

Does butchering fish leave cut marks?

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Received 3 October 2007; received in revised form 19 October 2007; accepted 22 October 2007

Abstract

Despite the fact that fish are a common component of coastal and other aquatic archaeological sites, cut marks are rarely reported on archaeological fish remains. To assess whether butchering practices leave cut marks on fish bones, we butchered 37 fish using stone tools and a metal knife following methods provided in ethnographic accounts and by modern fish processors. In contrast to archaeological analyses, our research demonstrates that butchering commonly produces cut marks on fish bones, with 4019 cut marks and 2167 cut mark clusters identified on the bones of 30 fish. Cut marks occurred frequently on vertebral neural and haemal spines, vertebral transverse processes, pterygiophores, ribs, and other bones not generally identified to low taxonomic categories by zooarchaeologists (e.g., family, genus, or species). To test our experimental data, we also analyzed 9391 archaeological fish remains from a Late Holocene shell midden on the California Coast, noting 33 previously undocumented cut marks. We hypothesize that the scarcity of cut marks reported on archaeological fish bones is the result of researchers overlooking cut marks because they occur primarily on undiagnostic bones, taphonomic factors such as root etching that may destroy or obscure cut marks, differences between fish, mammal, and bird anatomy, or ancient butchering strategies that relied on limited cutting of fishes.

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Keywords: Fish butchering; Cut marks; Experimental archaeology; Bone modification; Taphonomy

1. Introduction

Fish and other aquatic resources played an important role in human social, biological, and cultural evolution. Fundamental to understanding the significance of fish in ancient human economies, however, is documenting the ways that fish were procured, processed, and consumed by people. Evidence for processing manifests itself archaeologically in the form of burning, cut marks, body-part frequency, and other patterns. Despite being fairly common on archaeological mammal and bird bones (deFrance, 2005; Domínguez-Rodrigo, 2002; Lyman, 1987; Steadman et al., 2002), cut marks are rare on archaeological fish bones (e.g., Colley, 1990:216–217; Lyman, 1994:439). In an analysis of thousands of fish bones from natural and cultural deposits from the Northwest Coast, for example, Butler (1990, 1993) did not identify a single cut mark. While the frequency of cut marks on mammal

remains varies and is also sometimes limited (Lyman, 2005), the frequency of such marks on fish bones is consistently low. This lack of identified cut marks or other signs of butchering on fish bones limits the interpretation of prehistoric and historic fish processing when ethnographic evidence is unavailable.

The dearth of cut marks on fish bone may be attributed to a number of factors (e.g., butchering practices, post-depositional taphonomic processes, fish anatomy, and rushed inspection/analysis), but without experimental studies many of these factors remain speculative. Given the importance of fish and other aquatic remains in the human past (see Bailey and Milner, 2002; Erlandson, 2001; McBrearty and Brooks, 2000), we performed a set of butchering experiments designed to evaluate whether or not such practices leave cut marks or other signatures on fish bones. Here we present the first in a series of experiments dealing exclusively with fish bone modification and taphonomy. We address whether butchering fish results in cut marks and where cut marks occur on the skeleton.

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2. Materials and methods

Fifteen lithic blanks and a metal knife were used for butchering. The lithic blanks were knapped by Eren from a gray/blue chert from an unknown source using soft hammer direct percussion. The stone tools ranged in length (mm) from 52.66 to 90.49 (average 68.12), in maximum width (mm) from 57.07 to 94.60 (average 75.60), and in thickness (mm) from 2.81 to 24.32 (average 8.20). The metal knife is a standard non-serrated kitchen knife, with a length of 25 cm from handle to blade tip (13 cm blade, 12 cm handle), and a blade width of 2 cm.

We used spotted seatrout (*Cynoscion nebulosus*, $n = 4$) and red drum (*Sciaenops ocellatus*, $n = 3$) as trial specimens for the experimental methods described below. The trial specimens ranged in weight (g) from 190 to 1710 with an average of 653 and in standard length (cm) from 23 to 49 with an average of 32. These fish provided the opportunity to become familiar with the butchering process before proceeding with the catfish, flounder, and salmon. Although these were practice specimens, similar cut mark frequencies and distributions were noted. Some of these test specimens were slightly damaged (i.e., cranium sawed for otolith removal) during previous fisheries data collection, consequently they have been omitted from our analysis.

