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Zooarchaeological Implications for Prehistoric Distributions of Seabirds along the Norwegian Coast

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ABSTRACT. Investigation of the temporal and spatial distributions of zooarchaeological material can aid in understanding of the palaeoecology of nonhuman and human species. Northern gannets (*Sula bassanas)* and northern fulmars (*Fulmarus glacialis*) were first documented to breed in Norway during the present century. Skeletal remains of gannets and fulmars uncovered at Norwegian archaeological sites have been dated from approximately 7000 to 800 B.P. and from about 30 000 to 400 B.P. respectively. The modal occurrence of gannet specimens was 6000–5000 B.P. and that of fulmar material was 2000–1000 B.P., suggesting that in the postglacial period most gannets occurred in Norwegian waters earlier than did most fulmars. Recovered fulmar bones greatly outnumber those of gannets, a pattern consistent with relative abundances in Norwegian waters today, but one that might also reflect differential accessibility and/or prey preferences of previous coastal inhabitants. Proportionally more of the fulmar material was uncovered at proportionally more sites in North Norway, findings consistent with current species' distributions and with speculation of similar oceanographic conditions in previous millenia.

Key words: climatology, northern fulmar (*Fulmarus glacialis*), northern gannet (*Sula bassanas*), Norway, palaeoecology, seabirds, zooarchaeology

RÉSUMÉ. La recherche sur la distribution temporelle et spatiale de matériau zooarchéologique peut aider à comprendre la paléoécologie des espèces non humaines et humaines. On a établi pour la première fois au cours de ce siècle que le fou de Bassan (*Sula bassanas*) et le fulmar boréal (*Fulmarus glacialis*) se reproduisaient déjà en Norvège à une époque reculée. On a en effet découvert dans des sites archéologiques de Norvège, des restes de squelettes de fous et de fulmars datant respectivement d'environ 7000 à 800 ans avant notre ère et 30 000 à 400 ans avant notre ère. Parmi les spécimens de fous, ceux datant de 6000 à 5000 avant notre ère sont les plus fréquents et parmi les restes de fulmars, ceux datant de 2000 à 1000 avant notre ère sont les plus fréquents. Cette observation donne à penser qu'au cours de la période post-glaciaire, la fréquence maximale du fou dans les eaux norvégiennes a été antérieure à celle du fulmar. La quantité d'os de fulmars retrouvée dépasse largement celle d'os de fous, ce qui est en accord avec les quantités relatives actuelles d'oiseaux dans les mers norvégiennes, tout en pouvant aussi refléter l'accessibilité différentielle et/ou une préférence pour certaines proies qu'avaient les habitants précédents de la région côtière. Proportionnellement plus de restes de fulmars ont été découverts sur un nombre proportionnellement plus important de sites dans le nord de la Norvège, résultats qui correspondent aux distributions actuelles d'espèces et à la théorie suivant laquelle la situation océanographique était la même dans les millénaires qui ont précédé.

Mots clés: climatologie, fulmar boréal (*Fulmarus glacialis*), fou de Bassan (*Sula bassanas*), Norvège, paléoécologie, oiseaux marins, zooarchéologie

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INTRODUCTION

Zooarchaeological analyses can aid in the investigation and understanding of palaeoecology (Yesner, 1976; Schledermann, 1980; Hasegawa and DeGange, 1982; Montevecchi and Tuck, 1987). Faunal remains recovered at archaeological excavations can often provide information about species' distributions and abundances and their temporal fluctuations during prehistoric periods (Wintemberg, 1919; Friedman, 1934; Hall, 1969; Walker and Craig, 1979; Jordan and Olson, 1982; Meldgaard, 1988). Such information must be used cautiously, as artifacts were often transported long distances from points of origin via trading or transfer of material among neighboring or interacting groups (Lucas, 1903; Gilbert *et al.*, 1981), and faunal remains may also reflect differences in prey vulnerability and/or changes in the preferences, technologies or economies of former human inhabitants. Within these limitations, broad comparisons of significant zooarchaeological patterns with biological, palaeoecological and palaeoclimatological information can be both revealing and heuristic.

