Archaeofauna 11 (2002): 23-44

Atlantic Cod in The Missouri River: *Gadus morhua* from the Steamboat Bertrand

WALTER E. KLIPPEL[1] & CARL R. FALK[2]

(1) Departament of Anthropology, University of Tennessee, Knoxville, TN, USA 37996
(2) PaleoCultural Research Group, 2998 Little Laurel Road, Sevierville, TN, USA 37862

(Received *27 August 2001*; accepted *23 January 2002*)

ABSTRACT: Wooden boxes containing over 25,000 skeletal elements representing the remains of Atlantic cod (*Gadus morhua*) were recovered from the steamer *Bertrand* that sank in the Missouri River en route from St. Louis, Missouri, USA to Fort Benton, Montana Territory in 1865. Detailed analyses of skeletal part frequencies and patterns of bone modification allow the identification of a distinctive 'signature' which may assist in the recognition of dried cod in archaeologically recovered food refuse. Some key features of assemblages containing dried cod include: a high relative frequency of paired diagnostic postcranial elements compared to cranial bones, a paucity of anterior abdominal vertebrae along with an absence of posterior abdominal vertebrae, a high frequency of abdominal neural arches without centra, and the presence of a large number of ribs in the absence of abdominal vertebrae. Measurements for the cleithrum and postcleithrum are presented, and weight and length estimates are calculated for the Bertrand cod using regression equations for modern cod likely taken from the same area of the North Atlantic. Comparison of the two samples permits inference of the method of capture (i.e. hand lines) for the Bertrand cod and contributes new information to a growing understanding of the impact of intensive harvesting on local fish populations.

KEY WORDS: ATLANTIC COD, *GADUS MORHUA*, SKELETAL PART, FREQUENCIES, BUTCHERING PATTERNS, REGRESSION ANALYSIS, NORTH AMERICA

RESUMEN: Cajas de madera que contenían mas de 25,000 restos de bacalao del Atlántico *(Gadus morhua)* se obtienen del buque a vapor Bertrand que se hundió en el Rio Missouri en Estados Unidos, en ruta desde San Luis, Missouri al Fuerte Benton, en el Territorio de Montana en 1865. Unos análisis de representatividad esquelética y el patrón de modificación de los huesos permiten identificar un "sello" distintivo, el cual puede ser utilizado en el reconocimiento del bacalao seco en residuos de alimentos recuperados arqueológicamente. Rasgos característicos de bacalao seco incluyen: una frecuencia relativamente alta de elementos postcraneales pares comparados con huesos craneales, una escasez de vértebras abdominales anteriores juntamente con una ausencia de vértebras abdominales posteriores, una alta frecuencia de arcos neurales abdominales sin centro y la presencia de un gran número de costillas supliendo la ausencia de vértebras abdominales. Se presentan medidas para el cleitro y el postcleitro y las estimaciones hechas para el peso y tamaño (la longitud) del bacalao de Bertrand fueron calculadas usando ecuaciones de regresión de bacalaos actuales obtenidos de la misma área del Atlántico Norte. La comparación de las dos muestras permite sacar una conclusión del método de captura (palangre) y proporciona nueva información para una mejor comprensión del impacto de la pesca intensiva de poblaciones locales.

PALABRAS CLAVE: BACALAO DEL ATLÁNTICO, *GADUS MORHUA*, REPRESENTATIVIDAD ESQUELÉTICA, MODELOS DE CORTES, ANÁLISIS DE REGRESIÓN, NORTEAMÉRICA

INTRODUCTION

Throughout the eighteenth and nineteenth centuries preserved meats played an important role in the development and expansion of the United States. The salting, smoking and drying of meat were common practices well into the late nineteenth century and the resulting products were widely transported (Berry, 1943; Gates, 1965; Walsh, 1982). While there are ample written records indicating quantities of marine fish were transported inland as part of this distribution system (McFarland, 1911: 160, 186; Cutting, 1955: 137; Ryan, 1986: 84; O'Leary, 1996: 122-131), fish remains from inland Historic Period contexts generally reflect local lacustrine and riverine habitats (e.g. Barber, 1976; Miller & Lewis, 1978; Mudar, 1978; Price, 1985:44; Scott, 1996) rather than marine environs (but see Martin & Colburn, 1989:149). This seeming incongruity may result from a combination of factors: less intensive field recovery techniques used in some historic site excavations, laboratory methods where only select diagnostic bones of the fish skeleton are routinely identified (see discussions in Leach, 1986; Wheeler & Jones, 1989; Perdikaris, 1998) and the discard of precisely these elements during initial processing at or near points of capture. The remains of Atlantic cod (*Gadus morhua*) recovered from a Missouri River shipwreck afford an opportunity to assess skeletal part representation and modification after primary butchery but prior to secondary processing, consumption, and final waste disposal. The Steamboat Bertrand, from which the cod remains described here were recovered, sank in the Missouri River just north of Council Bluffs, Iowa in North America's heartland. The Bertrand was transporting provisions and equipment to the gold fields of the Montana Territory during the spring of 1865 when it sank (see Petsche, 1974 and Corbin, 2000 for monograph length treatments).

HISTORICAL BACKGROUND

Early in the century, relatively inexpensive preserved fish products from the North Atlantic were shipped to southern ports. Slave markets absorbed large quantities of less popular fishes such as dried haddock, smoked and pickled herring (O'Leary, 1996: 130), as well as "refuse" cod that had been "sun burnt", "salt burnt" or otherwise damaged in preparation (Jensen, 1972: 93, 101). By the 1850s, New Orleans, situated at the mouth of the Mississippi River, was importing large quantities of preserved mackerel and cod; medium sized cod were popular for domestic use while smaller cod were considered most suitable for redistribution to plantations (O'Leary, 1996: 124). During this antebellum decade "... *most of the Maine fish that reached western tables did so indirectly via the river commerce of seaports like New Orleans*" (O'Leary, 1996: 131).

The outbreak of the Civil War in 1861 witnessed drastic changes in the movement of preserved meat. The Union Navy blockaded ship transport to and from southern ports. At the same time Union forces prohibited the movement of goods on the Mississippi River between New Orleans and St. Louis. However, by January 1861 the transport of commodities was possible by rail from Baltimore on the East Coast, through Cincinnati, to St. Louis (i.e., via the Baltimore and Ohio, Marietta and Cincinnati, and Ohio and Mississippi lines – Fishlow, 1965: maps 1 and 2). Baltimore was a significant importer of Atlantic cod and mackerel while Cincinnati was becoming a center of inland distribution for North Atlantic fish (O'Leary, 1996: 124, 150). Berry (1943: 596) has noted that in 1861 wholesale prices for "dry" cod ranged between 3.75 and 4.38 cents per pound at Cincinnati. "*Several important commodities were sold in Cincinnati by units or containers which suggest volume but were in fact units of weight. The box of dry cod ... contained a hundred pounds ...*" (Berry, 1943: 146).

PROCURING AND PROCESSING COD IN PREPARATION FOR TRANSPORT

How fish were processed and preserved in preparation for transport was in part dictated by the species of fish involved. The edible portions of cod, for example, contain less than one percent fat (Geiger & Borgstrom, 1962: 33) and as a result cod were often dried [stockfish] or salt dried [saltfish]. Fattier fish such as herring and mackerel (12.5% and 6.2% fat, respectively; Geiger & Borgstrom, 1962: 33) were not easily preserved by drying alone (Jason, 1965: 39) because their highly unsaturated fat oxidized and produced a rancid flavor (Cutting, 1962: 162).

Faulkner (1985) offers a fairly detailed summary reconstruction of eighteenth century land-based cod processing, including a lengthy consideration of cod salting and record and are not presented here. However, his description of the initial butchering process does warrant consideration:

Boats were tied up at the stage head, and the cod hoisted onto the platform using curved iron pikes about 30 cm (1 ft) long and fitted with long wooden handles. In managing the larger cod, they were assisted from above by boys using *gaffs*. The fish were then slid under the partition into the splitting room.

The cleaning process required three specialists, a *throater*, a *header*, and a *splitter*. The fish was first passed to the throater, dressed in a heavy apron and protective sleeves, who opened the belly of the cod from the throat to the anus. Denys (see Ganong, 1908) describes the throater's knife as long and pointed, the cutting edge curved toward the point, perhaps like a modern filetting knife. The fish was then passed to the header, similarly dressed, whose job it was to remove the entrails, save the roe and liver in baskets, and then to break off the head and throw it into the sea through an open hole in the floor at his feet. Finally, the fish was handed to the highly skilled splitter, who stood in a barrel near the end of the table, his apron draped outside the barrel to keep himself clean. His knife was much heavier than that of the throater, being straight, squared off at the end, and thickened along the back. The splitter grabbed a lateral fin in his mitted left hand, and steadied the fish against a batten nailed to the table. He then removed the flesh from one side of the spine, working from the fin to the tail, cut through the backbone at the tail, and then worked up the other side. Thus the entire ribs and spine, except for a few caudal vertebra were removed intact through the ventral opening, leaving a single piece of flesh opened to the tail (Faulkner, 1985: 66-67; emphasis in original).

