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“This is the way”: Knowledge networks and toolkit specialization in the circumpolar coastal landscapes of western Alaska and Tierra del Fuego

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ABSTRACT

One relevant dimension through which human populations articulate their occupation of the landscape involves the accumulation and interpersonal transmission of information pertaining to the spatio-temporal distribution, accessibility, and desirability of resources. The high productivity and resource diversity of coastal circumpolar landscapes enables them to sustain larger hunter-gatherer populations throughout the year. In circumpolar landscapes, marine mammals are a particularly highly ranked resource, as major sources of essential fats, proteins, and other nutrients. The adoption of specialized toolkits for marine mammal exploitation in open waters, encompassing watercraft and detachable harpoons, would have ensured that marine mammal hunting was a particularly rewarding and predictable endeavor. The first consistent adoption of toggling harpoons in southwestern Alaska is documented primarily at the height of the cold Neoglacial (ca. 4500–2500 BP), mirroring trends along the western Bering Sea coast. While maritime resource exploitation in northwestern Alaska also appears to have begun during the Neoglacial—particularly in the Kotzebue Sound area—specialized technological adaptations reflecting full-time maritime adaptations became more prominent in the wider region during the subsequent warmer period, in the context of population growth and increasing social connectivity. In contrast, the appearance of detachable harpoons at sites in the Beagle Channel (southern Tierra del Fuego) does not appear to be associated with any significant climatic changes, developing locally around 6500 BP after an initial period of human settlement in the region which lacked such adaptations. Therefore, we argue that the pathways toward the adoption of specialized toolkits enabling a maritime-oriented subsistence strategy in circumpolar coastal environments emerged primarily as the outcome of the consolidation of knowledge networks derived from the habituation of hunter-gatherer-fisher communities to predictable ecological conditions during periods in which the coastal landscapes they inhabited had become relatively stable.

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Introduction

The organization and subsistence strategies of past and present Indigenous communities around the world have long been a focus of academic research. In an age of rapid climate change and major socio-economic transformations, people living in harsh circumpolar coastlines are facing a growing number of challenges: the melting of sea ice and glaciers are causing sea levels to rise and coastal erosion is increasing, factors which will conceivably lead to forced migrations into unfamiliar territories away from their ancestral lands (e.g., Maldonado et al. 2013). In yet another exercise in cultural resilience—after having had to deal with the ravages of colonization—the local communities of western Alaska, informed by their historical experiences and their cumulative traditional knowledge, will have to continue developing novel settlement and subsistence strategies to cope with ongoing climatic and socio-economic changes (Sloan 2019). This cultural repertoire, which will form the basis of future adaptations to ongoing climate change, may be complemented with a comprehensive analysis of the archaeological evidence, particularly when interpretations are informed by participatory ethnographic fieldwork (e.g., Knecht and Jones 2019; Lim et al. 2021; Lim and Linares-Matás 2021).

In this paper, we argue that assessing the cross-cultural nature of socio-economic organization of Holocene hunter-gatherer-fisher communities living in circumpolar landscapes may offer a broader and more nuanced understanding of the different pathways toward maritime-oriented adaptations. Given the shared links between the regions of the circumpolar north, we focus on the coastlines of western Alaska and southernmost South America, two historically unrelated and geographically-distant cultural sequences, to provide a more independent characterization of the different processes that may have been involved in the development of specialized toolkits for the hunting of pinnipeds and other marine mammals (Crockford and Frederick 2007; Fitzhugh 2016; McCartney 1975; Orquera 2005; Orquera and Piana 2009; Yesner 2004).

Geographic and environmental context

Note: When the names of Indigenous communities are mentioned for the first time, we have used accepted common nomenclature to refer to them, followed by any alternative names in brackets. For example: “Selk’nam (Ona).”

