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## **Bioarchaeology and Cod Fisheries: A New Source of Evidence**

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### **Abstract**

Archaeological excavations in the North Atlantic basin over the past two decades have recovered large amounts of fishbones from datable deposits extending back over 8000 years in some areas. Coverage of the last 1000 years (with particular emphasis on the climatic cooling of the “Little Ice Age”) is increasingly complete. Recent research makes it possible to reconstruct live lengths from commonly recovered fishbone elements. Preliminary findings indicate that cod of 1 to 1.5 m were being regularly taken in the eleventh to nineteenth centuries throughout the North Atlantic. Changes in fish size and mix of species taken probably reflect technological as well as biological variables. The development of commercial fisheries and the interaction of climate are major research concerns of the North Atlantic Biocultural Organization (NABO), and recent NABO data from Iceland, Greenland, and northern Norway are reported here. Both archaeology and fisheries science may benefit from more active collaboration toward a better integration of a growing body of bioarchaeological evidence with existing documentary and statistical records.

### **Introduction**

This study is a preliminary and somewhat limited attempt to communicate across major disciplinary barriers. It is preliminary in that it cannot present a complete review of bioarchaeological evidence for medieval and early modern fisheries in any portion of this wide study area because ongoing research on major collections now underway will surely modify any specific statements made here within the next few years.

It is limited in that we do not pretend that this small research group adequately represents the many workers active in the field of maritime zooarchaeology. Closely comparable

work is now being carried out with materials from the Shetland Islands (Bigelow, 1984), Caithness, and Orkney (Barrett, 1993) and by a wide range of scholars active in the International Congress of Archaeozoologists (ICAZ; Brinkhuizen and Clason, 1986). The ICAZ fish working group is acting to coordinate fishbone research worldwide (IOAN, 1992) and will certainly play the leading role in any comprehensively systematic attempt to integrate bioarchaeology with fisheries biology. Several useful reviews of fishbone bioarchaeology summarize current research trends and review the literature (Casteel, 1976; Colley, 1983, 1990; Wheeler and Jones, 1989; Jones, 1991; Rojo, 1991), and we do not attempt to duplicate this coverage here.

This article is also inevitably unsatisfactory as the need to address a wide range of topics is best treated in a monograph format that is comprehensible to a well-educated but non-specialist audience. But, the necessarily limited space of a short paper runs the risk of simultaneous oversimplification and obfuscation by intradisciplinary jargon. This paper is thus not a theoretical statement, not a literature review, and not a fully developed presentation of basic data. What then do we hope to accomplish by presenting it in such a distinguished collection of international fisheries research?

Our presentation has three major objectives:

- (1) To alert the fisheries science community to the existence of a previously unused body of data of potential significance in its efforts to develop long-term models of changing fish populations in different parts of the North Atlantic. Climatologists (Bryson and Murray, 1977; Wigley et al., 1981; Ogilvie, 1991), agricultural historians (Biddick, 1984), historical ecologists (Cronon, 1983; Crosby, 1986; Crumley, 1994), and biogeographers (Dugmore, 1987; Buckland, 1988) have begun to make extensive use of bioarchaeological data in integrative modeling. Fisheries biologists have not yet made similar use of these increasingly abundant data. Our own experience suggests that this is the result of disciplinary divisions that discourage communication rather than a reasoned rejection. Informing the fisheries science community of the existence of these data is a necessary first step.
- (2) To stimulate a dialog with fisheries scientists on the appropriate and more effective use of archaeological fishbone evidence for the mutual benefit of maritime archaeology and marine biology. Such dialog has proven highly productive with a wide range of terrestrial natural scientists during the past two decades. Holocene paleoecologists, in close cooperation with bioarchaeologists and historians, are now producing a dramatic new picture of a wide range of terrestrial ecosystems significantly shaped and directed by preindustrial societies worldwide (for review see Butzer, 1981; Roberts, 1989; Crumley, 1994). The old view of a pristine prehuman landscape has been banished along with the expectation of a wholly "natural" baseline suitable for starting management models (Cronon, 1983; Crosby, 1986). With the active cooperation of specialists in diverse fields, multiauthored and genuinely multidisciplinary syntheses have generally replaced unsophisticated "data raids" by one discipline upon another in such dryland investigations of human-landscape

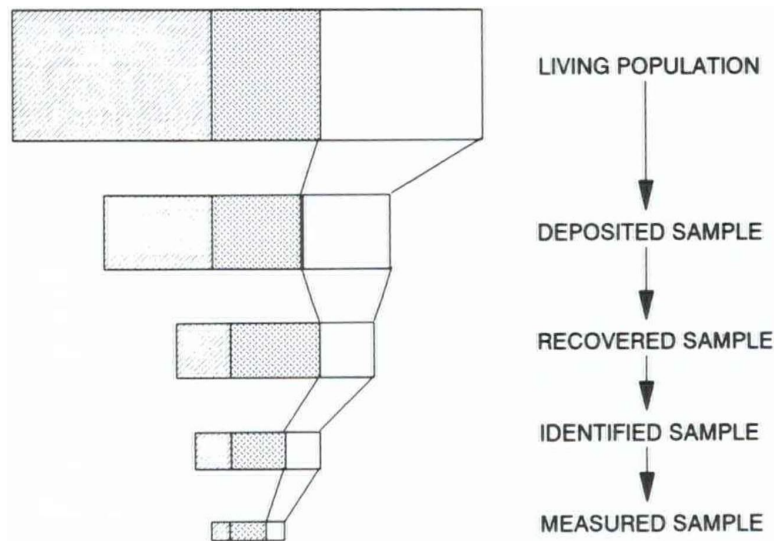
interaction. The complementary interdisciplinary links that will allow comparable sophistication in maritime human-seascape interaction are only weakly developed at present. We hope that this article will be a small step toward such integration, if only by provoking fisheries scientists to educate maritime bioarchaeologists about the complexity of the marine ecosystems they know so well.

- (3) To underline a clear trend in widely separated archaeological fishbone collections that may be of immediate relevance to current fisheries science and management debates. A growing number of substantial, well-excavated bioarchaeological collections suggest that some stocks of cod and other commercial species regularly taken by past North Atlantic fishers were substantially larger and older than most current landings in the same area. These patterns are strongly evident in substantial animal bone collections dating back to the ninth century (AD) and are unlikely to be the result of archaeological sampling error. While these patterns may eventually be demonstrated to be artifacts of preservation, chance, or past fishing practices, we feel that the existence of this widespread pattern urgently needs to be brought to the attention of the professional fisheries community.

### **Data limitations**

However, it is important to emphasize the limitations of zooarchaeology as well as its proven potential. Zooarchaeology cannot provide a direct count of living animals in some ancient sea, nor does this subdiscipline provide a menu for particular meals or reliable estimates of caloric intake of any past human population. Most of the zooarchaeological evidence we now have has been subjected to a daunting range of transformations by ancient humans, scavengers, decay, and archaeological recovery techniques. Much recent research has sought to identify and quantify these taphonomic<sup>1</sup> agents of attrition and sources of statistical "noise." We certainly understand the limits of inherent precision of resolution and the critical issues of sample size and adequacy far better today than a decade ago (Rackham, 1983; Grayson, 1984; Bonnichsen and Sorg, 1989), but more work is still needed in these areas.

Figure 1 presents a simplified model of the degree of attrition suffered by bioarchaeological samples in their transformation from a portion of a living organism in a living population to a preserved and recovered bone sample. As the figure suggests, only a small percentage of the excavated sample that can be identified to species level can be used for an osteometric study such as is employed in this article. The over 30 000 bone fragments thus far identified to species level from the Icelandic site of Stóraborg (Snæsdóttir, 1991a, b) produce only 186 cod premaxillae and 254 dentaries that can be used to reconstruct cod length, despite favorable conditions of preservation and careful excavation.



**Figure 1.** Attrition of archaeological samples. Any archaeological collection is a small fraction of the material originally deposited. This figure illustrates the effect of nonrandom reduction of the original sample of bones by the effects of decay and differential recovery. The horizontal bar is divided into three major taxa, the clear bar representing cod. Note the changes in relative proportion resulting from different forces of attrition, and the tiny fraction of the original sample that can be measured. Archaeofauna are thus proxy measures of past living populations.

