Journal of California and Great Basin Anthropology | Vol. 37, No. 2 (2017) | pp. 169–182

Native American Fisheries of the Southern Oregon Coast: Fine Fraction Needed to Find Forage Fish

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Tushingham and Christiansen (2015) recently reviewed data from 22 fish assemblages from coastal archaeological sites in northern California and southern Oregon. They characterized the assemblage from the Chetco Indian village of Tcetxo *(35-CU-42) as dominated by nearshore littoral fish including rockfish, surfperch, and greenlings, drawing from Ricks' (2012) analyses reported in Minor (2012). Our recent analyses of fine-screened samples from* Tcetxo *reveals that both surf smelt and northern anchovies were abundant, but only in materials recovered using 1 mm. mesh screens. This demonstrates the importance of analyzing fine-screened materials to document Native American fishing practices along the Pacific coast, especially to find the remains of forage fish, which form the foundation of entire marine ecosystems. Overall, our data support Tushingham and Christiansen's thesis that Native Americans living along the coast of northern California and southern Oregon focused substantial fishing effort on mass-capture of smelt, anchovies, and other forage fish.*

The Chetco Indian village of *Tcetxo* (35-CU-42) is located on the Port of Brookings-Harbor property on the southern Oregon coast. The port's commercial receiving dock was badly damaged by a tsunami in March 2011 (generated by the Tōhoku earthquake) and required extensive repairs. Geotechnical testing in advance of the repairs encountered midden deposits buried under asphalt and gravel that proved to be a remnant of the Chetco village originally recorded in 1935 (Fig. 1). In documenting the continued existence of this site, Rick Minor and Heritage Research Associates conducted small-scale excavations to sample the deposits and recovered a variety of cultural remains from the remnant shell midden, dated to 2,000–1,300 B.P. (Minor 2012). Julie Ricks (2012) analyzed over 25,000 vertebrate faunal remains, most of which were fish. Rockfish was the most common taxon; greenlings, striped surfperch, and salmonid also were abundant, and lingcod, hake, surfperch, cods, sculpins, herring, buffalo sculpin, starry flounder, and cabezon were also identified. With the exception of salmonid, which could have been caught farther upriver, these fish typically inhabit estuarine and near-shore environments, like those adjacent to the site.

During the course of the archaeological investigations, a total of 28 2-liter bulk samples were collected, but these were not processed until recently. In 2015, as part of Madonna Moss's *Zooarchaeology* course at the University of Oregon, she and her students (including Page-Botelho) processed and screened these samples, with the intent of identifying any small fish that may not have been previously recovered. The 2011 excavations had employed 1/8-inch mesh screens, so we started

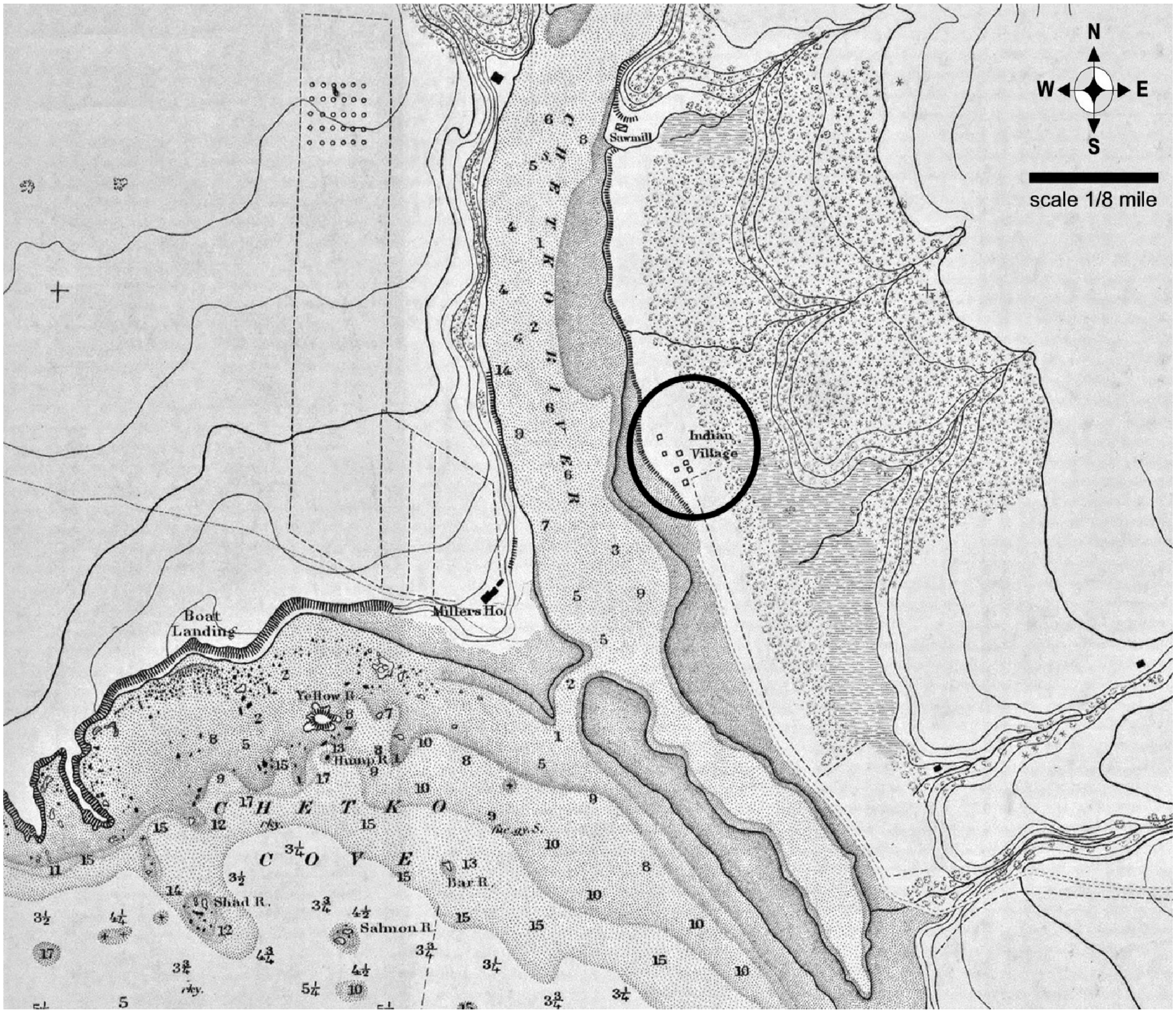

Figure 1. Portion of the U.S. Coast and Geodetic Survey Chart for "Chetko Cove." This 1891 edition is almost unchanged from the original chart issued in 1874. The "Indian Village" shown in the circle corresponds to the Chetco settlement of *Tcetxo* represented by archaeological site 35-CU-42.