During historic times, northern gannets (*Sula bassana*) were first documented breeding in Norway in 1947, when they were reported nesting at Runde (Valeur, 1947). Northern fulmars (*Fulmarus glacialis*) first nested in Norway at Runde early in the present century, and by 1947 the breeding population was considered to be 350 pairs (Valeur, 1947; Barrett and Vader, 1984). Barrett and Vader (1984) indicate that archaeological evidence suggests that gannets and possibly fulmars bred in former times in North Norway. If so, it might be expected that a preponderance of the remains of these species would occur at northern archaeological sites. If prehistoric distributions were consistent with historical ones (Fisher, 1952; Nelson, 1978), one would expect to find most fulmar specimens in the north and most gannet specimens in the south. To explore these possibilities and to gain better understanding of former occurrences of seabirds along the Norwegian coast, the spatial and temporal distributions of bones of these and other avian species recovered from archaeological sites are statistically compared. Findings are considered in terms of prehistoric climatological conditions.

MATERIALS AND METHODS

The Zoological Museum at the University of Bergen is the national repository for nonhuman bones uncovered at Norwegian archaeological sites. Bone material, museum catalogues, and published and unpublished reports were searched for avian specimens. Bones were dated whenever possible and were grouped by date and county. References regarding dating of material, which is based on archaeological evidence or radiocarbon measurements, can be found in Hufthammer (1982). Undated material is considered prehistoric, i.e., usually ≥1000 B.P.

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Bones of fulmars, gannets and all other avian species combined were statistically analyzed and compared for significant patterns among spatial and temporal distributions. For analytical purposes, counties from and including Nordland northwards were grouped as northern Norway, while those from and including Nord Trøndelag southwards were grouped as southern Norway. For temporal analyses, bones were assigned to these categories: <1, 1–2, 3–4, 5–6, 7–8 and (for the fulmar data) >8 millenia B.P. When gannets and fulmars were compared with one another and with other avian species, the oldest bones were classified as >7 millenia B.P. Chi-square (x^2) tests (Siegel, 1956) were used to assess spatial and temporal distributions. Following tests of normality of data distributions, one-way analyses of variance and Mann-Whitney U tests were used as appropriate to compare the datings of archaeological sites (at which avian bones have been recovered) in northern and southern Norway. Statistical significance is taken as $P < 0.05$.

RESULTS

More than 120 gannet bones have been uncovered at 26 archaeological sites along most of the Norwegian coast (Table 1; Fig. 1). These specimens are unevenly distributed among counties ($x^2_7 = 185.05$, $P < 0.001$). Most have been recovered in Møre and Romsdal (37%, 46/124) in southern Norway and in Nordland (34%, 42/124), and about 9% (11/124) have come from Rogaland. Gannet specimens were recovered at 6 sites in Møre and Romsdal, 5 sites in Nordland and 4 sites in Finnmark. Gannet bones constituted significantly different proportions of the avian bones recovered in the 8 counties in which gannet bones were recovered ($x^2_7 = 112.3$, $P < 0.001$). Although most of the gannet bones have been recovered in Møre and Romsdal and in Nordland, gannet bones make up very small percentages of the total avian material collected from these counties, i.e., 0.5 and 1.4% respectively. In other counties where fewer gannet bones have been recovered, they make up much larger percentages of the avian material (Nord Trøndelag — 12.5%; Rogaland — 4.5%; Sør – Trøndelag — 4.5%; Sogn and Fjordane — 4.2%). Some individual sites also have high percentages of gannet material. Approximately 20% of the avian material identified to species at Aakvik, Donnes, was from gannets. At Kaupang, gannet bones constituted 10% of the avian material. These percentages are even more striking in view of the high number of species recorded at each of these sites.

