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Stable isotope analysis of human bone and ethnohistoric subsistence patterns in Tierra del Fuego

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Abstract

Ethnohistoric records from Tierra del Fuego suggest that precontact Fuegians could be subdivided into three major groups: the Yamana, maritime hunter-gatherers of the Beagle Channel and islands to the south; the Selk'nam, terrestrial hunter-gatherers of southernmost Patagonia; and the Haush, a little-known group that seems to have combined elements of both Yamana and Selk'nam lifeways. However, the observed ethnographic patterns reflect societies whose way of life was significantly altered by European contact, habitat alteration, and exploitation of some of the key resources upon which Fuegian peoples were historically dependent. To test the linkage between ethnohistorically recorded subsistence patterns and prehistoric lifeways in the region, stable carbon and nitrogen isotopes were assayed from human burials that date within the last 1500 years before European contact. Isotopic analyses substantially confirm the ethnohistorically documented patterns, but also reveal some anomalies, such as Yamana populations who may have been more dependent on terrestrial resources (i.e., guanaco). Data from the Haush region suggest primary dependence on marine resources, like the Yamana, while the Selk'nam demonstrate limited use of such resources. Stable isotopic analysis can thus be used to test hypotheses concerning the validity of archaeological and ethnohistoric data.

Keywords: Patagonian prehistory; Fuegian peoples; Ethnohistory; Hunter-gatherers; Bioarchaeology; Paleodiet; Bone chemistry; Carbon isotopes; Nitrogen isotopes

Introduction: stable isotopes and hypothesis testing

The analysis of stable isotopes, particularly carbon and nitrogen isotopes, from human bone has in the course of the last 15 years shifted from a novel approach to reconstructing long-term human diet to a well-established methodology and body of data that has been used to test a wide range of hypotheses related to ancient human subsistence. Ten to 15 years ago, the major concerns in stable isotopic studies were in establishing the validity of the methodology: examining concerns about the impacts of diagenesis on stable isotopic values; about the affect heating or burning had on animal or human bone stable isotopic values; about sampling procedures and variability within human skeletons in stable isotopic values; about obtaining an adequate range of stable isotopic values from potential food sources to compare with the values from ancient human bone; about differences in stable isotopic values from different laboratories and their relation to laboratory analytical procedures for those isotopes; about mathematical procedures for relating stable isotopic values to percentages of items contributing

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to ancient diets; about the extent to which trophic level effects were reflected in stable carbon and nitrogen isotopes; about the length of the dietary signal of stable isotopic values from human bone; about bone collagen versus bone apatite values and their interpretation; and about the impact of protein versus lipid fractionation in bone on the interpretation of stable isotopic values (Ambrose, 1991, 1993; Ambrose et al., 1997; Schwarcz, 1991, 2000). Hal Krueger's work was critical in resolving many of these issues (Krueger, 1991; Krueger and Sullivan, 1984), and he provided all of the stable isotopic data contained in this paper. While not all of these issues are totally settled today, they have been sufficiently addressed to make possible significantly more sophisticated testing of hypotheses concerning ancient human diets.

One of the main areas of hypothesis testing made increasingly possible by more rigorous methodologies for analyzing stable isotopes from human bone is ethnographic and/or ethnohistoric models for hunter-gatherer subsistence. This is particularly critical, given revisionist approaches to hunter-gatherer subsistence and lifestyle, which have focused on the degree to which ethnographic data reflect not pristine relics of the Pleistocene but peoples affected to varying degrees by European historical contact of several centuries in duration. If one wishes to test the veracity of ethnographic models of hunter-gatherer subsistence, there are essentially two choices. One is to examine faunal samples from late prehistoric/precontact sites, but these are dependent on vagaries of preservation, of taphonomic interpretation, and of sampling error in the sense that they tend to preserve better in coastal than terrestrial settings, thereby giving rise to potentially biased interpretations of subsistence and settlement patterns. The second is to focus on stable isotopes in human bone, which offer a long-term dietary record, and can be used to compare with ethnographically or ethnohistorically reported patterns. Offsets between those data may sometimes be attributable to localized factors—particularly if ethnographic descriptions and archaeological samples are not from the same immediate vicinity. On the whole, however, such differences are likely to be attributable to historic transformations that give us pause in using ethnographic models to reflect the realities of precontact subsistence and settlement patterns.

Transformation of traditional hunter-gatherer subsistence in Tierra del Fuego

The ethnohistorical record

The traditional hunter-gatherers of Tierra del Fuego (Fig. 1) in the Southern Cone of Argentina and Chile, including the "canoe Indians" (Yahgan or Yamana and Alakaluf or Kaweshkar) of the Chilean archipelago and the Beagle Channel region, and the "foot Indians" (Ona or Selk'nam and Haush or Mannekenk) of Patagonian Tierra del Fuego, provide a case where ethnographic models may not accurately reflect the realities of precontact subsistence and settlement patterns. These peoples have been the subject of ethnographic descriptions from the time of Magellan's voyages to their extinction in the mid-20th century. Perhaps the most famous description of the people of the "Uttermost Part of the Earth"—to use Lucas Bridges' (1948) term—was by Charles Darwin, who reported on his contact with these people in his reflections on the "Voyage of the Beagle." Darwin (1839) described the Fuegians as naked savages, cannibals with pagan rituals, possessing speech "scarcely deserving... to be called articulate." Those ideas were reflected by later authors, including the famous compilations of Gusinde (1922, 1937). Even in the 1960s, Service (1963, p. 27) still described Tierra del Fuego as "one of the world's most miserable habitats for a naked, primitive people" who were "complacent and uninventive." Even those such as Steager (1963), who criticized such ideas, suggested that it was a lack of "capability" for developing complex technology for offshore fishing and sea mammal hunting that rendered deep sea fish and sea mammals "inaccessible" to the canoe Indians. In addition, the relative scarcity of terrestrial resources (predominantly guanacos) forced them instead, to seek out lower-yield littoral resources such as shellfish, nearshore fish, penguins, waterfowl, and occasionally fur seals at haulouts where they were more easily obtained. This subsistence pattern resulted in "episodic hunger," generally low regional population density, and a lack of permanent settlements. Stuart (1972, 1973, 1980) echoed those views, suggesting that it was particularly a dependence on shellfish that kept the Fuegians in nearly constant movement, overexploiting shellfish beds and being forced to move every few days.