Most of the bones of most of the animals that died to feed the human occupants of an ancient site never reach the zooarchaeologist—representation is far less than one bone per animal. Except in exceptional circumstances of catastrophic deposition of whole skeleta (as in a bison drive or similar mass kill) (Speth, 1983), bones are usually so scattered that it is unlikely more than a very few were derived from the same individual. Archaeological bone collections (archaeofauna) are thus samples of a far larger ancient population. Zooarchaeological collections are proxy, not direct, measures of past economy and land use. We are normally comparing patterns in highly transformed samples, not counting whole skeletons.

Trends in such proxy data sets need to be carefully investigated to determine whether they are wholly the result of postdepositional attrition or if they reflect some surviving patterning in the original economy. Are patterns in individual archaeofauna effectively random? Are clearly nonrandom patterns primarily structured by the differential preservation and recovery of the basic data? Such proxy data gain their strength and utility through systematic comparison of large samples from well-controlled contexts. Both comparisons of different evidence from the same archaeological site and intersite comparisons of similar materials dated within a narrow temporal framework are now becoming increasingly possible in our region.

One site is a curiosity, two produce controversy, but fifty produce quantifiable patterns with interesting outliers. North Atlantic archaeologists now rarely need to argue the merits

of a single site in isolation but instead are honing their skills in pattern recognition. Such intersite comparisons often demonstrate multiple indicators with the same overall patterning that allows workers to better identify the stochastic "noise" of taphonomy and the preserved outlines of past behavior. Subtle, small-scale shifts in species abundance or morphology tend to disappear in the random noise of archaeological excavation and taphonomic attrition. When a zooarchaeological pattern appears that crosscuts multiple site collections and is recognized by multiple workers in different research centers, it tends to be neither local nor subtle.

This paper reports some selected patterns observed by many workers in a growing number of North Atlantic archaeofauna which we feel are neither random nor shaped entirely by postdepositional taphonomy. However, the satisfactory *explanation* of these patterns is by no means clear-cut. Are persistently repeated patterns in archaeofauna that differ from modern fauna in the same area the result of local or regional biological changes in the prey population, technological changes by the human predators, or archaeological sampling problems? Such explanations will surely require prolonged interdisciplinary cooperation to develop. Before we turn to such specific interpretive issues, some general cultural background may be helpful.

## **Historic background and research history**

### ***North Atlantic Region***

Viking-age Scandinavian populations expanded into the North Atlantic between 800 and 1000 AD, probably colonizing the eastern island groups of the Shetlands, Faroe, Orkney, northern Hebrides, and Scottish mainland by 825. The more distant western islands, Iceland, Greenland, and Vinland, were settled within the next three generations—Iceland (traditionally) by 874, Greenland by 985, and Vinland sometime around 1000. This wave of seaborne migration carried an initially homogeneous culture, technology, and economy into the western hemisphere. The first settlers shared a hierarchical, chiefly political organization, a well-developed seafaring tradition, a subsistence economy based primarily on domestic animals and some cereal cultivation, and an opportunistic readiness to exploit available wild resources of both sea and land.

Subsequently, during the Medieval period, the various island communities became less homogeneous in subsistence and trading economies, while at the same time undergoing political integration into a Norwegian (and later Danish) Atlantic realm. The increasing diversification of economic strategy in the later Middle Ages partly reflected local adaptation to significantly different local environments but also seems tied to the relative distance from continental market centers. Archaeological research in some eastern North Atlantic Norse settlements has revealed an eleventh- to twelfth-century transition from Viking period (ca. AD 800–1100) architecture and artifact assemblages to a Late Norse pattern that persisted through the Middle Ages (Bigelow, 1985, 1992; Batey, 1987). This transition reflects increased importation of durable goods from urban centers, expansion and elaboration of fishing technology, adoption of domestic pottery-making, and some less well-understood changes in butchery practice and settlement layout. A Late Norse transition in Iceland is less evident, and it now seems doubtful that the somewhat isolated Greenland

colony ever underwent the same sort of transition as can be documented in the eastern island communities. All of these Scandinavian Atlantic communities had significant impact on local flora, fauna, and landforms. By the later Middle Ages, soil erosion and declining fertility were growing problems in Iceland and Greenland (McGovern et al., 1988; Christensen, 1991; Fredskild and Humle, 1991; Hansen, 1991; Jakobsen, 1991).

Beginning around 1300, the climatic cooling known as the "Little Ice Age" began to have a varied but significant impact on local subsistence economies all across the North Atlantic (Ogilvie, 1981, 1991; McGovern, 1990; GISP2, 1992). While the coldest portion of the Little Ice Age seems to have occurred at the end of the seventeenth century, most of the Scandinavian North Atlantic communities felt major effects by the early fourteenth century. The entire region is marginal to submarginal for cereal agriculture, and many other components of the transported continental agricultural system were at the edges of their climatic tolerance limits. The region as a whole is thus particularly vulnerable to relatively small-scale shifts in northern hemisphere climate.

The later Middle Ages and Early Modern period saw the complete extinction of the Greenlandic colony (ca. 1450–1500) and major loss of population in Iceland, while the eastern settlements in Shetland and Orkney apparently experienced modest prosperity and population stability or increase. The available evidence thus far suggests that the eastern island communities were more successful in their long-term adaptation to changes in their natural and social environments.

What role did the expansion of commercial fisheries in the later Middle Ages have in the different histories of the eastern and western North Atlantic? How did local elites and commoners respond to the different options provided them by changing natural and commercial environments after initial settlement? How did the existing patterns of exploitation of marine and terrestrial resources affect local decisions to adopt or forego a transition to full-scale commercial fishing? Did preindustrial fishers have the capacity to affect local fish stocks? The answers to these questions may suggest the complexity of the social dimension of the spread of large-scale fishing in our region.

## **Fish allometry**

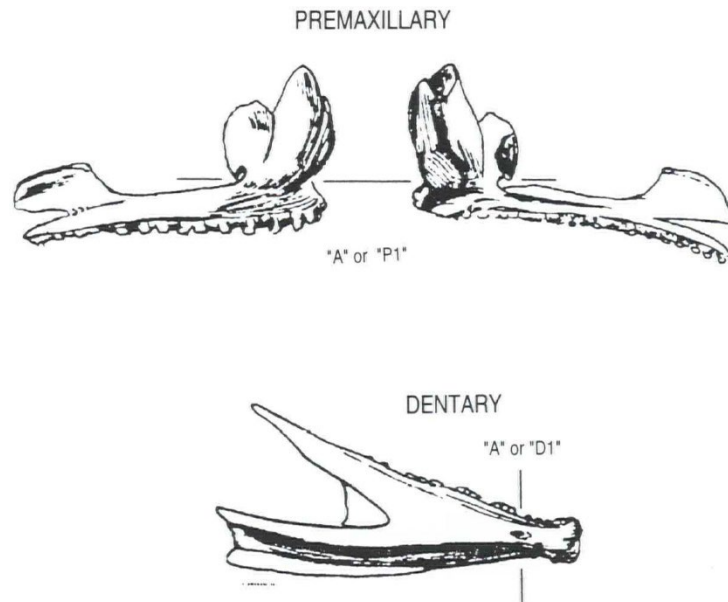
### *Methodology*

The estimation of the size of fish from archaeological remains is not new. There are many studies in which various cranial elements have been used to estimate the size (either length or weight) of the animal (summarized in Casteel, 1976; Bigelow, 1984; Rojo, 1986; Amorosi, 1989; Wheeler and Jones, 1989; Colley, 1990; Jones, 1991; Barrett, 1992). Studies simply comparing the archaeological bone with a modern bone (where the size, weight, and age were known for modern comparative specimens; see Casteel, 1976) have given way to more refined statistical analyses (for review see Colley, 1983; Jones, 1984, 1991).