A similar mid-nineteenth century process, conducted on ship, has been described and illustrated (Figure 1) by Goode & Collins (1887a):

Usually between 8 and 9 o,clock in the morning the loud cry of 'Dory!' brought the skipper and the crew from the interior of the vessel, often interrupting a pleasant morning snooze. The dory from which this cry had proceeded was pulled alongside the vessel amidship, and there kept in place by the cook's hold upon the forward painter and the skipper's on the stern painter. Meanwhile the fish were thrown upon the vessel's deck by the two men in the dories; pitched up heartlessly over the side by a pew, and often falling heavily upon the upturned edge of the plank forming the checkerboards.

When all hands are in readiness to dress the fish, the splitting tables are taken from their perch on the liver-butts and fastened up in their places. The tub is also put in its place ready for the header. One man, called the 'idler,' now fills the tubs, and then active work begins. The 'throater,' standing by the side of the tub farest from the table, now takes a cod from the tub, seizing the fish's jaw in his left hand. He lifts the fish up to the edge of the tub and poises him there, belly upward, on the supra-occipital bone. With the well sharpened and pointed knife in his right hand, he makes a transverse cut across the throat, just behind the gills. Introducing the knife at this opening he cuts down the belly, laying open the abdominal cavity, and making also one cut on each side downward he separates the head from the sides, and, with another, separates all the viscera of the belly from those of the head. Finally, still holding the fish thus poised, he presses with the right hand upon the fish's belly, and breaks off the body from the head at the first vertebra. The fish then falls into the tub, and the fisherman cuts the skin of the head through, when it does not break off of itself, and then throws it into the sea. The first followed by a second and a third, till all the fish in the tub have been beheaded and opened.

On the opposite side of the tub, between it and the table and close to the vessel's side, stands the 'gutter.' He takes the headless fish from the tub, hauls them upon the splitting table. With his left hand he opens the abdominal cavity and with the other tears loose all the organs contained therein. The livers he throws into a basket placed to catch them and the stomach and reproductive organs quickly find there way into the ocean.

The fish is next pushed across the table and laid hold of by the splitter. He is armed with a very sharp and somewhat peculiar shaped knife. The blade, which is of very well tempered steel, is somewhat curved flatwise. With the back of the fish braced against the cleat in the center of the table he makes a long incision down the ventral surface, continuing the opening made by the throater, and splitting the flesh close by the side of the backbone almost to the tail. The fish is then ope-

FIGURE 1

Mid-nineteenth century cod fish processing aboard a fishing schooner at George's Bank (from Goode, 1887).

ned as the leaves of a book, and the tail allowed to hang over the inner edge of the table; with a sharp stroke he then cuts under the backbone and loosens it so that he can catch the end in his fingers. Seizing this with his left hand he cuts under it toward the head of the fish, and with a few strokes separates the backbone from the body, allowing the latter to drop to the deck and throwing the former into a pile that is collecting for the cook (Goode & Collins, 1887a: 179-181).

Despite some terminological differences (e.g., header, gutter), the two descriptions are markedly similar. Both provide some expectations of the kinds of cod remains that might be expected in Historic Period archaeological contexts, particularly if cod were first transported as stockfish or saltfish as we believe they were in the case of the Bertrand.

COD REMAINS FROM THE BERTRAND

Preserved meats that were being transported by the Bertrand include products from cattle, pigs, sheep, mackerel, oysters, sardines, and cod (Finck *et al.*, 1971: 1427-1432; Petsche, 1974: 52, 55, 56, 58; Scott, 1977; Dudek & Elkins, 1983: 645-646). The oysters and sardines were canned and the mackerel contained in small barrels. The mackerel were found to be so malodorous that they were apparently discarded soon after recovery. Only the cod are considered here.

The cod was shipped in wooden boxes with the consignee listed as G. P. Dorris, Virginia City (Petsche, 1974: 52). One cod box (Figure 2) from the Forward Port Cargo area (FPC#165) has inside dimensions of 60 cm by 39.4 cm by 24.4 cm and is constructed of boards between 1.3 cm and 1.6 cm thick. One end of the box is stenciled with:

FIGURE 2
Box of cod remains recovered from the Bertrand showing articulated caudal vertebral columns at lower right.

"100 lbs., Large, Bay Fundy, Cod Fish, F. Snow & Co., Fish Dealers." The opposite end is labeled "116 lbs." with black paint. The latter may indicate the total weight of cod and container. While uncertain provenience information prohibits a box-by-box comparison, cod bones from this box and at least three additional boxes from the Forward Starboard Cargo area (FSC# 215, 235, 246) are described below and summarized in Table 1. Though we cannot be certain, it is likely that each of these additional boxes also contained ca. 100 lbs. of cod (see Berry, 1943: 146, cited above).

ELEMENT	Unmodified	Modified	% modified	TOTAL
OSTEOCRANIUM				
Epibranchial	0	1	100	1
Opercle	0	1	100	1
Pterotic	0	20	100	20
Supraoccipital	2	19	90	21
Supratemporal	163	0	0	163
TOTAL	**165**	**41**		**206**
PECTORAL GIRDLE				
Cleithrum	217	13	6	230
Coracoid	149	0	0	149
Pectoral fin ray	3754	0	0	3754
Postcleithrum	145	6	4	151
Posttemporal	22	80	78	102
Scapula	98	0	0	98
Supracleithrum	105	6	5	111
Radial	272	0	0	272
TOTAL	**4762**	**105**		**4867**
PELVIC GIRDLE				
Basipterygium	169	0	0	169
TOTAL	**169**	**0**		**169**
VERTEBRA & RIBS				
Abdominal centrum	6	0	0	6
Abdominal neural arch	200	633	76	833
Caudal centrum	1661	271	14	1932
Caudal arches	1628	701	30	2329
Anterior pleural rib	54	350	87	404
Posterior pleural rib	1086	978	47	2064
TOTAL	**4635**	**2933**		**7568**
PTERYGIOPHORES, MEDIAN FIN RAYS & UROPHORES				
Pterygiophore	3296	0	0	3296
Median fin ray	9493	0	0	9493
Urophore	75	0	0	75
TOTAL	**12864**	**0**		**12864**
TOTAL	**22595**	**3079**		**25674**

TABLE 1
Skeletal part frequencies and bone modification of cod bones from the Bertrand.

OSTEOCRANIUM

The supraoccipital is the most posterior bone of the neurocranium. Twenty one recognizable fragments are present in the Bertrand sample. The thin ventral margins of the supraoccipital crests are cut above the foramen magnum to an area of considerable thickening and widening along the dorsal border and the dorsal margins are broken on 19 specimens (Figure 3a). Two additional supraoccipital fragments lack clear evidence of cutting. Tool marks probably resulted from the first cut made by the "throater" and breakage occurred when he removed the head from the body over the edge of the tub (Goode & Collins, 1887a: 180 – see quote above).

The paired pterotic bones of the adult cod neurocranium extend nearly as far toward the posterior as does the supraoccipital. The posterior ends of 20 cut pterotic bones (Figure 3b) were recovered from the Bertrand. All 20 fragments are cut completely through and were probably separated from their anterior portions by the "throater" while separating the sides from the head (Goode & Collins, 1887a: 180).

In cod, four pairs of delicate supratemporal bones occur near the nap, above the opecular series (Cannon, 1987: 55; Wheeler & Jones, 1989: 92). While these small fragile bones are not often recovered from archaeological contexts, 119 relatively complete and 44 fragmented supratemporals are present in the Bertrand sample. None are cut.

Other bones of the osteocranium represented here include one epibranchial and one opercle fragment. Epibranchials are paired in the branchial apparatus and articulate dorsally with the pharyngobranchials and ventrally with the ceratobranchials. The single, right, epibranchial from the Bertrand has been cut on its anterior margin (Figure 3c). Paired opercles lie just anterior to cleithrae in the pectoral girdle. The opercle fragment represented here consists of a right posterior angle that is cut through the posterior incisure and broken both above and anterior to the angle (Figure 3d).