A broader perspective on the ethnohistoric record from Tierra del Fuego suggests that the impact of European contact may have been largely responsible for a historical shift in subsistence from much more active involvement in large mammal hunting (fur seal and sea lion hunting offshore and guanaco hunting onshore) to fishing, bird hunting, and, particularly, shellfish collection, a phenomenon which continued from the 19th through the mid-20th century. Earlier ethnographers e.g., Weddell (1825), Darwin (1839), and Pickering (1848) seem to suggest that seal hunting was of primary importance to the canoe Indians, followed by fishing and bird hunting. Ethnographers of the late 19th century, including Snow (1861) and Bridges (1885), appear to rank seals as secondary or tertiary in importance, with fishing predominating. Finally, ethnographers at the beginning of the 20th century universally rank seals near the bottom of the list in importance, and shellfish near the top.

Fig. 1. The great island, Tierra del Fuego (Argentina and Chile). *Source*: Lothrop (1928).

If this historical transformation in subsistence is valid, why did it take place? To begin with, by the early 19th century, 300 years of sporadic contact had already occurred (cf. Gallez, 1976; Piana and Orquera, 1987); already by Cook's (1778) time, the Fuegians possessed numerous European trade goods. During the early 19th century, however, the level of contact increased significantly, with regular steamship service established with England, and visitation by ships engaged in the Northwest Coast fur trade and California Gold Rush. However, following Vidal and Winograd (1986), Yesner (1993) suggested that it was primarily competition with European sealers and whalers, beginning in the early 19th century, that brought about the profound transformations in Fuegian subsistence and settlement patterns. In addition, on land, the encroachment of European settlers, and later farmers and ranchers, led to decimation of the terrestrial guanaco populations. This competition for and elimination of these high biomass, high fat resources pushed the canoe Indians, in particular, toward greater dependence on available shellfish, fish, and bird resources. The narrow tidal range (ca. 1 m) and small intertidal zone forced both the development of diving by women to obtain subtidal shellfish, and the necessity of moving more frequently to new shellfish beds as a response to relatively quickly reduced return rates from shellfish exploitation, setting up the subsistence pattern described by later ethnographers (cf. Chapman, 1982; Clay, 1982; Rosfeld, 1985).

The removal of these high fat resources may have exacerbated the effects of European-introduced infectious disease, particularly in a cold climate where the demand for fats to generate higher metabolic rates was critical. As a result of these factors, a historical decline in population ensued, with a population reduction from 3000 to 950 individuals occurring between 1850 and 1884 (Bridges, 1885), to 300 individuals by 1903 (Hyades, 1903), to 175 individuals by 1908 (Furlong, 1917), to 70 individuals by 1925 (Gusinde, 1937), and essentially to extinction by 1968 (Valory, 1968).

The archaeological record

Archaeological data from the late prehistoric period ("Recent Phase") of the northern Beagle Channel region in Argentine Tierra del Fuego, dating from ca. 1500–500 ^{14}C years BP, suggest that late precontact subsistence was, in fact, more dependent on sea mammal hunting and guanaco hunting than the ethnographic record suggests. This is reflected, in particular, from data in the Playa Larga site, excavated by the University of Alaska Anchorage in 1988 and 1991, which dates entirely to the late prehistoric period (Yesner, 1990, in press). Recent phases of other multicomponent sites in the region, particularly Lancha Packewaia (Orquera et al., 1978), show a similar pattern. Data from these sites have been used to reconstruct details of Yahgan fur seal and sea lion hunting (Schiavini, 1994) and the seasonality of sea mammal exploitation (Lanata and Winograd, 1986). Faunal analyses also demonstrate that both sea mammals and guanaco were probably still more important in periods preceding the Recent Phase of the Beagle Channel (Saxon, 1979). The latter suggests that some dispersal of human populations and greater settlement mobility may have taken place in the Recent Phase of the Beagle Channel, even before European contact, in response to a somewhat greater dietary importance of shellfish. The cause of that change is unknown—it may be due to climate change, human population growth, or some combination of the two (Yesner, 1990)—but it may have resulted in increased vulnerability to the competition over sea mammal resources introduced by European contact, thus exacerbating a subsistence trend that was already developing.

Regional (ethnic) variability in subsistence patterns

Given this scenario, it is important to establish the degree to which such shifts in subsistence might be verified through the analysis of stable isotopes in human remains associated with these late prehistoric sites. Before doing so, however, it is necessary to establish the regional variability in ethnographically reported subsistence patterns, so that these can be linked to any regional variations in the late prehistoric data. This will also help to establish whether regional dietary differences have been retained over time, as an index not only to ethnicity but also to the degree of disturbance that may have been created as a result of European contact.