by screening the bulk samples over 2-mm. mesh and sorting out identifiable fish bone. In processing the first sample, however, Moss could see that many small fish vertebrae were slipping through the 2-mm. mesh, so we proceeded to screen the fines over 1-mm. mesh. From the 1 mm. material in 14 of the 2-liter samples, we sorted out fish vertebrae and any diagnostic fish bones, but not all bone fragments. Because northern anchovy (*Engraulis mordax*) has historically been an important fishery in the Chetco River estuary (Gaumer et al. 1973:12, 14), we were interested in whether or not we could find this species at 35-CU-42. In a similar vein, because contemporary Tolowa still fish for and dry surf smelt (*Hypomesus pretiosus*) in northern California (Lewis 2000; Tushingham and Bencze 2013; Tushingham et al. 2013), that fish also seemed a likely candidate species. We anticipated that the remains of other smelt, topsmelt, herring, or sardines might also have been present in the *Tcetxo* deposits.

Forage fish are small schooling fish that consume plankton and in turn are consumed by larger predators, including other fish, birds, and marine mammals. Since they are near the bottom of the food chain, forage fish play critical roles in marine food webs around the world.

Forage fish are also used by people. Today, 90% of the forage fish catch is "reduced" to fishmeal or fish oil used in the agriculture, aquaculture, and pet food industries (Lenfest 2010; Pikitch et al. 2012). Forage fish serve as baitfish in commercial fisheries, but some people do eat some forage fish (e.g., Thornton et al. 2010a, 2010b). In recent years, the extraction of forage fish from the ocean has increased, and fisheries scientists are concerned about how over-exploitation of forage fish has caused declines in seabird and marine mammal populations (Essington et al. 2015; Pauly 2010; Pikitch et al. 2012). Yet over the course of human history, aboriginal people have sustained themselves by eating forage fish, amongst a wide range of other marine animals. The Lenfest Forage Fish Task Force argues that because marine populations are interconnected, we must take a multispecies approach to fisheries and wildlife management and conservation (Lenfest 2010). Along the Pacific shoreline of southern Oregon and northern California, the indigenous people have a long tradition of using forage fish, as demonstrated at *Tcetxo* and other pre-contact sites (Tushingham and Christiansen 2015; Tushingham et al. 2016).

BACKGROUND ON *TCETXO*

Located on the east bank of the Chetco River near its mouth, *Tcetxo* was one of the main settlements of the Chetco Indians, and in fact was the village for which the people and river are named. The Chetco were one of a number of groups of Athapaskan speakers that are commonly subsumed today under the name Tututni (Miller and Seaburg 1990). At the present time, the site is located on a point of land adjacent to a section of the river that has been dredged for development of a boat basin. The site was identified by Berreman (1935a, 1935b) during his pioneering archaeological survey of the Oregon coast. Berreman noted that severe erosion had removed much of the archaeological deposit, leading him to estimate that "only the back half of an extensive midden remains" (Berreman 1935a:6). Beginning at the eroded river bank, Berreman excavated a test trench into the 10-foot-deep midden, drew a rough sketch of the stratigraphy, and collected a small number of artifacts. Berreman's observations and notes on this work are summarized in the report on the 2011 investigations at *Tcetxo* (Minor 2012:30–34).

The later history of the site was reconstructed, in large part, through interviews with Archie McVay (born January 22, 1921; died April 23, 2016), the son of B. W. McVay, who owned the property at the time of Berreman's visit in 1935. According to Archie McVay, the location of the village was referred to by local residents as the "Indian Mound." The mound was highest, an estimated 12 feet, in the area where archaeological investigations were conducted in 2011. The Indian Mound was cut off abruptly along the river bank by erosion.

The river bank in the site vicinity remained relatively intact until 1959, when—following completion of jetties at the mouth of the Chetco River in 1958—Archie McVay began dredging the river channel to improve port facilities. The first dredging occurred "right off" the area of archaeological investigations in 2011. In 1960, in a further effort to improve port facilities, Archie McVay used a bulldozer to level the Indian Mound. Structural remains from Native American houses, as well as human skeletal material, were exposed, and the McVays collected a substantial number of artifacts from the Indian Mound at that time.

At the time of the 2011 investigations, the north half of the site area (Fig. 2.) was covered by an asphalt roadway used by trucks transporting fish off-loaded from boats at the port's receiving dock. The remainder of the site area was covered by a layer of compressed gravel. This asphalt and compressed gravel covering the surface precluded hand excavation. Instead, mechanical equipment was used to excavate through the compressed gravel and into the underlying deposits. Overall, the midden sampled during the 2011 investigations was situated at elevations between roughly 3.0 m. (9.84 ft.) and 4.25 m. (13.94 ft.) above sea level (based on NAVD 88).

Four short mechanical trenches (MTs) were excavated roughly 5 m. apart to obtain a cross-section of the deposits at intervals along a roughly 25-m.-long transect extending inland from the river bank. During a visit to the site while archaeological investigations were underway, Archie McVay estimated that Berreman's trench was very close to the location of backhoe trench MT3, excavated in 2011. The sediments consisted of sand or sandy loam that tended to slump as it dried out, but culturally sterile deposits were reached in all of the trenches As determined during deep trenching at the conclusion of the fieldwork, the sterile loamy-sand