PECTORAL GIRDLE

Bones of the pectoral girdle (i.e., cleithrae, coracoids, postcleithrae, posttemporals, radials, scapulae, and supracleithrae) are well represented among the remains from the Bertrand. Atlantic cod cleithrae, postcleithrae, posttemporals, and

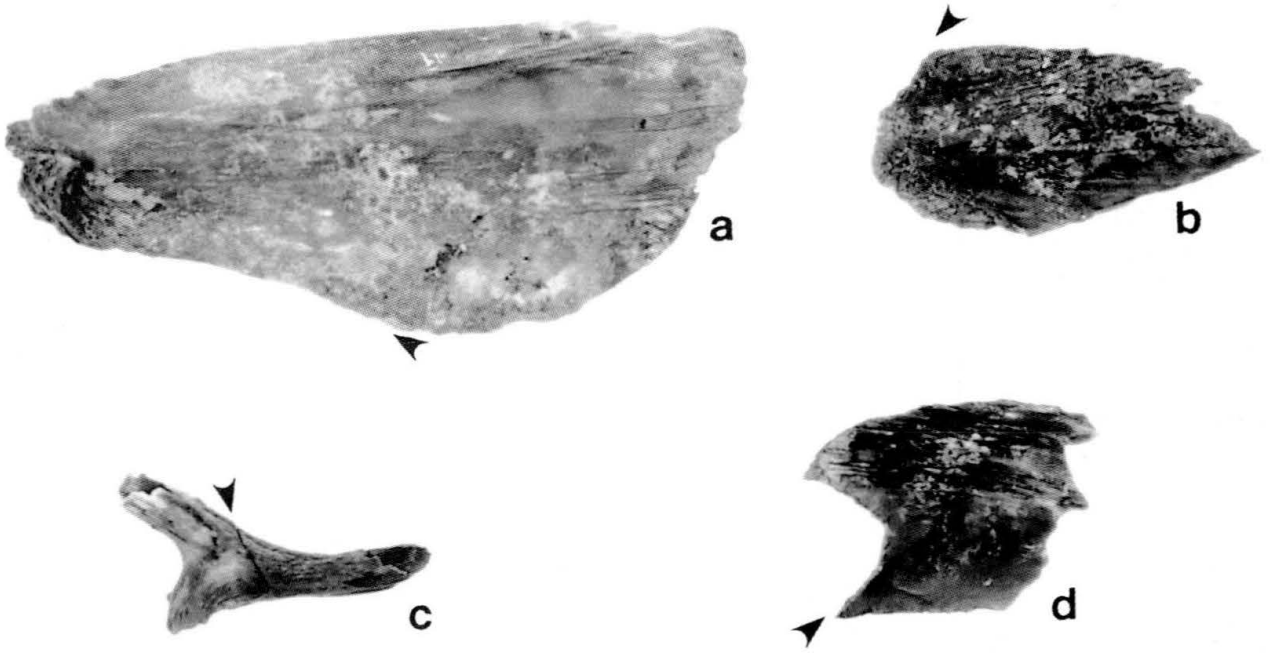

FIGURE 3
Modified cod cranial fragments from the Bertrand: a) cut and broken supraoccipital, b) cut posterior pterotic fragment, c) right epibranchial with light cut mark on anterior margin, d) cut and broken right opercle fragment. Arrows point to cut surfaces (a, 40.5 mm supraoccipital length).

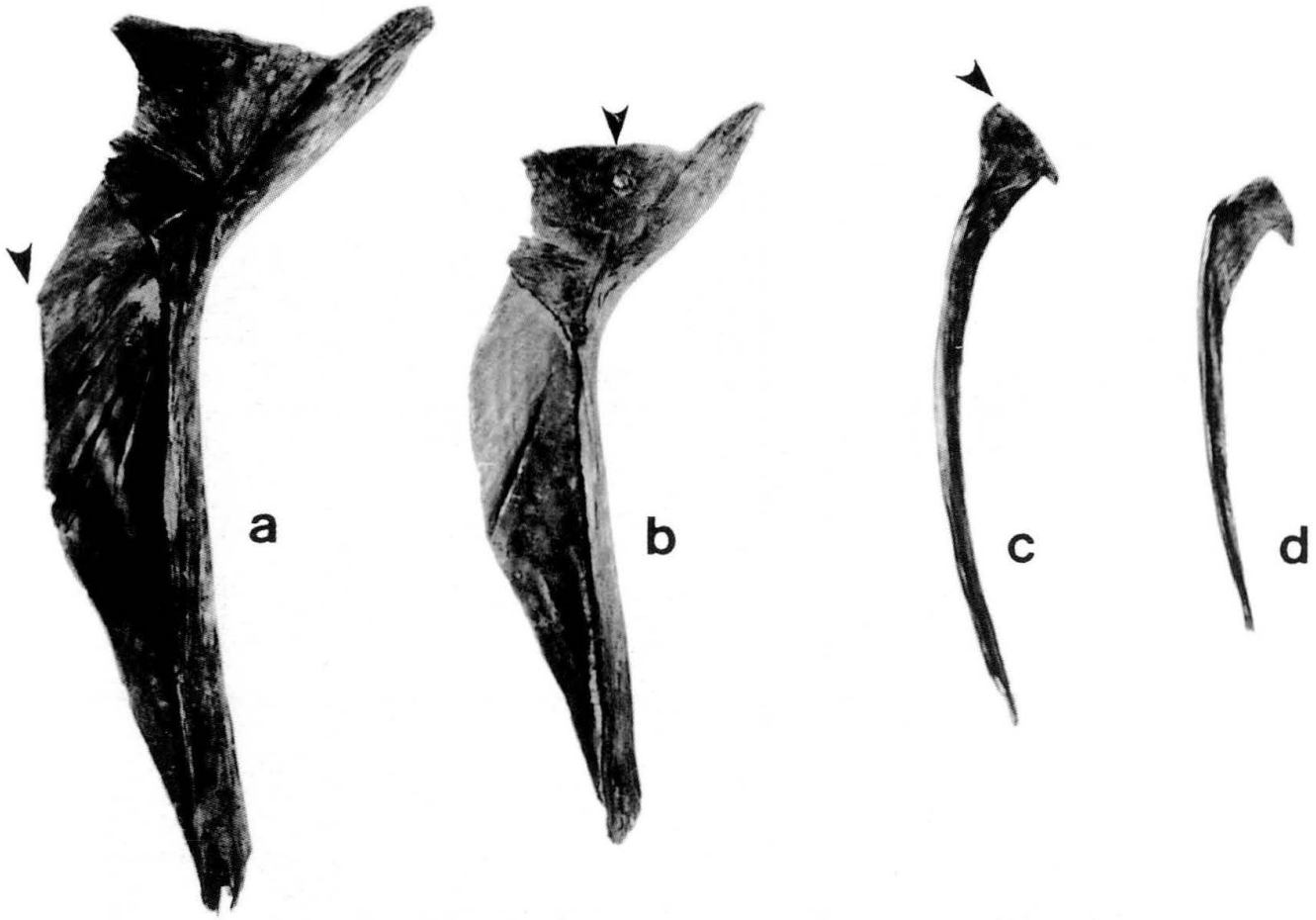

FIGURE 4

Cod cleithrae and postcleithrae from the Bertrand: a) left cleithrum with severed posterior margin, b) left cleithrum with pew hole near dorsal margin, c) right unmodified postcleithrum, d) right postcleithrum with severed anterior margin. Arrows point to cut and punctured surfaces (a, 134.1 mm cord length).

supracleithrae are relatively solid and fairly distinct from similar bones in other species of fishes. The cleithrum is the largest single bone in the Atlantic cod (Figure 4a). Two hundred thirty cleithrae and cleithrum fragments are in the extant collection. One hundred thirty-five are complete enough to determine side based on dorsal fragments (i.e., 60 left, 75 right).

Thirteen of the cleithrae were modified in handling and processing. Six of these (four right, two left) are punctured from the lateral sides (Figure 4b). Puncture holes range between three and four millimeters in diameter and were probably produced by pews when the cod were being handled "in the round". Goode & Collins (1887b: 140) provide an 1861 account of unloading cod with "pitchforks" in Labrador, and Goode (1887: Plate 34) illustrates the use of double-pronged pews in "Discharging fare of George's codfish at Gloucester, Mass" (Figure 5). The remaining seven (six left, one right) cleithrae appear to have been cut during processing. The ventral process is completely cut from one of the specimens while a second has been cut along the posterior margin. The other five specimens are cut along the dorso-posterior margins. Cut marks are likely the result of the first cut by the "throater" or the subsequent separation of the sides from the head (Goode & Collins, 1887a: 180).

Postcleithrae in Atlantic cod are slender, elongate, bones that have a broad process at the anterior end (Figure 4c). One hundred and fifty-one complete and fragmented postcleithrae are represented. A minimum of 130 specimens is represented by dorsal portions (62 left, 68 right). The broad anterior ends are cut on six left and three right postcleithrae (Figure 4d). These cuts also result from the first cut by the "throater" or in separation of the sides from the head (Goode & Collins, 1887a: 180).