Ethnographic data

According to historic and ethnographic accounts, Tierra del Fuego was originally home to four distinct ethnic groups, as noted above: the Ona or Selk'nam; the Yahgan or Yamana; the Alakaluf or Kaweshkar; and the Haush or Mannekenk (Fig. 2). The Selk'nam occupied the more arid northern region of the Great Island of Tierra del Fuego, a southerly extension of the Patagonian steppe. They were traditionally described primarily as hunters of guanaco (*Camelus guanicoe*), a camelid that inhabits the Patagonian steppe country. However, it has been suggested that the Selk'nam may have utilized coastal regions of Tierra del Fuego, not only for guanaco hunting but for sea mammal hunting as well. This may have taken place primarily during the winter, when fats would have been in relatively short supply and guanacos themselves were leaner, and therefore sea mammal fats may have been at a premium. There are few offshore islets for sea mammal haulouts or rookeries off the Atlantic coast of Tierra del Fuego

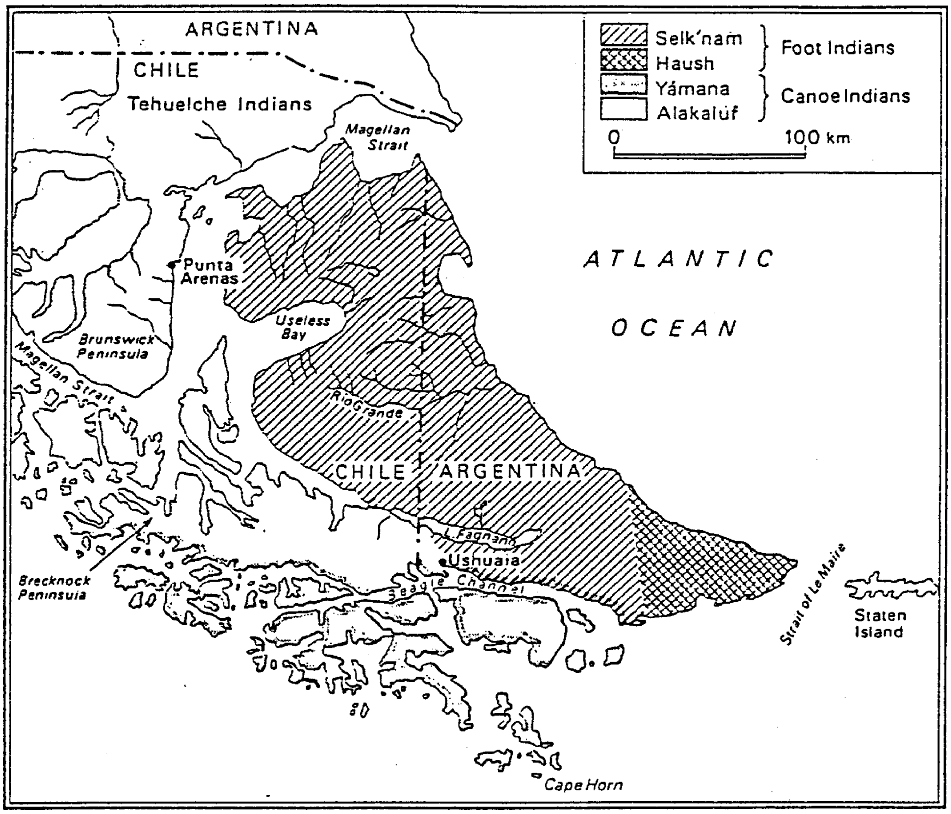

Fig. 2. Ethnic subdivisions in Tierra del Fuego. *Source*: Lothrop (1928).

(i.e., in the Selk'nam region), requiring that they be hunted on shore. Although fur seal and sea lion populations in the region today have been largely decimated, historical records suggest that these animals were more pelagic in the summer and hauled out to a greater extent in winter (Lanata and Winograd, 1986). However, some may have been taken on a year-round basis (Borrero, 1983). Unfortunately, the Selk'nam were largely exterminated by sheep ranchers who expropriated their former domain during the late 19th and early 20th centuries, so that it is difficult to reconstruct their subsistence regime in detail (Borrero, 1991; Massone et al., 1993; Gusinde, 1937).

The Yahgan or Yamana traditionally occupied the Beagle Channel region and the islands of the Chilean archipelago to the south; they bordered to the west on the economically similar but linguistically distinctive Alakaluf (Hwalakalup) with whom they shared an essentially maritime lifeway. The latter involved exploitation of sea mammals, including southern fur seals (*Arctocephalus australis*) and southern sea lions (*Otaria flavescens*); sea birds, including cormorants and Magellanic penguins, and shellfish, particularly mussels and limpets.

The Haush is a poorly known group occupying the southeastern part of the Isla Grande. Their traditional subsistence is thought to have been based on a combination of coastal and interior resources, and thus intermediate between Selk'nam and Yamana lifeways, although they have been generally classed as "foot Indians," as opposed to the more maritime Yamana and Alakaluf.

Archaeological data

Recent archaeological research in Tierra del Fuego has brought into question a number of assumptions about the history of these populations. Research at several sites on the northern (Patagonian) part of Tierra del Fuego has generally confirmed the importance of guanaco in the prehistoric diet (Borrero, 1983, 1991). In fact, new work on mid-Holocene sites with excellent faunal preservation suggests that guanaco continued to be the dominant subsistence resource throughout the Holocene period. However, recent archaeological work in the area of Cape San Pablo, in the southern Selk'nam territory in an area of open deciduous forest-steppe borderlands, suggests that both sea mammals and shellfish may have played a greater dietary role in that region, at least on a seasonal basis (Lanata, 1985).