For the experiment, we butchered 10 hardhead catfish (*Ariopsis felis*), 10 summer flounder (*Paralichthys dentatus*), and 10 coho salmon (*Oncorhynchus kisutch*; Table 1). These fish were captured using nets (hardhead catfish), an otter trawl (summer flounder), or were diverted into a hatchery during spawning runs (coho salmon). These species also have distinct body sizes and morphologies, diverse geographic distributions, and represent taxonomic families frequently encountered in archaeological assemblages. Hardhead catfish are found in both prehistoric and historic faunal assemblages from the Florida Gulf coast (e.g., Quitmyer and Massaro, 1999; Walker, 1992) and the Atlantic coast of the southeastern United States (e.g., Crook, 1984; Reitz, 1982, 2004). Summer flounder are infrequent or absent in archaeological assemblages (Tveskov, 1997), but winter flounder (*Pseudopleuronectes americanus*) are commonly identified in northeastern US Atlantic coast sites (e.g., Spiess and Lewis, 2001) and share similar size ranges, habitats, and geographic distributions with summer flounders (Murdy et al., 1997; Robins and Ray, 1986). Coho salmon and other species of the genus *Oncorhynchus* are common in archaeological sites in the Pacific Northwest and the Canadian Plateau, playing a fundamental role in Northwest Coast subsistence for millennia (e.g., Butler, 1990, 1993; Butler and Campbell, 2004).

Weight and standard length measurements were recorded for each fish (Table 1). All fish were kept frozen and were thawed just prior to being butchered, with measurements taken after the fish had thawed. Our fish skeletal element terminology follows Cannon (1987, flounder and salmon), Mundell (1975, catfish), and Wheeler and Jones (1989:122–124, general).

A total of 37 fish ($n = 7$ trial and $n = 30$ experimental) were butchered following two methods (A and B). Method A was used to butcher the trial species (i.e., spotted seatrout

Table 1
Measurements of experimental specimens

Specimen	Weight	SL
AF-01	373.5	26
AF-02	414.2	26
AF-03	411.8	31
AF-04	399.0	30
AF-05	677.7	33
AF-06*	569.7	30
AF-07*	503.5	30
AF-08*	517.8	30
AF-09*	541.5	28
AF-10*	374.6	27
OK-01	4083.9	64
OK-02	4867.0	67
OK-03	4911.6	68
OK-04	3133.6	57
OK-05	4306.0	65
OK-06*	1979.0	48
OK-07*	4127.3	63
OK-08*	3008.9	56
OK-09*	2951.4	59
OK-10*	6193.7	67
PD-01	1106.6	39
PD-02	625.0	32
PD-03	880.9	35
PD-04	780.0	36
PD-05	236.6	23
PD-06*	852.6	33
PD-07*	887.7	34
PD-08*	750.1	36
PD-09*	865.8	34
PD-10*	940.3	35

AF, *Ariopsis felis*; OK, *Oncorhynchus kisutch*; PD, *Paralichthys dentatus*; SL, standard length. The * indicates those specimens butchered with the metal knife; all others butchered with stone tools. All weights in grams and SL in centimeters.

and red drum), hardhead catfish, and coho salmon and is based on Rousseau's (2004:18–22) experimental method, which incorporates butchering strategies documented in a number of ethnohistoric and ethnographic accounts of salmon butchery in the Pacific Northwest and Alaska (Emmons, 1991; Gideon, 1989; Hoffman et al., 2000; Kennedy and Bouchard, 1992). For Method A, a fish is placed on its side and an incision is made from the anus to the pectoral fins. Next, the head and viscera are removed. The initial ventral incision is extended from the anus to the caudal fin and the fish is laid open and flat with the vertebral column exposed. Cuts are then made laterally on both sides of the vertebral column, severing rib attachments. Finally, the vertebral column and caudal fin are cut off of the remaining filets.

Method B, as demonstrated by a local fish market employee, was used to butcher the morphologically distinct summer flounder. After placing the flounder on its blind side, the initial incision is made along the length of the dorsal fin, from the pectoral girdle to the caudal fin. Following the initial incision, long strokes are used to separate away the filets. The same incision is made along the anal fin, and long strokes are used to remove the ventral portion of the fillet. A cut is made posterior to the pectoral girdle to completely remove the fillet. The head and viscera are removed. Finally, placing

the flounder on its ocular side, the same process is used to remove the blind-side fillet. The vertebral column, ribs, and dorsal, anal, and caudal fins remain articulated.