Such comparative approaches are most effective if a large number of modern specimens are available for comparison with the excavated specimens. Modern examples should be close to the size of archaeological fish recovered and should also include a wide range of variability sufficient to account for the natural variation of bone size in the species (Desse, 1984). Wheeler and Jones (1976) have carried out such an analysis for the Atlantic cod

(*Gadus morhua*) using two bone elements in the skull—the premaxillary and dentary (see also Morales and Rosenlund, 1979; Rojo, 1986).

Measurements taken on the dentary and premaxillary follow Wheeler and Jones (1976) and are illustrated in Figure 2. They were taken with a digimatic caliper (Mitutoyo, Model Series 500), reading to the nearest 0.01 mm. The dentary measurement described as "D1" by Jones (1991) is the dentary depth taken at the mental foramen (Rojo, 1991). The measurement taken on the premaxillary is the length of the constricting neck of the anterior portion (or symphyseal margin, Rojo, 1991) of the ascending and articular processes.



**Figure 2.** Osteological measurement points. The premaxillary and dentary are two skeletal elements that regularly survive in measurable condition in archaeological collections. Standard measurement points follow Wheeler and Jones (1989). "A" or "P1" = premaxillary width; "A" or "D1" = dentary depth.

The regression formulae as developed by Wheeler and Jones (1976) are:

$$\text{Dentary "A" or "D1": } Y = (80.14 \times X) + 102.3$$

and

$$\text{Premaxillary "A" or "P1": } Y = (60.83 \times X) + 10.35$$

The "A" notation follows Wheeler and Jones's (1976) original paper. Jones, in his 1991 thesis, describes the same measurement but gives a different notation, "D1." Similarly, Jones later assigns the notation "P1" in his 1991 study for the premaxillary measurement. We suggest that Jones's 1991 terminology be accepted as standard to avoid confusion.



### *Limits of precision*

Both Härkönen (1986) and Jones (1991) have argued that these regression formulae do not provide a statistically calculated confidence or prediction interval. Both these authors have extensively demonstrated that the relationship of bone element size to estimated fish length for small to medium-sized individuals is fairly regular. However, in large-sized animals this relationship has been described by Jones (1991, pp. 115–116) as more variable.

The true importance of Jones's careful study is not that it flags yet another area of statistical imprecision in fuzzy archaeological data sets but that Jones's method and results establish a practical limit to cod length reconstruction regression formulae. Jones (1991, pp. 116–165) further investigated this problem by examining bone measurements of the cleithra, dentaries, premaxillae, and otoliths of modern cod, saithe (*Pollachius virens*), pollock (*P. pollachius*), haddock (*Melanogrammus aeglefinus*), and ling (*Molva molva*). His meticulously gathered findings demonstrate three important points:

1. Selected fishbone and otolith size parameters were indeed strongly correlated with fish total length (many of Jones's graphs show an  $r$  value of  $> 0.95$ ).
2. Large fish produce bones and otoliths which are more generally irregular in their proportions relative to fish length than those of small fish. Older fish appear to have more variable growth rates.
3. Most bone elements show a size relationship that is curvilinear. Growth slows with age.

Of particular interest for this study is Jones's second result, namely, that large fish produce a more variable length size than those of smaller individuals. Our reconstructions of cod length from archaeological specimens are thus most accurate for smaller fish, but the precision of the reconstruction decreases with the larger individuals. Jones's data indicate that the regressed reconstructed cod estimated at 140 cm show a  $\pm$  variation just under 20 cm (Jones, 1991, figs. 43 and 44). For larger specimens, our data might be better presented as a probability range rather than as a point estimate (e.g., 120–160 cm rather than 140 cm). While single-point estimate figures will be used in this preliminary presentation, users should be aware of the variability inherent in the reconstructions.

As noted, a practical response to inherent fuzziness in archaeological (or any other) data is to expand the number of data points and increase their geographical and temporal range. If distributions prove consistent, or at least present logical patterns of variability, we may have some basis for separating signal from noise. This article adopts this comparative approach, presenting data from three different parts of the medieval–early modern North Atlantic, where three distinct (but related) human populations interacted with at least three distinct "cod stocks."

### *Greenlandic data*

A substantial number of quantifiable archaeofauna have been recovered from both the Eastern Settlement (modern Qaqortoq and Narsaq districts in the extreme south) and the smaller Western Settlement (modern Nuuk district in the southwest) during nearly one hundred years of professional archaeological research (see McGovern, 1985b for summary,

also Nyegaard, 1992). None of the nearly 30 excavated archaeofauna have contained more than a tiny number of fish bones, despite extensive sieving efforts since 1976 and generally excellent conditions of organic preservation. While Norse Greenlanders undoubtedly exploited fish more than the bone collections document, it also seems clear that they did not participate in a commercial fishery comparable to those documented historically and by zooarchaeology from Iceland, Shetlands, and North Norway.

Most of these Greenlandic animal bone collections are from the later phases of the Norse occupation, when Greenlandic cod stocks were probably adversely affected by cooling climate (see Jonsson, 1993; Buch et al., 1994; Dickson et al., 1994). However, three stratified collections from Greenland are now radiocarbon-dated to the settlement period (ca. 985–1100), one from the Eastern Settlement at Narsaq (0 17a, Vebæk, 1993) and two (V51 Sandnes, V48) from the Ameralla region of the Western Settlement (McGovern et al., 1983; McGovern and Bigelow, 1984; McGovern, 1985a; Arneborg, 1991; Vebrek, 1993). These collections provide a view of economic organization in the Medieval Warm Period (MWP) prior to impacts of the Little Ice Age (Table 1).

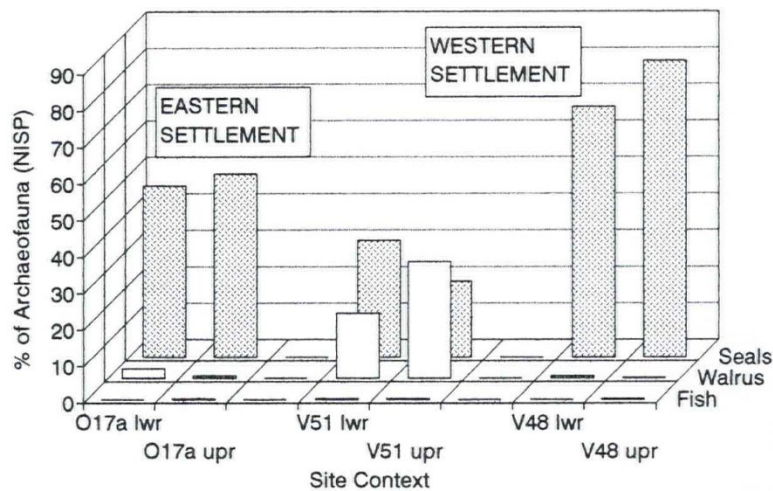
**Table 1.** Animal bone collections from eleventh century and fourteen–fifteenth-century sites in Greenland. Three stratified sites from the extinct Norse colony in West Greenland provide a comparison of economic organization in the settlement period (ca. AD 985–1100) and the end of the Norse occupation (ca. AD 1350–1450). Only large collections are included (NISP = number of identified specimens). Note that even during the Medieval Warm Period of the eleventh century fishbones make up only a trace element in the bone collections. Seals and walrus apparently provided subsistence and market products. Data from McGovern (1985) and the NABO Zooarchaeology Database.