Further south, the same is even truer in the territory of the ethnographic Haush. Faunal remains from several sites on the Mitre Peninsula, including Valentine Bay and Policarpo Bay, have suggested that sea mammals, shellfish, and other marine resources may have been more important in the diet than is suggested by the limited ethnographic accounts. In Yamana territory, work at sites such as Lancha Packewaia (Orquera et al., 1978), Shamakush (Orquera and Piana, 1987, 1999), Isla el Salmon (Figuerero Torres and Mengoni Gonalons, 1986), Bahia Golondrina (Figuerero Torres and Mengoni Gonalons, 1988), and Playa Larga (Yesner, 1990) has shown that the subsistence base of late prehistoric populations may have been very different than that recorded in ethnographic accounts, with a greater importance of both sea mammals and guanaco to late prehistoric populations (Yesner, 1993).

Human bone stable isotope data from Tierra del Fuego

Given the above, we sought out human skeletal data from the Fuegian region in order to elucidate late prehistoric subsistence patterns from stable isotopic data, and to compare them both to the faunal assemblages studied to date from various Fuegian sites, and to the ethnographic patterns reported in the literature.

Fourteen human skeletal samples were obtained from various regions of Tierra del Fuego (Table 1). Four samples (Nos. 1–4) were obtained from the northern end of the Isla Grande, in the prehistoric habitat of the Selk'nam. These samples are currently housed in the Museo Etnografico in Buenos Aires (Nos. 1–3) and the Museo Territorial de Tierra del Fuego (No. 4). Samples Nos. 1 and 2 were obtained by F. Cubas in the early 20th century, and have no further provenience data; sample No. 3 is from the Rio Grande region (Fig. 3). These samples all postdate 1500 ^{14}C years BP. The fourth sample from the Selk'nam region is from a coastal shell midden site at Punta Maria (Fig. 3), excavated by Borrero (1986), and also postdates 1500 ^{14}C years BP. Six of the samples (Nos. 5–10) are from the Mitre Peninsula, on the north shore of the traditional Haush region of southeastern Tierra del Fuego. The Haush samples are from shell middens (Fig. 3): three are from the Caleta Falsa site (Guichon and Chapman, 1991), and are dated to 850 yr BP; two are from the Maria Luisa site, postdating 1000 yr BP (Guichon, 1986, 1987), and one is from Rancho Donata in Policarpo Bay (Guichon and Chapman, 1991). All of these samples derive from relatively recent archaeological projects: those from Caleta Falsa are from work in the 1970s by Chapman and Hester (1973), while those from the Maria Luisa and Policarpo Bay sites are from work in the 1980s by Lanata (1985, 1986, 1990, 1997; cf. Gomez Otero et al., 2001). Finally, four of the samples (Nos. 11–14 in Table 1) are from the traditional Yamana region of the Beagle Channel (Fig. 3). One sample is from a shell midden within the confines of the modern city of Ushuaia, on the northern Beagle Channel shore. The other three samples are from the southern coast of the Beagle Channel: two from Hoste Island and one from Navarino Island. All are from shell middens, and are referred to the Recent Phase of the Beagle Channel, postdating 1500 yr BP.

Hal Krueger subjected each sample to stable carbon and nitrogen isotope analysis at Geochron in Cambridge, MA. For carbon isotopes, both collagen and apatite bone fractions were analyzed, while for nitrogen isotopes, the collagen fraction was analyzed. Following the general standard, rib bones were used for analyses wherever possible; this applied to all specimens except Nos. 6–9, from the Mitre Peninsula. For these specimens, the radius, clavicle, and metatarsal (No. 6), carpal bones (Nos. 7 and 8), and

Table 1
Stable carbon and nitrogen isotope data from Fuegian skeletons

No.	Location	Site type	Age	Sex	Collagen $\delta^{13}C$	Apatite $\delta^{13}C$	$\delta^{15}N$ (‰)	$\Delta^{13}C_{ap\text{-}coll}$
1	North TDF	Int.	Adult	?	−21.1	−15.7	+12.6	5.4
2	North TDF	Int.	Juv.	F	−21.9	−15.6	+9.9	6.4
3	Rio Grande	Int.	Adult	M	−20.3	−15.9	+11.9	4.4
4	Punta Maria	Midden	Adult	?	−18.6	−14.8	+10.8	3.8
5	Maria Luisa	Midden	Adult	F	−9.1	−8.1	+18.0	1
6	Maria Luisa	Midden	Juv.	F	−14.2	−10.4	+14.7	3.8
7	Caleta Falsa	Midden	Adult	F	−11.8	−9.7	+18.5	2.1
8	Caleta Falsa	Midden	Juv.	F	−11.6	−9.9	+18.3	1.7
9	Caleta Falsa	Midden	Adult	M	−13.3	−10.6	+15.1	2.7
10	Policarpo	Midden	Adult	F	−11.6	−7.9	+17.2	3.7
11	Ushuaia	Midden	Adult	?	−12.6	−10.6	+18.8	2
12	Hoste Island	Midden	Adult	?	−13.3	−10.7	+17.2	2.6
13	Hoste Island	Midden	Adult	M	−16.8	−13.4	+13.2	3.4
14	Navarino Island	Midden	Adult	M	−18.5	−13.9	+10.6	4.6