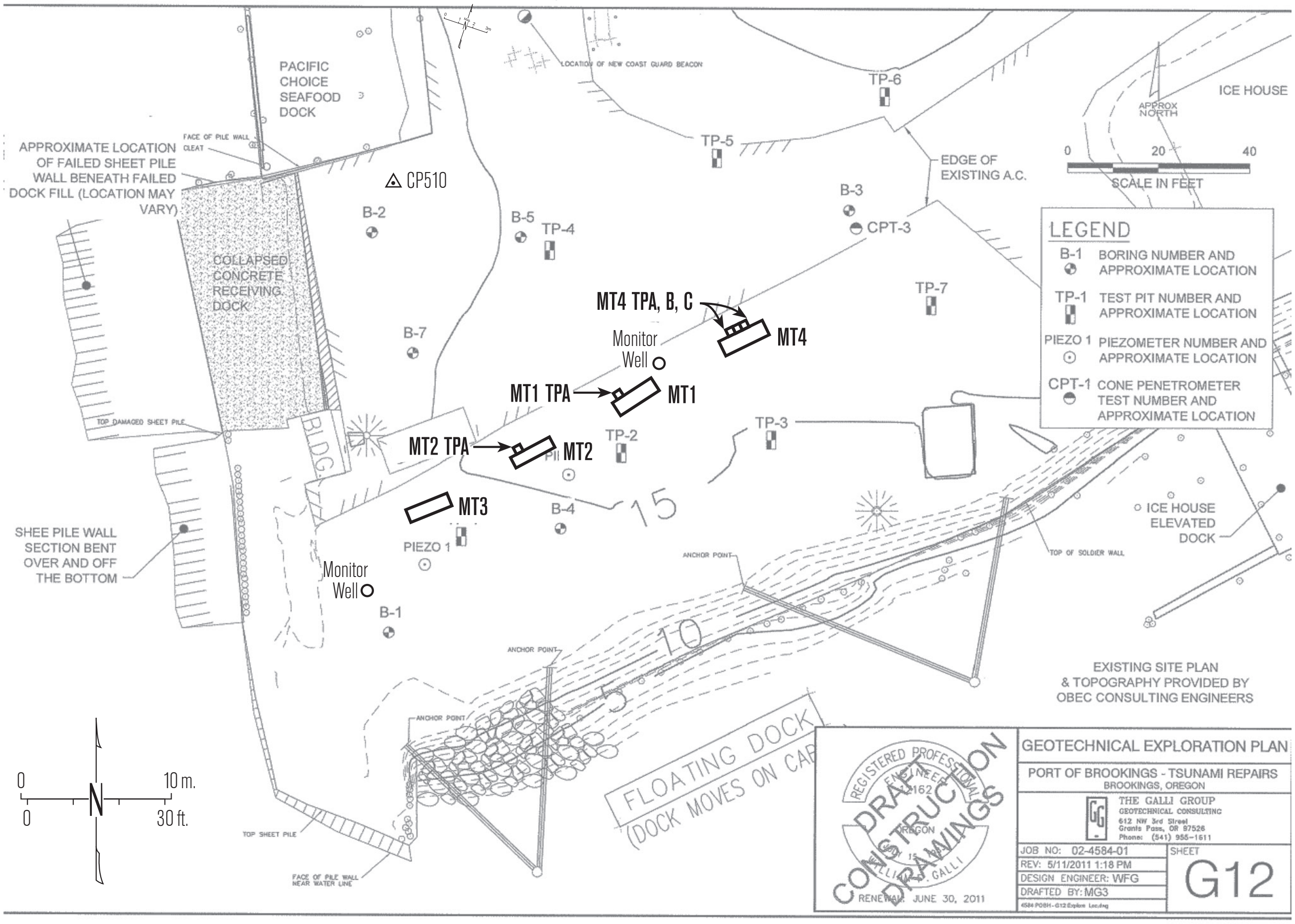

Figure 2. Locations of mechanical trenches (MTs) and hand-excavated test pits (TPs) at site 35-CU-42.

generally extended to 2.5 m. below surface, where it was underlain by rounded and sub-rounded cobbles in a coarse gray sand matrix that corresponds to natural river deposits. The stratigraphic sequence suggests that the archaeological deposits that formed the Indian Mound accumulated within alluvial sand and silt on a point bar along the east side of the Chetco River.

Once an idea of the horizontal and vertical extent of the archaeological deposits had been obtained, the focus of the investigations turned to obtaining samples of the cultural materials in the midden for use in interpreting the age and nature of the site occupation. Three methods were employed in sampling the midden: (1) controlled excavations by hand were undertaken in 10-cm. levels, subdivided according to stratigraphy as appropriate, in 50×50 cm. test pits (TPs) placed in the trench walls; (2) portions of the archaeological deposits removed during mechanical trenching totaling 5.1 $m.^3$ were dry-screened through 1/8-inch mesh in the field; and (3) recognizing that more intensive analysis would be needed to recover very small archaeological remains, 2-liter bulk samples were collected by 10-cm. levels in two test pits in the densest midden, totaling 28 2-liter bulk samples in all.

The test pits in the north walls of MT1 and MT2 encountered shell-midden deposits containing a high density of animal bones (Fig. 3). The contents of each of these 10-cm. levels were bagged by stratum and processed in the lab, where they were dry-screened through 1/8-inch mesh. Analysis by Julie Ricks found that rockfish made up 67% of the fish identified to at least the family level (n=2,280; Ricks 2012:87–88). California mussels, available along the open rocky intertidal zone not far from the site, were the primary focus of shellfish gathering (Ricks 2012).

To establish the age of the occupation represented in the Indian Mound's basal archaeological deposits,