Settlement	Eastern		Western		Western	
	n	n	y	y	y	y
Sieved?						
Site status	Middle		High		Low	
Site locality	Narssaq	Narssaq	Ameralla	Ameralla	Ameralla	Ameralla
Sample size (NISP)	1,073	505	503	1,832	1,159	3,679
Site name	0 17a	0 17a	V 51	V 51	V 48	V 48
Phase	Lower	Upper	Phase 1	Phase 5	Phase 1	Phase 4
Approx. dates (AD)	ca. 1000	? terminal	ca. 1000– 1175	ca. 1250– 1325	ca. 1000– 1100	ca. 1300– 1350
Total % NISP						
Total domestic	35.51	37.5	16.9	15.87	15.01	9.84
Caribou	8.01	4.37	7.95	16.09	4.4	4.54
Birds	2.89	1.19	4.37	11.15	6.04	3.46
Cetaceans	3.17	4.17	4.57	3.19	0.09	0.42
Seals	46.97	50.2	32.01	20.76	68.51	81.26
Walrus	2.33	0.6	17.69	32.02	0.6	0.18
Fish	0	0.2	0.2	0.05	0	0.22
Molluscs	0	0	15.31	0.82	4.83	0

As Table 1 indicates, Greenlandic settlers of the MWP did not exploit fish any more heavily than their descendants living at the beginning of the Little Ice Age. Some changes between the early and final phases (only the top and bottom of the deep middens at V51

and V48 are presented here) are evident, but these economic changes are evolutionary, not revolutionary—cod fishing did not boom and then bust (Fig. 3). From the beginning, Norse Greenlanders apparently adopted a very different approach to marine resource extraction and transatlantic commercial contact, emphasizing seal hunting and long-distance hunts for walrus ivory and other high arctic products (McGovern, 1985a, 1992). If cod fish were indeed plentiful in southeast Greenland during the settlement period, the Norse Greenlanders did not choose to exploit them intensively. Norse Greenlanders of the eleventh and twelfth centuries (like their descendants in the fourteenth and fifteenth centuries) apparently centered their marine hunting effort on seals, not cod.

As emphasized elsewhere (Keller, 1991; McGovern, 1991), Norse Greenland may serve as a classic example not of implacable climate impact on humans but of the effect of human politics and social organization on resource use. The Greenlandic case also underlines the need to examine all the evidence for a past economy—zooarchaeological, locational, paleoecological, and historical—in attempting to assess climate impact on a particular economic component. Fluctuations in the cod catch that stressed Icelandic settlements in the later Middle Ages may not have bothered the Greenlanders at all.



**Figure 3.** Major marine taxa exploited in Norse Greenland. The lowest (eleventh century–Medieval Warm Period) levels of three Norse sites in Greenland compared to upper levels (fourteenth–early fifteenth century–Little Ice Age). Even during the Medieval Warm Period prior to AD 1300, fish were not extensively exploited in either the modern Nuuk district (V 51, V 48) or the modern Narsaq District (O 17a). See also Table 1.

### *Icelandic data*

The Icelandic data collected for this article represent a varied set of samples (Tables 2, 3) from stratified, multicomponent sites of Viðey (Hallgrímsdóttir, 1987a, b, 1989, 1991a, b, 1992; Amorosi and McGovern, 1993) and Bessastaðir (Smith, 1987; Baldursson, 1990; Amorosi, 1991; Ólafsson 1991, Amorosi et al., 1992) located in the greater Reykjavík vicinity, the abandoned farmstead of Miðbær (Amorosi and McGovern, 1989), located on the island of Flatey in Breiðafjörð, western Iceland, the church farms of Svalbarð in the northeast

(Amorosi, 1989, 1991, 1992), and Stóraborg located on Iceland's south coast (Snæsdóttir, 1987, 1991a, b; Amorosi, 1989, 1991). Historically, these sites functioned as "elite" farmsteads. The sites of both Bessastaðir and Viðey served in the medieval period as the chieftain's manor; Viðey also served as the site of a cloister. In the more recent past, both sites served as quasi-Danish colonial residences in the 1700–1800s. The sites of Svalbarð and Stóraborg were church farms throughout much of their history, and it is surmised that the site of Miðbær served in a similar capacity. Animal bone data from these farms provide interesting evidence of access to an apparently wide range of resources.

**Table 2.** Animal bone collections from ninth- to thirteenth-century sites in Iceland. Five sites dating to the Icelandic Settlement Period (traditionally ca. AD 870–930) and the Commonwealth Period (AD 930–1264) provide a sampling of economic strategies in different parts of Iceland in the two periods. Note the highly variable role of fishing in the early Middle Ages in these samples. Only larger collections are included in this table. Data from Amorosi (1991) and the NABO Zooarchaeology Database.

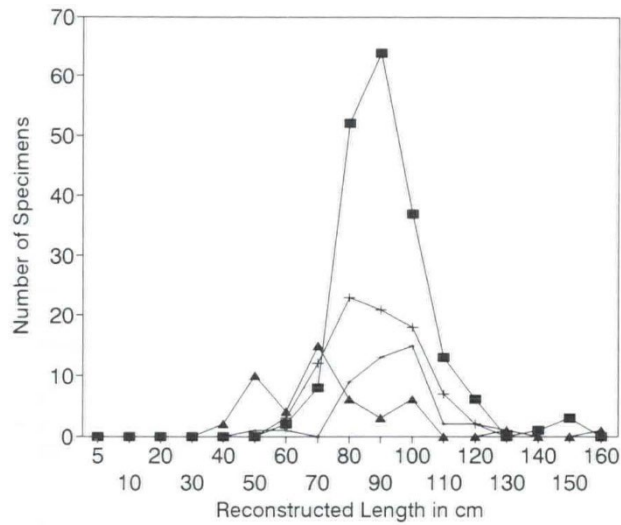
Sieved?	n	n	y	y	n	y
Site status	?	?	Middle	High	High	High
Site locality	Reykjavík	Westman Is.	Eyja fjord	Þistilsfjörð	Hrafnkelsdal	Þistilsfjörð
Site territory	SW coastal	S coastal	N inland	NE coastal	E far inland	NE coastal
Sample size (NISP)	517	1,860	1,656	1,502	1,492	1,594
Site name	Tjarnargata 4	Herjólfsdalur	Granastaðir	Svalbarð-2	Aðaiþol	Svalbarð-4
Phase	Settlement	Settlement	Commonwealth	Commonwealth	Commonwealth	Commonwealth
Approximate dates (AD)	9th century	9th century?	ca. AD 950	AD 1050–1150	before AD 1158	AD 1150–1250
Total % NISP						
Total domestic	33.75	22.7	86.15	37.22	97.86	15.31
Birds	62.87	74.8	0.81	8.52	1.81	37.89
Cetaceans	0.42	0.23	0	2	0	3.01
Seals	0.21	0.55	0	6.06	0	3.01
Other mammals	0.63	0	0	0	0.07	0
Fish	2.32	1.72	12.55	42.74	0.27	34.76
Molluscs	0	0	0.49	3.46	0	6.02

**Table 3.** Animal bone collections from later Medieval to Early Modern sites in Iceland. Six sites from different parts of Iceland that span the later Medieval (ca. 1264–1550) to Early Modern (ca. 1550–1800) periods provide a sample of later economic strategies. Note the increasing relative percentages of fish in collections from Breiðafjörð (Miðbær) and Reykjavík area (Nesstofa, Viðey, Bessastaðir) and the consistently high relative percentages of fish in the collections from the south coast (Stóraborg) and the northeast (Svalbarð). Only larger collections are included. Data from Amorosi (1991) and the NABO Zooarchaeology Database.

