CHAPTER 12

Processing the Patterns

Elusive Archaeofaunal Signatures of Cod Storage on the North Pacific Coast

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Archaeological research in the eastern North Pacific, from the Aleutians to the Washington coast, has tended to focus on the evidence for salmon fishing and storage in the prehistoric record (Ames 1981, 1994; Butler and Chatters 1994; Cannon 1991, 2001; Coupland 1998; Fladmark 1975; Hayden 1997; Hoffman, Czederpiltz, and Partlow 2000; Matson 1983, 1992; Matson and Coupland 1995; Partlow 2000, 2006; Schalk 1977). There are several key reasons for this. First, salmon have been historically important to eastern North Pacific peoples (Davydov 1977; Emmons 1991; Veniaminov 1984). Secondly, salmon fit Testart's (1982:523) preconditions for large-scale intensive storage: they are spatially and temporally predictable and abundant, and with the right technology, large numbers of salmon could be harvested, processed, and stored for the winter. Finally, intensive storage of species such as salmon can help cushion against seasonal resource scarcity (i.e., the winter months; Rowley-Conwy 1982:533), can lead to decreased mobility by both inhibiting it and making it less necessary (Testart 1982:524), and may contribute to increased social complexity (Ames 1985; Soffer 1989; Steffian, Saltonstall, and Kopperl 2006:99; Wesson 1999).

By contrast, discussion of the importance of Pacific cod in prehistory has been relatively rare. Yet, historically, Pacific cod has been an important resource for many eastern North Pacific peoples, including the Aleut (Jochelson 1933; Lantis 1984; Turner 1886), the Alutiiq of Prince William Sound (Birket-Smith 1953) and the Kodiak Archipelago (Davydov 1977; Holmberg 1985), the Eyak and Tlingit (de Laguna 1972, 1990a, 1990b; Oberg 1973), the

Haida (Langdon 1979), the Nuu-chah-nulth (Arima and Dewhirst 1990), and the Quinault (Hajda 1990). According to ethnohistorical records, some Native peoples dried Pacific cod for storage in the nineteenth and twentieth centuries (Davydov 1977; Emmons 1991; Gideon 1989; de Laguna 1972; Newton and Moss 1984; Oberg 1973; Turner 1886). The extent to which cod were dried for storage prior to the arrival of Russians in the eighteenth century and the beginning of the commercial cod fishery in the mid-nineteenth century, however, is unclear. Cod make up a substantial percentage of the fish remains from many North Pacific sites (Hanson 1995; Kopperl 2003; Maschner 1997; Moss 1989a; Orchard 2003; Yarborough 2000), and several researchers have suggested that Pacific cod, like salmon, may have been dried and stored prehistorically (e.g., Bowers and Moss 2001; Cannon 1991; Croes 1995; Croes and Hackenberger 1988; Moss 2004; Saltonstall and Steffian 2006).

To what extent do Pacific cod fit Testart's preconditions for large-scale intensive storage? Pacific cod are available year-round, although they are more abundant and easier to locate and catch during the spring and summer and along specific banks. They could be harvested in large numbers in a short period of time by longline fishing out of small boats (Cobb 1927; Shields 2001). Storage may have been made possible by air-drying or smoking, as with salmon. Therefore, Pacific cod meet Testart's four preconditions for intensive food storage: they are abundant, seasonally available, easily harvestable with longlines from small boats, and storable.

If Pacific cod were dried and stored by Native peoples prehistorically, how do we identify this in the archaeological record? Unfortunately, obvious storage facilities containing abundant cod bones have not been found, although some codfish (Gadidae) were found in the subfloor pit assemblage from a small house excavated at Agayadan Village (49-UNI-067) on Unimak Island (Hoffman 2002:115). Less direct evidence might be features for drying and smoking (e.g., drying racks, smudge pits), tools for cod capture or processing (e.g., cod hooks), and associated cod bones. Based on Pacific cod bones and hundreds of deep-sea fishing hooks associated with drying racks and smudge fires at the Hoko River Wet/Dry site (45-CA-213), Croes and Hackenberger (1988:76–77; Croes 1992, 1995) argued that Pacific cod were caught and processed for storage ca. 3000–2500 BP on the Washington coast. Based on large numbers of Pacific cod bones and processing tools associated with a distinctive (15–42 cm thick) layer of wood charcoal suggestive of a smokehouse at the Horseshoe Cove Site (49-KOD-415), Hays (2007) and Steffian and others (2006:116; Saltonstall and Steffian 2006:56, 83) argue that Pacific cod were caught and processed for storage ca. 3700–3300 BP in the Kodiak Archipelago.

Although the smoking and drying facilities at these sites are suggestive, we cannot be certain that they were used for cod. Another approach is to evaluate the faunal record of cod skeletal part representation. Differential skeletal part representation has been used to argue for the presence of stored salmon in North Pacific sites and also stored cod in North Atlantic sites (e.g., Amundsen et al. 2005; Barrett 1997; Butler and Chatters 1994; Hoffman, Czederpiltz, and Partlow 2000; Partlow 2000, 2006; Perdikaris 1999).

This paper summarizes the ethnohistorical evidence for Pacific cod storage by eastern North Pacific peoples and analyzes the skeletal part evidence from fifteen cod assemblages recovered from thirteen eastern North Pacific sites, including part of the Horseshoe Cove site and the Hoko River Wet/Dry site. This skeletal part evidence is compared against expectations for cod storage and also with selected North Atlantic assemblages interpreted as probable processing and storage sites for Atlantic cod during the historic dried codfish trade.

Pacific Cod

Pacific cod (*Gadus macrocephalus*), also known as true cod or gray cod, is an economically important groundfish, or demersal fish, of the true cod family, Gadidae. Other important North Pacific cod fishes of Gadidae include walleye pollock (*Theragra chalcogramma*), Pacific tomcod (*Microgadus proximus*), and saffron cod (*Eleginus gracilis*). Pacific cod are found just above the sea bottom, usually at depths of less than 350 m (Mecklenburg, Mecklenburg, and Thorsteinson 2002:296), along the large continental shelf area from northern California to the Alaska Peninsula (Kasahara 1961:16). They appear to be most abundant in the western part of the Gulf of Alaska around the Shumagin Islands, Chirikof Island, and the Kodiak Archipelago (Mundy and Hollowed 2005:91).

Pacific cod continue to grow throughout their lives. In the Gulf of Alaska, they mature between five and eight years of age, by which time they average about 67 cm in length (DiCosimo and Kimball 2001:3). They can live to be as old as eighteen or nineteen years (DiCosimo and Kimball 2001:3; Witherell 2000:2) and reach total lengths up to 120 cm (Mecklenburg, Mecklenburg, and Thorsteinson 2002:296). Trawl-caught fish today average 70–75 cm in total length and 4.5 kg (Mecklenburg, Mecklenburg, and Thorsteinson 2002:296).

In general, the distribution of adult Pacific cod is strongly tied to water temperature. Adult cod prefer waters between 0°C and 10°C (Kasahara 1961:66). Consequently, in winter they usually concentrate in the warmer waters along the shelf edge at depths between 100 and 200 m, moving back to shallower waters that warm up in the spring and summer (DiCosimo and Kimball 2001:3; Kasahara 1961:66–67). Along southcentral Alaska and British Columbia, however, the water temperature does not vary as much from summer to fall; hence in some areas, cod are available year-round, although they are more abundant in spring and summer than in winter (Cobb 1927).