After butchering, the skeletons were cold-water macerated (Reitz and Wing, 1999:363–364). After nearly 3 months, a light detergent-based enzyme was added to a majority of the flounder specimens to help speed the maceration process. Once the skeletons were cleaned, the bones of each specimen were carefully inspected twice for cut marks. Both individual cut marks and cut mark clusters (groups of cut marks <3 mm apart) were recorded. Occasional hacks through vertebrae resulting from the severing of the head or tail were noted. All skeletons used in this experiment are housed in the Department of Anthropology, Southern Methodist University.

Like all archaeological experiments, this one possesses limitations, the most obvious being the butchering method. In the event that prehistoric/historic populations were not butchering fish, but rather roasting/smoking them whole (e.g., Robbins et al., 1994:260; Stewart and Gifford-Gonzalez, 1994), cut marks would not appear on the bone. Alternatively, a different butchering strategy might produce a different number or patterning of cut marks. However, our method incorporates observed butchering accounts from the Pacific Northwest and is a fairly common approach used to butcher fish.

Experience is another factor potentially influencing the results of this study. Although Eren has experience butchering mammals with stone tools, this experiment represents the first time either Willis or Eren butchered fish. To minimize the effects of experience, seven trial specimens were butchered, as described above. Nevertheless, it is also likely that archaeological faunal assemblages were in part produced from the actions of novice or less experienced participants (e.g., in a learning context; see Shea, 2006), as well as people who regularly butchered fish and other animals. These potential concerns aside, the following results have important implications for evaluating how ancient peoples processed fish.

Various studies of cut mark frequencies have also suggested that the frequency of bones with cut marks is positively correlated with butchering intensity, as measured by counting the number of strokes when cutting (Abe et al., 2002; Lyman, 1992, 1994:301–303). However, an experimental test of this assumption shows that there is no statistically significant relationship between the number of tool strokes and the number of observable cut marks (Egeland, 2003). For this study, we did not count the number of tool strokes, leaving this as an avenue for future research.

3. Results

3.1. Does butchering fish produce cut marks?

Our research suggests that cut marks resulting from butchering fish are common. For hardhead catfish, the total cut mark count for butchering with stone tools ranges from 15 to 147 cut marks per fish, while the total for the metal knife ranges from 3 to 25 per fish (Fig. 1a). For coho salmon, the total cut mark count using stone tools resulted in a range of 232