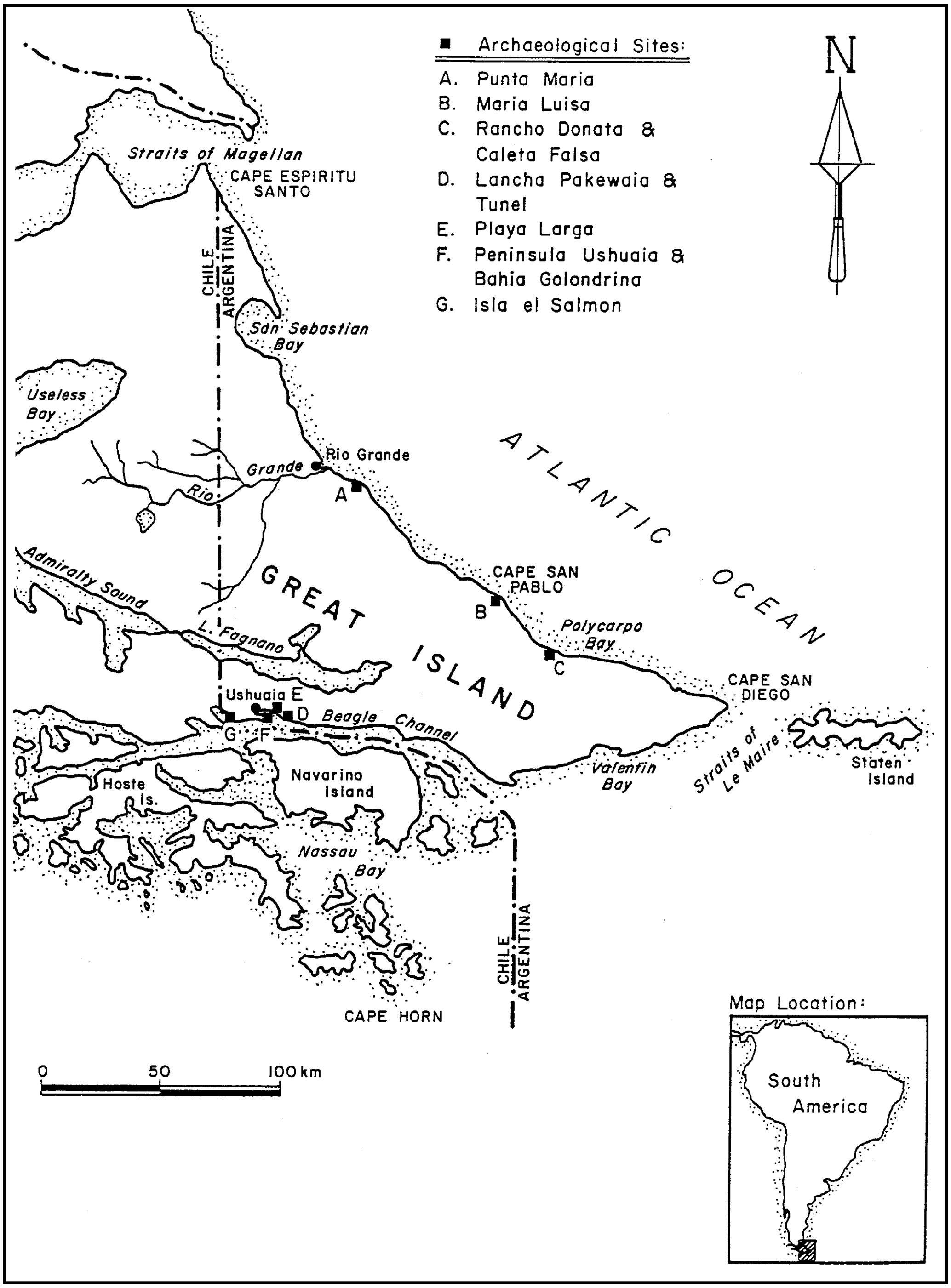

Fig. 3. Archaeological sites in Argentine Tierra del Fuego cited in the text.

fibulae (Nos. 6 and 9) were used, respectively. However, as Chisholm et al. (1983) have demonstrated, there are strongly positive correlations between carbon isotopic readings from various human skeletal elements, with relatively small variance.

Baseline data for stable carbon and nitrogen isotopic analyses

No independent samples were taken for stable isotopic readings of local foods, established either archaeologically or ethnographically, with one exception (see below). However, Albero et al. (1996) have previously shown $\delta^{13}C$ values of −11.8‰ for *A. australis* (southern fur seal) bone collagen from the Tunel site on the northern Beagle Channel; Gomez Otero et al. (2000) have produced $\delta^{13}C$ values of −11.1‰ for *O. flavescens* (southern sea lion) in north-central Patagonia, and Sealy (1986) has demonstrated similar values for *Arctocephalus* from South Africa. From other archaeological samples, Walker and DeNiro (1986) have shown a mean $\delta^{13}C$ value of −13.0‰ for sea mammal bones. Marine birds such as the Magellanic penguin (*Spheniscus magellanicus*) from Tierra del Fuego have $\delta^{13}C$ values of around −19‰, while marine fish have $\delta^{13}C$ values in the range of −19 to −22‰ (Gomez Otero et al., 2000). Taylor and Slota (1979) have shown a mean $\delta^{13}C$ value of −17.7‰ for conchiolin from shell samples, although mussels from Tierra del Fuego have produced $\delta^{13}C$ values of around −21.5‰. Altogether, marine foods tend to show $\delta^{13}C$ values between −9 and −19‰, with most values falling between −12 and −18‰. Sea mammal values tend to fall closer to the former end of the range, while shellfish and marine fish values tend to fall toward the latter end of the range (Fig. 4).