Pacific cod have been fished commercially in the Bering Sea and the Aleutians since the last half of the nineteenth century (Bakkala 1984:157; Cobb 1927; Kasahara 1961:71; Shields 2001). By contrast, as late as the early 1960s, the waters south of the Alaska Peninsula had never been fished intensively for Pacific cod (Kasahara 1961:73). Significant contemporary catches of Pacific cod have occurred near Buldir Island and the Island of Four Mountains in the Aleutians, south of Kodiak Island and the Alaska Peninsula west to Unimak Island in the Aleutians, in Hecate Strait between the Queen Charlotte Islands and mainland British Columbia, off the north coast of Washington around the southern end of Vancouver Island, and just off the north end of Vancouver Island (Bakkala et al. 1984: Figures 2–3).

Cod Fishing in the Ethnohistorical Record

The eastern North Pacific, a large region that stretches from the Aleutians in the northwest to Washington in the south, was home to many different Native peoples. The location of abundant cod populations and the ways in which different people used those resources have probably changed through time (Bowers and Moss 2001:159; Causey et al. 2005; Hunt and Stabeno 2005; Shields 2001; Turner 1886). For example, according to Turner (1886:90), Pacific cod were not seen around Attu Island in the Aleutians prior to 1873. To what degree the ethnohistorical record accurately reflects subsistence practices prior to contact with Euro-Americans and Russians is debatable (Hanson 1995; Yarborough 2000); nevertheless, the ethnohistorical record is worth examining for evidence of the importance of Pacific cod to North Pacific peoples.

Although salmon and halibut were generally ranked the highest in lists of important fish resources (Rousselot, Fitzhugh, and Crowell 1988:153), the ethnographic literature indicates that Pacific cod were also an important subsistence resource to many North Pacific peoples (Arima and Dewhirst 1990; Birket-Smith 1953; Davydov 1977; Hajda 1990; Holmberg 1985; Jochelson 1933; de Laguna 1972, 1990a, 1990b; Langdon 1979; Lantis 1984; Oberg 1973; Turner 1886). On a cautionary note, although Suttles (1990:25) lists the true cods as one of the more important saltwater fishes to peoples of the Northwest Coast, he acknowledges that the term *cod* was applied to "a variety of fishes not always distinguished in the ethnographic literature." Likewise, Hanson (1995:31) suggests that the "cod" caught historically by the Straits Salish may have been lingcod (*Ophiodon elongatus*) or rockfish (*Sebastes* spp.).

Native fishers traditionally caught Pacific cod by line-fishing from small boats throughout the North Pacific (Black and Liapunova 1988:55; Clark 1984:189–190; Haggarty et al. 1991:84; Holmberg 1985:47; de Laguna 1972:391, 1990a, 1990b; Rousselot, Fitzhugh, and Crowell 1988:154). Large numbers were probably caught from inshore banks using hand lines, a well-documented technique for the early twentieth-century commercial fisheries (Cobb 1927:389; Jochelson 1933:11; Shields 2001:20). Although cod are currently available year-round, spring and summer may have been the prime seasons for Native cod fishing because of safer weather conditions, cod abundance during spawning, larger size, and better taste (Birket-Smith 1953:39; Cobb 1927:389; Crowell and Laktonen 2001:176; Davydov 1977; Haggarty et al. 1991:84; Jochelson 1933:11; Oberg 1973:73; Veniaminov 1984:361). During the nineteenth century, the Aleut caught cod primarily during the summer, when they were abundant and easily caught within two miles from shore, whereas during the winter, they kayaked more than ten miles from shore in order to catch cod (Jochelson 1933:11). The season when Pacific cod were most abundant closer to shore may have varied from one area to another (see Moss, this volume). In the Aleutians, cod were most abundant in February and March in some places, while in others they did not show up until July or September (Turner 1886:89). On the Northwest Coast, deep-sea fishing for cod near offshore islands was one of the principal subsistence activities from March to July among the Chilkat Tlingit (Oberg 1973:66, 73). Deep-sea cod fishing was replaced by salmon fishing in July and August (Oberg 1973:74).

Cod Storage in the Ethnohistorical Record

According to ethnohistorical accounts, cod were dried by some Native peoples during both the colonial Russian period and the commercial fishing period in the mid-nineteenth century. To what extent this was a product of Russian and American expectations and economies or a continuation of previous subsistence practices is unclear. This section summarizes the ethnohistorical evidence for cod storage by North Pacific peoples.

For the Aleutians, there is conflicting ethnohistorical evidence regarding both cod storage for personal use and the importance of storage in general. According to one account, Aleuts were trading dried cod to the Russians by 1764 (Jochelson 1933:5). Similarly, in 1802, Sauer (1802:161) wrote of a group of Aleut drying cod for the winter, but noted it was only for trade with visiting Russians. According to Veniaminov (1984:276), who came to the Aleutians during the early to mid-nineteenth century, wet weather did not "permit the Aleuts to store much because the only possible method of fish preservation is by [air] drying." On the other hand, in his history of the Russian-American Company, Tikhmenev (1978:407) wrote that cod were dried on Unalaska Island during the mid-1800s, and Turner (1886:90) observed the Aleut drying large numbers of cod for the winter for their own use in the late nineteenth century. In their recent summary, McCartney and Veltre (2000:506, 512) argued that "[f]ood storage was a critical aspect of Aleut life" enabling them to survive the winter when resources were scarce. In his history of fishing in the Aleutians, Jacka (1999:219) includes "deep water" fish, presumably including cod, among the fish that the Aleuts "split and air-dried on racks," before storing them in sea lion stomachs to prevent them from growing moldy in the damp climate. According to Lantis (1984:176), however, the Aleut did not store much food prehistorically "except for the festivals," as the damp weather made drying difficult and because resources were available year-round.

Like the Aleutians, the Kodiak Archipelago is a prime cod-fishing area today, but it is uncertain the degree to which cod were dried and stored prehistorically. With the arrival of the Russians on Kodiak Island in the late eighteenth century, the Alutiiq were put to work catching and drying or salting thousands of fish for the Russians (Gibson 1978:372). How many of these dried fish were cod is unclear. Because of the endless rains, most fish were salted, while those that were simply dried were often not considered edible by the Russians (Gibson 1978:372). Gideon (1989:41) mentions dried cod among the Alutiiq during his visit to the Kodiak Archipelago ca. 1803–1809. On the other hand, Davydov (1977:232), who visited the region around the same time, wrote that cod were not stored by the Alutiiq but rather eaten fresh just until the salmon began running. The Alutiiq considered rotting fish heads delicacies and cod heads were so valued for this purpose that the cod were killed so as not to damage the head (Davydov 1977:172, 174).