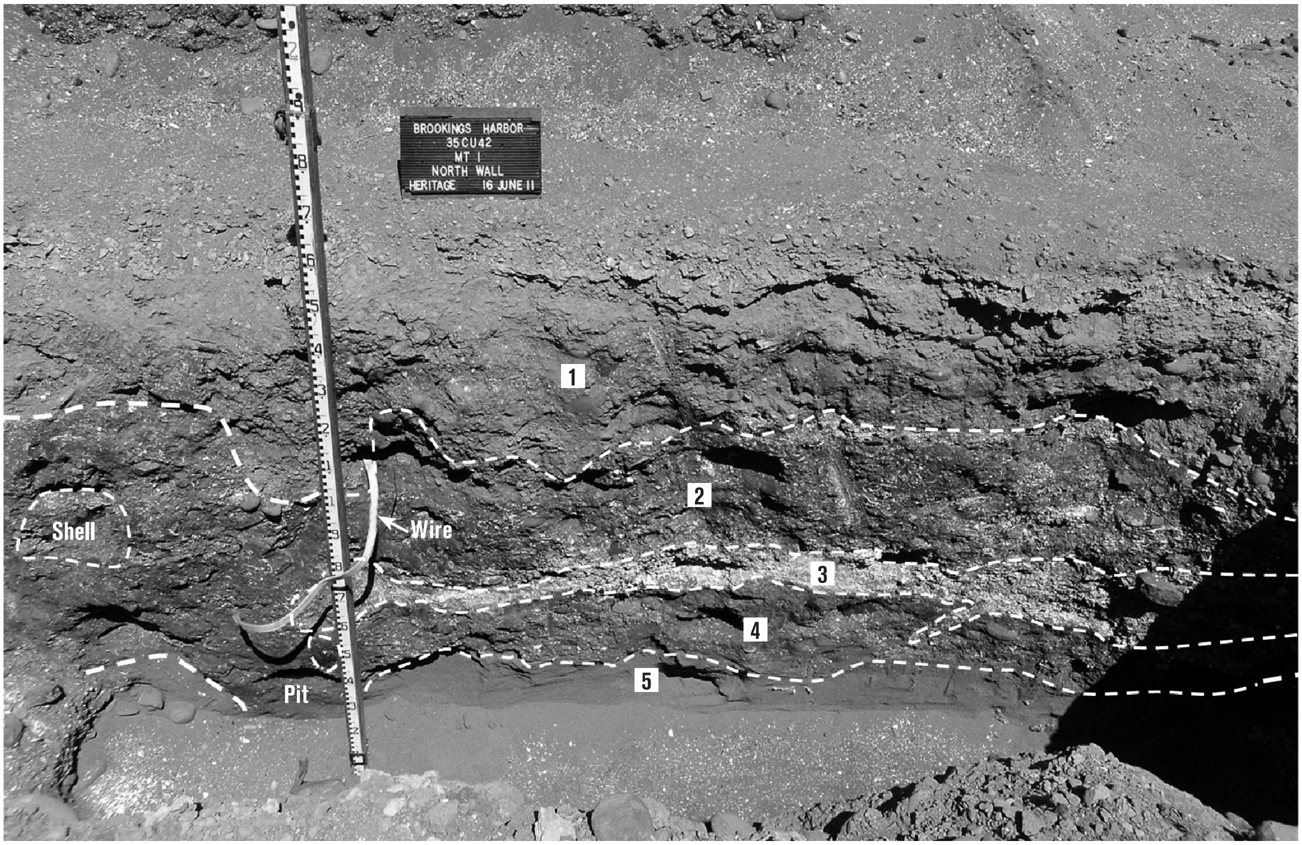

Figure 3. Photograph of stratigraphy in the north wall of MT1.
- **Stratum 1: compressed gravel overburden in light gray (10YR 7/1) sandy matrix.**
- **Stratum 2: light to moderate shell in dark gray (7.5YR 4/1) sandy loam.**
- **Stratum 3: dense shell in dark gray (7.5YR 4/1) sandy loam.**
- **Stratum 4: light shell in dark gray sand (10YR 4/1).**
- **Stratum 5: culturally sterile brown (10YR 5/3) loamy sand.**

charcoal recovered from the top and bottom of the midden was submitted for radiocarbon dating. For increased precision, all four samples were dated by means of the Accelerator Mass Spectrometry (AMS) process. The samples were collected during controlled excavations in MT2 and MT4.

The oldest radiocarbon date, 2,010 ± 30 B.P., was obtained from a sample taken from the bottom of the cultural deposit in MT4. The charcoal on which this date is based was collected from compact Stratum 4, the lowest artifact-bearing layer, immediately above the pebble/cobble deposit of Stratum 5. A later radiocarbon date of 1,740 ± 30 B.P. was obtained from charcoal collected from Stratum 2 near the top of the shell midden. These two dates bracket the age of the occupation represented in the archaeological deposits exposed in MT4.

Two more radiocarbon dates indicate the age of the archaeological deposits in MT2. Charcoal collected from the shell-midden deposit designated Stratum 5, immediately above the culturally sterile sand of Stratum 6, yielded a radiocarbon date of 1,530 ± 30 B.P. A later radiocarbon date of 1,310 ± 30 B.P. was obtained from charcoal recovered in Stratum 3 near the top of the shell midden. These two dates bracket the age of the shell midden deposits exposed in the north wall of MT2.

In both areas, the cultural deposits were found to span a limited range of time of perhaps 200 to 300 years. It is noteworthy that the two earliest dates from the site are both from MT4 and pertain to occupation farther inland from the river bank. The two latest dates are associated with deposition of shell-midden deposits closer to the river. This pattern supports the interpretation by geomorphologists that the archaeological deposits in MT4 represent an inland remnant of an older and more extensive occupation along the point bar.

The 2011 investigations recovered 47 flaked stone tools, 74 cobble tools, 894 pieces of debitage, 84 artifacts of bone/antler/tooth, 13 shell beads, and one complete and 18 fragmentary clay pipes. The small contracting-stem projectile points, large and small notched sinkers, antler wedges, bone fishhooks, *Olivella* shell beads, shark-tooth pendant, bone head-scratcher, and fired clay pipes are artifact types characteristic of the pre-contact Gunther Pattern, with an antiquity of 2,000 years at this site.

Since the upper portions of the Indian Mound were removed during bulldozing in 1960, the investigations in 2011 sampled the archaeological deposits at the base of the mound, corresponding with the earliest occupation at *Tcetxo*. Radiocarbon dates bracket the age of the occupation contained in these strata to between approximately 1,300 and 2,000 years B.P. Consequently, the archaeological investigations in 2011 primarily shed light on the prehistoric occupation at the settlement that became the Chetco Indian village of *Tcetxo* noted in the ethnographic literature (Dorsey 1890; Drucker 1937; Waterman 1925).

The results of investigations in the prehistoric component at *Tcetxo* considerably expand the information available about the pre-contact material culture and lifeways of the Chetco people, previously known almost entirely from excavations in 1936 and 1937 at the Lone Ranch Creek Mound, the Chetco village of *natłt'ené-dʌnne*' located about 10 km. north of Brookings on the Curry County coast (Berreman 1944). In view of the clear association of these settlements with the ethnographic Chetco Indians, the radiocarbon dated evidence from *Tcetxo* suggests that the Athapaskan-speaking ancestors of the Chetco people have been residing on the southern Oregon coast for over 2,000 years (Minor 2012).