Almost 600 fulmar bones have been recovered from 28 Norwegian archaeological sites (Table 2; Fig. 2). Like the gannet bones, the fulmar remains are unevenly distributed among counties ($x^2_7 = 483.6$, $P < 0.001$). Ninety-two percent (549/598) of the fulmar specimens were recovered in Finnmark and Nordland; 6% (38/598) were found in Møre and Romsdal. Fulmar bones have been uncovered at 12 sites in Finnmark, 5 sites in Nordland and 4 sites in Møre and Romsdal. Fulmar specimens made up significantly different proportions of the avian bones in the 8 counties where they were recovered ($x^2_7 = 437.16$, $P < 0.001$) and constituted the highest percentages of avian bones in those counties where the most fulmar bones were collected: 6.2% (216/3507) at Nordland and 4.5% (333/7371) at Finnmark (Table 2; Fig. 2). At the Toften II site in Andøy fulmar accounted for 59% (134/224) of the avian bones, at Bleik in Andøy 11% (66/587) of the avian bones were fulmar, and at Vardøhus fulmar specimens made up 10% (74/727) of the avian total.

TABLE 1. Gannet material recovered from Norwegian archaeological sites (see Fig. 1 for site locations)

	Site	Kommune	Dated (B.P.)	Number of fragments[a]
	Rogaland (R)			
1	Gaasehilleren	Sola	~3000	1(6)2
2	Vistehulen	Randaberg	8000-6100	10(237)29
	County summary		8000- ~3000	11(243)
	Hordaland (H)			
3	Ruskeneset	Bergen	3100-2600	2(31)16
4	Bryggen	Bergen	800-600	3(221)27
	County summary		3100-600	5(252)
	Sogn Og Fjordane (SF)			
5	Grønehelleren	Solund	5500-4100	4(109)17
6	Baatekletten	Askvoll	age unknown	1(1)1
7	Ovn. Lillebatalden	Flora	age unknown	1(33)18
	Country summary		5500-4100	6(143)
	Møre Og Romsdal (MR)			
8	Dollsteinhola	Sandsøy	5600-3500	29(8068)124
9	Skylehammeren	Aalesund	1800-1400	1(5)4
10	Kaupang	Aalesund	900-800	10(100)23
11	Skjonghelleren	Giske	~2500	1(38)20
12	Sauehelleren	Midsund	1800-1400	~4(~60)22
13	Møislaatten	Tustna	age unknown	1(6)4
	County summary		5600-800	46(8277)
	Sør-Trøndelag (ST)			
14	Hestneshulen	Hitra	2500-1400	1(32)18
15	Ramsøy	Osen	2500-2000	4(79)21
	County summary		2500-1400	5(111)
	Nord Trøndelag (NT)			
16	Sandhelleren	Flatanger	age unknown	1(12)9
17	Kuhelleren, Halmøy	Flatanger	>3500	1(4)4
	County summary		>3500	2(16)
	Nordland (N)			
18	Langaasen	Vega	2900-2700	1(8)3
19	Aakvik, Dønnes	Herøy	5000-3500	10(59)12
20	Kirkehelleren	Traena	2500-2000	9(870)33
21	Storbaathelleren	Flakstad	5300-4600	21(1816)38
22	Toften II	Andøy	~1400-1200	1(228)15
	County summary		5000- ~1400	42(2981)
	Finnmark (F)			
23	Vardøhus	Vardø	2700-2400	2(727)13
24	Mortensnes	Nesseby	1250-850	1(103)13
25	Nyelv	Nesseby	4600-4100	3(663)21
26	Kjø-øya	Sør-Varanger	2700-2400	1(164)20
	County summary		4600-850	7(1657)
	Summary of sites where gannet bones were recovered		*8000-600*	*124(13 680)*

[a]First number indicates gannet bones; next is total number of avian bones identified to species in parenthesis; last number indicates total avian species represented at site. Domestic fowl are excluded from tabulation.

The bones of gannets and fulmars were collected at 26 and 28 coastal sites respectively and in 8 counties each. Gannet bones were uncovered at 15 sites where no fulmar bones were found. Fulmar bones were uncovered in 2 counties (Oslo; Troms) where gannet bones were not, and conversely, gannet bones were collected in 2 counties (Sogn and Fjordane; Nord Trøndelag) where fulmar bones were not. In comparison to each other, proportionally more fulmar bones were found at proportionally more sites in northern Norway (Table 3).