Northern Northwest Coast accounts conflict regarding drying of cod as well. De Laguna (1972:401–402) noted that some people in Yakutat smoked spring-caught cod historically, whereas Emmons (1991:149) claimed that the Tlingit never dried cod, but always ate it fresh. On the other hand, in the late nineteenth century, Knapp and Childe (1896:27) describe cod on drying racks in their idea of a typical Tlingit village. At the end of the nineteenth century, Kamenskii (1985) wrote that the Tlingit knew how to dry all kinds of fish (possibly including Pacific cod) for the long winters. Finally, de Laguna (1990b:206) cautioned that no single subsistence economy characterized the Tlingit; rather, families and local groups in different regions might focus on different resources at any one time. No doubt, the same was true elsewhere in the eastern North Pacific.

Such contradictory accounts suggest that not everyone dried Pacific cod. Therefore, we should not expect to see evidence for dried cod in all assemblages from all time periods and regions. The challenge is to discern where and when Pacific cod may have been dried in the past. For this reason, we chose to look at assemblages from different regions and time periods in the North Pacific.

Expectations for Faunal Evidence of Cod Storage

Skeletal part representation is one line of evidence used to support arguments for or against fish storage. For Pacific salmon, an overabundance of vertebrae has been interpreted as the remains of stored salmon (e.g., Butler and Chatters 1994; Hoffman, Czederpiltz, and Partlow 2000; Partlow 2000, 2006), while an overabundance of heads has been interpreted as the remains of salmon processing at a fish camp (Hoffman, Czederpiltz, and Partlow 2000). For Atlantic cod, an overabundance of cleithra and tail vertebrae has been interpreted as the remains of stored cod, while an overabundance of heads, underabundance of cleithra, and the presence of more abdominal than tail vertebrae has been interpreted, for the most part, as the discarded remains of cod processed for the dried cod trade (e.g., Amundsen et al. 2005; Barrett 1997). Expectations for Pacific cod storage can be derived from ethnohistorically documented methods of butchery, economic anatomy, and less directly, from practices used during the historic commercial cod trade (which included salting the drying fish, a practice not known to have been used by Native peoples in the eastern North Pacific prior to Euro-American contact).

Based on the few ethnohistorical accounts, Pacific cod may have had their heads removed, but may also have had some of their vertebrae removed as well. For example, in one twentieth-century Tlingit method, cod heads were removed prior to drying (Bowers and Moss 2001). Mitchell and Donald (1988:320) describe cod air-dried or smoked for storage on the Northwest Coast as "filleted with the skin on and intact at belly or back, so that the whole was spread out to dry." According to Turner's (1886) mid-nineteenth-century Aleutian account, dried Pacific cod retained tails, but may have retained other vertebrae and even the head. Turner (1886:90) describes how the Aleut processed cod for storage as follows:

> The head is partly severed from the body at the throat, the gills are taken out, a slit along the belly and the entrails are removed, the backbone is cut out on each side and either removed as far as the tail, which is left to hold the two sides together to allow them to be hung over a pole, or else it is left in and dried with the body. When fish are abundant this is rarely done. The sides are then cut transversely through the flesh to the skin and the body then hung up by the tail to dry.

Based on economic anatomy, we expect cod heads to be treated differently from bodies. Because fish heads tend to have the most fat, they are the part of the fish least conducive to drying. For example, according to one Makah elder (cited in Croes 1992:348), dried halibut heads only lasted a few months because of their high oil content. The same may have been true for Pacific cod heads, which are not only the fattiest part of the fish but the choicest part (Cobb 1927; Davydov 1977). For these reasons, cod heads probably were not dried very often, but rather eaten separately either fresh or as a rotting delicacy.

In both the Pacific and Atlantic commercial dried cod fisheries of the nineteenth and twentieth centuries, cod heads and often the abdominal vertebrae were removed during processing (Barrett 1997:619–620; Cobb 1927; Shields 2001). The dried cod retained the tail and may have retained the cleithra as well. The cleithrum is a large and robust pectoral fin element that often traveled with the dried Atlantic cod in the fish trade to help hold the fillet together (Amundsen et al. 2005:135–136; Barrett 1997:619–620). It is important to note, however, that while salt often was used to dry Atlantic and Pacific cod during the historic commercial fish trade, it was not used by Native peoples prehistorically in the eastern North Pacific.

In summary, it is likely that because of their higher fat content and value as a delicacy (e.g., Cobb 1927; Davydov 1977), Pacific cod heads may have been cut off and treated differently than bodies during processing for drying and storage. If Pacific cod were processed for storage in a manner similar to that described historically for the Northwest Coast as well as for the dried Pacific cod commercial fish industry, we might expect to see a dichotomy in Pacific cod assemblages: (1) those dominated by bodies and/or pectoral elements (i.e., cleithra), with significantly fewer heads indicative of the remains of stored cod, and (2) those dominated by heads with significantly fewer bodies indicative of the remains of cod processing and/or the consumption of fresh or rotting cod heads. If, however, Pacific cod were processed for storage similar to the manner described by Turner (1886), then the remains of stored cod may be difficult to distinguish from the remains of cod eaten fresh on site; both types of remains would include cod heads and bodies. Likewise, in the absence of separate disposal areas on site, assemblages containing the remains of both stored cod bodies and cod heads eaten either fresh or as rotting delicacies may be indistinguishable from assemblages containing whole cod eaten fresh.

Methods

For this analysis, we compiled the skeletal parts data from radiocarbon-dated cod assemblages throughout the eastern North Pacific. In order to ensure reasonable samples of skeletal parts, we selected assemblages with 300 or more specimens (NISP) identified to element from Pacific cod or cod family (Gadidae) bones recovered with quarter-inch or smaller screens. At sites with multiple components, we separately selected components that met our criteria. The final sample was fifteen assemblages from thirteen sites (Figure 12.1, Table 12.1). The majority of the assemblages are from the Kodiak Archipelago, where we have conducted much of our research.

Screen size was considered in the sample selection because it can affect skeletal part representation (Barrett 1997; Grayson 1984; Moss 1989b, 2004; Nagoaka 2005). Three studies suggest that assemblages recovered using quarter-inch screen adequately represent skeletal parts from medium- to large-size Pacific cod. First, Moss (2004:163) found quarter-inch screen to be satisfactory (when compared to finer screen fractions) in recovering the large Pacific cod bones from the Cape Addington Rockshelter site. Two other