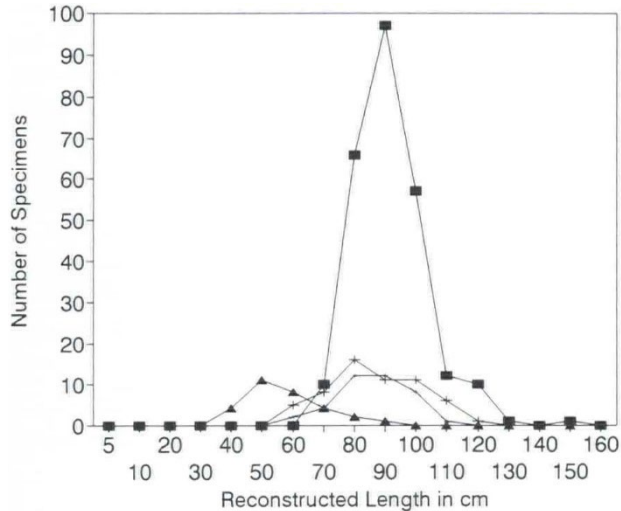
Sieved	y	y	y	y	y	n	n
Site status	?			High		High	
Site locality	Breiðafjörð			Þistilsfjörð		Reykjavík	
Site territory	NW coastal			NE coastal		SW coastal	
Sample size (NISP)	701	5,232	2,770	1,058	3,668	2,784	3,218
Site name	MIDBÆR			SVALBARD		VIDEY	
Phase	Lower	Middle	Upper	AU5	AU7/8	Medieval	Early modern
Approx. dates (AD)	ca. 1250–1400	ca. 1500–1600	ca. 1600–1700	ca. 1250–1400	ca. 1636–1800	L. Medieval	18th–19th century
Total % NISP							
Total domestic	2.28	0.97	0.42	27.32	10.2	41.56	18.46
Birds	40.9	33.21	12.27	6.81	1.28	21.3	20.73
Cetaceans	0	0	0	6.81	0.83	0.18	0.34
Seals	6.13	2.82	0.46	2.17	17.58	1.44	0.09
Other mammals	0	0	0	0	0.09	0.11	0
Fish	34.66	52.24	75.60	55.58	57.7	34.12	56.06
Molluscs	15.98	10.76	11.16	1.32	12.255	1.29	4.32
Sieved?	y	y	y	y	y	y	y
Site status	High			High		Medium	
Site locality	Reykjavík			Reykjavík area		South coast	
Site territory	SW coastal			SW coastal		S coastal	
Sample size (NISP)	2,187	1,171	5,894	95	11,096	19,189	10,686
Site name	NESSTOFA			BESSASTAÐIR		STÓRABORG	
Phase	Early	Middle	Late	L. Med.	Early Modern	Early	Middle
Approx. dates (AD)			17th–19th	14th–15th	17th–19th	ca. 1450–1600	1600–1700
Total % NISP							
Total domestic	1.83	5.38	0.78	95.79	8.12	13.01	18.61
Birds	0.1	0.09	0.41	1.05	1.21	1.0	0.49
Cetaceans	0	0	0	0	0.03	0.04	0.04
Seals	0	0	0.02	0	0.03	0.15	0.04
Other mammals	0	0	0	1.05	0.31	0	0
Fish	46.41	87.45	93.62	2.11	87.02	84.23	79.96
Molluscs	51.35	7.09	5.48	0	3.28	0.68	0.86

There are numerous archaeological patterns that can be observed in the Icelandic archaeofauna (cf. Amorosi, 1989, 1991). Those pertinent to this article include:

- (1) Icelandic sites have had a variable percentage of fish from settlement times onward (Table 2) with local geography and possibly status playing a major role (contrast inland sites like Granastaðir with Svalbarð). Unlike in Greenland, in Iceland there is clear evidence of locally significant subsistence fishing back to the tenth century (see discussion in Amorosi, 1989, 1991).
- (2) Cross-cutting all local variation there is a clear trend toward a greater relative percentage of fish in later sites (Table 3). The increase becomes particularly marked during later medieval times (ca. 1250–1500). By early modern times (ca. 1500–1800) fish bones dominate all recovered bone collections, composing between 60 and 90% of the total archaeofauna of existing early modern sites. While preservation and recovery factors certainly affect these numbers, the order-of-magnitude differences in overall pattern are clear cut. Zooarchaeology confirms the existing documentary evidence for the development of commercial fishing in Iceland and should allow greater detailed reconstruction in the future.
- (3) While some other species have been identified, the Icelandic archaeofauna is dominated by Atlantic cod. This seems to be the case for all time periods now documented. This is not the case in other North Atlantic archaeofauna, where other species are almost as common (Colley, 1983, 1990; Bigelow, 1984; Jones, 1991; Barrett, 1992).
- (4) Application of the osteometric techniques discussed earlier to these excavated collections has indicated a fairly consistent patterning in reconstructed cod lengths (Figs. 4, 5). Both the dentary and premaxillary specimens measured produce similar normal distributions, with a mean around 90–100 cm (except at Miðbær, where the mean is ca. 60 cm). The data are internally consistent and are unlikely to be the product of recovery or preservation alone. There is no significant variation in this distribution pattern through time at any site from ca. AD 1050–1800 (Table 4). Present data thus indicate remarkable stability in the recovered cod sample over a 400–800-year time period in the northeast, south, and southwest coastal regions. Internal consistency of data within sites and in intersite comparison is impressive and probably reflects real trends rather than taphonomic noise.



**Figure 4.** Distribution of reconstructed cod length based on premaxillary. Reconstructed cod lengths from Miðbær (Breiðafjörð), Viðey (Reykjavík), Svalbarð (Þistilsfjörð), and Stóraborg (south coast). While the mean reconstructed length on the premaxillary samples for Viðey (Reykjavík), Svalbarð (Þistilsfjörð), and Stóraborg (south coast) appears strongly unimodal with mean around 90–100 cm, the Miðbær premaxillaries suggest a less unimodal distribution of somewhat smaller individuals. ■ = Stóraborg; \* = Viðey; ▲ = Miðbær; + = Svalbarð.



**Figure 5.** Distribution of reconstructed cod length based on dentaries. Reconstructed cod lengths from Miðbær (Breiðafjörð), Viðey (Reykjavík), Svalbarð (Þistilsfjörð), and Stóraborg (south coast). While the mean reconstructed length on dentaries for Viðey, Svalbarð, and Stóraborg again appears strongly unimodal with a mean around 90–100 cm, the Miðbær premaxillaries again suggest a different distribution of smaller individuals. ■ = Stóraborg; \* = Viðey; ▲ = Miðbær; + = Svalbarð.

**Table 4.** Distribution of reconstructed cod length at Stóraborg. These data are aggregated by period (AD 1450–1600, 1600–1700, 1700–1800) and serve to indicate the stability of the distribution of reconstructed cod length over the ca. 350-year time period documented. Other Icelandic fishbone collections show similar stability in reconstructed fish length from ca. AD 1050–1800. Data from McGovern et al. (1985).

Length group (in cm)	Early phase ca. 1450–1600		Middle phase ca. 1600–1700		Later phase ca. 1700–1800		Total 15th–18th centuries	
	no.	%	no.	%	no.	%	no.	%
5–9	0	0.00	0	0.00	0	0.00	0	0.00
10–19	0	0.00	0	0.00	0	0.00	0	0.00
20–29	0	0.00	0	0.00	0	0.00	0	0.00
30–39	0	0.00	0	0.00	0	0.00	0	0.00
40–49	0	0.00	0	0.00	0	0.00	0	0.00
50–59	0	0.00	0	0.00	0	0.00	0	0.00
60–69	0	0.00	0	0.00	0	0.00	0	0.00
70–79	2	1.60	3	10.00	5	5.05	10	3.94
80–89	25	20.00	5	16.67	36	36.36	66	25.98
90–99	43	34.40	13	43.33	41	41.41	97	38.19
100–109	35	28.00	9	30.00	13	13.13	57	22.44
110–119	10	8.00	0	0.00	2	2.02	12	4.72
120–129	8	6.40	0	0.00	2	2.02	10	3.94
130–139	1	0.80	0	0.00	0	0.00	1	0.39
140–149	0	0.00	0	0.00	0	0.00	0	0.00
150–163	1	0.80	0	0.00	0	0.00	1	0.39
Total	125	100	30	100	99	100	254	100
Mean	89.56		83.29		91.86			
SD	3.53		2.96		2.97			
Range maximum	146.47		98.38		122.43			
Range minimum	65.53		64.73		78.35			

Measurement A (x) regression (after Bigelow, 1984)  $y = 80.14x + 102.3$ .

### *Northern Norwegian data*

There has been much archaeological research in northern Norway that has provided paleofisheries information (see Johansen, 1979, 1982; Holm-Olsen, 1981, 1986; Bertelsen, 1979) and has demonstrated that fishing has been an important economic adaptation in the region for thousands of years.

More specific forms of information about medieval and post-medieval fisheries have emerged at an increasing rate from excavations in the Lofoten and Vesterålen Islands, as well as the Karlsøy commune, Helgøy project in the past 15 years. These rugged island groups extend westward from North Norway's arctic coast. Although located well above the Arctic Circle, the islands enjoy a temperate to boreal climate, and they may have supported a range of possible economic adaptations, including pastoral agriculture (Bertelsen, 1991, p. 23).