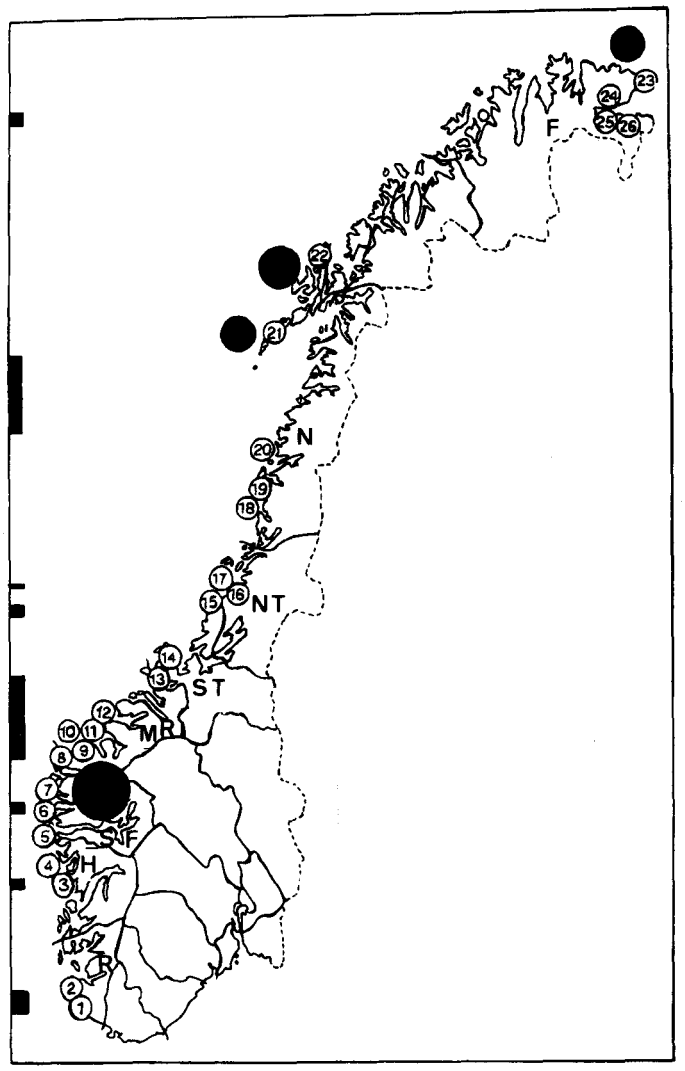

FIG. 1. Norwegian archaeological sites at which gannet bones have been recovered. Numbers and letters correspond to locations and counties given in Table 1. Bars along border of figure are proportional to the percentages of bones uncovered at adjacent counties on map. Circles are proportional to total breeding population at each of four gannet colonies as of 1985 (Montevecchi *et al.*, 1987); from south to north gannetries are located at Runde, Hovsflesa, Skarvklakken and Syltefjord.

TABLE 2. Fulmar material recovered from Norwegian archaeological sites (see Fig. 2 for site locations)