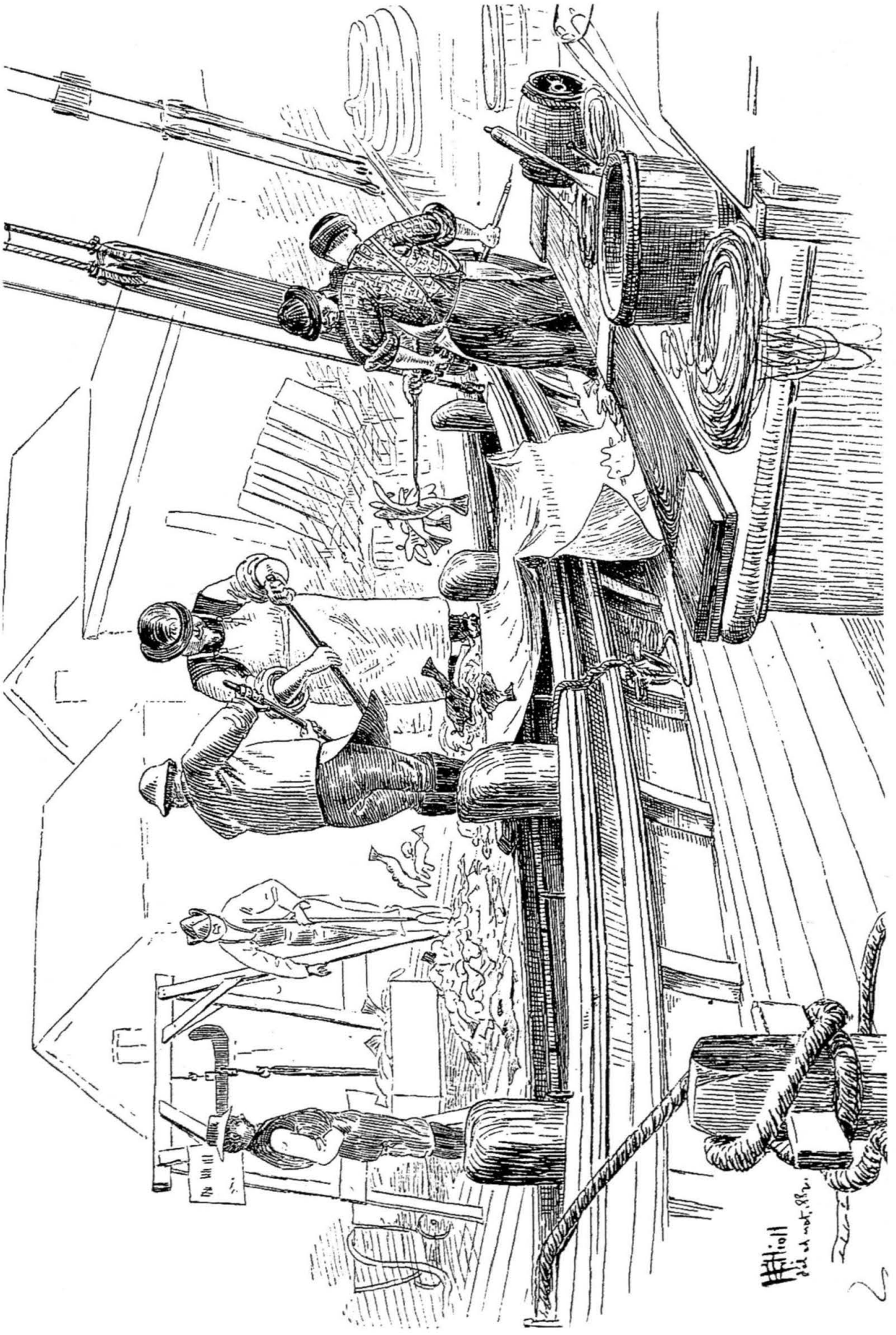

FIGURE 5

Discharging dressed cod with pews at Gloucester, Massachusetts during the mid-nineteenth century (from Goode, 1887).

Posttemporals were among the most extensively modified of the bones recovered. One hundred two (44 left, 58 right) posttemporals are represented. Of this total, 80 were cut by the "throater" in the process of separating the sides from the head (Goode & Collins, 1887a: 180). Intact cod posttemporal bones are forked (Figure 6a) toward the anterior and are firmly attached to the neurocranium by ligaments. The majority (77) of the shorter, lateral processes were cut completely off (Figure 6b) and anterior ends discarded with the heads. Eight of the mesial processes were also cut completely off (Figure 6c), while the mesial processes of an additional 18 specimens were only nicked. In the latter group the anterior ends remain attached to the posterior body of each posttemporal.

Supracleithrae in Atlantic cod are relatively short, stout bones compared to the postcleithrae. They are firmly linked dorsally to the posttemporals and ventrally with dorsal surfaces of cleithrae (Rojo, 1991: 161). A total of 60 right supracleithrae and 51 left supracleithrae were recovered from the Bertrand (Figure 6d). Five specimens have cut marks near their dorsal ends while a sixth exhibits a pew hole (Figure 6e). All were probably cut by the "throater" in separating the sides from the head (Goode & Collins, 1887a: 180).

The coracoid is a paired bone that occupies the ventral portion of the supporting skeleton of the pectoral fin (Rojo, 1991: 61). This element is relatively fragile and none of the 149 specimens from the Bertrand are totally complete. Minimums of 54 right and 43 left coracoids are represented. None show clear evidence of cutting or puncturing.

Cod scapulae are also paired bones in the pectoral girdle. They lie just above the coracoid, and like coracoids, are fairly fragile; none of the 98 scapulae from the Bertrand are entirely complete. Minimums of 47 right and 50 left specimens were recovered. None show evidence of having been cut or punctured during the butchering process.

Radials are small, fragile supporting ossicles of the pectoral fin rays and as many as four occur on

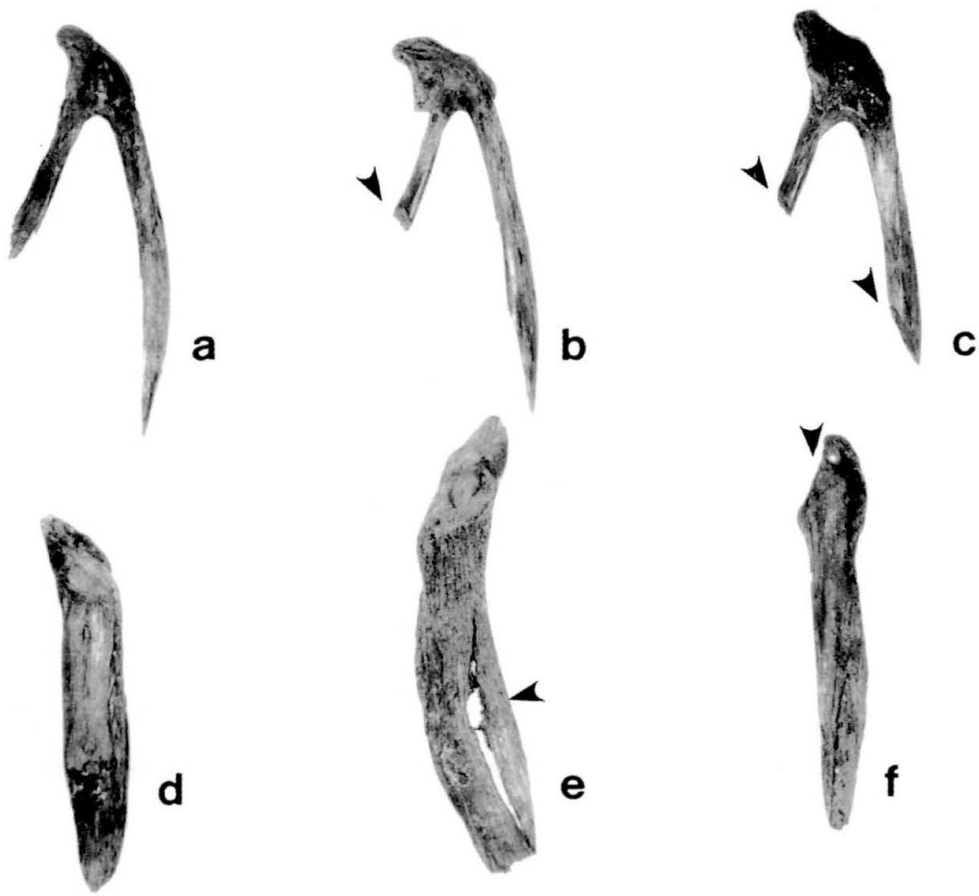

FIGURE 6

Cod posttemporals and supracleithrae from the Bertrand: a) unmodified right posttemporal, b) right posttemporal with severed lateral process, c) right posttemporal with ends of both processes severed, d) unmodified left supracleithrum, e) right supracleithrum with puncture hole, f) right supracleithrum with cut dorsal margin. Arrows point to severed processes and puncture (c, 56.5 mm total length).

either side of the cod. Two hundred seventy-two nearly complete and fragmented radials were recovered from the Bertrand; none were clearly modified during processing.