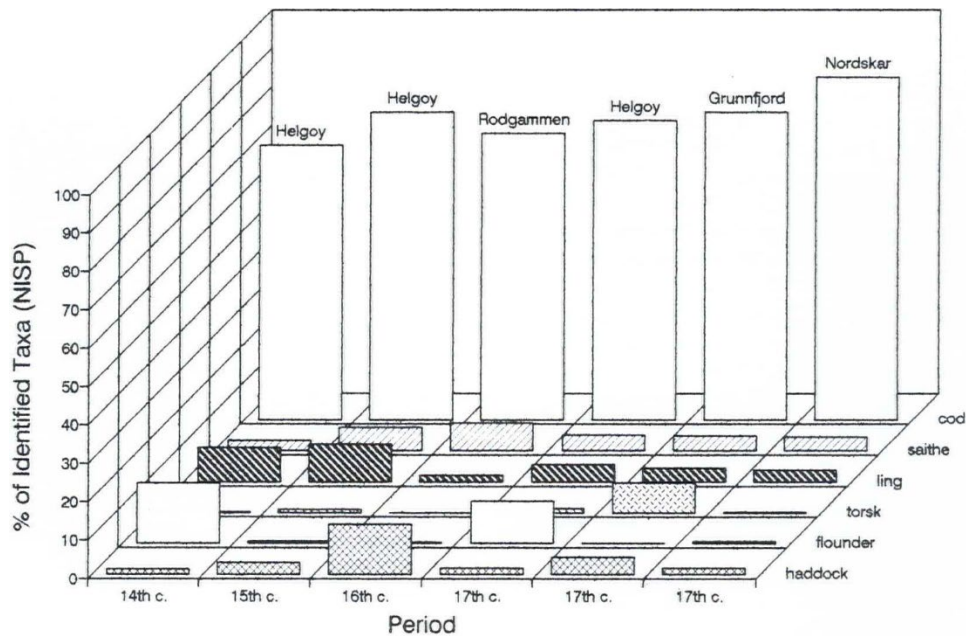
Late Medieval and Early Modern archaeofaunas from sites in the Karlsøy commune include high percentages of fishbones (Table 5). In common with Icelandic fishbone samples, the studied North Norwegian collections include a full range of domestic fauna



largely comprising cod remains, although on some sites the bones of saithe, ling, cod, haddock, and flatfish species have been recovered in greater than trace quantities (Fig. 6). Fish length data for these collections have not been published.

**Table 5.** Animal bone collections from later Medieval to Early Modern sites in northern Norway. Four sites from the Karlsøy region in Arctic Norway that have produced substantial animal bone collections. The Helgøy farm mound collection indicates a major increase in relative percentage of fishbones between the mid-fourteenth and mid-fifteenth centuries. Ongoing research should help clarify the changing mix of subsistence and commercial resource exploitation strategies in this important fishing region. Data from the NABO Zooarchaeology Database, courtesy of Reidar Bertelsen and Inger-Marie Holm-Olsen.

Sieved?	y	y	y	y	y	y
Site locality	Karlsøy	Karlsøy	Karlsøy	Karlsøy	Karlsøy	Karlsøy
Sample size (NISP)	2,308	3,618	3,608	32,982	11,396	20,177
Site name	Helgøy	Helgøy	Rodgamme	Nordskar	Helgøy	Grunnfjord
Phase	14th century	15th century	16th century		17th century	
Approx. dates (AD)	1350	1450	1505	1530	1600	1600
Total % NISP						
Domestic	46.14	9.73	6.57	1.2	10.5	2.89
Caribou	0.04	0.25	0	0.04	0.09	0.03
Birds	3.12	0.88	0.36	0.29	1.41	67.00
Cetaceans	0	0	0.03	0.12	0	0
Seals	8.67	2.21	0	0.05	0.15	0.03
Fish	42.05	86.93	92.93	93.27	87.85	30.04
Molluscs	0	0	0	0	0	0

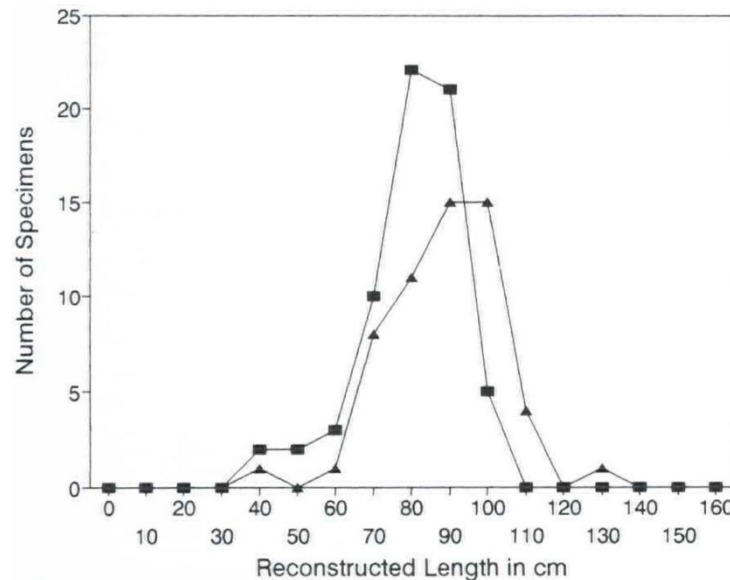


**Figure 6.** Fish species composition in North Norwegian archaeofauna. While several fish species have been identified from North Norwegian sites, the majority in all periods were cod (data courtesy Reidar Bertelsen and Inger-Marie Holm-Olsen).

Excavations at the site of Vågan, near the center of the modern Lofoten fishing industry, have also produced large fishbone collections that will eventually yield vital information on medieval and post-medieval commercial fishing. Investigations at Vågan have documented the evolution of a proto-urban center, a process which began ca. AD 1200 (Bertelsen, 1979, 1991; Bertelsen et al., 1987). "Storvågan" developed into an important node in the growing Norwegian codfish trade of the Middle Ages, sending dried fish south to Bergen and ultimately to the Hanseatic trade network during the fourteenth and seventeenth centuries (Urbariczky, 1992). While extensive studies of stratigraphy, site architecture, and artifacts have been undertaken, zooarchaeological analyses are just beginning. The Storvågan archaeofauna now number approximately 60 000 identified fragments (Perdikaris, 1993), and the sample will increase while excavations continue.

Although analyses are ongoing, some clear zooarchaeological trends are already apparent in the Storvågan collections (Fig. 7). The great variability in cod size in the early and late phases could reflect the influence of several ecological, technological, and consumption variables. The analysis is too preliminary to distinguish the particular variable accounting for the diverse cod size present at Storvågan at different times. More concrete indicators may possibly be identified when the site's faunal analysis is completed. The data cited here are from the 1985–1987 excavations and are dated to the tenth to nineteenth centuries. The most important trend discernible at this time is that the relative mean lengths of cod whose bones were deposited at Storvaagan over its long occupation largely ranged from 650 to 900 mm (Fig. 7). This size range compares well in its upper limits with

the larger fish caught in Iceland (Amorosi, 1989) and Shetland (Bigelow, 1984) during the various premodern periods discussed above.



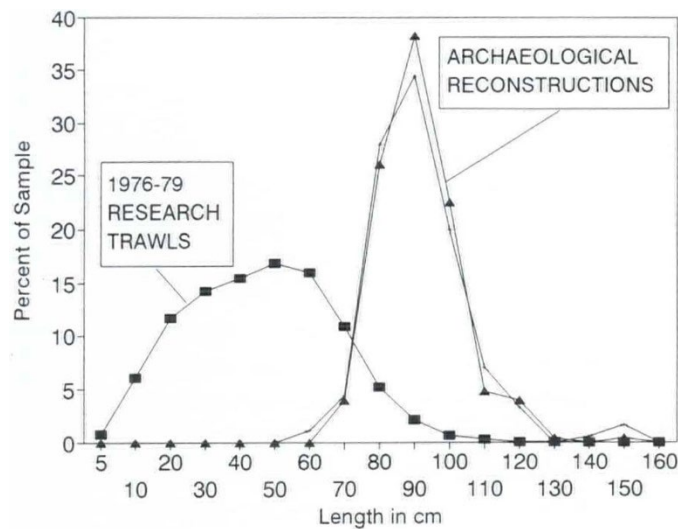
**Figure 7.** Distribution of reconstructed cod length from Storvågan, Northern Norway. Both dentary and premaxillary reconstructions indicate medieval cod slightly smaller than those from medieval Icelandic sites. ■ = Dentary; ▲ = premaxillary.