In contrast, terrestrial C_3 plants have $\delta^{13}C$ values ranging from around −23 to −28‰. In Tierra del Fuego, river fish and waterfowl that feed off these plants tend to show similar $\delta^{13}C$ values, of around −23 to −25.5‰. Herbivore bones tend to show $\delta^{13}C$ values of ca. −21 to −26‰. As noted above, although Patagonian foxes and small mammals were present, by far the most important terrestrial mammal was the guanaco (*C. guanicoe*). In the literature there are suggestions that guanaco, like white-tailed deer in North America, will occasionally feed on seaweed when they migrate to the coastal zone in winter, where they may have been utilized by the Selk'nam or their ancestors. Given that situation, it is possible that guanaco might show a more marine signal in carbon isotopes. To that end, we separately tested guanaco bone from the Atlantic coast of Tierra del Fuego (cf. Borrero, 1990). The resulting $\delta^{13}C$ value of −20.5‰ falls toward one end of the range of typical C_3 feeding herbivores, but is clearly within that range. Similar $\delta^{13}C$ values of −21.8‰ have since been produced by Orquera and Piana (1997; Piana and Orquera, 1987) from the Shamakush site on the Beagle Channel (Fig. 3). Slightly more enriched $\delta^{13}C$ values of −19.8 and −18.4‰ have been produced by Fernandez and Panarello (1992) from more northerly samples in Neuquen and Rio Negro, respectively, possibly indicating a greater influence of C_4 plants in the guanaco diet in northern Patagonia. Humans, as carnivores, should be expected to show a further $\delta^{13}C$ enrichment of about 2‰ from these herbivore values.

Similar studies of stable nitrogen isotopes have established baseline values for their interpretation. Marine primary consumers (plankton and mollusk feeders) $\delta^{15}N$ values average +12.3‰, while because of an approximately 3‰ trophic level enrichment, marine secondary consumers (fish eaters) tend to show higher

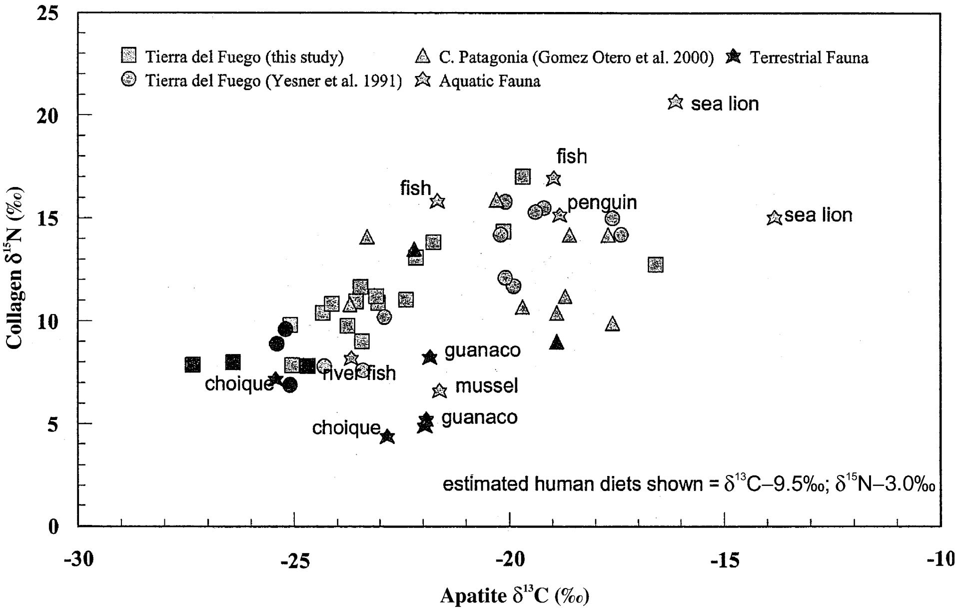

Fig. 4. Patagonia: isotopic composition of human diets. Fanual bone collagen samples corrected −2‰ ($\delta^{13}C$) to simulate flesh; modern riverine and terrestrial samples corrected +1.5‰ ($\delta^{13}C$) to account for industrial depletion. *Source*: Gomez Otero et al. (2001).

$\delta^{15}N$ values of around +16.5‰ or greater. From Tierra del Fuego, fish and penguin samples have produced $\delta^{15}N$ values in the range of +15 to +17‰, and *Otaria* (sea lion) has produced values of +22.6‰ (Fig. 4). Walker and DeNiro (1986) have shown a range of $\delta^{15}N$ values for archaeological sea mammal remains from ca. +12 to +19.4‰, with a mean value of +17.4‰. Considering the trophic level enrichment, human $\delta^{15}N$ values should be expected to range from ca. +15 to +22‰, with the latter reflecting a nearly purely marine diet (Schoeninger et al., 1982). In fact, $\delta^{15}N$ values of about +21‰ have been obtained from human remains from the Aleutian Islands, where ethnographic and archaeological data converge on suggesting a diet heavily focused on sea mammals, with lesser amounts of marine fish, anadromous fish, sea birds, mollusks, and echinoderms (Yesner, n.d.).