As many as 18 pectoral fin rays occur on either side of the Atlantic cod. Their proximal ends, supported by radials, have short processes that extend nearly perpendicular to the long axis of the ray. Median fin rays, on the other hand, are supported by pterygiophores and have nearly spherical proximal ends. Rays from pectoral and median regions are quite distinct from each other. A total of 3,754 complete and proximal pectoral ray fragments are present in the sample. None appear to have been altered during processing.

PELVIC GIRDLE

Basipterygia are relatively distinct fragile paired bones of the pelvic girdle that support the pelvic fins. At the anterior end they are attached to the cleithrae by ligaments. One hundred and sixty-nine complete and fragmented specimens were recovered from the Bertrand. Minimums of 43 right and 48 left basipterygia are represented. None of the pelvic bones appear to have been modified during processing.

VERTEBRAE AND RIBS

Vertebrae in Atlantic cod vary in number between 55 and 75; generally, those hatched in the cold waters of the Arctic have more vertebrae than those hatched in more southern temperate waters (Wheeler & Jones, 1989: 108). A sample of just over 80 Atlantic cod caught off the coast of Nova Scotia had four anterior abdominal (cervical) vertebrae, 13 to16 posterior abdominal (thoracic) vertebrae and 51 to 55 caudal vertebrae (Rojo, 1991: 175). Caudal vertebrae in cod have strongly developed neural and haemal arches that easily distinguish them from posterior abdominal vertebrae which lack haemal arches but, instead, have transverse processes (parapophyses) that project laterally from each side of their centra. Parapophyses project strongly downward in the last abdominal vertebrae, while in the first three caudal vertebrae, the haemal arches are quite broad and easily distinguished from other tail vertebrae. The four anterior abdominal vertebrae lack both parapophyses and haemal arches.

A total of 1,938 relatively complete and 30 highly fragmented vertebrae centra were recovered from the Bertrand. Excluding the fragmented specimens, six are unmodified anterior abdominal (cervical) vertebrae while the remaining 1,932 are caudal vertebrae. Posterior abdominal vertebra centra are totally missing and none of the caudal centra have the broad haemal arch characteristic of the first three vertebrae in the caudal series. Two hundred seventy-one of the caudal centra were cut in processing; the left lateral centra of 166 specimens (Figure 7c-d) were nicked when the tail was split longitudinally. Stevenson (1899: 391) has noted that a cut is made "*... along the left edge of the backbone to the tail, inserting the knife no deeper than is necessary for cutting out the backbone. With a horizontal stroke he [the "splitter"] cuts through the backbone about two-fifths of the distance from the tail ... and separates the upper three-fifths of the backbone from the body, the lower two-fifths remaining with the fish. The cut through the backbone should be horizontal toward the head, passing through two or three vertebra, and it should not be deep enough to damage the muscles lying along the backbone and thus weakening the lower part of the fish.*" One hundred five of the Bertrand centra were bisected diagonally (Figure 7 a-b) in the process of removing the anterior vertebral column. Bisected caudals probably also resulted from sectioning dried cod to fit in boxes (see below). Twenty-one small fragments (parapophyses, prezygapophyes, postzygapophyes, etc) were cut from their centra and an additional 33 were broken.

Most neural arches from abdominal cod vertebrae can be distinguished from caudal vertebra arches by the porous dorso-lateral surface of abdominal arches. However, neural and haemal arches from caudal vertebrae are more difficult to differentiate once they have been separated from their centra.

A total of 3,165 arches and arch fragments are included in the sample; 833 are clearly from abdominal vertebrae. Of these, 633 are cut diagonally from their centra (Figure 8a, b). The remaining 200 are broken and show no evidence of cutting. Of the 2,296 neural and/or haemal arches from caudal vertebrae, 1,628 are broken while 668 are cut diagonally from their centra (Figure 8c).

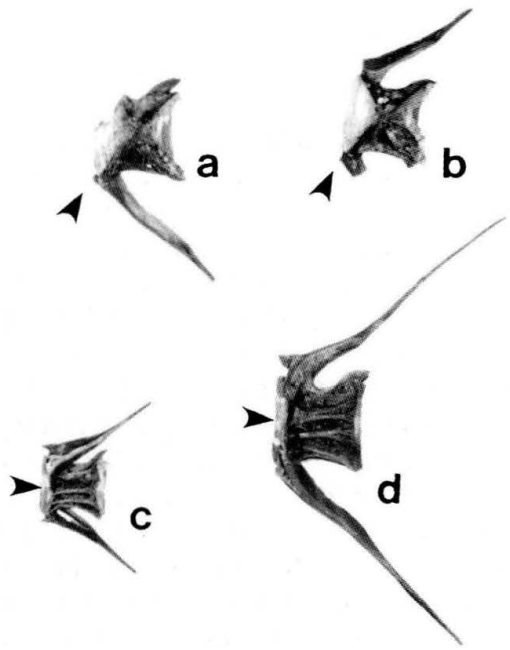

FIGURE 7
Modified cod caudal vertebrae from the Bertrand: a-b) diagonally bisected caudal vertebrae, c-d) caudal vertebrae with cut left lateral centra margins. Arrows point to cut surfaces (d, 13.0 mm centrum length).

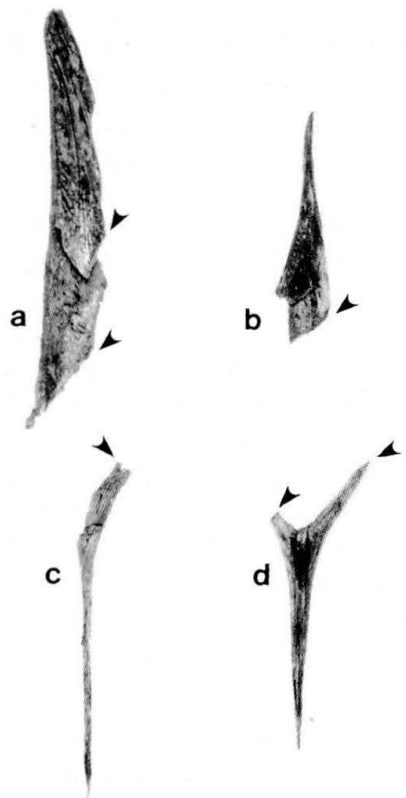

FIGURE 8
Modified cod neural and haemal vertebral arches from the Bertrand: a-b) cut abdominal neural arches, c) cut caudal neural or haemal arch, d) cut anterior caudal haemal arch. Arrows point to severing cuts (a, 46.7 mm spine length).

Thirty-three additional cut haemal arches (i.e., from the 1st, 2nd, or 3rd in the caudal series) are also present (Figure 8d). Arches were cut from their centra by the "splitter" while removing the anterior three-fifths of the vertebral column (Stevenson, 1899: 931).

Paired pleural ribs that articulate at either side of abdominal vertebrae generally project outward and downward from vertebra parapophyes (Rojo, 1991: 146). However, pleural ribs in cod vary considerably from front to back (Figure 9). The anterior most ribs (ca. three on each side) attach directly to the 3rd, 4th, and 5th centra (Markle, 1989: 73), are relatively short and thick, have hollow distal ends (Figure 9d), and project strongly outward. More posterior ribs are pointed, thin (Figure 9a), and project more noticeably downward.

Over 85% (350) of the 404 anterior abdominal ribs have been cut in two (Figure 9e). Except for one proximal fragment (Figure 9f), cut anterior abdominal ribs are only represented by their distal ends; proximal ends were removed by the "splitter" with the abdominal vertebrae during processing (Goode & Collins, 1887a: 181). Thirty-two are complete and 22 are broken distal ends. Only 47% (978) of the 2,064 posterior ribs are cut in two. Cut posterior ribs are represented solely by distal fragments (Figure 9b,c).

PTERYGIOPHORES, MEDIAN FIN RAYS, AND UROPHORES

Interneural and interhaemal pterygiophores that support dorsal and anal fin rays are among the more common fish bones recovered from the Bertrand. The first interneural of the cod's first dorsal fin is fan-shaped and morphologically distinct from other interneurals and interhaemals. Sixty-two first interneurals are present in the sample; 3,234 unidentified pterygiophores are also present. None appear to have been modified during processing.