*Modern and archaeological cod length*

It will be apparent that the archaeologically reconstructed lengths of cod described in this article form distributions different from those observed in most modern cod stocks. Other workers (Colley, 1983, 1990; Bigelow, 1984; Jones, 1991; Barrett, 1993) describe similar archaeological samples with mean reconstructed cod length around 90–100 cm from the Shetland Islands, Orkney, and Caithness. These distributions appear to extend back beyond the Norse period into the Pictish Iron Age in Orkney and Caithness (Colley 1983, 1990; Jones 1991). While sample sizes and conditions of preservation vary, it is apparent from both published data and anecdotal communication with a wide range of other researchers that this pattern of large (presumably old) cod is extremely widespread in the growing bioarchaeological record. The existence of this distribution is not controversial and appears to constitute one of those robust archaeological patterns that is neither local nor subtle.

Figure 8 illustrates the difference in distribution of reconstructed archaeological cod from the south coast site of Stóraborg (near modern Skogar) and measured modern cod from southern and southwest Iceland. Modern data are drawn from four years of research trawls (1976–1979) reported by Pálsson (1983, Table 4) and are based on a total sample of 10 476 fish. Table 6 presents the raw data for the 1976–1979 research trawls (first column) and the reconstructed archaeological cod length distributions for what are presently the four largest fish archaeofauna from Iceland: Stóraborg (south coast), Viðey (Reykjavík),

Miðbær (Flatey in Breiðafjörð in the northwest), and Svalbarð (Þistilsfjörð in the northeast). The archaeological data are represented by 745 measured fish premaxillae and dentaries drawn from archaeofauna totaling 80 820 fragments identified to species level. When these sites are temporally disaggregated by phase, they show no significant change in distribution pattern in either measurable element (Table 4). Additional sites are now under analysis.



**Figure 8.** Comparison of modern and archaeological cod length distributions. Distribution of reconstructed cod length from Stóraborg (south coast) compared to modern fisheries trawls from NE, NW, E, and S Iceland 1976–1979 (Pálsson, 1983). The archaeological collections lack cod smaller than 40 cm and contain many specimens 100 cm and longer. This pattern is strongly shaped by the medieval fishing methods (mainly hand lines) and does not directly reflect the actual distribution of medieval cod populations. See Table 6 for the comparative numerical data. ■ = Modern; \* = premaxilla; ▲ = dentary.

**Table 6.** Modern and Medieval cod length distribution in Iceland. Cod measured during systematic fisheries trawls during 1976–1979 (north, northeast, east, and south coasts) are compared to reconstructed cod length distributions from Stóraborg (south coast), Viðey (Reykjavík), Miðbær (Breiðafjörð, northwest coast), and Svalbarð (Pistilsfjörð, northeast coast). Note the absence of cod reconstructed as less than 40 cm in length, except at Miðbær on the island of Flatey. Medieval fishing gear, unlike modern fisheries trawls, seems to have selected against smaller fish. Note, however, the substantial number of fragments (both dentaries and premaxillaries) from the archaeological sites which derive from fish 100 cm and longer (bottom rows).

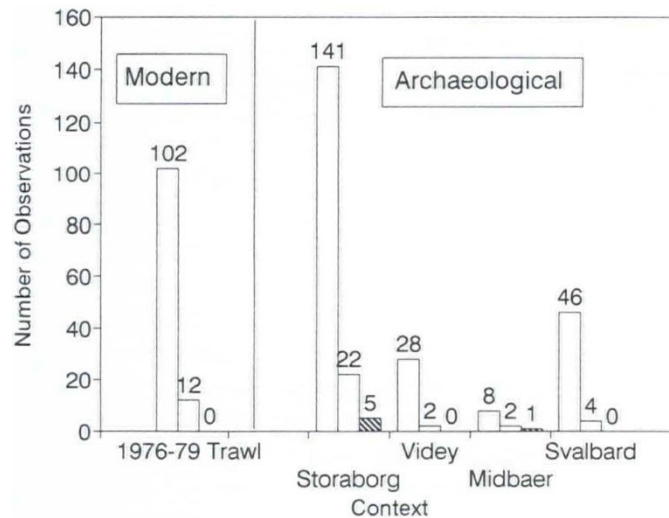
Length groups (in cm)	Measured fish	Archaeological reconstructions							
	Icelandic trawl fisheries 1976–1979 total	Stóraborg 15th–18th c. total Premax.	Stóraborg 15th–18th c. total Dentaries	Viðey 13th–18th c. total Premax.	Viðey 13th–18th c. total Dentaries	Miðbær 13th–18th c. total Premax.	Miðbær 13th–18th c. total Dentaries	Svalbarð 11th–18th c. total Premax.	Svalbarð 11th–18th c. total Dentaries
5–9	83	0	0	0	0	0	0	0	0
10–19	632	0	0	0	0	0	0	0	0
20–29	1220	0	0	0	0	0	0	0	0
30–39	1489	0	0	0	0	0	0	0	0
40–49	1622	0	0	0	0	2	4	0	0
50–59	1765	0	0	1	0	10	11	0	0
60–69	1669	2	0	1	2	4	8	3	5
70–79	1133	8	10	0	4	15	4	12	8
80–89	538	52	66	9	12	6	2	23	16
90–99	223	64	97	13	12	3	1	21	11
100–109	62	37	57	15	8	6	0	18	11
110–119	28	13	12	2	1	0	0	7	6
120–129	4	6	10	2	0	0	0	2	1
130–139	8	0	1	0	0	1	0	1	0
140–149	0	1	0	0	0	0	0	0	0
150–159	0	3	1	0	0	0	0	0	0
160–169	0	0	0	0	0	1	0	0	0
Total	10476	186	254	43	39	48	30	87	58
Number >= 100 cm	102	60	81	19	9	8	0	28	18
Number >= 120 cm	12	10	12	2	0	2	0	3	1
Number >= 140	0	4	1	0	0	1	0	0	0

Source\*: Olafur K. Pálsson (1983) Feeding habits of demersal fish species in Icelandic waters. Rit Fiskideildar 7(1) Marine Fisheries Inst., Reykjavík, Iceland.

Table 6 reveals that the distributional pattern of Figure 8 is somewhat deceptive, as the archaeological collections simply lack any cod smaller than 40 cm reconstructed length, and these make up 48% of the research trawls. This clearly does not imply that cod smaller than ca. 40 cm were absent from waters about Iceland in medieval or early modern times. Instead, it seems likely that premodern fishing technology and perhaps seasonality of fishing effort selected for large fish and missed the smaller and younger animals taken by the modern research trawls. Thus, comparison of the lower tails of the archaeological and modern fish size distributions is meaningless.

However, inspection of Table 6 suggests that there is something odd about the upper tail of the modern and archaeological fish length distributions. Given the different overall distributions, percentage comparisons of modern and medieval–early modern cod length is fruitless, but the raw numbers continue to raise questions. Figure 9 compares the raw numbers of cod of 100 cm length and larger taken in the 1976–1979 trawls with the raw counts of measured bones recovered from the sites. Note that while the four-year research trawl effort turned up only 102 fish longer than 100 cm (of a total landing of over 10 000 fish) the site of Stóraborg alone generated 141 bones allowing reconstruction of length over 100 cm. The 1976–1979 fisheries trawl recovered only 12 cod longer than 120 cm; Stóraborg produced 22 bones indicating length over 120 cm. Even allowing for imprecision of

measurement, these raw figures suggest that substantial numbers of cod 100 cm long and longer were being landed in the past at many locations around Iceland.