METHODS—BULK SAMPLE ANALYSIS FOR SMALL FISH

Over the last 20 years, on the Northwest Coast and across the northeast Pacific more generally, use of 1/8-inch mesh screens (3.175 mm.) has become standard for archaeological analysis (McKechnie et al. 2014; Moss and Cannon 2011). This represents a step beyond past practices and allows for meta-analyses (e.g., McKechnie and Moss 2016), which have identified robust and significant trends across fairly large geographic regions. Yet in many cases, use of 2-mm. mesh or even 1-mm. mesh screening might be necessary to recover small fish of interest. For example, this technique has been shown to be profitable in coastal Australia (Ross and Duffy 2000), and was recommended as the standard by Wheeler and Jones (1989) almost 30 years ago. Given their small size, the bones of forage fish are especially prone to loss and are numerically under-represented unless fine-mesh sieving and laboratory analysis of bulk samples are undertaken (Cannon 2000; Moss 2007; Moss et al. 2011). Various investigators have found that analyses of fine-screened samples of fish bones often result in "dramatic" changes in the relative abundances of various fish taxa (e.g., McKechnie 2005, 2012:161). In their recent review, Tushingham and Christiansen (2015:212) claim that "employing small (1/16″) screen size sampling is also essential to better understand the importance of small forage fish." This is certainly true in the case of *Tcetxo*, although identification of such small remains is not an easy task.

As mentioned earlier, 28 2-liter bulk samples were taken from *Tcetxo*; a 2-liter bulk sample was taken from each of 11 levels in Test Pit A in MT1. A total of 17 bulk samples were taken from TPA in MT2, even though there are only 14 levels. This is because levels 7, 10, and 11 in TPA in MT2 each encompassed more than one stratum. From level 7, for example, one bulk sample was taken from Stratum 3 and the other from Stratum 4. From MT2 TPA, we analyzed three bulk samples: from the top, middle, and bottom, Levels 1, 7 (Stratum 4) and 14, respectively. The sample from Level 14 (MT2 TPA) is the most closely associated with a radiocarbon date of ~1,500 B.P. The sample from Level 1 (MT2 TPA) is most closely associated with a radiocarbon date of ~1,300 B.P.

Even though 2-liter samples comprise a relatively small volume of matrix, processing such materials through 2-mm. mesh and then 1-mm. mesh is very time-consuming. We describe our methods in detail in an effort to respond to Gobalet's (2017) critique, but also with the hopes that other investigators can benefit from our experience. We used 8-inch-diameter geological sieves, the size of which meant that only about 0.25 liters could be processed at a time. This means that sieving

Table 1

SMALL FISH BONES (<2mm. >1mm.) IDENTIFIED FROM *TCETXO*, 35-CU-42[a]

	MT1-TPA											MT2-TPA			
	to-30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110	110–120	120–130	to-10	60–70	130–140	Total
Cottid (sculpins)	–	–	5	2	–	–	–	1	–	–	–	–	–	–	8
Embiotocid (surfperches)	2	2	–	1	–	–	2	–	–	–	–	–	–	–	7
Engraulis mordax (northern anchovy)	32	41	11	3	5	9	31	14	6	3	5	118	40	21	339
Gobiesox maeandricus (northern clingfish)	–	–	–	–	–	–	4	2	–	–	–	–	–	–	6
Hypomesus pretiosus (surf smelt)	138	137	75	34	112	202	75	90	22	10	16	139	114	43	1,207
Mallotus villosus (capelin)	1	–	1	–	–	–	–	–	–	–	–	–	–	–	2
Salmonid (salmon/trout)	1	–	–	–	1	–	–	–	–	–	–	–	–	–	2
Vertebrae to ID	2	6	2	2	2	4	–	1	3	1	1	11	9	6	50
Unidentifiable vertebrae	8	16	7	7	9	26	36	23	16	3	4	163	58	33	409
Total	**184**	**202**	**101**	**49**	**129**	**241**	**148**	**131**	**47**	**17**	**26**	**431**	**221**	**103**	**2,030**

[a]Depths recorded in cm. below datum

each size fraction (of each 2-liter sample) requires sifting eight "screen-loads." The fines are then scanned for fish bones, requiring good light, magnification, patience, and the ability to recognize and handle small fish bones. While we sorted out all bone from the 2-mm. mesh, only vertebrae and elements that looked identifiable from the 1-mm. mesh were selected. Ten undergraduate students were involved in the process, but Moss checked all the fines of each sample to insure the recovery of all potentially diagnostic fish bones. We suspect that the *Tcetxo* samples were actually easier to process than bulk samples of some shell middens because much of the matrix was sand, which slipped through the screens relatively easily. Materials other than bone (shell, rock, charcoal, vegetal fragments) were not retained from the 1-mm. fraction, nor was the residue that passed through the 1-mm. screens. We estimate that this laboratory work required 320 hours of labor to process 14 2-liter samples, with more than 20 hours spent per sample. We recognize that students were being trained to recognize bone and that all samples had to be carefully checked, but even so, this is clearly a labor-intensive process.

The processing described thus far does not capture the work of taxonomic identification accomplished by Moss. Although some 2 mm. bone is large enough to identify without magnification, small fish bones less than 2 mm. in size—i.e., those retained in the 1 mm. screens—require sorting and identification with a microscope. All 1 mm. bone from each sample from MT1, Test Pit A (MT1 TPA, Levels 1-11) and from three samples from MT2, Test Pit A (MT2 TPA, Levels 1, 7 [Stratum 4], and 14) was examined. The results of the taxonomic identifications are presented in Table 1. Fragments that could not be identified to element were not counted because not all bone fragments had been pulled from the 1 mm. samples. Table 2 lists the species available for comparison in the North Pacific Comparative Collection housed in the Department of Anthropology at the University of Oregon.

Over 25 years ago, Driver (1992) called for a more detailed consideration of identification procedures in zooarchaeology, and this is of paramount importance with regards to inter-observer inconsistency in the identification of fish remains, as documented by Gobalet (2001). As recently articulated by Nims and Butler

Table 2

SMALL FISH SPECIES IN THE NORTH PACIFIC COMPARATIVE COLLECTION, UNIVERSITY OF OREGON[a]

Engraulidae:	*Anchoa compressa*	deepbody anchovy (3)
	Engraulis mordax	northern anchovy (OSU)
Clupeidae:	*Clupea pallasi*	Pacific herring (11)
	Sardinops sagax	Pacific sardine (4)
Osmeridae:	*Hypomesus olidus*	pond smelt (OSU)
	Hypomesus pretiosus	surf smelt (4)
	Hypomesus pretiosus	surf smelt (OSU)
	Osmerus mordax	rainbow smelt (OSU)
	Thaleichthys pacificus	eulachon
Atherinopsidae:	*Atherinops affinis*	topsmelt (2)
	Atherinopsis californiensis	jacksmelt (1)

[a]Listed following Page et al.[2013], with the number of specimens in parentheses and those on loan from Oregon State University [OSU] indicated.