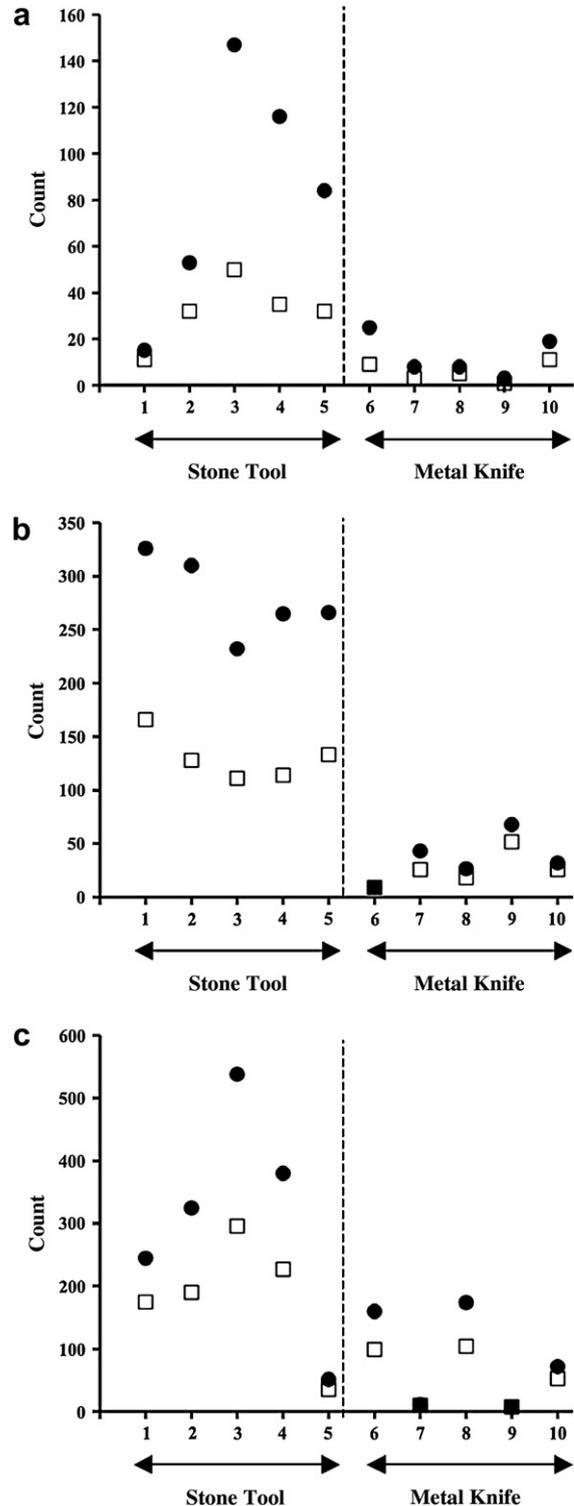


Fig. 1. Individual cutmarks (circles) and cluster (squares) counts for (a) hardhead catfish (*Ariopsis felis*), (b) coho salmon (*Oncorhynchus kisutch*), and (c) summer flounder (*Paralichthys dentatus*). Values on the x-axis represent the specimen numbers.

to 326 cut marks per fish, while the total with the metal knife ranges from 9 to 68 per fish (Fig. 1b). For summer flounder, the total cut mark count using stone tools ranges from 51 to 538 per fish, while the total with the metal knife ranges from 7 to 174 per fish (Fig. 1c). These data indicate that

butchering with hand-held stone tools generally results in more cut marks than butchering with a metal knife, a pattern that is statistically significant (hardhead catfish, $t = 3.0754$, $p = 0.0342$; coho salmon, $t = 12.7621$, $p < 0.0001$; summer flounder, $t = 2.5441$, $p = 0.0472$).

3.2. Where do cut marks appear?

Due to the relative dearth of bone diversity in the axial skeletons of fish, cut marks are distributed on a limited number of elements (Figs. 2–6). Table 2 shows where cut marks appear on the fishes. Cut marks on catfish vertebrae make up 59% and 35% of the total number of cut marks produced by stone and metal tools, respectively. Over 90% of the cutmarks on catfish vertebrae are on the vertebral neural and haemal spines and transverse processes, rather than on the centra. Cut marks on ribs, fin rays, and unidentifiable bone fragments contribute another 27% of the total cut marks for the catfish butchered with the stone tools, and 59% for the metal knife. The remaining cut marks for catfish were located on the ventral surface of the Weberian complex vertebrae (resulting from butchering mistakes made when removing the head), the pectoral and second dorsal spines, and the cleithrum.