Western Alaska

There exist no official boundaries for the environmentally diverse regions that constitute western Alaska. However, for the purpose of this study, we define it as the westernmost islands and coastal regions of Alaska, USA (Figure 1). This stretches from the Aleutian and Kodiak Archipelagos in the Bering Sea and Gulf of Alaska respectively, to the Kotzebue Sound in the Chukchi Sea, to the north. Despite the often-challenging climate of these environments (Table 1), the archaeological record of western Alaska exhibits a long and rich history of human settlement and activity dating back millennia (Friesen and Mason 2016). These past inhabitants subsisted on migratory animals and edible plants on a seasonal basis throughout the year, in ways that resemble the lifeways of contemporary Native Alaskan people who call this place home: The Unangan (Aleut),



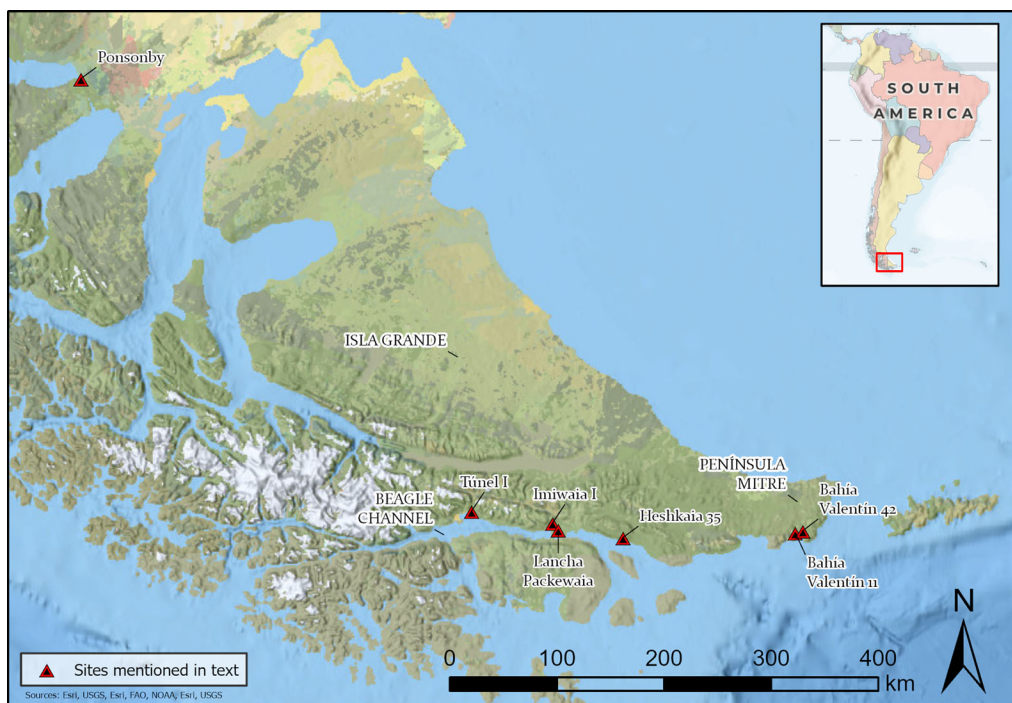
Figure 1. Extent of coastal western Alaska, ranging from the Aleutian Archipelago in the south to the Kotzebue Sound in the north. Note the location of archaeological sites mentioned in the text.

the Sugpiaq (Alutiiq), the Yup'ik, and the Iñupiat. Although these peoples endured catastrophic societal upheaval in the form of introduced diseases and cultural suppression by colonial entities since the eighteenth century, they have succeeded in retaining much of their unique ways of life and world view. There is an abundance of ethnographic enquiry done in partnership with these groups, and these are crucial for understanding how past inhabitants of western Alaska survived in these very same landscapes.

Table 1. Summary of approximate values for relevant environmental parameters in several regions from western Alaska and Tierra del Fuego discussed in the paper.

Region	Location	Climate	Average cold season temperature	Average warm season temperature	Average rainfall
Aleutian Archipelago	Southwestern Alaska	Subpolar Oceanic Climate (Cfc)	1 °C	9.8 °C	2000 mm
Kodiak Archipelago	Southwestern Alaska	Subarctic With Cool Summers and Year-Round Rainfall (Dfc)	1.4 °C	9.3°	1900 mm
Kotzebue Sound	Northwestern Alaska	Dry Subarctic Climate (Dfc)	−16.4° C	5.4° C	280mm
Beagle Channel	Tierra del Fuego	Subpolar Oceanic Climate (Cfc)	1.3 °C to 4 °C	6-9 °C	520 mm

The climate classification follows the system outlined by Kottek et al. (2006).