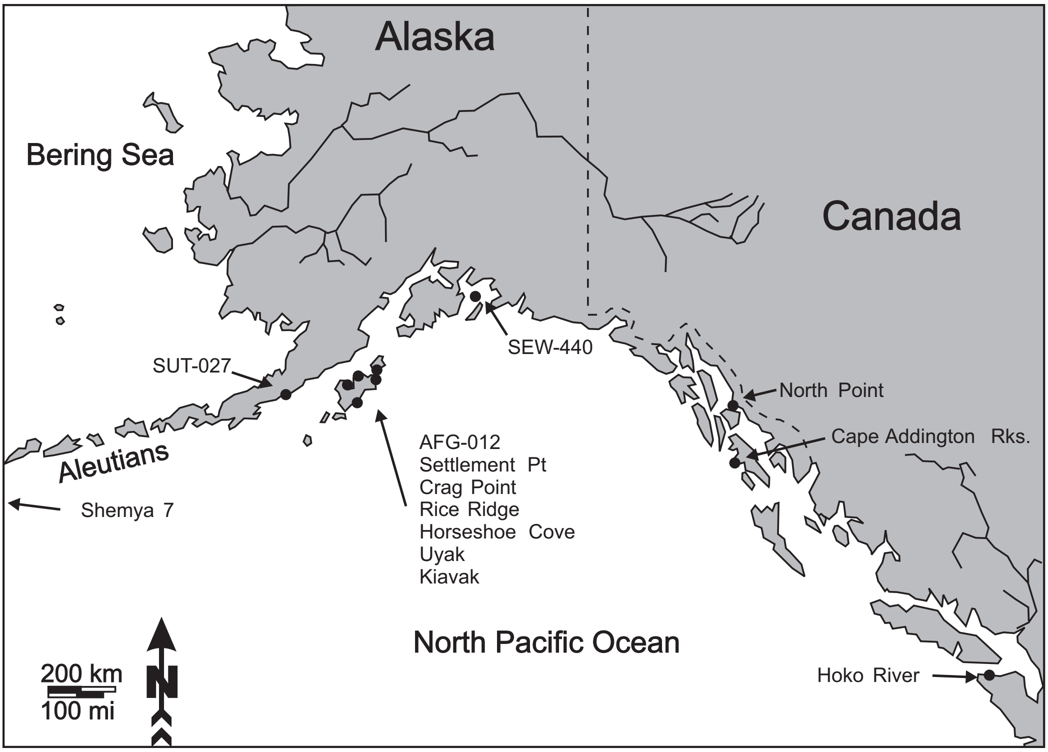

Figure 12.1. Location of North Pacific sites with cod assemblages analyzed in this chapter.

tests were made by the senior author for this study. In the first, a comparison of gadid skeletal parts (%MAU) by three screen sizes (half-inch, quarter-inch, eighth-inch) from the Settlement Point midden and house floor assemblages indicated no significant difference in cod skeletal parts based on screen size. All three screen sizes (half-inch, quarter-inch, eighth-inch) were cranially dominated. In the second test, a comparison of Pacific cod vertebra types (thoracic, precaudal, caudal) by screen size at the 49-AFG-012 site demonstrated no difference between the quarter-inch and eighth-inch samples.

A potential bias in skeletal part representation for gadids that is not present for other fishes such as salmon is the small size of characteristic tail elements. There is a strong likelihood of cod ultimate vertebrae being underrepresented due to their small size (Barrett 1997:625). Cod ultimate vertebrae are rarely identified in archaeological assemblages. To what degree missing tail elements in a cod assemblage are a product of screen-size bias or postdepositional destruction of the ultimate vertebrae rather than differential processing is unclear. Barrett (1997:625) believes a screen size as small as 1 mm is needed to recover Atlantic cod ultimate vertebrae. Because caudal vertebrae are smaller than thoracic and precaudal vertebrae, it is possible that low numbers of caudal vertebrae in a cod assemblage is also a function of screen size rather than cod processing. For this reason, low numbers of cod tails in an assemblage may simply be a function of the smaller size of the tail elements compared to the rest of the skeleton, rather than an indication that cod tails were removed from the site prior to deposition.

Table 12.1. North Pacific cod assemblages analyzed in this chapter

Site #	Site name (assemblage)	Region[a]	Sample used (taxon, NISP)	Screen size	Age (RYBP)[b] (# of dates)	Source
49-KOD-099	Kiavak (bulk samples)	Kodiak	Gadidae, 690	1/8"	331±32 (2 dates)	Clark 1974; Partlow 2000
49-AFG-012	None	Kodiak	Gadidae, 4469	1/8"	350±42 (2 dates)	Partlow 2000
49-SEW-440	None	PWS	Gadidae, 373	1/4"	380±60 (1 date)	Yarborough 2000
49-AFG-015	Settlement Point (midden)	Kodiak	Gadidae, 4022	1/8"	392±28 (4 dates)	Partlow 2000
49-AFG-015	Settlement Point (HF1)	Kodiak	Gadidae, 3110	1/8"	600±38 (2 dates)	Partlow 2000
49-KOD-145	Uyak (HF 7)	Kodiak	Pacific cod, 390	1/4"	1270±100 (1 date)	Kopperl 2003
49-SUT-027	None	Alaska Peninsula	Gadidae, 551	1/4"	1470±35 (2 dates)	Vanderhoek and Myron 2004; Schaaf and Bender, pers. comm. 4/28/2006
49-CRG-188	Cape Addington (Stratum V)	NWC	Pacific cod, 466	1/4"	1785±38 (3 dates)	Moss 2004
49-KOD-044	Crag Point (HF 1B)	Kodiak	Pacific cod, 529	1/4"	2194±47 (3 dates)	Kopperl 2003
49-ATU-061	Shemya 7 (Pit 1)	Aleutians	Gadidae, 7705	1/8"	2670±86 (2 dates)	Lefevre, West, and Corbett 2001; Partlow 1997
45-CA-213	Hoko River Wet	NWC	Gadidae, 592	hydraulic	2861±55 (3 dates)	Croes 1995; Croes, pers. comm. 11/28/2006
49-SUM-25	North Point Wet	NWC	Pacific cod, 2089	1/4"	2996±48 (2 dates)	Bowers and Moss 2001
49-KOD-415	Horseshoe Cove (SD2)	Kodiak	Gadidae, 1513	1/8"	3364±34 (4 dates)	Hays 2007, pers. comm. 7/5/2008; Saltonstall and Steffian 2006
49-KOD-363	Rice Ridge (HF Level B)	Kodiak	Pacific cod, 1689	1/4"	3930±80 (1 date)	Kopperl 2003
49-KOD-363	Rice Ridge (Level C)	Kodiak	Pacific cod, 566	1/4"	5070±40 (1 date)	Kopperl 2003

a. PWS = Prince William Sound; NWC = Northwest Coast.
b. If there was more than one date, then the radiocarbon dates were averaged using CALIB REV 5.0.1 (Stuiver and Reimer 1993).

The skeletal parts data can be expected to vary by cod treatment and site type. All else being equal (including density-mediated attrition; see Smith et al., this volume), if cod are not stored, then we expect all skeletal parts to be represented. If cod are stored, then fish camps would have discarded portions such as heads (presumably also consumed on site) and abdominal vertebrae, whereas multiseason winter villages could be expected to lack these elements. These can be considered initial expectations against which to compare the skeletal part representation in the assemblages.

Analyzing Skeletal Part Representation

Faunal analysts often quantify skeletal parts using minimal animal units (MAU; Binford 1984), calculated by dividing the minimum number of elements (MNE; Bunn 1982) by the frequency of that element in a particular animal. Often, MAUs are normed relative to the highest MAU in the assemblage to produce %MAUs. Recently, Grayson and Frey (2004) suggested using "normed NISPs" (NNISP) in place of MAUs as a simpler measure that can serve the same purpose. Normed NISPs are calculated by dividing the number of identified specimens (NISP) per element by the frequency of that element in a complete skeleton. For assemblages in which the bones are not highly fragmentary, MNE and NISP values will be very similar. Rather than compare MAU or NNISP values for each skeletal element, some researchers compare the frequencies of "butchering units" (Lyman 1979). This approach has been used by faunal analysts comparing skeletal parts for salmon and Atlantic cod (e.g., Amundsen et al. 2005; Partlow 2006). In these cases, %MAUs or %NNISPs are calculated for body regions that are treated differently during processing for drying (i.e., cranial, pectoral, thoracic vertebral, precaudal vertebral, caudal vertebral) based on the maximum MAU or NNISP value for each region.