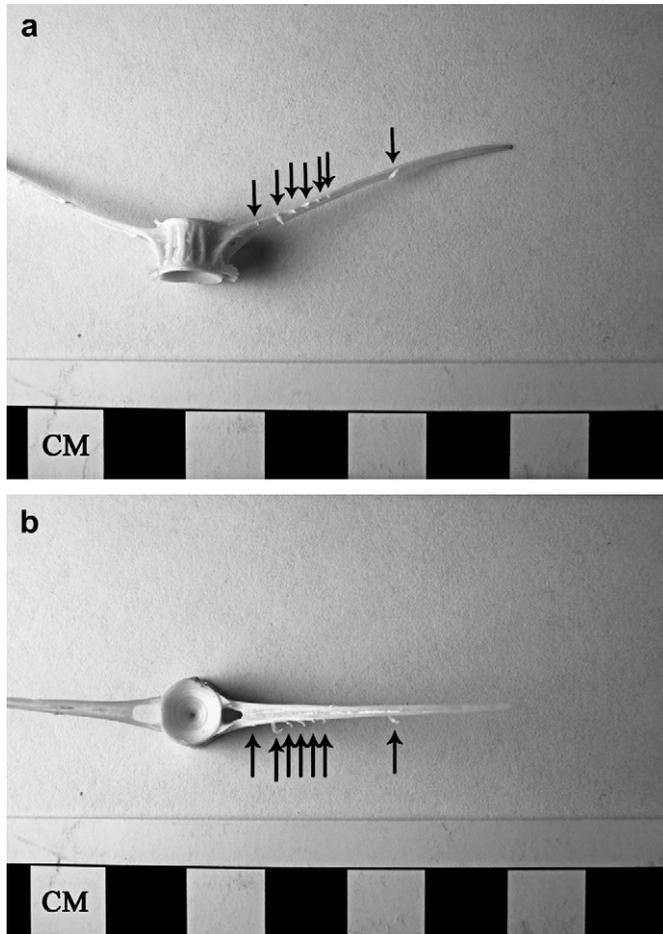


Fig. 2. Two views of cutmarks on a caudal vertebra from fish specimen PD-03 (summer flounder): (a) side view of cutmarks and (b) overhead view showing bone shavings.



Fig. 3. Cutmarks on a cleithrum from fish specimen AF-03 (hardhead catfish).

Cut marks on coho salmon vertebrae provide 41% and 17% of the total number of cut marks produced by stone and metal tools, respectively. Similar to the catfish, over 90% of the cut marks located on coho salmon vertebrae occur on the vertebral neural and haemal spines. For the stone-tool butchered salmon, cut marks on ribs account for 46% of the total, pterygiophores 12%, and the lower postcleithrum and unidentifiable bone fragments each less than 1% of the total cut marks. For the salmon butchered with the metal knife, 82% of the total cut marks occurred on ribs, with 3% of the cut marks on pterygiophores and less than 1% on the expanded neural spine.

For the summer flounder, cut marks on vertebrae make up 44% and 11% of the total number of cut marks produced by stone and metal tools, respectively. Approximately 90% and 75% of these cut marks occur on the neural and haemal spines for stone-tool butchered flounder and metal knife butchered flounder, respectively. The majority of the cut marks for both the stone-tool and metal knife butchered flounder are

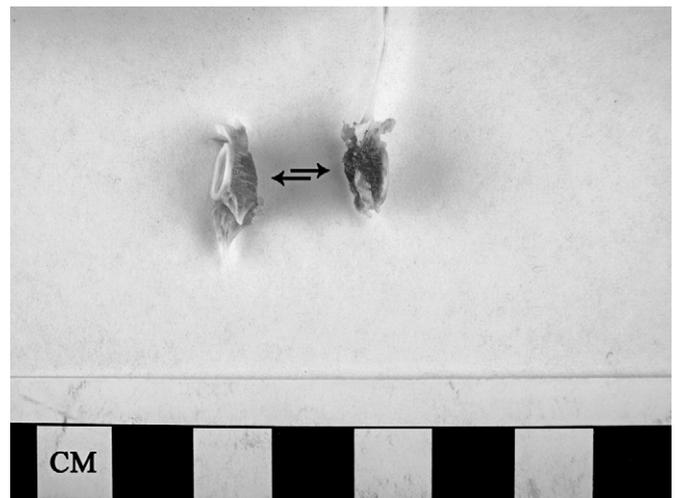


Fig. 4. Sheared precaudal vertebra from fish specimen PD-06 (summer flounder).



Fig. 5. Cutmarks on a rib from fish specimen AF-05 (hardhead catfish).

distributed on pterygiophores (52% and 75%, respectively). Less than 10% of cut marks were located on ribs, fin rays, the postcleithrum, interhaemal spine, and unidentified bone fragments.

4. Discussion

The presence and abundance of cut marks on fish skeletons in our study is surprising given their apparent absence in most archaeological fish analyses. We believe this discrepancy can be attributed to a variety of factors (e.g., cut mark distribution, the small size of cut marks, fish body morphology, and taphonomic processes), though future experiments will help to determine which factors have the most influence on a given assemblage.

The vast majority of experimental cut marks were distributed on vertebral neural and haemal spines, vertebral transverse processes, ribs, and pterygiophores. It is not uncommon for the vertebral neural and haemal spines and transverse processes to break off of centra post-depositionally as a result of trampling or other taphonomic agents (Wheeler and Jones,