**Figure 2.** Location of the Beagle Channel and the Península Miter of Isla Grande, in Tierra del Fuego. Note the location of archaeological sites mentioned in the text.

Tierra del Fuego

At the other polar extreme is Tierra del Fuego, a region located in the southern tip of the South American continent, currently divided between Chile and Argentina. This cold, stormy, and wet coastal landscape comprises an irregular mosaic archipelago of mountainous and forested environments. The Beagle Channel (180 km long by 4–7 km wide) is one of the main waterways in the region, bisecting Isla Grande de Tierra del Fuego along its southern coast (Figure 2). This former glacial valley was flooded with seawater during the Early Holocene marine transgression (ca. 8300 cal. Before Present

(BP)), gradually leading to the establishment of a fully marine ecosystem with low water salinity and high nutrient load (Candel, Borromei, and Louwye 2018). There were four main Fuegian indigenous hunter-gatherer groups: the Kawésqar (Alacalufes) who live along the Pacific Coast of Chile down to the Magellan Strait, the Selk'nam (Ona) who lived in northeastern Tierra del Fuego, the Manek'enk (Haush) who lived in Península Miter (Argentina), and the Yaghan (Yámana), the most maritime-oriented group, who lived along the Beagle Channel, Isla Navarino, and in the islands and coastlines south of the Magellan Strait (Bridges 1948; Chapman 2010; Furlong 1917; Lothrop 1928). However, their populations were utterly decimated—and their lifeways irrevocably disrupted—by diseases and habitat dispossession following colonial encounters and the arrival of missionaries from the seventeenth to the early-twentieth centuries; the Selk'nam in particular suffered a systematic genocide from ca. 1886 led by ranch farmers and bounty hunters amidst a “gold rush,” with the acquiescence of Argentinian and Chilean officials (Chapman 2010; Gusinde 1982; Spears 1895). The southernmost South American heritage discussed here is located in the ancestral lands of these groups.

“Our survival is our strength”: Toward an understanding of the subsistence strategies of circumpolar hunter-gatherer-fishers

After initial settlement in a novel environment, habituation—understood as the increasing familiarity over time with the distribution, behavior, seasonality, and returns of different resources in the landscape—favors procurement predictability among hunter-gatherer-fisher communities. Greater prey encounter rates tend to encourage investment in procurement and processing technology to maximize net nutritional returns (Clark and Linares-Matás 2020; Hawkes and O'Connell 1992; Linares-Matás and Clark 2021). Landscape knowledge accumulation is a gradual process, punctuated by significant milestones such as the discovery of the properties of a specific resource, or the adoption of a particularly efficient resource acquisition strategy. Its temporality is contingent on the demographic dynamics of cultural transmission, i.e., the ways in which innovations appear, spread, and persist within the socio-economic repertoire of the community (Boyd and Richerson 1982; Derex and Boyd 2016; Granovetter 1973; Lycett 2014), and the influence of external ecological factors: climatic predictability and geomorphological stability would have assisted in the consolidation of landscape knowledge, on which subsistence strategies rely.

In the context of hunter-gatherer ecology, the carrying capacity of a particular landscape is defined as the maximum number of people following a specific resource procurement strategy that the environment can sustain over the long-term (Glassow 1978). In addition to factors affecting the consolidation and disruption of landscape knowledge networks, an imbalance in the equilibrium between population size and the carrying capacity of the local environment could lead to socio-ecological and nutritional stress among the population, especially in the absence of suitable cultural coping mechanisms (Binford 1980; Hayden 1972; Kelly 1995; Winterhalder and Smith 1981). This is particularly acute in the unforgiving conditions of circumpolar landscapes, where societies need to actively develop ways of restoring the balance between demographic size and resource availability to ensure their survival (Fitzhugh 2003; McCartney 1975). Amongst