Another method of measuring skeletal part representation is to simply count all the MNEs (rather than the highest one) across the different body regions without calculating MAUs or NNISPs and compare them with the percentages of MNEs expected for a whole fish (e.g., Norton, Kim, and Bae 1999; Wigen 2005). This method, while simpler, may suffer from identification biases. For example, often faunal analysts do not identify all the elements in a fish assemblage, particularly ribs, spines, and branchial arch bones, which makes it difficult to compare the assemblage to the expected MNEs for a whole fish. Additionally, some elements are more distinctive to taxon than others. By taking the highest MNE for a particular body region instead, potential bias due to interanalyst identification protocols is eliminated.

We chose Grayson and Frey's (2004) NNISP measure, allowing us to compare a variety of assemblages and include those reported as NISP counts. There is little concern here with problems of differential fragmentation in using NISP rather than MNE counts, because the cod remains from the North Pacific assemblages tend not to be highly fragmentary. In addition, we chose to analyze skeletal part distribution across three body regions: cranial, pectoral, and vertebral, with a further breakdown of vertebral into thoracic, precaudal, and caudal for assemblages that had those data. The pelvic and tail regions were excluded from our analysis because (1) the pelvic region in cod is represented by the basipterygium, which is easily broken and not often found in assemblages, and (2) the tail region is represented by the ultimate vertebrae, which is one of the smallest bones in a cod, as explained above. To norm the vertebrae NISPs, the number of each type of vertebrae was counted in Partlow's comparative Pacific cod specimens. The vertebrae NISPs were then divided by the number of times that vertebrae type appeared in a Pacific cod skeleton (thoracic = 5; precaudal = 15; caudal = 33).

The cod assemblages analyzed here are mixtures of Pacific cod (*Gadus macrocephalus*) and cod family (Gadidae) data. For some assemblages, cod remains were identified to the family level only, although the majority of the cod remains were probably Pacific cod.

For other assemblages, cod remains, including vertebrae, were identified as Pacific cod. For a third type of assemblage, although some elements were identified to species, many (particularly vertebrae) were not. For these latter assemblages, since vertebrae are critical in skeletal part representations, we combined cod skeletal parts data from species and family-level identifications and analyzed them at the family level. In the following tables and figures, AC = Atlantic cod, G = Gadidae, and PC = Pacific cod.

Results and Discussion

The skeletal parts data using three body regions from the fifteen North Pacific cod assemblages are displayed on the left side of Figure 12.2 (see also Table 12.2). The proportions for a complete cod are shown for comparison. On the right side of the graph are the skeletal part representations of selected North Atlantic cod assemblages. Three major observations can be made about the North Pacific assemblages. First, heads are well represented at the North Pacific sites, all of which have more than 34 percent of NNISP composed of cranial elements (33 percent is expected for a complete cod). Second, none of the North Pacific assemblages look like the inland Icelandic North Atlantic site of Hofstaðir, which is dominated by pectoral and vertebral elements but contains very few cranial elements. These have been interpreted as the remains of consumed stored cod, where the heads were cut off elsewhere during processing and the bodies with pectoral fins and some vertebrae were transported to the site (Amundsen et al. 2005). Third, the North Pacific assemblages broadly resemble the other North Atlantic sites, all of which are coastal. Several North Pacific assemblages are most similar to the Scottish site of Earl's Bu, which has been interpreted as a combination of the remains of stored cod and cod brought to the site whole (Barrett 1997).

Despite the variation, many North Pacific assemblages have an overabundance of heads and an underabundance of vertebrae compared to a complete cod. The Horseshoe Cove and Hoko River Wet site assemblages, both suggested in the literature as possible locations of cod processing for storage, are not significantly different from the majority of other North Pacific assemblages. The most unusual site here is the North Point Wet Site, which has more vertebrae than expected for a complete fish and an underabundance of pectoral elements.

In Figure 12.3 (see also Table 12.3), the vertebral region was further divided into three sections: thoracic, precaudal, and caudal, since it is possible that abdominal vertebrae (thoracic and precaudal) may have been cut out of a cod during processing for storage, while caudal vertebrae may have traveled with the dried cod. Since not all North Pacific assemblages provided these data, only six of them are considered and shown to the left of the complete cod.

There is considerable variation in these six North Pacific assemblages as well, but all have more cranial bones and fewer caudal vertebrae than a complete cod. The lack of caudal vertebrae is inconsistent with stored cod, based on the ethnographic and historic evidence noted earlier that stored cod retained tails. Alternatively, these six assemblages could match expectations of remnants of processing for storage if this activity took place

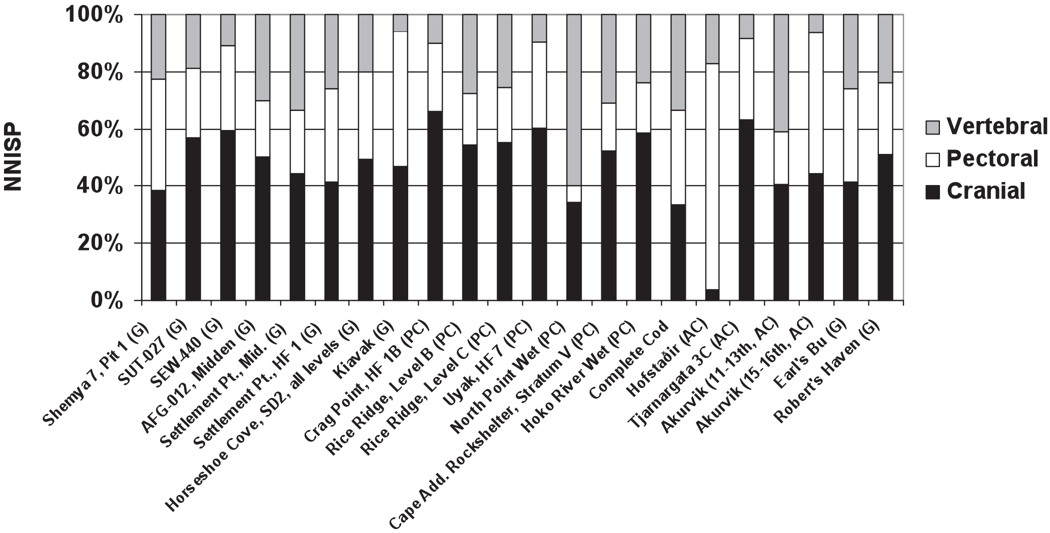

Figure 12.2. Gadid skeletal parts from North Pacific and North Atlantic sites. AC = Atlantic cod; G = gadid; PC = Pacific Cod. "Complete Cod" indicates skeletal parts expected from a whole fish. Data from Table 12.2.