Fin rays in the dorsal and anal median fins vary considerably in number (Lythgoe & Lythgoe, 1992: 78). Paired median rays have nearly spherical proximal ends and can readily be distinguished from rays of the pectoral fins. A total of 9,493 complete and proximal median ray fragments were recovered. None were cut during processing.

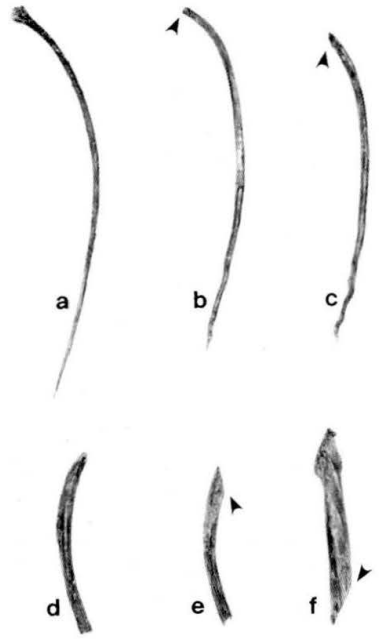

FIGURE 9
Cod pleural ribs from the Bertrand: a) unmodified posterior pleural rib, b-c) cut distal portions of posterior pleural ribs, d) unmodified anterior pleural rib, e) cut distal portion of anterior pleural rib, f) cut proximal portion of anterior pleural rib. Arrows point to severing cuts (a, 84.5 mm rib length).

Small, recognizable, bones of the tail (i.e., urophores) include 44 ural and preural centra, as well as 31 hypurals. None were purposefully modified.

MISCELLANEOUS

Three thousand twenty-six broken fragments and segments of fin rays, posterior abdominal ribs, and vertebral arch spines are too fragmentary to differentiate. Three hundred twenty fragments and segments of flat bones from the pectoral girdle (e.g., cleithrae, coracoids, scapulae) are also present. Finally, 298 additional specimens are too fragmented to determine the kind of bone from which they were broken.

SIZE ESTIMATES OF COD FROM THE BERTRAND

Numerous methods have been employed to estimate the size of Atlantic cod from bones recovered from archaeological contexts (e.g., Wheeler & Jones, 1976; Scott, 1977; Enghoff, 1983, 1989, 1994; Bigelow, 1984; Rojo, 1986, 1987, 1991; Amorosi, 1989; Barrett, 1993; Brinkhuizen, 1994; Perdikaris, 1996). Unfortunately, the majority of these methods entail comparing measurements of archaeologically recovered bones with regression equations that have been generated for cranial elements (e.g., articular, dentary, hyomandibular, maxillary, opercular, quadrate, premaxillary, preopercular) and vertebrae on recently harvested fish. As discussed above, cranial elements and anterior abdominal vertebrae are extremely rare among the cod bones from the Bertrand and the large number of caudal vertebrae that are present cannot be credibly identified as to position along the caudal series. The use of undifferentiated vertebrae from Cellar's Cove in Nova Scotia, for example, obligated Rojo (1990: 101) to assume that each vertebra belonged to a different fish – an assumption that is clearly untenable with respect to vertebrae from the Bertrand.

Among the ten elements for which Rojo (1986) provides regression equations (based on 107 modern Atlantic cod), two are from the pectoral girdle, the cleithrum and postcleithrum. Both elements are fairly well represented in the Bertrand sample and regression equations for both total length and "round" weight are provided by Rojo (1986: 345, 346). Further, it is likely that the Bertrand cod (from "Bay Fundy") were harvested from the same statistical area (4X of the North Atlantic Fisheries Organization) from which Rojo's modern sample was taken. Rojo (1986: 330) has suggested that "*The regressions obtained from this sample are only valid for the population and the size range from which the sample is taken. However, they can be applied to past material with a certain degree of confidence. Extrapolation outside the range studied is very inaccurate, especially when estimating weight and age*". To emphasize his point, Rojo (1986: 330) notes that for the same otolith length (15 mm), the length of Atlantic cod from two different areas of the Northwest Atlantic varied from 507 to 602 mm.

Chord length (Morales & Rosenlund, 1979: 39) was measured on 45 right and 33 left cleithrae from the Bertrand. Twenty elements appear to have both dorsal and ventral ends completely intact while 24 additional specimens are only slightly eroded (< two millimeters) on the ventral end (marked "+" in Table 2). Thirty-four specimens appear to be eroded more than two millime-

Catalogue Number	Specimen Number	Cleithrum CL(mm)	Side L/R	Estimated Length(cm)	Estimated Weight (g)
4563	1	92.2++	R	60.2	2090
5170	12	97.9+	R	63.4	2442
5170	10	98.5++	R	63.7	2481
5170	19	100.8+	R	65.0	2635
4565	31	101.3++	R	65.3	2669
4565	29	102.8++	R	66.1	2772
5170	17	103.1++	R	66.3	2793
5170	16	103.4++	R	66.5	2815
4565	35	103.5+	R	66.6	2822
5170	13	103.5+	R	66.6	2822
4563	2	105.2	R	67.5	2943
5170	5	105.3	R	67.6	2951
4565	34	105.9++	R	67.7	2995
4565	39	107.9++	R	69.0	3144
5170	7	109.0	R	69.6	3228
4565	32	110.0	R	70.2	3305
4565	38	110.4+	R	70.4	3336
4565	30	111.9++	R	71.3	3355
5170	8	112.6	R	71.7	3512
318	248	113.4+	R	72.1	3577
4565	36	115.3+	R	73.2	3734
5170	11	116.7	R	74.0	3853
318	247	117.0	R	74.1	3879
4565	33	119.8++	R	75.7	4125
4567	17	123.1++	R	77.5	4426
4565	40	126.3+	R	79.4	4731
4565	48	127.5	R	80.0	4848
5170	23	128.8++	R	80.8	4978
5170	20	129.5+	R	81.2	50.48
5194	11	130.0+	R	81.5	5099
5170	1	130.4	R	81.7	5140
5170	3	132.1++	R	82.6	5316
5170	18	133.9++	R	83.7	5506
5170	9	137.0++	R	85.4	5843
5170	4	137.1+	R	85.5	5854
5170	25	141.9	R	88.2	6400
318	249	142.5++	R	88.5	6471
4565	37	143.9	R	89.3	6638
5170	24	145.5+	R	90.2	6831

5170	21	146.7+	R	90.9	6978
5194	4	147.0+	R	91.0	7015
4565	49	150.4+	R	92.9	7444
4565	41	153.4++	R	94.6	7835
5170	15	168.0+	R	102.9	9921
5170	6	172.0++	R	105.1	10546
4565	53	99.1	L	64.1	2521
4565	58	101.0++	L	65.1	2648
5170	45	103.1+	L	66.3	2793
5170	46	104.6+	L	67.4	2900
4565	59	104.9++	L	67.3	2922
4565	56	106.3+	L	68.1	3024
4563	15	106.3++	L	68.1	3024
5170	44	106.7++	L	68.3	3054
5170	43	107.3++	L	68.7	3098
5170	42	107.4++	L	68.7	3106
5170	40	108.2+	L	69.2	3166
5170	41	110.8+	L	70.6	3368
4565	54	110.9	L	70.7	3376
4565	60	111.1++	L	70.8	3391
4565	57	115.2+	L	73.1	3726
318	243	119.2++	L	75.4	4071
5170	39	119.5	L	75.5	4078
5194	1	122.0	L	77.0	4324
5170	36	127.0++	L	79.8	4799
4565	55	128.9	L	80.8	4988
5149	2	129.0++	L	80.9	4998
5170	37	129.1++	L	81.0	5008
5170	34	133.8	L	83.6	5495
5170	49	134.2	L	83.8	5538
5170	35	135.2	L	84.4	5645
4565	61	135.5++	L	84.6	5678
5170	30	141.0++	L	87.7	6296
5170	33	141.1	L	87.7	6307
5170	29	148.0++	L	91.6	7140
5170	31	155.0+	L	95.5	8050
5170	28	165.0++	L	101.2	9468
5170	27	175.0+	L	106.8	11030
4565	62	177.2++	L	108.0	11394

TABLE 2

Estimated whole length and weight of cod from the Bertrand based on cleithrum cord length.

ters but less than one half centimeter on the ventral end (marked "++" in Table 2). The remaining specimens are too fragmented to warrant measuring. Table 2 presents cord length measurements (Morales & Rosenlund, 1979: 38, "cl.c.-1" but abbreviated "CL" in Table 2) on cleithrae from the Bertrand as well as the estimated total lengths and weights using Rojo's (1986) regression equations (i.e., total length = 82.62 + 5.630 maximum length; round weight = 0.0166 x maximum length$^{2.5958}$). Length and weight estimates based on the eroded bones are undoubtedly conservative. If, for example, Specimen Number 6 had been a full five millimeters longer (i.e., 177 mm chord length) the estimated total length would have been about three centimeters longer and the estimated weight about 815 grams heavier than the Table 2 values.