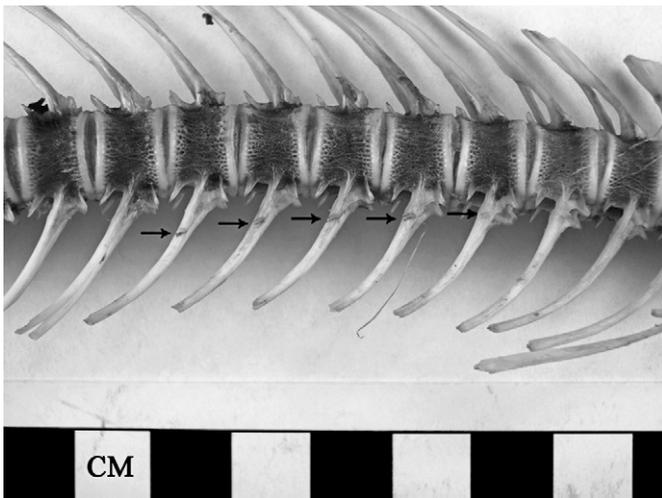


Fig. 6. A series of cutmarks from a single butchering stroke on fish specimen OK-05 (coho salmon).

Table 2
Cutmark distribution percentages

Element	Count	Percent
<i>Hardhead catfish: stone tool</i>		
Thoracic vertebrae	39	9
Precaudal vertebrae	96	23
Caudal vertebrae	79	19
Rib	105	25
Unidentified bones, fragments	5	1
Pectoral spine	26	6
Second dorsal spine	10	2
Fin ray	4	1
Cleithrum	24	6
Weberian complex vertebrae	35	8
<i>Hardhead catfish: metal knife</i>		
Thoracic vertebrae	8	5
Precaudal vertebrae	24	16
Caudal vertebrae	21	14
Rib	84	58
Unidentified bone fragments	1	1
Pectoral spine	9	6
<i>Coho salmon: stone tool</i>		
Thoracic vertebrae	90	6
Precaudal vertebrae	152	11
Caudal vertebrae	327	24
Rib	642	46
Fin ray	1	<1
Pterygiophore	170	12
Lower postcleithrum	3	<1
Unidentified bone fragments	5	<1
<i>Coho salmon: metal knife</i>		
Thoracic vertebrae	15	8
Precaudal vertebrae	4	2
Caudal vertebrae	11	6
Rib	142	82
Pterygiophore	6	3
Expanded neural spine	1	<1
<i>Summer flounder: stone tool</i>		
Thoracic vertebrae	5	<1
Precaudal vertebrae	119	8
Caudal vertebrae	560	36
Interhaemal spine	29	2
Postcleithrum	2	<1
Rib	19	1
Fin ray	10	<1
Pterygiophore	676	44
Unidentified bone fragments	119	8
<i>Summer flounder: metal knife</i>		
Thoracic vertebrae	14	3
Precaudal vertebrae	19	4
Caudal vertebrae	19	4
Interhaemal spine	14	3
Postcleithrum	1	<1
Rib	3	<1
Fin ray	1	<1
Pterygiophore	317	75
Unidentified bone fragments	36	8

Bone terminology follows Cannon (1987, flounder and salmon), Mundell (1975, catfish), and Wheeler and Jones (1989:122–124, general).

1989: 108). Once separated from the centrum, vertebral spines and processes, along with ribs and other undiagnostic fish bones, are not useful for precise taxonomic identification. Thus, the evidence for fish butchering may be present in faunal

assemblages, but is overlooked due to the distribution of cut marks on elements that are not carefully examined beyond a weight and/or a count of osteichthyan bone. The results presented here suggest that researchers should examine undifferentiated fish bone for evidence of butchering.

Another compounding factor that may lead to the discrepancy between the experimental results and faunal analyses is the quality of the cut marks themselves. The majority of the cut marks tend to be small and shallow; even on fresh, clean bone, a magnifying glass was occasionally needed to identify the cut marks. Given that fish bone is often less likely to preserve as well as more robust mammal bones (Butler and Chatters, 1994; Colley, 1990; Lyman, 1984, 1994; Wheeler and Jones, 1989), it is possible that taphonomic processes (e.g., trampling, root etching, and human or other animal digestion) may remove or obscure the signatures of fish butchering. To test this idea we are currently working on a second, multi-year experiment designed to address the influence of post-depositional processes on the preservation of fish bone cut marks.

Although the primary goal of the current experiment was not to compare stone and metal tools, but rather whether fish butchering produces observable cut marks, we note that butchering with stone tools generally resulted in a higher number of total cut marks than butchering with the metal knife. Further research is needed to test this hypothesis.