**Figure 9.** Comparison of counts of modern and archaeological cod larger than 100 cm. While differences in collection method make direct comparison of modern and medieval length distributions questionable (Fig. 7), the absolute number of modern cod recovered in research trawls from 1976 to 1979 show the 100 cm or larger size class is smaller than the absolute number of similarly large-sized cod bones recovered from archaeological sites. Cod 100 cm and larger are now comparatively rare in the waters around Iceland. It appears that such large cod were not uncommon in medieval–early modern times. Also see Table 6 for data. [First bar] = > 100 cm; [second bar] = > 120 cm; [third bar (striped)] = > 140 cm.

Note again that these archaeological data are not counts of individual fish but samples of a distribution of a far larger number of individuals. Fishers operating out of Stóraborg between ca. AD 1450 and 1840 landed not just 254 cod but many thousands of fish, 254 dentaries of which have survived. While level of fishing effort by individual farms is difficult to calculate for even the nineteenth century, it is instructive to realize that if we conservatively estimate a landing of 500 cod per year at Stóraborg, the zooarchaeological distribution data suggest that around 30% would be 100 cm or longer, yielding a figure of around 150 cod longer than one meter (700 cod per year would produce around 200 such cod, 200 per year would produce 60 one meter or greater cod). While such estimates are highly speculative, they may serve to illustrate how many landed fish might stand behind the archaeological samples. Both the fisheries data in Pálsson (1983) and anecdotal reports by modern fishermen suggest that even the lowest estimated landing rate of cod 100 cm and above would be difficult to duplicate today, even with modern gear.

How can these patterns be explained? Three major approaches to explanation are open to us:

- (1) On all sites now known to North Atlantic zooarchaeologists, forces of attrition and archaeological recovery have systematically skewed the sample reaching the laboratory. Small individuals have been systematically destroyed or rendered unidentifiable, and larger animals are disproportionately represented. The bioarchaeological data are thus mainly noise and reflect little or nothing about past fishing or fish stocks.
- (2) Past fishing methods (in most cases some form of hand line with baited hook), fishing locations, and preferred fishing seasons have all differentially selected for large individuals. Small cod only rarely entered the archaeological record and thus are not often reflected in the excavated samples. The bioarchaeological data thus mainly reflect selective exploitation of fish stocks by past fishers and reflect little or nothing about the actual characteristics of any past cod stock.
- (3) While forces of attrition and recovery and the technology and culture of past fishers have certainly skewed the archaeological sample distribution, the root cause of the differences between modern (post AD 1900) and archaeological cod measurements lies in significant differences between age/size structures of the different cod populations sampled. Cod greater than 100 cm long were regularly landed by preindustrial fishers all across the North Atlantic from ca. AD 800 to 1840, and cod greater than 120 cm were common enough to be landed often enough to appear regularly in the archaeological record. Several cod stocks in the North Atlantic thus held substantially higher proportions of large, old cod than do modern cod stocks in the same area.

These three avenues of explanation are of course not entirely mutually exclusive, and further research will be needed to better understand which most accurately explains the observed distribution of archaeological data. However, we feel that even with the present data some explanations are more likely than others.

As better controlled archaeological data enter the record, the first explanation (the "null hypothesis" of overwhelming taphonomic noise) seems increasingly less persuasive. Archaeofauna derived from sieved excavations and laboratory floated whole-soil-column samples in Iceland do not produce reconstructed cod size distributions markedly different from less intensively sieved contexts. Some species (especially herring and most salmonids), have overall a much poorer chance of preservation and recovery than Atlantic cod, and all otoliths are particularly sensitive to soil acidity. However, there is little measurable difference in bone density between premaxillae and dentaries of cod ca. 40–80 cm long and those of cod 90–120 cm long. In practice, the smaller mouth parts of the smaller individuals are less subject to breakage than the larger bones of very large cod and thus are *more* likely to survive in measurable state. As Table 6 indicates, some cod bones in the 50–80 cm reconstructed range are present in virtually all the reported archaeofauna. While attrition and recovery problems will always remain significant, they do not appear to account for the patterns observed.

The second explanation of different fishing gear and strategies by premodern fishers certainly has considerable merit. Archaeofaunas are not random samples of any biological

distribution. Culturally patterned selective filters are at work even in simple human economies, regularly collecting some individuals of some species and failing to secure others. As many maritime social scientists working with modern fishing populations have pointed out, we still know too little about the interaction of local fishers and local fish stocks. As Table 6 suggests, there is some interesting variability between sites in different parts of Iceland, which demands more intensive investigation of local factors affecting fishing and fish stocks. Preindustrial fishers tended to be exploiters of local ecosystems, not whole biospheres (McGoodwin, 1990), and we need to be careful to select appropriate geographical and temporal scales for our analyses. There would appear to be fruitful ground for cooperation between maritime archaeologists, ethnologists, historians, active fishers, and fisheries scientists in improving our understanding of long-term local level interactions in the past.

The third explanation implying a substantially different distribution of age/size classes in several premodern cod stocks in the North Atlantic region cannot be proven on the basis of current bioarchaeological data, but it cannot be dismissed either. The existing archaeological data (both as distributions and as raw counts) from Iceland would be difficult to generate from what we know of modern cod stocks in the area. Archaeological data from other parts of the North Atlantic suggest similar unexpected abundance of large cod in several other stocks. More extensive comparison of landing records and research trawls with bioarchaeological samples and closer and more systematic integration of bioarchaeological data and fisheries records would seem to be indicated.

### **Concluding points**

Virtually all these data are in some respect preliminary, and we clearly have a good deal of work to do to refine and expand this bioarchaeological evidence for past fisheries. We are only getting to the position where a useful contribution can be made to the ongoing debates concerning fish population dynamics and management strategies. More excavated archaeofauna, integrative modeling, and cooperative work with other archaeologists, historians, and natural scientists will be required before the full potential of these data sets can be realized.

While these data are only beginning to be tapped for fisheries science, they by no means represent a small or closed set incapable of rapid expansion. New excavations underway throughout the region and continued analyses of already excavated samples promise major improvement in our ability to contribute more fully in the near future. To mention only a few important localities: major fish-rich collections from Strandasýsla in northeast Iceland include a matched home farm at Gjögur and a multiphase fishing station at Akurvík now urgently await analysis (Amorosi and McGovern, 1992), substantial archaeofauna from Sandwick (Bigelow, in progress) Shetland and Freswick in Caithness (Morris, Batey, Rackham et al., in press), and major fishing station collections from Roberts Haven in northern Scotland are nearing completion (Barrett, 1992). This very brief and preliminary presentation can only suggest the full potential of this approach; the near future will see far more useful tools offered to North Atlantic natural scientists by historical ecologists using archaeological evidence.



Three points may serve to close this preliminary, limited, and ultimately incomplete presentation:

1. Environmental baseline estimates used for a wide range of urgent management questions regularly lack time depth beyond the limits of the instrumental record. Archaeological and historical data can help to fill these gaps, both by providing basic data (such as cod length, ca. AD 1300) and by improving integrative models of long-term human-resource interaction.
2. Coastal sites rich in fish remains are lost or damaged each year through marine erosion and human action. Proposed global warming, sea-level rise, and accelerated coastal development indicate rapidly accelerated threat in the near future. While capable of rapid expansion with existing techniques, this long-term bioarchaeological record is fragile and in urgent need of recovery.
3. Human subsistence and commercial economies are (and have been) complex and multistranded. Marine and terrestrial components of past economies are strongly interrelated and attempts to use bioarchaeological data for environmental reconstruction must take a wide range of social and ideological factors into account. As the example of Norse Greenland suggests, humans are not simply random samplers of past environments. Effective use of bioarchaeological data requires active cooperation of trained bioarchaeologists with fisheries biologists and maritime anthropologists. We cannot simply extract fishbone percentages from bone reports and relate these to climate curves or landing data without significant potential for error. Genuine, active interdisciplinary cooperation is required if we are all to make full use of these new (if ancient) data.

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## Note

1. Taphonomy is the study of all the processes of deposition, decay, and destruction that intervene between the death of an ancient organism and its study in the modern laboratory. This is a major subfield of both paleontology and zooarchaeology.

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