Table 12.2. Cod assemblage skeletal part representation by three body regions (NNISP)

Assemblage[a]	Cranial	Pectoral	Vertebral	Source (NISP counts)
North Pacific				
Shemya 7, Pit 1 (G)	122.00	124.00	71.19	Partlow n.d.
49-SUT-027 (G)	14.00	6.00	4.67	Schaaf and Bender, pers. comm., 4/28/2006
49-SEW-440	15.00	7.50	2.80	Yarborough 2000:appendix A
49-AFG-012, Midden (G)	80.00	31.50	47.80	This paper
Settlement Pt., Midden (G)	57.00	28.50	42.80	This paper
Settlement Pt., HF 1 (G)	46.00	36.00	28.90	This paper
Horseshoe Cove, SD2 (G)	39.00	24.00	16.00	Hays, pers. comm., 7/5/2008
Kiavak (G)	29.00	29.50	3.56	This paper
Crag Point, HF 1B (PC)	28.00	10.00	4.25	This paper
Rice Ridge, Level B (PC)	44.00	14.50	22.38	This paper
Rice Ridge, Level C (PC)	17.00	6.00	7.80	This paper
Uyak, HF 7 (PC)	19.00	9.50	2.98	This paper
North Point Wet (PC)	20.00	3.50	35.00	Bowers and Moss 2001, table 4
Cape Add. Rockshelter, Stratum V (PC)	11.00	3.50	6.50	Moss 2004, tables 9–12
Hoko River Wet (PC)	10.00	3.00	4.10	Croes, pers. comm., 11/28/06
North Atlantic				
Hofstaðir (AC)	1.00	20.50	4.44	Amundsen et al. 2005, table 7
Tjarnargata 3C (AC)	715.00	322.50	94.60	Amundsen et al. 2005, table 7
Akurvik (11th–13th, AC)	46.00	21.00	46.70	Amundsen et al. 2005, table 7
Akurvik (15th–16th, AC)	124.00	137.50	17.50	Amundsen et al. 2005, table 7
Earl's Bu (G)	88.00	69.00	55.00	Barrett 1997, tables 1 and 3
Robert's Haven (G)	258.00	127.50	119.80	Barrett 1997, tables 1 and 3

a. (AC) = Atlantic cod; (G) = cod family; (PC) = Pacific cod

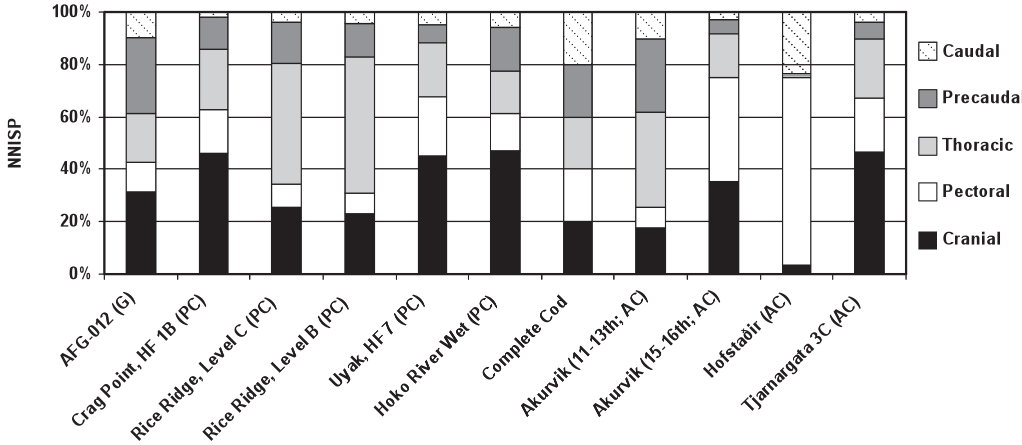

Figure 12.3. Gadid skeletal parts from North Pacific and North Atlantic sites (including vertebrae type). AC = Atlantic cod; G = gadid; PC = Pacific cod. "Complete Cod" indicates skeletal parts expected from a whole fish. Data from Table 12.3.

Table 12.3. Cod assemblage skeletal part representation by five body regions (NNISP)

Assemblage[a]	Cranial	Pectoral	Thoracic	Precaudal	Caudal	Source (NISP counts)
North Pacific						
AFG-012 (G)	80.0	28.5	46.6	73.5	24.7	This paper
Crag Point, HF 1B (PC)	28.0	10.0	14.2	7.3	1.3	This paper
Rice Ridge, Level B (PC)	44.0	14.5	98.4	24.0	8.5	This paper
Rice Ridge, Level C (PC)	17.0	6.0	30.8	10.8	2.5	This paper
Uyak, HF 7 (PC)	19.0	9.5	8.6	2.8	2.1	This paper
Hoko River Wet (PC)	10.0	3.0	3.4	3.6	1.2	Croes, pers. comm., 11/28/2006
North Atlantic						
Akurvik (11th–13th; AC)	46.0	21.0	94.5	72.0	27.3	Amundsen et al. 2005, table 7
Akurvik (15th–16th, AC)	124.0	137.4	58.5	18.7	11.0	Amundsen et al. 2005, table 7
Hofstaðir (AC)	1.0	20.5	0.3	0.1	6.8	Amundsen et al. 2005, table 7
Tjarnargata 3C (AC)	715.0	322.5	344.5	100.9	58.4	Amundsen et al. 2005, table 7

a. (AC) = Atlantic cod; (G) = cod family; (PC) = Pacific cod at these sites. When the North Atlantic sites are viewed in this way, Hofstaðir is again the most distinctive. This site contains mostly pectoral elements and caudal vertebrae, consistent with the consumption of stored cod. In contrast, the coastal North Atlantic sites contain very few caudal vertebrae, consistent with processing for the trade and transport of cod tails away from the site.

To provide context for interpretation, one could look to skeletal part patterns found for other potentially stored fish in the North Pacific. For example, Norton and others (1999) interpreted the skeletal part representation of large fish at the coastal Korean site of Konam-Ri as the remains of fish processed for drying and storing. This assemblage was cranially dominated (65 percent MNE) but also had postcranial bones (35 percent MNE) (Norton, Kim, and Bae 1999:159). A similar skeletal pattern was found at an Aleutian site interpreted as a salmon fish camp by Hoffman and others (2000:705). This assemblage was also cranially dominated (fifteen MAU cranial versus five MAU postcranial) but had substantial postcranial remains as well, a pattern contrasting sharply with that found at the Settlement Point site, Agayadan Village, and Keatley Creek (Butler and Chatters 1994: Figure 5; Hoffman, Czederpiltz, and Partlow 2000: Figure 4; Partlow 2006). These three village sites, overwhelmingly dominated by salmon vertebrae and/or fin elements and yielding very few head bones, appear to contain primarily the remains of stored salmon.

How do we interpret the North Pacific cod assemblages? Since the North Pacific sites broadly match the coastal North Atlantic sites, does that mean all are remnants of processing for cod storage? Or are they combinations of cod processing, storage, and/or consumption? The latter interpretation was made for the North Atlantic site Tjarnargata 3C (Figure 12.3, far right), which was considered a *combination* of the remains of larger cod processed for the fish trade (some of the pectoral and vertebral elements leaving the site as part of the dried cod) and the remains of smaller cod consumed whole on site (Amundsen et al. 2005).