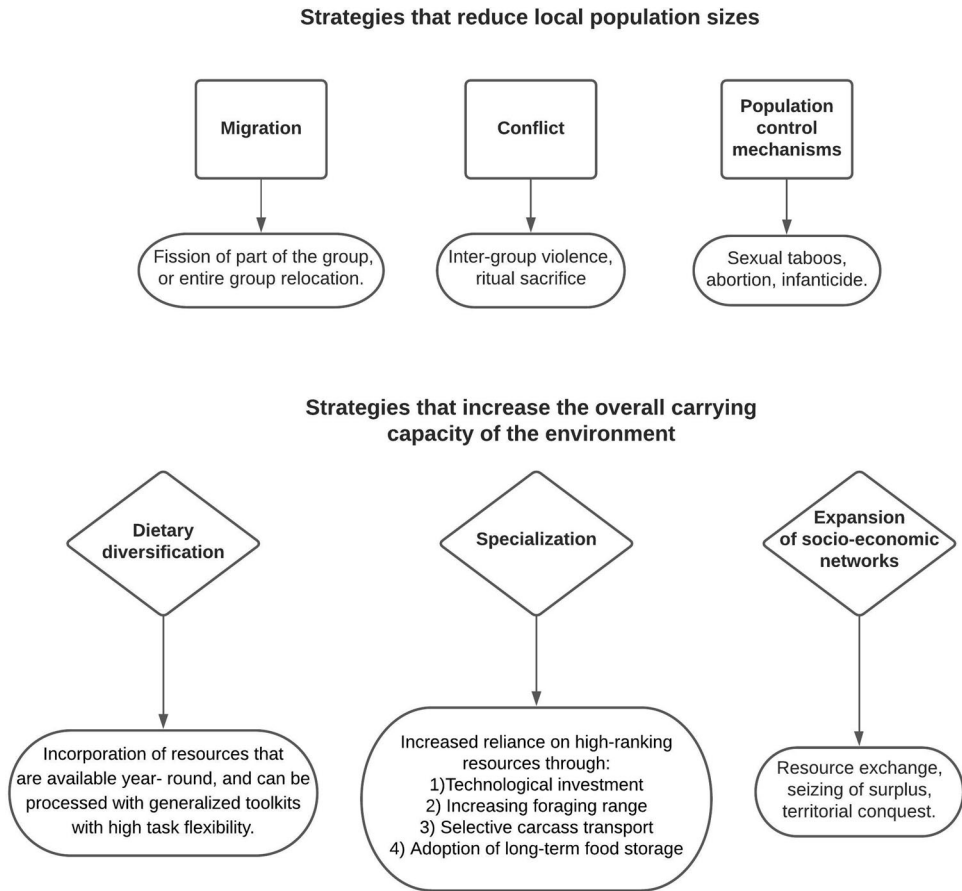


Figure 3. Framework for understanding the strategies that hunter-gatherer-fisher communities, including those in circumpolar coastal landscapes, may deploy to regulate the complex set of relationships between population size and the carrying capacity of the environments in which they live.

the Yup'ik people of the Yukon–Kuskokwim Delta (southwestern Alaska), a number of shared cultural conventions were socially enforced to prevent and cope with resource scarcity, in addition to mechanisms that physically enhanced food security, such as the drying or smoking of herring and salmon (Fienup-Riordan 2007; Lim and Linares-Matás 2021). These expectations took the form of *qanruyutet* (sing. *qanruyun*), orally-transmitted codes of conduct for living a good life (Fienup-Riordan 1995). Many Yup'ik communities in the early twentieth century widely believed in *Ellam Yua*, an ensouled universe that reacts to the actions of its inhabitants: failure to adhere to *qanruyutet* involving expectations of compassionate behavior, particularly those pertaining to the sharing of food and subsistence knowledge, would entail negative consequences, in the form of an inability to obtain resources in the near or distant future (Fienup-Riordan 2007). Gusinde (1982) also mentions how food-sharing and other aspects of prosocial behavior were of utmost importance for the Selk'nam and the Kawésqar of Tierra del Fuego. Among hunter-gatherer-fishers living in circumpolar coastal landscapes, such imbalances between demographic size and carrying capacity can be caused by endogenous factors—primarily a rate of demographic growth under favorable conditions that

