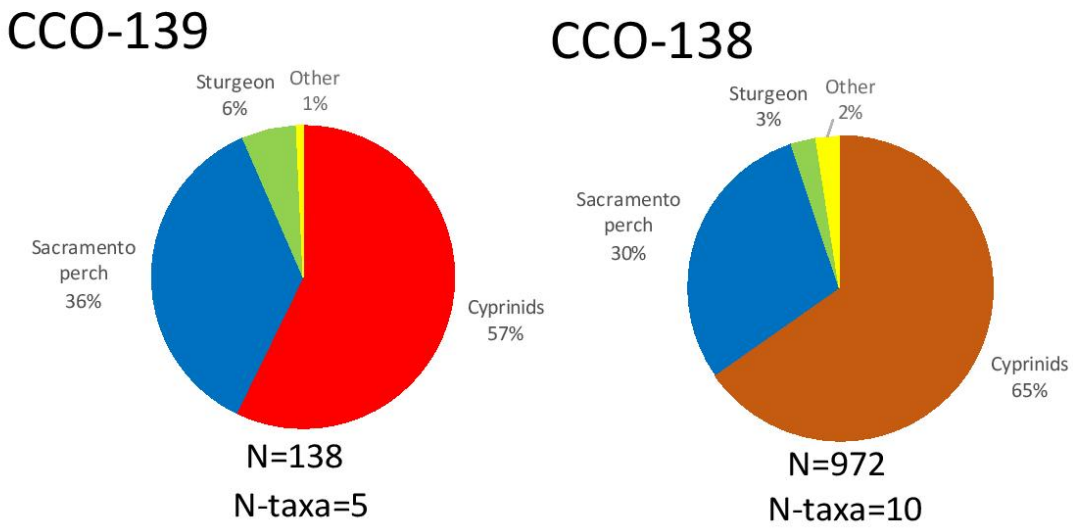
Taxon	Common Name	CCO-138		CCO-139		Total	
		n	%	n	%	n	%
Acipenser sp.	Sturgeon	25	3	8	4	33	3
Acipenser transmontanus	White Sturgeon	1	-	-	-	1	-
Cyprinidae	Minnow family	611	63	77	39	688	62
Gila crassicauda	Thicktail Chub	8	1	1	1	9	1
Lavinia exilicauda	Hitch	5	1	-	-	5	-
Ptychocheilus grandis	Sacramento Pikeminnow	11	1	1	1	12	1
Catostomus occidentalis	Sacramento Sucker	7	1	-	-	7	1
Onchorynchus spp.	Salmon and Trout	7	1	1	1	8	1
Spirinchus thaleichthys	Longfin Smelt	7	1	-	-	7	1
Archoplites interruptus	Sacramento Perch	288	30	50	26	338	30
Embiotocidae	Surfperch	1	-	-	-	1	-
Gasterosteus aculeatus	Threespine Stickleback	1	-	-	-	1	-
Identified Specimens		972	100	138	100	1110	100
Unidentified Actinopterygii	Unidentified Ray-finned fish	1649	-	57	-	1706	-
Total		2621	-	195	100	2816	100
N-taxa		10	-	5	-	10	-

Other Taxa

Five additional taxa were identified. Salmonids were scarcely represented with only eight identified specimens; two species of the anadromous pacific salmon and one species of trout are native to the region. Seven elements were identified as Sacramento sucker (*Catostomus occidentalis*). Suckers are bottom browsers that consume algae, invertebrates, and organic matter with their fleshy protrusible lips. The Sacramento sucker is widely distributed in the California Delta, and its tributaries. Seven longfin smelt (*Spirinchus thaleichthys*) elements were also identified from CCO-138. They are small, silvery fish that can tolerate both saltwater and freshwater environments. They are most common in San Pablo Bay, where they spend the summer. In August, they move into Suisun Bay and in the winter, they congregate for spawning at the upper end of Suisun Bay and the lower reaches of the Delta. Another small forage fish identified was three-spine stickleback (*Gasterosteus aculeatus)*. They typically reside in quiet waters with heavy growth of aquatic plants and feed on small invertebrates. Three-spine stickleback also exist as an anadromous variety, which migrate into the shallow water of the Delta to spawn from April through July. Lastly one element was identified to the surfperch family (Embiotocidae). Surfperch are typically found along shallow waters of the Pacific Coast; however the California Delta is home to two species, the exclusively freshwater tule perch (*Hysterocarpus traskii*), and the euryhaline shiner perch (*Cymatogaster aggregate*).