(2017:760), "increasing the transparency of analytic methods used in zooarchaeology would produce much more robust records of archaeological animal remains." For this reason, we describe the identification methods used in this study for the benefit of future investigators.

From *Tcetxo*, two distinctive types of vertebrae were common: those ultimately identified as surf smelt, and northern anchovy. Because of the relative abundance of these species and their cultural importance (discussed below), we describe their morphology to assist other researchers. In light of Gobalet's (2001, 2017) cautions about misidentification of fish bones, and his examples of illustrating and describing small fish bones (e.g., Gobalet et al. 2004, 2005), we have been conservative and are compelled to outline our identification notes.

Having noticed shape differences in the vertebrae of our comparative specimens, we used a Nikon AZ100 multizoom microscope and digital sight camera software to measure some of our comparative specimens. In surf smelt (*Hypomesus pretiosus*) vertebrae, the length of the centrum (in the cranial to caudal direction) is about the same as the width of the centrum, with a length-to-width ratio approximating 1.0 (Fig. 4). The hole in the centrum for the notochord is relatively large. We also found a surf smelt gill raker in the archaeological samples (Fig. 5; MT1-TPA, surface to 30 cmbd.).

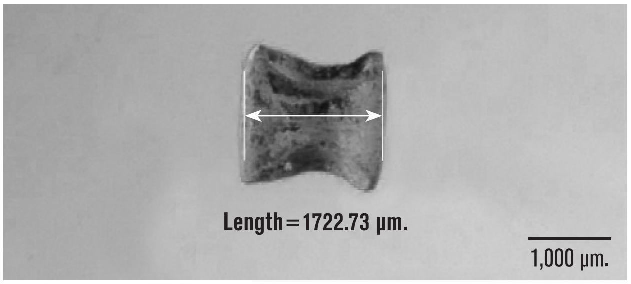

Figure 4. Surf smelt (*Hypomesus pretiosus*) vertebra from *Tcetxo*, with the centrum having a length-to-width ratio approximating 1.0.

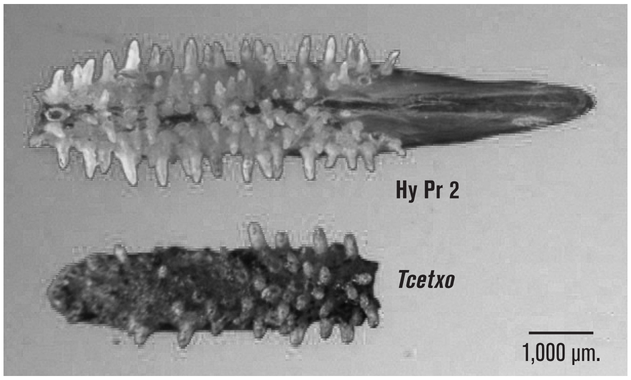

Figure 5. Surf smelt (*Hypomesus pretiosus*) gill raker found in archaeological sample MT1-TPA, to 30 cmbd. (below), shown with comparative specimen (above).

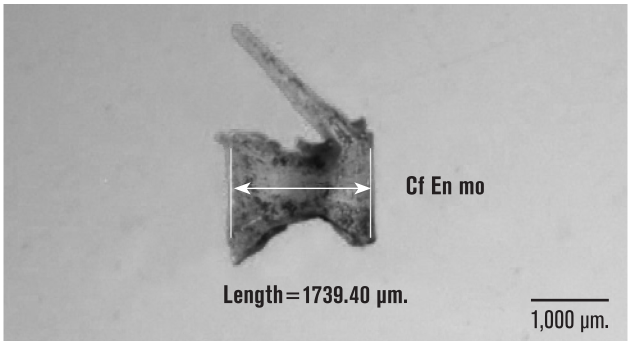

Figure 6. Northern anchovy (*Engraulis mordax*) vertebra, with the centrum having a length-to-width ratio approximating 1.3.

In northern anchovy (*Engraulis mordax*) vertebrae, the centrum is elongated; i.e., the length of the vertebra (in the cranial to caudal direction) is longer than its width. The length-to-width ratio approximates 1.3 (Fig. 6). The centrum is hourglass-shaped, with a narrow "waist." The centra do not exhibit lateral ridges (in cranial to caudal direction), but smooth wide surfaces.

Although topsmelt (*Atherinops*) and clingfish (*Gobiesox*) have elongated vertebrae like anchovies, they are distinguishable. Topsmelt vertebral centra are similar in overall shape, but exhibit multiple lateral ridges running in the cranial to caudal direction. Clingfish have a single lateral ridge (at least on some vertebrae in the column), and have more robust neural and hemal spines than do anchovy. Although three-spine stickleback (*Gasterosteus*) vertebrae are also elongated, Gobalet (personal communication, 2015) notes that the centra of precaudal and caudal vertebrae of this taxon differ from one another and could be confused with northern anchovy. Gobalet also notes that the distinctive spines and scutes of three-spine stickleback are typically present if the species occurs in an archaeological assemblage. No scutes or spines of three-spine stickleback have been found at *Tcetxo*. These four taxa can be distinguished from sardines (*Sardinops sagax*), whose vertebral centra are not elongated; they are closer to the overall dimensions of the smelt. The length-to-width ratio of sardine centra is even lower than smelt (0.8) and their centra have thinner "waists" than smelt. Surf smelt can be distinguished from eulachon (*Thaleichthys pacificus*), because eulachon have several longitudinal ridges along the surface of the centra. Like surf smelt, eulachon centra do have relatively large diameter holes for the notochord.

Moss lacks the expertise to identify all the small fish vertebrae found at *Tcetxo*. As shown in Table 1, there is a category of vertebrae that could be identified to taxon given more time, expertise, and a more comprehensive comparative collection. This category makes up 2.5% of the 1 mm. vertebrae. There is a much larger category of unidentifiable vertebrae, which comprise 20% of the total; these are specimens that are too badly fragmented, eroded, or soil-covered to be identified. This group also includes caudal vertebrae that are too close to the tail to identify. The vertebrae of small greenlings, rockfishes, flatfishes, and cottids all become very hard to distinguish when they originate near the tail fin. The proportion of unidentifiable vertebrae in MT2 was larger than that in MT1.