5. An archaeological correlate

To provide an archaeological test of the experimental data, we analyzed an assemblage of 9391 fish bones previously reported by Rick (2007:110–111) from Unit 2 at CA-SMI-163, a Protohistoric and Historic period village site on San Miguel Island, California. The assemblage is well preserved and contains roughly 17 different marine fishes, including rockfish (*Sebastes* spp.), surfperch (Embiotocidae), cabezon (*Scorpaenichthys marmoratus*), California sheephead (*Semicossyphus pulcher*), and other common kelp bed and rocky shore fishes. Of the 9391 bones, 8182 were spines, rays, ribs, or small, fragmented bones not identifiable to low taxonomic categories. During the previous analysis, no cut marks or definitive evidence of processing other than burning were noted. The assemblage of bird ($n = 422$) and mammal ($n = 65$) remains from the site was considerably smaller than the fish assemblage, but cut marks were noted on six of the marine mammal bones and one bird bone.

Only a single utilized flake was identified as a cutting tool in the CA-SMI-163 assemblage. No metal or glass tools were identified at this site, although some shell beads were drilled with iron needles (Rick, 2007:34). We suspect people were primarily using expedient stone tools to butcher fish and other animals, but it remains possible that metal and possibly shell tools were at least occasionally used as well.

All of the identified and undiagnostic fish bones were reanalyzed for this study to determine if any of the bones had cut marks that were previously unrecognized. Thirty-three cut marks were identified on 16 bones, with only two of these bones (rockfish vertebrae) identified beyond undifferentiated

bony fish. The remaining bones consisted of unidentified ribs, spines, and small bone fragments. Several other specimens had ambiguous marks that could either be root etching or cut marks that were too small to differentiate. Because only 0.17% of the total assemblage contained cut marks, in this case evidence for butchering appears to be quite limited. This could be a result of several factors. The fish may have been consumed with limited or no formal filleting or other cutting. Alternatively, the cut marks could be obscured or erased by post-depositional processes, especially root etching. In this case, we suspect that a combination of the butchering strategy and post-depositional processes may account for the dearth of cut marks. Without the experimental data, however, no signs of butchering would have been identified.

6. Conclusions

Our conclusions have important implications, especially for distinguishing natural from cultural fish assemblages and for understanding food-processing techniques. With the dramatic increase of taphonomic studies over the past few decades, numerous researchers have worked to delineate the characteristics separating natural from cultural assemblages in coastal and other aquatic regions (Butler, 1990, 1993; deFrance, 2005; Erlandson and Moss, 2001; Erlandson et al., 2007; Gifford-Gonzalez et al., 1999; Stewart, 1991; Van Neer and Muñiz, 1992). Due to the low frequency of cut marks observed on fish bone, several studies have focused on fish body-part frequency and skeletal completeness (Butler, 1990, 1993; Hoffman et al., 2000). Our data illustrate the need for researchers working with fish assemblages to consider the potential presence of cut marks on undifferentiated fish bones within these assemblages. Through the examination of (often overlooked) bony fish fragments, researchers may discover another line of evidence to support the argument for a cultural assemblage when a site lacks other cultural markers. This research also adds to a growing number of studies that demonstrate the utility of experimental analyses for better understanding the archaeological patterning of fish and other faunal remains (e.g., Butler and Schroeder, 1998; Nagaoka, 2005). We hope this study will prompt other researchers to conduct butchering experiments on fish and other animals to help test and refine the data and interpretations presented here.

Acknowledgements

This project was supported by the Institute for the Study of Earth and Man at Southern Methodist University (SMU) and Mustafa and Kathleen Eren. We thank Bob McMichael, Sean Fisk, and the Florida Fish and Wildlife Research Institute (FWRI), St. Petersburg, FL, for donating the hardhead catfish, red drum, and spotted seatrout; Gary Nelson and the Massachusetts Division of Marine Fisheries, Gloucester, MA, for the summer flounder; and John Kerwin, Larona Lavallie, and the Washington Department of Fish and Wildlife Cowlitz Hatchery for the coho salmon. Ramon Ruiz-Carus and Richard E. Matheson Jr. of the FWRI provided invaluable assistance in

bone identification. Alan Humason of the SMU Department of Chemistry graciously provided access to fume hoods. Thanks also to Scott and Joanne Willis for their encouragement and support. Finally, we thank Ken Gobalet, three anonymous reviewers, and Richard Klein for comments on earlier versions of this manuscript.

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