DISCUSSION

Identified fish remains from CCO-138 and CCO-139 are dominated by locally available small bodied freshwater species, notably minnows and Sacramento perch (Figure 3). In terms of taxa representation, the two assemblages are extremely similar, as would be expected of sites close to one



Cyprinid includes counts for thicktail chub, hitch and Sacramento pikeminnow.

Figure 3. Comparison of Specimens Identified to Family Level Or Lower (NISP %) from CA-CCO-138 and CA-CCO-139.

another. As well, the taxa proportions mirror assemblages from other Delta sites (Gobalet, et al. 2016; Gobalet, et al. 2004). Occurrence of seasonally available species such as white sturgeon and longfin smelt suggests yearlong occupation of the area.

Species richness from the Hotchkiss Mound (n-taxa=10) assemblage is greater than the Simone Mound (n-taxa=5). Hitch, Sacramento sucker, longfin smelt, surfperch, and three-spine stickleback were unique to Hotchkiss Mound. Although this greater species richness is consistent with an expanding diet breadth from the Middle to Late Period, such a difference is likely not a byproduct of intensified fishing, but rather the result of an incongruity in sample size. Sample size has been shown to be directly correlated with species richness (Lyman 2008), and the Hotchkiss Mound ichthyofaunal assemblage is almost seven times larger than that of the Simone Mound. Taxa unique to the Hotchkiss Mound make up fewer than 1% of its total assemblage, suggesting that these taxa were not of significant dietary importance. Additionally, both stickleback (on average 3 to 5 centimeters standard length (SL) and longfin smelt (on average 12 to 14 centimeters SL) are small bodied forage fish that are predated on by larger taxa. Given their low frequencies (n=1, n=7, respectively) it is possible that they were introduced into the assemblage via stomach contents from larger taxa.

The comparison between isotopic and zooarchaeological data is hindered by external factors, such as the limitations in identification. As mentioned, cyprinids species are extremely difficult to distinguish osteologically; however, there are species-level differences in carbon and nitrogen values, depending on their life history, and trophic level (Talcott, et al. 2018). Therefore, variation between assemblages may exist, but cannot be discerned due to the constraints of faunal identification. Isotopic analysis of the cyprinid remains themselves would be fruitful for future research. Diet within species also varies according to life histories, for instance juvenile Sacramento perch prey on invertebrates while adults are piscivorous (Crain and Moyle 2011). Thus, stable isotope analysis paired with morphometric size reconstruction can elucidate age related dietary variation.

Additionally, differential preservation between fish taxa may have skewed representation. In taphonomic burial experiments using modern samples, Hash et al. (2015) found that Sacramento perch bones were more likely to preserve then those of cyprinids. However, ethnographically recorded practices such as bone pulverization and processing near capture sites have been used to explain the paucity of salmonids in the archaeological record. Despite these possibilities, the proportions of these fish taxa are consistent between sites.

The human isotope data suggest that individuals from these two sites consumed different diets. From our analysis, the differences in stable carbon and nitrogen values between the two mound sites is not explained by differences in ichthyological assemblages. However, it is possible that these differences are driven by variation in the proportion of particular cyprinids species in the diet, and/or life history stage of the fish (i.e., size). Additionally, difference may reflect variations in consumption of non-fish resources. Bird, mammal, and shellfish remains were present in the flotation samples, but not identified due to time constraints. Similarly, the difference may have been driven by changes in the proportion of fish relative to other fauna consumed, and not just fish type. Therefore, a complete faunal analysis is required to assess how proportion of different fish species compared to other classes of animals changed through time. Morphometric size reconstruction can also be utilized in the future to assess level off intensity of the fisheries by elucidating the fishing technologies used. Future research should seek to address this possibility by conducting stable isotope analyses on the fish bones themselves.

CONCLUSION

Our analysis shows that despite human bone collagen isotopic differences between CCO-138 and CCO-139, targeted fish taxa from the prehistoric riverine fisheries of the Contra Costa County remained consistent from the Middle to Late Period. Although stable carbon and nitrogen isotope values are slightly elevated in Late Period individuals from CCO-138, local freshwater minnows and Sacramento perch were the most common taxa in both assemblages. Future zooarchaeological analysis of the complete assemblage will shed light on how subsistence strategies changed through times.

ACKNOWLEDGEMENTS

We thank the Archaeological Conservancy for granting permission to collect soil samples, Andrew Scott and Susan Talcott for washing and sorting samples, and the National Science Foundation (grants BCS-1318543 and BCS-1318532 issued to Jelmer W. Eerkens and Eric J. Bartelink) who provided funding for some of this research.

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