RESULTS

From her analysis of the 1/8-inch screen material recovered from *Tcetxo*, Ricks (2012:87–88) found that rockfish made up 67% of the fish identified to at least the family level (n=2,280). Greenlings, salmonid, and striped surfperch occurred in comparable numbers, contributing between 6.3% and 6.6% to the total identified to family. Less common were Pacific hake (3.7%), lingcod (2.5%), and cabezon (2%), with all other genera (Pacific herring, shiner perch, buffalo sculpin, and starry flounder) making up less than 2%. We believe that this robust sample is a good representation of the fish of this size range.

The analysis reported here is confined to those specimens that passed through the 2-mm. mesh but were caught in the 1-mm. mesh screens from the 14 bulk samples analyzed (Table 1). Surf smelt was the most abundant, making up 77% of the 1 mm. fish identified to family (n=1,571). Northern anchovy was the second-most abundant taxon, making up 22% of the 1 mm. fish identified to family. Small numbers of sculpin (cottid), surfperch (embiotocid), northern clingfish (*Gobiesox maeandricus*), salmon/trout (salmonid), and capelin (*Mallotus villosus*) were also identified.

From these results, we infer that surf smelt and northern anchovy were both routinely taken by the inhabitants of *Tcetxo*. We do not suggest that these species were more abundant (or more important) than rockfish, nor do we argue that they were of greater dietary significance than any of the other fish, such as greenlings, salmon, or surfperch, etc. The only small forage fish species identified by Ricks (2012) was Pacific herring, which made up 1.2% of the fish identified to family. Based on this, we had expected to identify herring in the 1 mm. samples, and were surprised not to have identified any herring vertebrae. The small forage fish best represented in our samples, and present in all 14 samples, are surf smelt and northern anchovy.

Surf smelt was the most abundant taxon, making up 77% of the 1 mm. fish identified to family (n=1,571). In MT1, the proportion of surf smelt varies from 67% to 96%, but there is no temporal trend. In MT2, surf smelt make up smaller proportions, ranging from 54% to 74%. Along the sandy shorelines of northern California and southern Oregon, the Athapaskan-speaking Chetco, Tolowa, and Tututni people have fished for surf smelt for a very long time; archaeological evidence from *Tcetxo* indicates that surf smelt had been harvested as early as 1,500 years B.P. The Tolowa and Tututni would watch seabirds (especially the gulls and pelicans) for signs of the smelt run in July or August (Lewis 2000). The

Tolowa and Tututni developed a specialized technology particularly well-suited to surf smelt (known as *lhvmsr*); it involved wading into the breaking surf with a large, A-framed dip net with a very fine mesh that allowed for the capture of these small fish. The nets were (and are) "precisely knotted, arranged and sewn onto a "V" shaped wooden structure so that the net will "belly out" and the smelt will not escape" (Lewis 2000:7). Fishing camps were established on the beach in the dunes for a few weeks to work the fish run and process the fish. Once caught, the fish were gutted and the heads removed and returned to the ocean. The fish were then laid out in rows on layers of grass and beach pebbles to prevent them from accumulating sand. These oily fish are dried through the combined action of sun, wind, and hot sand. This practice is of continuing cultural importance. For example, in 2014, two families caught and processed an estimated 700 lbs. of smelt (Tolowa 2015). We suggest that the relative abundance of these small fish in the *Tcetxo* bulk samples indicates that this technology, and the knowledge of how to process *lhvmsr*, has an antiquity of at least 1,500 years.

Northern anchovy was the second-most abundant fish in our samples, making up 22% of the 1 mm. fish identified to family. In MT1, anchovies made up between 4% and 28% of the fish identified to family. Anchovies made up higher proportions in MT2, ranging from 26% to 46%, but again, no temporal trend is evident. Anchovies are available in estuarine channels near *Tcetxo*, but commercial anchovies were fished outside the mouth of the estuary (Gaumer et al. 1973). The peak season for anchovies has been July.

Table 3 presents catch data of sports and recreational fishermen for the Chetco River system in 1971. As shown, northern anchovy was by far the most numerous fish caught: more than 25,500 anchovies were caught from shore and more than 4,100 were caught from boats during this one year, comprising ~70% of the catch. Members of the surfperch family (embiotocid—i.e., silver, striped, and redtail surfperches) contributed substantial numbers for a total of 6,274 fish (15%). All the surf smelt were caught from shore, totaling 1,888 fish, making up 4%. Comparable numbers of Chinook salmon were caught from shore and boat, while most trout were caught from boats.

These data are interesting to compare to those from the *Tcetxo* archaeological assemblage because they support the historical importance of anchovy in this region. At the same time, however, these data do not adequately capture the importance of surf smelt. We suggest a technological explanation—that using hook and line fishing (as done by today's sports fishers) is inadequate for capturing smelt, while the traditional Tolowa-Tututni A-framed dip net is a superior way of capturing surf smelt. The 11 bone fishhooks found in the *Tcetxo* artifact assemblage are evidence of hook and line fishing (Minor 2012:67–68), but the smelt remains themselves indicate use of a net. Neither northern anchovy nor surf smelt are listed in the landing statistics for fish caught commercially in the Brookings-Gold Beach region today (ODFW 2017).

Table 3

1971 CHETCO ESTUARY ANGLERS' CATCH – MAJOR TAXA[a]

	From shore		From boat		Total	
Taxon	Number	%	Number	%	Number	%
northern anchovy	25,506	68.1	4,164	81.1	29,670	69.7
silver surfperch	2,856	7.6	–	–	2,856	6.7
striped seaperch	1,900	5.1	–	–	1,900	4.5
surf smelt	1,888	5.0	–	–	1,888	4.4
redtail surfperch	1,486	4.0	32	0.6	1,518	3.6
starry flounder	796	2.1	–	–	796	1.9
chinook salmon	771	2.1	660	12.9	1,431	3.4
Pacific herring	646	1.7	–	–	646	1.5
kelp greenling	387	1.0	32	2.2	419	1.0
cutthroat trout	13	0	244	4.8	257	0.6
other (21 species)	1,054	2.8	–	–	1,054	2.5
unident fish	126	0.3	–	–	126	0.3
Total	**37,429**		**5,132**		**42,561**	

[a]Gaumer et al. 1973:14.