	Site	Kommune	Date (B.P.)[a]	Number of fragments[b]
	Oslo (O)			
1	Mindets tomt	Oslo	850-800	1(98)18
	County summary		850-800	1(98)18
	Rogaland (R)			
2	Slettabø, Ogna	Eigersund	4000-3700	1(11)7
3	Vistehulen	Randaberg	8000-6100	3(237)29
	County summary		8000-3700	4(248)
	Hordaland (H)			
4	Blomvaag	Øygarden	12 700-12 100	1(116)16
	County summary		12 700-12 100	1(116)16
	Møre Og Romsdal (MR)			
5	Dollsteinhola	Sandøy	5600-3500	31(8068)124
6	Kaupang	Aalesund	900-800	2(100)23
7	Skjonghelleren	Giske	~30 000	2(1863)14
7	Skjonghelleren	Giske	~2500	3(38)20
	County summary		~30 000-800	38(10 069)
	Sør-Trøndelag (ST)			
8	Televerkstomten	Trondheim	1000-500	1(803)51
9	Ramsøy	Osen	2500-2000	1(79)21
	County summary		2500-500	2(882)
	Nordland (N)			
10	Kirkehelleren	Traena	2500-2000	4(870)33
11	Storbaathelleren	Flakstad	5300-4600	9(1816)38
12	Toften II	Andøy	1600-1400	134(228)15
13	Dverberg	Andøy	650 or 450-250	3(6)4
14	Bleik	Andøy	2000-1300	66(587)11
	County summary		5300-350	216(3507)
	Troms (T)			
15	Gaardshaugen	Helgøy	~400	1(326)26
16	Nordskar	Karlsøy	<800	1(45)10
17	Vanna	Karlsøy	~700	1(20)5
	County summary		<800-400	3(391)
	Finnmark (F)			
18	Iversfjord	Gamvik	~4500	7(250)27
19	Vardøhus	Vardø	age unknown	74(727)13
20	Mortensnes	Nesseby	700-500	1(17)8
21	Angsnes	Nesseby	1800-1500	1(9)4
22	Karlebotn	Nesseby	5300-4800	14(462)13
23	Gropbakkengen	Nesseby	6300-4500	3(21)9
24	Gressbakken	Nesseby	4400-3900	98(3905)32
25	Nyelv	Nesseby	4600-4100	35(817)15
25	Nyelv	Nesseby	4600-4100	26(663)21
26	Kjø-øya	Sør-Varanger	2700-2400	32(164)20
27	Mestersanden	Sør-Varanger	2700-2000	41(270)20
28	Makkhola, Kjelmøy	Sør-Varanger	2700-2400	1(66)14
	County summary		6300-500	333(7371)
	Summary for sites where fulmar bones were recovered		~30 000-350	598(22 782)

[a]Data from Simonsen (1974-82), Solberg (1976), Skjølsvold (1977), Helskog (1980), Hufthammer (1982), Larsen *et al.* (1987), Lie (1990).

[b]First number indicates fulmar bones; next is total number of avian bones identified to species in parentheses; last number indicates total avian species represented at site. Domestic fowl are excluded from tabulations.

In an analysis of all Norwegian archaeological sites where avian bones have been recovered, there was no statistically significant difference in the proportions of sites in the northern and southern parts of the country from which fulmar and/or gannet bones and other avian species were recovered. Fulmar recoveries alone, however, were made at proportionally more northern sites than were bones of avian species other than fulmars and gannets (x_1^2 =6.14, $P < 0.02$). Gannet bones, in turn, were recovered at northern and southern sites in proportions that were not significantly different from those of other avian species. More fulmar bones were recovered at northern sites than were other avian bones (x_1^2 = 764.7, $P < 0.001$), whereas gannet bones were not.

Gannet bones were recovered at sites dated from approximately 7000 to 800 B.P., whereas the dates associated with fulmar bones ranged from about 30 000 to 400 B.P. (Tables 1 and 2). Both gannet and fulmar bones were unevenly distributed with respect to the millenia from which these materials were collected (for gannets x_4^2 = 53.39, $p < 0.001$; for fulmars x_5^2 = 639.5, $P < 0.001$), and temporal distributions of the bones of the two species were significantly different from one another