A complication in the hunt for evidence of stored Pacific cod is that winter villages in the Aleutian and Kodiak regions tended to be located near prime cod-fishing banks (Clark 1987; Haggarty et al. 1991). Thus, even with storage, presumably some fresh fish were consumed and, therefore, discarded in winter villages. The majority of the assemblages come from sites interpreted as multiseason villages or campsites. The exceptions are the three Northwest Coast assemblages and the Horseshoe Cove site from Kodiak, all of which have been interpreted in the literature as spring/summer fish camps. Yarborough (2000:235) suggests the 49-SEW-440 site in Prince William Sound may have been occupied either during spring or fall. Thus, cod assemblages from many North Pacific winter villages reflect cod processing, consumption, and storage. Unless we can find different disposal contexts within these sites for these activities, any faunal signature of cod processing or storage may be obscured by other activities involving cod. What other lines of faunal evidence can be used?

Another way to look at the cod data is to calculate the proportion that cleithra contribute to the total cod NISP of an assemblage, a method that some researchers have used in the North Atlantic (e.g., Amundsen et al. 2005:136). If cleithra traveled with dried cod, low percentages are expected for the remains of cod processing, and larger percentages are expected

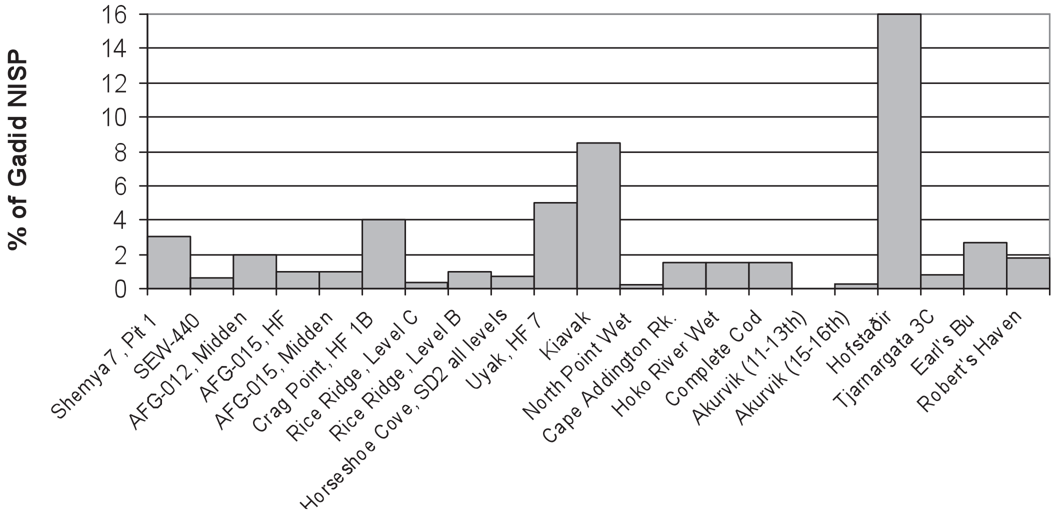

Figure 12.4. Cleithra as a proportion of gadid NISP. "Complete Cod" indicates percent expected from a whole fish. To calculate the percent cleithra in a complete cod, we did not count those elements frequently not identified in assemblages, such as ribs, spines, radials, hypurals, and branchial arch elements. The result was that cleithra make up approximately 1.5 percent of 130 cod bones frequently identified in assemblages.

Table 12.4. Archaeological Pacific cod live-length estimates

Region	Site	Length estimate (cm)	Source
Aleutians	Adak 009 (49-ADK-009)	44–112	Orchard 2003, table 6.16
Aleutians	Adak 011 (49-ADK-011	36–105	Orchard 2003, table 6.16
Aleutians	Buldir 008 (49-KIS-008)	54–107	Orchard 2003, table 6.16
Aleutians	Shemya 2 (49-ATU-021)	38–120	Orchard 2003, table 6.16
Aleutians	Shemya 7 (49-ATU-061)	35–125	Orchard 2003, table 6.16
Prince William Sound	Lowell Homestead (49-SEW-682)	47–68	Yarborough 2000, 185
Kodiak Archipelago	Settlement Point (49-AFG-015)a	46–80	This paper
Kodiak Archipelago	49-AFG-012[a]	57–68	This paper
Northwest Coast	Cape Addington Rk. (49-CRG-188)	Most >67	Moss 2004, 163

a. Live-length estimates based on dentary measurements using Orchard's (2003) dentary measurement #2 and corresponding regression formula.

for the remains of dried cod. This method has the advantage of simplicity and avoids the sensitivity to changes in one body region typical of the closed arrays in Figures 12.2 and 12.3.

Figure 12.4 shows the proportions of cleithra for the ten assemblages with these data. The majority have low percentages of cleithra (less than 4 percent). This matches expectations for cod processing sites in the North Atlantic (e.g., Amundsen et al. 2005) but also comes close to the proportion that cleithra compose of a complete Pacific cod. This low proportion of cleithra, however, does not match expectations for sites with stored cod, such as North Pacific winter villages. Assemblages with the highest percentages of cleithra include the Icelandic site of Hofstaðir and Kiavak village on Kodiak Island. These could be interpreted as resulting from consumption of dried cod with cleithra attached. The large

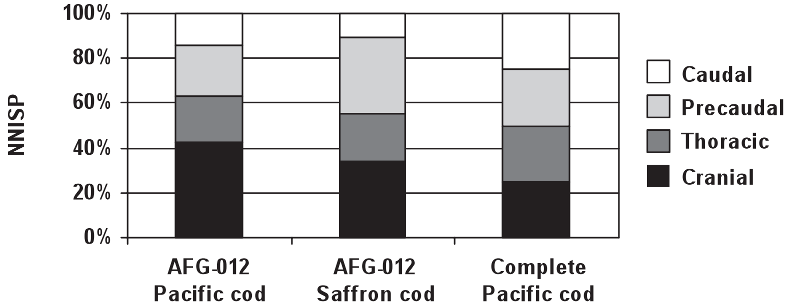

Figure 12.5. Gadid skeletal parts from 49-AFG-012. Data from Table 12.5.

Table 12.5. 49-AFG-012 skeletal part representation by large (Pacific) and small (Saffron) cod

Cod	Cranial[a]	Thoracic	Precaudal	Caudal
Pacific cod				
NISP	26.00	31.00	102.00	143.00
NNISP	13.00	6.20	6.80	4.33
Saffron cod				
NISP	67.00	205.00	1000.00	697.00
NNISP	67.00	41.00	66.60	21.12

a. The highest cranial NNISP for Pacific cod came from the premaxilla and for Saffron cod from the basioccipital.

number of cod head elements in the Kiavak assemblage, however, argues against the consumption of mostly dried cod bodies at this site.

Another consideration in interpretation of the skeletal part representation data is fish size. Small fish may be processed differently from large fish when drying for storage (e.g., Butler 1996; Greenspan 1998; Norton, Kim, and Bae 1999), so skeletal part signatures may vary by fish size. Indeed, the historic North Pacific and North Atlantic fish trade selected only larger cod (roughly 60–110 cm) for drying (Cobb 1927; Perdikaris 1999:390). Smaller cod were presumably consumed fresh. Live-length estimates from several North Pacific assemblages suggest most Pacific cod remains are from individuals large enough to be considered worth drying by North Atlantic standards (Table 12.4). Thus, it is possible that prehistorically, small cod were not dried, while large cod were. Alternatively, based on economic anatomy, small cod may have been dried whole, while larger cod had the fat-rich heads cut off and consumed on site while the bodies dried. In either case, the smaller cod remains should reflect whole cod deposited on site, while the larger cod remains should reflect differential treatment of heads and bodies.