DISCUSSION AND CONCLUSIONS

Almost 30 years ago, Wheeler and Jones (1989:50) recommended that for the recovery of fish bones, all material be screened through 1 mm. mesh. As Nagaoka (2005:951) has shown, carnivorous fish with large, robust mouth elements will be more likely to be recovered in 1/4-inch mesh screens than herbivorous fish with small, delicate mouth parts. As Cannon (1999:205) observed, many investigators have argued that mesh size can affect which taxa are recovered, their taxonomic richness, and their relative abundance (e.g., Butler 1993; Casteel 1972; Grayson 1984; James 1997; Nagaoka 2005; Wheeler and Jones 1989). In one case, Vale and Gargett (2002) argued that fine-mesh screening did not add additional taxa, but did strongly influence taxonomic abundances, and a larger sample size may have increased species richness (Zohar and Belmaker 2003). McKechnie's (2012:161) analyses of fine-screened samples showed that "dramatic" changes occurred in the relative abundance of fish taxa. However, we are not advocating for the use of smaller mesh screens (or full recovery by flotation) in each and every case. Small forage fish may not have been taken by all coastal peoples in all places. Nonetheless, it is certainly true that if we do not expend some effort looking for these small-bodied fish through the analysis of bulk or flotation samples, we will not find them.

In their review of 513,605 fish remains identified from 222 sites from Oregon to southeast Alaska, McKechnie and Moss (2016) found that Pacific herring and the various species of Pacific salmon were the most ubiquitous taxa, occurring in 96–98% of the assemblages. The abundance of herring, probably the most important forage fish of the Northwest Coast, has attracted a great deal of recent research (McKechnie et al. 2014; Moss et al. 2011, 2016; Speller et al. 2012; Thornton et al. 2010a, 2010b; Thornton and Hebert 2015; Thornton and Kitka 2015). Returning to the forage fish found at *Tcetxo*, anchovies were found in 35% of the Northwest Coast assemblages, with smelts (osmerids) having the same degree of ubiquity. Anchovies were identified in sites as far north as Grenville Channel, B.C., but have not been identified in Alaska or Haida Gwaii (McKechnie and Moss 2016:481). Anchovies were most common in west Vancouver Island sites, and those around the city of Vancouver and Puget Sound. There is hardly any ethnographic information about the use of anchovies on the Northwest Coast (McKechnie and Moss 2016). In contrast, the use of one smelt species, eulachon, is relatively well-documented ethnographically around the Nass River mouth and near Bella Coola, and there is some record of its archaeological occurrence in these regions (Brewster and Martindale 2011). Smelt fishing is known from Oregon and Washington ethnographically (Drucker 1937:233; Stewart 1977:85), but has not as yet been well documented archaeologically.

In addition to their importance in marine food webs, forage fish are highly nutritious for humans. Forage fish are generally short-lived species in which toxins do not bio-accumulate to a dangerous degree (U.S. 2015:24). Although they are not as rich as herring, smelts and anchovies provide large amounts of Omega-3 fatty acids, EPA (eicosapentaenoic acid), and DHA (docosahexaenoic acid), in addition to selenium (Moss 2016). Among the indigenous peoples of the Pacific coast, forage fish such as herring, eulachon, smelt, anchovies, and sardines were some of a vast array of traditional foods in diverse diets. People living along the coast certainly understood the ecological relationships between species and took advantage of this knowledge (Monks 1987; Thornton and Kitka 2015; Thornton et al. 2010a).

Analysis of the 1 mm. fraction from the *Tcetxo* bulk samples has resulted in identification of two forage fish not identified previously in the faunal assemblage: surf smelt and northern anchovy. *Tcetxo* no longer stands out as an anomaly among the set of 22 sites analyzed by Tushingham and Christiansen; smelt were very abundant in the 1 mm. fraction of the bulk samples we analyzed from the site. We offer an addendum to their characterization of *Tcetxo* (Tushingham and Christiansen 2015:211–212); the Gunther Pattern as evident at *Tcetxo* includes the mass harvest, and probably storage, of surf smelt 1,500 years ago. This is consistent with the recent work of Tushingham et al. (2016) at the Manila site along Humboldt Bay, where smelt were also mass-harvested. Northern anchovy was also a very important fish taken by *Tcetxo*'s residents. Although anchovies may also have been mass-harvested, the twentieth century record of this fishery indicates that large numbers of anchovies can be taken by hook and line (Gaumer et al. 1973).

We agree with Tushingham and Christiansen (2015) that a wide range of fish beyond salmon were and are important to the Native American peoples of southern Oregon and northern California. Among these important fish are small forage fish that tend to be under-represented in archaeological faunal assemblages. To find such small fish bones and to better understand their importance in Native fisheries, it should become standard practice to screen at least some bulk samples through 1 mm. mesh to determine whether small fish remains are being lost through coarser screen sizes. Such screening cannot be done effectively in the field, but should be conducted under controlled laboratory conditions. We conclude that forage fish are ecologically and cultural significant and have been routinely under-represented in most archaeological studies of fish remains along the north Pacific coast.

ACKNOWLEDGEMENTS

The archaeological investigations at *Tcetxo* were carried out by Heritage Research Associates under a subcontract with OBEC Consulting Engineers, the primary contractor for repairs to facilities at the Port of Brookings-Harbor following the tsunami in 2011. Moss is grateful to Torrey Rick (Smithsonian) for his interest in this project and for putting her in touch with Ken Gobalet (California State University, Bakersfield). She is also greatly indebted to Gobalet for sharing publications and expertise through correspondence. We thank all the 2015 Zooarchaeology students who processed the *Tcetxo* bulk samples: Ian Fox, Leo Hirsch, Amy Lane, Maddie MacLeod, Sarah Mendiaz, Jordan Pratt, Molly Shelton, Laurie Starr, Hannah Wellman, and Christina Young. Both Virginia Butler (Portland State University) and Brian Sidlauskas (Oregon State University) loaned comparative specimens, and both have contributed special support to this project. Thanks are due Gyoung-Ah Lee (University of Oregon) and Sarah Mendiaz for the micro-photographs of fish bones. David Lewis's master's research has been a source of inspiration regarding the living tradition of Tolowa surf smelt fishing. We also thank Bill Hildebrandt and Adie Whitaker for their editorial advice and Shannon Tushingham and Alex DeGeorgey for their peer reviews, all of which substantially improved this paper. The efficiency of Kaely Colligan is much appreciated.

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