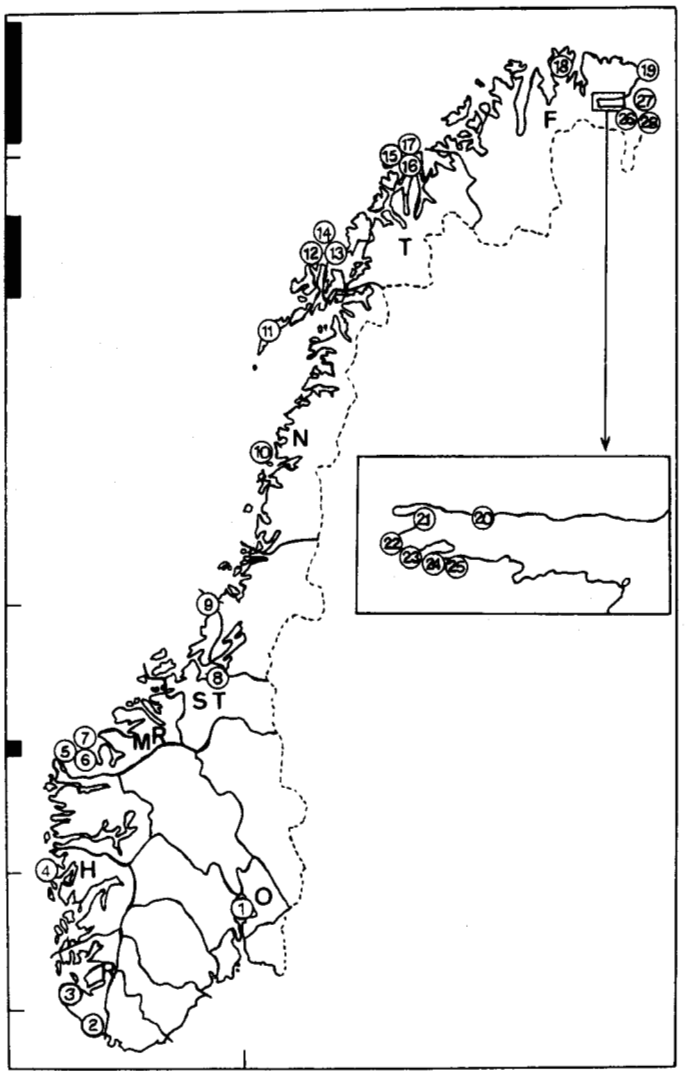

FIG. 2. Norwegian archaeological sites at which fulmar bones have been recovered. Numbers and letters correspond to locations and counties given in Table 2. Bars along border of figure are proportional to the percentages of bones uncovered at adjacent counties on map. Most of the known breeding population of fulmars in Norway is at Runde (Barrett and Vader, 1984), the site of the largest Norwegian colony of gannets.

($x_4^2 = 127.4$, $P < 0.001$). Eighty percent of the fulmar bones were dated from 4000 to 1000 B.P., whereas 80% of the gannet specimens were dated from 6000 to 1000 B.P. (Fig. 3). The modal intervals of occurrence were 2000–1000 B.P. for fulmars (51%) and 6000–5000 B.P. (46%) for gannets. There is no evidence to suggest differential survival of the bones of these different-sized species (R. Lie, University of Bergen, pers. comm. 1988).

The bones of other avian species were dated from 9000 to 300 B.P. The temporal distribution of these bones tended to be more bimodal than those of the gannets and fulmars (Fig. 3) and was significantly different from each of them (for gannets $x_4^2 = 41.12$, $P < 0.001$; for fulmars $x_4^2 = 406.6$, $P < 0.001$). Fifty-eight percent (4605/7968) of the bones of other avian species were recovered from sites dated <3000 B.P. and 37% (2960/7968) between 7000 and 3000 B.P. (Fig. 3). There were no significant differences in the dates of sites in northern and southern Norway at which bones of fulmars (F test; $P > 0.05$), gannets (F test; $P > 0.05$) and other avian species (Mann-Whitney U test; $P > 0.05$) were recovered.

TABLE 3. Comparison of the numbers of archaeological sites at which gannet and fulmar bones have been collected and of gannet and fulmar bones collected in southern and northern Norwegian coastal regions

	Gannet	Fulmar
	Sites	
Southern Norway	17	9
Northern Norway	9	19
	$x_1^2 = 4.71$, $P < 0.05$	
	Bones	
Southern Norway	75	45
Northern Norway	49	551
	$x_1^2 = 203.3$, $P < 0.01$	