Results of stable carbon and nitrogen analyses from human skeletal data

Table 1 lists the stable carbon and nitrogen isotopic results for each of our samples from Tierra del Fuego. In each case, the $\delta^{13}C$ data for bone gelatin (collagen) and apatite are given, followed by $\delta^{15}N$ values for gelatin. The results are highly consistent. Although $\delta^{13}C$ values for all samples range from ca. −9 to −22‰, these values fall into two distinct groups. Samples 1–4, from the Selk'nam region of northern Tierra del Fuego, show the greatest clustering in both stable carbon and nitrogen isotopic values (Fig. 5), with gelatin $\delta^{13}C$ values ranging from −18.6 to −21.9‰, and $\delta^{15}N$ values ranging from +9.9 to +12.6‰. Such values strongly suggest a predominantly terrestrial food base, and are similar to other values obtained for central Patagonia (Gomez Otero et al., 2000; Grammer et al., 1998), for Patagonian Tierra del Fuego (Barberena, 2002; Kelly et al., 2000; cf. Fig. 6). The strong positive correlation between collagen $\delta^{13}C$ and $\delta^{15}N$ values (Fig. 5) is consistent with diets with protein varying from mainly terrestrial C_3 (low values) to mainly marine (high values).

For these Selk'nam region samples, the $\delta^{13}C$ values from the bone apatite fraction relative to the collagen fraction ($\Delta^{13}C_{ap-coll}$) are enriched between 3.8 and 6.3‰, while those from all regions of Tierra del Fuego are enriched between 1.0 and 4.6‰ (Fig. 7). Where the difference values are >4.4‰, the protein sources have lower ^{13}C values than the bulk diet (Ambrose et al., 1997; Ambrose and Norr, 1993). Conversely, where difference values are <4.4‰, the protein sources have higher $\delta^{13}C$ values than the non-protein sources. This suggests that C_3 (guanaco?) meat was the major dietary constituent for late prehistoric populations in the Selk'nam region. Relatively high differences of 5.4 to 6.4‰ between bone collagen and apatite $\delta^{13}C$ values may suggest that some C_4 plants, as well as relatively high C_3 protein consumption from guanaco, may have been part of the ancient Selk'nam diet. Low difference values are consistent with diets in which most of the protein comes from ^{13}C-enriched marine resources.

These results are particularly interesting in light of the fact that the human remains come from coastal shell middens containing sea mammal and shellfish as well as guanaco remains, and thus reflect the importance of stable isotopes as long-term indicators of human diet.

With one exception, all of the other samples from both the Yamana and Haush regions show values reflective of major components of marine foods in the diet, varying from 55 to 95% of the total diet (Table 1; cf. Yesner, 1988). In this sense, the Yamana and Haush samples are similar to an earlier Holocene (6500 BP) burial from Punta Santa Ana, in the Alacaluf region of the southern Chilean archipelago, which showed a $\delta^{13}C$ value of −13.2‰ and a $\delta^{15}N$ value of +20.0‰, as well as three burials from the Magellan Straits region (Punta Dungeness, Punta Olympia, and Bahia Santiago) which show slightly more depleted $\delta^{13}C$ values ranging from −13.9 to −14.4‰, and slightly less enriched $\delta^{15}N$ values ranging from +15.8 to +16.8‰ (Barberena, 2002, pp. 82–83). The sample from Ushuaia, on the northern shore of the Beagle Channel—the core of traditional Yamana territory—shows the highest $\delta^{15}N$ value (+18.8‰). Other samples from the south side of the Beagle Channel, however, show somewhat lower values, including sample No. 13 from Hoste Island and sample No. 14 from Navarino Island. In fact, the latter sample is the only one from either the historical territories of the Yamana or Haush that shows a relatively low (ca. 40%) contribution of marine protein to the diet. It is interesting in this regard that Navarin Island was thought to have harbored some of the largest populations of guanaco in the Beagle Channel region during precontact times (Bird, 1938), and that the Navarin Island guanaco was a larger variety (Bridges, 1948).

Samples from the Haush region (Nos. 5–10) generally show a strong component of seafood in the total diet. The samples from Policarpo Bay and the Caleta Falsa sites, in the heart of the Haush territory, show the strongest marine dietary patterns. One sample from the Maria Luisa site (No. 6), located closer to the Haush/Selk'nam boundary, shows intermediate values for both $\delta^{13}C$ and $\delta^{15}N$, as might be expected on the basis of ethnographic data. The other sample from the same site, however (No. 5), shows both carbon and nitrogen isotopic values consistent with a sea mammal diet. It is important to note that the Maria Luisa sample is the only one from the modern Haush territory, which is not associated with a coastal shell midden containing marine faunal remains, yet stable

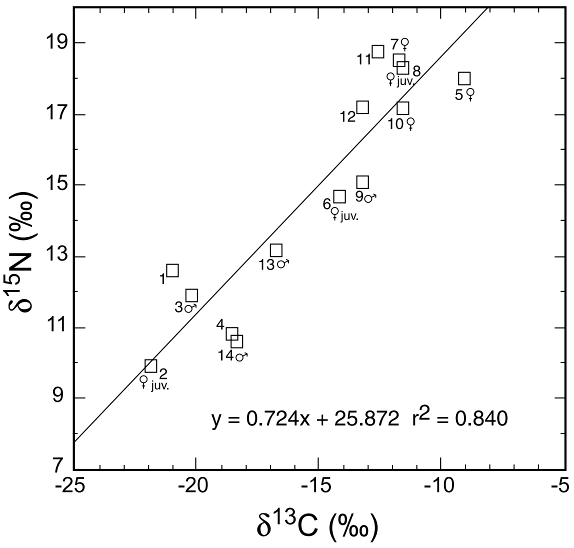

Fig. 5. Stable isotope values for carbon (gelatin) and nitrogen from human skeletal remains, Argentine Tierra del Fuego. Numbers correspond to sample numbers listed in Table 1. Sex of individuals is indicated by an appropriate sign. Juveniles are designated 'J'; all others represent adults.

isotopic values are consistent with marine faunal exploitation. In fact, for this sample, the carbon isotopic values are unusually high; considering the unusually small difference (1‰) between the collagen and apatite values for $\delta^{13}C$. However, small collagen-apatite differences in $\delta^{13}C$ are also associated with high levels of sea mammal consumption.