A minimum of 130 postcleithrae is included in the Bertrand sample. Seventy-three of these (36 right and 37 left) are complete enough to measure greatest height (see Morales & Rosenlund, 1979: 40, 41 "pcl.gr.h." but abbreviated "GL" here in Table 3), a measurement for which Rojo (1986) provides regression equations (total length = 67.87 + 9.059 maximum length; round weight = 0.0428 x maximum length$^{2.6472}$). Length and weight estimates for the Bertrand specimens are presented in Table 3. Twenty-seven specimens are essentially intact. Less than complete bones are designated as above: slightly eroded ("+" = < two millimeters; 27 examples) and moderately eroded ("++" = two to five millimeters; 11 examples).

A comparison of the estimated lengths of the Bertrand cod that were shipped from Fundy Bay during the mid-nineteenth century to a late twentieth century sample taken with hand lines from near Fundy Bay (Rojo, 1986: 330) shows an interesting similarity. Rojo has suggested that his late twentieth century size distribution (Figure 10) is characteristic of "... *most fish samples, especially when they are collected with only one type of fishing gear. Large specimens trail to the right of the distribution in small numbers, as there are few of them in a particular population*" (Rojo, 1986: 340). The estimated lengths of Bertrand cod, when plotted on Rojo's scale, is striking in that the shape of the curve is very similar, with large specimens trailing to the right in small numbers (Figure 10). Capture methods greatly influence size distributions (Rojo, 1986: 330) and the similarity illustrated in Figure 10 probably indicates that the Bertrand cod were also caught with hand lines, a method in common use in the Western Atlantic during the 1850s and 1860s (O'Leary, 1996: 164).

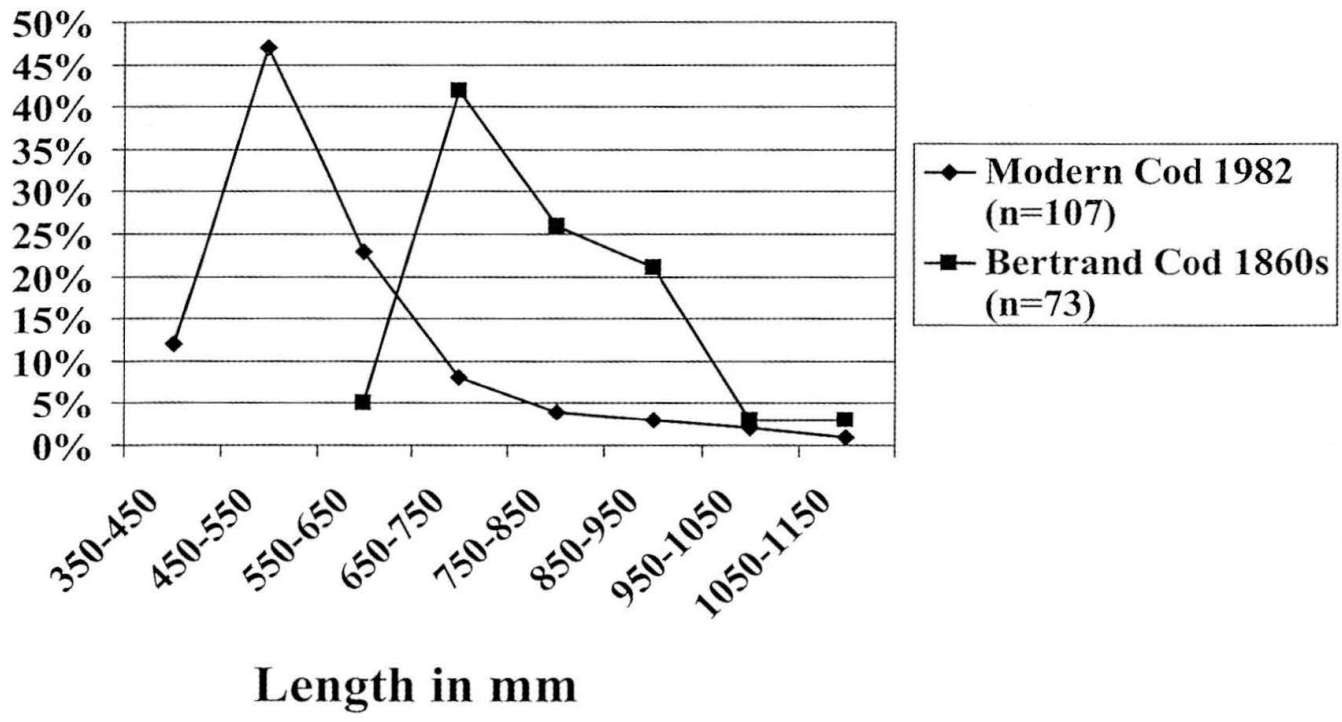

FIGURE 10
A comparison of Bertrand cod length, estimated on greatest height of postcleithrae, with a late twentieth century sample reported by Rojo (1986: 340).

Catalogue Number	Specimen Number	Postcleithrum GH(mm)	Side L/R	Estimated Length(cm)	Estimated Weight (g)
4565	10	64.0++	R	64.8	2587
5178	32	65.1	R	65.8	2706
4565	8	66.8+	R	67.3	2897
4565	9	66.9+	R	67.4	2909
5178	29	67.1+	R	67.6	2932
5178	33	68.0	R	68.4	3037
5178	35	68.6	R	68.9	3109
4565	5	69.5	R	69.8	3218
4567	101	70.1++	R	70.2	3292
5178	30	71.1+	R	71.2	3418
5178	28	71.3+	R	71.4	3443
5178	36	71.4	R	71.5	3456
4565	4	71.5	R	71.6	3469
5178	37	72.3	R	72.3	3572
4565	1	72.7	R	72.7	3625
5178	31	73.3	R	73.2	3705
4566	32	74.0+	R	73.8	3799
4565	3	75.2	R	74.9	3964
4565	2	75.6	R	75.3	4020
4565	12	77.6	R	77.1	4308
4565	6	77.9	R	77.4	4352
4563	60	77.9+	R	77.4	4352
4567	189	79.3	R	78.6	4563
4567	117	80.1++	R	79.3	4685
4565	7	80.2+	R	79.4	4701
4565	11	82.8++	R	81.8	5115
5178	27	82.6+	R	81.6	5082
5178	40	84.9++	R	84.9	5690
318	10	86.6	R	85.2	5760
5178	25	87.6+	R	86.1	5938
5179	34	89.2	R	87.6	6230
4566	31	90.0	R	88.3	6378
4563	61	91.5++	R	89.7	6664
5178	26	93.2+	R	91.2	6997
5178	39	93.8++	R	91.8	7116
5178	38	110.3	R	106.7	10928
4565	20	61.7+	L	62.7	2348
4565	22	62.0+	L	63.0	2378
5178	3	62.1+	L	63.0	2389

318	2	64.9	L	65.6	2684
4565	25	65.1	L	65.8	2706
5178	13	68.8	L	69.1	3133
5178	9	69.5	L	69.7	3218
5178	19	69.9+	L	70.1	3267
4565	23	69.9+	L	70.1	3267
4565	21	70.6+	L	70.7	3354
5178	10	71.2	L	71.3	3430
5178	15	72.9++	L	72.8	3651
5178	17	73.2+	L	73.1	3691
4565	24	73.3	L	73.2	3705
5178	2	73.6	L	73.5	3745
4565	19	74.3	L	74.1	3840
4565	18	74.5	L	74.3	3867
5178	1	75.3+	L	75.0	3978
5178	8	77.4	L	77.0	4279
4567	196	79.6++	L	78.8	4608
5178	11	81.2	L	80.4	4858
4563	50	82.4+	L	81.4	5050
318	2	82.6	L	81.6	5083
5178	14	83.1++	L	82.1	5164
4563	48	83.5	L	82.4	5230
5178	16	86.3	L	85.0	5708
318	1	86.8	L	85.4	5796
4565	17	87.5	L	86.1	5920
5178	21	87.5+	L	86.1	5920
5178	20	89.4+	L	87.8	6268
5178	5	90.7+	L	89.0	6511
4563	49	92.1+	L	90.2	6780
5178	12	95.1+	L	92.9	7380
5178	18	95.7+	L	93.5	7504
5178	6	102.2	L	99.4	8930
4565	26	103.7++	L	100.7	9281
5178	7	110.5+	L	106.9	10981

TABLE 3
Estimated whole length and weight of cod from the Bertrand based on postcleithrum greatest height.