One site where we can evaluate this is 49-AFG-012 on Afognak Island, for which Partlow recently identified selected gadid elements to species. Using Orchard's (2003) Pacific cod regression for premaxilla measurement #3, saffron cod (n = 54) are estimated to be 21–38 cm in fork length and Pacific cod (n = 21) 53–86 cm. The skeletal part frequencies for these small versus large cod at 49-AFG-012 are similar (Table 12.5, Figure 12.5). At least at this site, Pacific cod were not processed and disposed of differently than saffron cod, and thus we find no support for the storage hypothesis. Comparable data were not available for other North Pacific sites.

Conclusion

Neither the ethnohistorical nor the zooarchaeological records examined here provide *compelling* evidence for Pacific cod storage in the eastern North Pacific. Instead, both records provide conflicting evidence. Whereas some historic records report Native peoples drying cod (e.g., de Laguna 1972; Turner 1886), others report that cod were always eaten fresh and never dried (Davydov 1977; Emmons 1991). The skeletal parts represented at the majority of sites examined here have a slight overabundance of crania and slight underabundance of vertebrae compared to a complete cod. This is weakly consistent with expectations for storage processing, wherein there should be overrepresentation of heads and underrepresentation of vertebrae. But the fact that nearly all sites have this pattern regardless of time or location undermines the cod storage argument, unless we assume that this practice was nearly universal throughout the record. Furthermore, most of the sites are thought to be winter villages, which arguably should represent consumption of stored cod rather than processing, and thus be composed of an overabundance of vertebrae and underabundance of heads. The most unusual North Pacific site examined here, the North Point Wet Site, provides the best case for cod storage (see also Smith et al., this volume). This site stands out with its overrepresentation of vertebrae, nearly twice that expected for a complete cod or any other North Pacific site. On the other hand, it still has a moderate proportion of cod heads (34 percent NNISP, almost identical to that expected for a complete cod) and a very low proportion of cleithra, both of which could be viewed as inconsistent with the storage interpretation. Keeping in mind that a variety of factors can affect element frequencies, including transport, differential element destruction, and cultural preferences (Friesen 2001:316; Smith et al., this volume), and after comparing these assemblages with some of the Atlantic cod assemblages, we offer several observations.

First, perhaps Pacific cod were dried and stored for the winter prehistorically, but site disposal contexts obscure the faunal signature. Like some of the coastal North Atlantic assemblages, many of the Pacific cod assemblages may represent *combinations* of the remains of cod processed for storage and cod consumed fresh on site. Pacific cod assemblages at winter villages may be a mixture of large stored cod, cod heads consumed fresh as delicacies, and whole small cod consumed fresh year-round, while those interpreted as fish camps may be combinations of cod processing and cod consumed fresh on site. Archaeofaunal signatures of Pacific cod storage may be obscured by the co-location of processing, storage, and consumption at these sites.

Second, neither the Pacific cod nor many of the Atlantic cod assemblages present compelling evidence for cod storage, based on skeletal parts representation alone. Multiple lines of evidence are necessary and could include cutmarks and live-length estimations (e.g., Amundsen et al. 2005; Barrett 1997; Perdikaris 1999), cod found in storage features, and obvious evidence of drying and/or smoking structures (e.g., Croes 1995:233; Saltonstall and Steffian 2006:56, 83). In the Atlantic region, stable isotope analyses of cod bones are being used to differentiate nonlocal and local cod populations (Barrett et al. 2008; Bourque, Johnson, and Steneck 2008). Since dried Pacific cod probably did not travel very far from where they were caught prior to the commercial era, this technique probably would not aid in finding evidence of prehistorically stored Pacific cod.

Third, the role of differential element survivorship in cod skeletal part representation needs to be addressed. Beyond the fragility of cod basipterygia, cod elements may have significant differences in survivorship that could affect skeletal part distributions. Significant differences in head versus vertebrae bone densities and survivorship have been found for salmonids, with strong implications for the evaluation of salmon skeletal part data (Butler and Chatters 1994; Lubinski 1996). We need to assess to what degree missing cod elements may be due to an "accident of preservation, or an accident of sampling" (White 1956:402). Smith's (2008; Smith et al., this volume) study found basipterygia the least dense cod bone, but found little difference in bone density values between selected head elements and vertebrae. Based on these results, differential bone density would not explain the overrepresentation of heads found in most North Pacific assemblages. However, more density data are needed to bolster this assessment since the bones measured by Smith exclude those that made up the maximum NNISP values in our study (e.g., the basioccipital, parasphenoid, urohyal, and premaxilla). Interestingly, the dentary, which had the highest bone density value (Smith et al., this volume), gave us the highest NNISP value for Cape Addington Rockshelter. Another possible cause of differential survivorship is intentional destruction of some elements over others. For example, Smith et al. (this volume) argue that Pacific cod heads, with their high fat content, were more likely to be broken and boiled, hence less likely to be preserved in the archaeological record. But the majority of assemblages examined here have more heads than bodies, suggesting that in these cases cod heads were not preferentially broken and boiled compared to cod bodies.

Given the arguments for resource intensification and the record for salmon, the investigation of cod storage would benefit by inclusion of older assemblages. The debate continues over when and where people began storing salmon in earnest in the eastern North Pacific. Matson (1992:423) suggested the period from 3500–3000 BP marks the time on the Northwest Coast when the "salmon-storage economy came into being." Alternatively, based on their identification of a consistent pink salmon fishery (using ancient DNA) at the site of Namu, Cannon and Yang (2006; Cannon, Yang, and Speller, this volume) have argued that salmon storage occurred as early as 7000 BP on the Northwest Coast. In the Kodiak Archipelago, Steffian and others (2006:123) have argued that the period from 4000 to 3000 BP was a time of "intensified production and focused storage," in particular of salmon resources but also, perhaps, of Pacific cod. The majority of the cod assemblages examined here fall within the time period when increasing evidence of salmon storage is found in different regions of the eastern North Pacific. Cod assemblages from more ancient sites, such as the 8,200-year-old Chuck Lake site (49-CRG-237) in southeast Alaska (Ackerman, Reid, and Gallison 1989:13), could be particularly informative.

The question of whether, how much, and/or when different Native peoples stored Pacific cod in the eastern North Pacific is still unanswered. Nevertheless, the large numbers of Pacific cod remains at prehistoric sites throughout the region attest to the importance of this resource to North Pacific peoples. The availability of Pacific cod and other codfishes such as saffron cod and Pacific tomcod year-round in some areas may have been just as important as their abundance during the spring and early summer months. For example, Mishler (2001:38) writes of an incident when the salmon runs collapsed in 1935 and one Alutiiq man described surviving that winter by living off cod he jigged for from the shore. He said "the codfish saved us from starvation" (Mishler 2001:38).

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