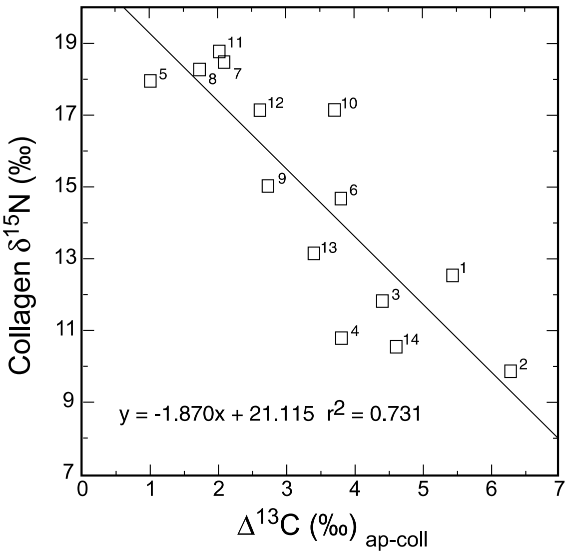

Fig. 7. Fuegian human bone collagen $\delta^{15}N$ and $\delta^{13}C$ values. *Source*: Ambrose (pers. commun., 2003).

In general, the $\delta^{15}N$ isotopic values from the Fuegian skeletons show a stronger correlation with $\delta^{13}C$ values from bone collagen ($r^2 = 0.84$) than from bone apatite ($r^2 = 0.77$) (Fig. 5). This reflects the fact that control of collagen isotopic composition is largely through the consumption of dietary protein, primarily derived from animal sources, and particularly favoring marine proteins (Ambrose and Norr, 1993; Schwarcz, 2000).

No age or gender effect was noted on stable isotopic values within this relatively small sample of human remains. However, it is important to note that no infant

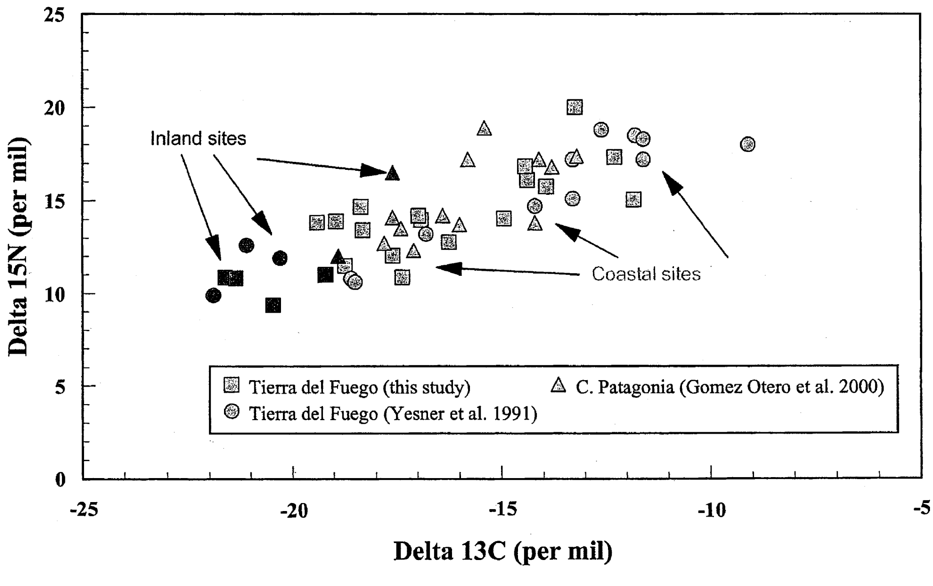

Fig. 6. Patagonia: stable isotope ratios in human bone collagen. *Source*: Gomez Otero et al. (2001).

skeletons were included, and that the Haush samples were predominantly female (5 out of 6 samples), while the Yamana samples were male (both samples for which gender was recorded).

Conclusion

Stable carbon and nitrogen isotopic data from human skeletal remains from Tierra del Fuego suggest fundamental confirmation of ethnohistoric data for the precontact period, with some modifications. These data suggest that Selk'nam groups probably did not make significantly greater use of coastal resources in the past; that Haush groups may have had a significant marine dietary component; and that some Yamana groups, at least, may have had a larger terrestrial dietary component than is suggested by ethnohistoric accounts. As noted above, those accounts, which depict the Yamana primarily as shellfish eaters, may reflect a culture whose subsistence base was profoundly altered by European contact, including elimination of terrestrial species such as guanaco by ranchers and others. These species may have formed a more important part of the precontact diet than the ethnohistoric record currently indicates (Yesner, 1990, 1993, in press). At the least, the dietary dynamics of the Haush and Yamana appear to be more complex than previously suspected. Because of the relatively small sample size, limitations on chronological control, and predominant source of the samples from shell midden sites, additional work should be undertaken to confirm these results. However, the stable isotopic data, as provided by Hal Krueger and Geochron, appear to offer significant possibilities for long-term dietary reconstruction and testing of ethnographic and ethnohistoric hypotheses concerning diet in the Fuegian region, supplementing the established record from late prehistoric faunal assemblages. In fact, they offer greater possibilities for long-term dietary reconstruction than do the archaeofaunal data, whose main value is for high time-resolution, site-specific dietary reconstructions.

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