The obvious difference between the Bertrand cod size distribution and the late twentieth century sample can be attributed to heavy exploitation brought on, in part, with the widespread use of trawls by the 1860s (Innis, 1940: 329). The "spike" in the Bertrand cod distribution is at 700 mm while the peak in Rojo's sample is 200 mm shorter, at 500 mm. Amorosi (1989: 211) has noted a similar difference between late medieval cod remains from Storaborg in Iceland and modern samples collected during Icelandic Fisheries research that he attributes to continuous heavy exploitation. Interestingly, the Storaborg peak is close to 950 mm, while the shape of the size distribution is, again, quite similar to Rojo's (1986: 340) sample. Wheeler (1978: 74) has suggested that "*The effects of fishing pressure can ... be seen on the maximum size of fish such as cod from medieval and other periods which are on average much larger than the average size landed today. This effect is confirmed by literary evidence of the sizes of fish captured in the nineteenth century compared with present-day maxima ...*" Jackson *et al.* (2001: 631) also note a decrease in the body size of Atlantic cod in the coastal Gulf of Maine, attributing a rapid decline to increased use of mechanized fishing technology in the early twentieth century.

Finally, with respect to size of the Bertrand cod, as noted above, the inside length of a surviving cod box (FPC#165 [DESO-739]) was 60 cm. If we allow for a 25 percent reduction in total length as a result of head removal then cod with a total length of 80 cm would just fit in a 60 cm-long container. The largest cod, even allowing for up to 20 percent linear shrinkage during drying would probably have to be cut in two to fit in such a container. This could account for some of the bisected vertebrae among the Bertrand specimens and could also indicate that various portions of a large dried cod might potentially end up in separate containers.

In addition, many of the cleithrae shown in Figure 2 appear much nearer the center of the packing box than might be expected if beheaded, dried, cod had been placed in this 60 cm-long container. Also several of the caudal vertebral columns pictured in the lower right hand corner are still articulated, indicating very little shifting of the bones within this box since the cod were packed in the mid-1860s. This further suggests that many of the dried cod had been sectioned prior to packing.

DISCUSSION AND SUMMARY

Over 25,000 cod bones were recovered from the Bertrand (Table 1) and, as expected from the descriptions provided by Faulkner (1985) and Goode & Collins (1887a), the overwhelming majority (>99 %) is postcranial. However, the large majority of these (e.g., fin rays, pterygiophores, radials, and detached vertebral arches) would be difficult to identify to species if co-mingled with fish bones representing other taxa and recovered from a more "normal" archaeological context, particularly one that did not include specimens contained in a box marked "Fundy Bay Cod".

Far more diagnostic elements are found in the cranial area. Rojo (1991) illustrates and describes 37 relatively diagnostic major, paired, bones in the cod skeleton (Cranial: angular, ceratohyal, dentary, ectopterygoid, epihyal, endopterygoid, epiotic, exoccipital, hypohyal, hyomandibular, intercalar, interhyal, interopercle, lateral ethmoid, maxilla, metapterygoid, opercle, palatine, parietal, premaxilla, prootic, preopercle, pterotic, pterosphenoid, quadrate, retroarticular, sphenotic, subopercle symplectic; Postcranial: basipterygium, cleithrum, coracoid, postcleithrum, posttemporal, scapula, supracleithrum). Of these, 30 (81%) are from the disarticulated cranium and skull (excluding the gill apparatus) while only 7 (19%) similarly diagnostic, paired, bones are postcranial. These same bones from the Bertrand include 21 (2%) cranial and 899 (98%) postcranial, indicating that among paired diagnostic bones, postcranial elements are in the vast majority. A high relative frequency of paired postcranial elements compared to paired bones of the osteocranium can be viewed as one attribute of dried cod.

In Eastern North America fish vertebra centra are sometimes identified to species (e.g., *Amia calva*) or genus (e.g., *Lepisosteus* sp.) but generally are not identified below class (i.e., Osteichthyes). In fact, Perdikaris (1998: 66) has noted that Anglo-American faunal analysts have traditionally concentrated on fish cranial elements and largely ignored postcranial bones. Notwithstanding, cod vertebrae are fairly distinct with parallel ridges connected by a fine bony lattice on their lateral margins. In addition, posterior abdominal centra have relatively distinct deep longitudinal sulci in their ventral margins. Rojo (1991) has reported that cod from the waters near Nova Scotia have

approximately 53 abdominal (including cervical) and caudal vertebrae. In whole cod just over one-third of the vertebrae are abdominal. All but six of the 1,938 centra from the Bertrand are from caudal vertebrae; the few abdominal vertebra centra that are present are anterior abdominal from the "cervical" area. Thus the scarcity of anterior abdominal vertebra centra, together with the absence of posterior abdominal vertebra centra, can also be used to characterize the skeletal configuration in dried cod.

The presence of a high frequency of abdominal neural arches without centra can be taken as another signature for dried cod. Similarly, large numbers of fish ribs in the absence of abdominal vertebrae might serve as a signature for dried cod — especially in the case of the distinct, hollow, outward projecting, anterior abdominal ribs.

Patterns of bone modification may also be useful in identifying dried cod in archaeological contexts. The pterotics and supraoccipitals from the osteocranium are extensively modified (Table 1) but, by themselves, would be difficult to identify to species. The same is true of abdominal neural arches and abdominal pleural ribs; over 75 % of both elements are cut in our Bertrand sample. Finally, over 75% of the postemporals from the Bertrand have distinct modifications; in all instances where cutting was observed, the anterior ends of the lateral processes have been completely removed. In addition, a fair number of their mesial processes have also been cut (see description above).

Cod skeletal part representation from the Bertrand is generally similar to that reported from at least two sixteenth century European shipwrecks. The Atlantic cod sample from the Mary Rose that sank near Portsmouth, England in 1545, for example, included 3,804 specimens. No cranial elements were present and over 70% of the identified elements were caudal vertebrae (Hamilton-Dyer, 1995: 28). However, unlike the Bertrand sample, more than seven percent of the cod bones from the Mary Rose were posterior abdominal vertebrae (i.e. "other precaudal vertebrae").

Fish remains found in wooden barrels recovered from a late sixteenth century merchant vessel (Scheurrak SO1) that sank in the Dutch Wadden Sea are even more similar to our Bertrand sample. The fish bones identified as Atlantic cod in Barrel # 1, for example, include one opercular and two supraoccipitals. Other *Gadus morhua* elements include 17 cleithrae, 10 supracleithrae, and four posttemporals from the pectoral girdle, as well as 160 caudal vertebrae, two urostyles, and eight first dorsal pterygiophores from the "trunk". Bones from Barrel # 1 that were only identified to family (Gadidae) include 18 postcleithrae, 16 coracoids, 14 scapulae, 20 basipterygia, 29 radials, and nearly 4,000 miscellaneus pterygiophores, costae (ribs), lepidotrichs (fin rays), spines and transverse processes from vertebrae, etc (Brinkhuizen, 1994: 198). In other barrels containing mixed taxa, Brinkhuizen (1994: 204) noted cod posterior abdominal vertebrae and suggested they were only present in smaller fish that could be dried without their removal.

Although not described in detail, Brinkhuizen (1994: 204) illustrates tool marks on cod bones that are very similar to those observed in our Bertrand sample; posttemporals with lateral and mesial processes removed, cut cleithrae and supracleithrae, cut abdominal vertebra neural spines and ribs in the absence of centra, as well as bisected caudal vertebra centra.

None of the attributes observed among the cod remains from the Bertrand, Mary Rose, or Scheurrak SO1 will likely serve alone as a signature for the recognition of dried cod in domestic food refuse. However, taken in combination, the attributes described above should provide a credible means of identifying this important food source that was utilized in much of eastern North America and the Caribbean during the Historic Period. Historic records suggest that particular attention should be afforded fish remains from enslaved African contexts. The Bertrand's unrealized destination suggests that cod bones should also be expected in mining camps as far away from the North Atlantic as the Montana Territory in Western North America during the mid-nineteenth century.

ACKNOWLEDGEMENTS

We thank the Desoto National Wildlife Refuge for permission to study the cod bones from the Bertrand; Sarah Tuttle and Jennifer Stafford were especially helpful in expediting the loan of the material and searching photographs and other records for information relevant to the cod remains. Jefferson Chapman and Susan Frankenberg provided space for our studies at the University of Ten-

nessee's Frank H. McClung Museum. Miles Wright prepared photographs of the cod bones in Figures 3, 4, 6-9, while Figure 2 is from the Desoto National Wildlife Refuge archive. Judy Patterson assisted with the size estimations of cod from the Bertrand and drafted Figure 10. This article is a written version of a paper presented at the 66th Annual Meeting of the Society for American Archaeology, New Orleans, Louisiana, USA.

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