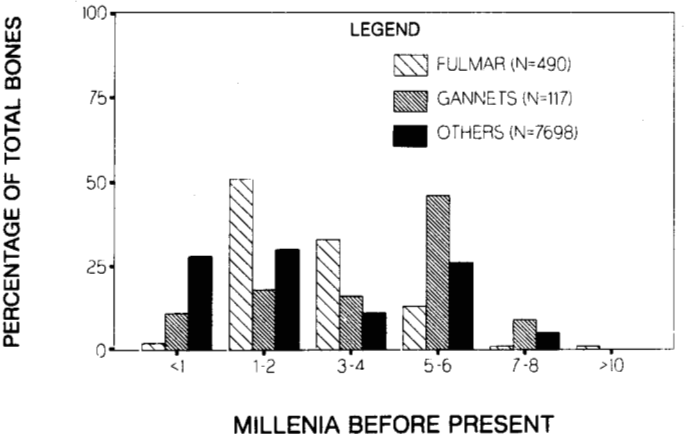

FIG. 3. Temporal distributions of the percentages of the total number of gannet and fulmar bones and those of other avian species recovered at Norwegian archaeological sites.

DISCUSSION

In view of current knowledge indicating that fulmars began breeding in Norway in the present century and that gannets did so within the past 50 years, it is informative to document that both species have occurred along the Norwegian coast for many millenia. In comparison to gannets and to other avian species, proportionally more of the fulmar material was obtained from proportionally more archaeological sites in northern Norway. Recent and present breeding distributions of fulmars are much more arctic in extent that those of boreal water gannets (Fisher, 1952; Nelson, 1978), and the geographic distribution of the specimens from Norwegian archaeological sites is consistent with a similar distribution in past millenia. In a somewhat related vein, specimens from coastal archaeological sites in eastern and western Canada suggest that avian species diversity in previous postglacial millenia is comparable to present species diversity (Montevecchi and Tuck, 1987; Hobson and Driver, 1989). Currently, the largest concentrations of breeding fulmars and gannets in Norway are located in the southern part of the country at Runde (Barrett and Vader, 1984; Montevecchi *et al.*, 1987).

Five times more fulmar bones than gannet bones were recovered. This difference is in the same direction as recent Norwegian breeding populations (Røv *et al.*, 1984; Montevecchi *et al.*, 1987) and seems consistent with present relative abundances of these species in Norwegian waters. Former relative abundance may have been similar, although interspecific differences in accessibility and/or the prey preferences of human hunters could have biased prehistoric ratios.

Temporal distributions of specimens suggest that gannets may have been more abundant along the Norwegian coast 5–6 millenia ago than in the more recent past. Fulmars, in turn, may have been more abundant 1–2 millenia ago than in the more distant or the more recent past. The temporal distributions of the gannet and of the fulmar bones are unlikely to be a simple reflection of human settlement patterns, as indicated by the differences between each of their temporal distributions and that of all other avian species collected at archaeological sites. The occurrence of gannets in Norwegian waters from approximately 7000 B.P. is consistent with warm climatological conditions (Cushing, 1982) and with their occurrence in Denmark at this time (M. Meldgaard, University of Copenhagen, pers. comm. 1989). Bengtson (1984) reported that Icelandic sagas indicated severe sea ice conditions along the Norwegian coast from the 13th through 17th centuries and suggested that these conditions may have significantly facilitated the great auks' extinction. Although great auks were likely gone from former Norwegian breeding sites well before this period (Hufthammer, 1982), such a climatological/oceanographic change would be consistent with a cessation of possible nesting by fulmars and gannets during these centuries (e.g., Barrett and Vader, 1984). There are few bones from fulmar and from other species during this period, although 13% (16/124) of the bones from gannets (primarily temperate and subarctic zone breeders) were from this period. More than two-thirds (69%, 11/16) of the gannet bones, however, were from southern Norway, where oceanographic conditions were probably milder than more northerly ones and would have presumably supported the gannets' relatively warm-water pelagic prey (Kirkham *et al.*, 1985; Montevecchi and Barrett, 1987).

Distributional studies of zooarchaeological material from other marine birds and mammals with different dietary and habitat preferences will lead to the generation of testable hypotheses about paleoecology and oceanography. The integration of these investigations with dietary reconstructions based on stable isotopic analyses of bone collagen (Hobson and Montevecchi, in prep.) will permit the testing of hypotheses about paleo-oceanographic food webs.

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