outstrips resource availability—or by external regulating factors, often in relation to drastic changes in the abundance or predictability of the resource subsistence base due to resource overexploitation and/or climatic changes (see Halstead and O’Shea 1989; Lewis et al. 2020; McCartney 1975). We argue that human populations develop two main sets of strategies to deal with imbalances in the relationships between population size and landscape carrying capacity (Figure 3).

Conflict, migration, and direct population control can prove effective means of addressing the demographic side of population–environment imbalances, and there are ethnographic accounts of all three mechanisms amongst contemporary groups in western Alaska and the Chukotka Peninsula. For example, around AD 1300–1850—prior to European contact—the Yup’ik communities of the Yukon–Kuskokwim Delta underwent a period of internecine inter-group violence, in a context of scarcity and stress during the Little Ice Age (Knecht and Jones 2019). This is further reflected in the oral histories recorded by Fienup-Riordan and Rearden (2016), as the causes for past individual violent events, particularly between coastal and riverine communities, are either directly attributed to conflict over resources, or could be read as allegories for the loss of the ability to carry out crucial subsistence activities, such as hunting. Fienup-Riordan and Rearden (2016, 19) believe that differential access to coastal resources, also highly coveted by those living further inland, was a major source of tension. It is thus worth remembering that interpersonal and inter-group violence tend to have not only a demographic impact in terms of lives lost, but they can also involve the seizing of stored surplus and/or territorial expansion, which are processes that may enhance overall resource availability in the short-term and the long-term respectively, at the expense of alienating and dispossessing another group (see Earle 2000; Wahl and Trautmann 2012).

Cultural taboos in the form of *qanruyutet* pertaining to population control were still present in some Yup’ik communities in recent memory. Elders Joshua Phillip and Paul John (Fienup-Riordan 1995, 166) have spoken: a hunter’s inappropriate interactions with women would directly jeopardize his ability to gather resources—physical contact or close proximity with women outside of marriage would decrease encounter rates with fish or game. Yámana elders also strictly monitored the behavior of unmarried teenagers to prevent sexual encounters (Gusinde 1990). Certain myths and legends may also play a role in effectively communicating the cultural anxieties associated with more traumatic means of population control. Among the Yup’ik, there are said to be supernatural creatures that embody the personhood of those infants that were deliberately abandoned in the wilderness during times of starvation, similar to the *myling* of Scandinavian folklore, and of other northern circumpolar cultures (Lantis 1990). Population movement is another recurrent feature among hunter-gatherer societies as a way to alleviate local resource depletion and diminishing returns. On the opposite side of the Bering Sea, Krupnik and Chlenov (2009, 14) interviewed Siberian Yup’ik Elders who recalled a major and deliberate migration of their people westward in the early twentieth century with the aim of improving their declining socio-economic prospects by joining emerging regional trade networks. This also highlights the interrelated nature of these socio-economic strategies.

Similarly, the ethnographic and zooarchaeological record of hunter-gatherer societies demonstrate that there is often a degree of overlap along a behavioral continuum between

diversification and specialization in procurement strategies, generally articulated through the seasonal scheduling of resource exploitation, and/or a degree of gender-based division of labor (Fienup-Riordan 2007; Fitzhugh 2016; Gusinde 1990; Sloan 2019). Certain resources, such as littoral fish, marine birds and their eggs, crabs, and especially shellfish and berries, are often readily available during the summer in circumpolar environments (Collins, Clark, and Walker 1945; Fienup-Riordan 2007; Jochelson 1933; McCartney 1975; Sheppard 1986). Collecting shellfish and gathering berries, available in dense resource patches, requires a certain degree of familiarity with their distribution patterns: for example, the Yámana women prided themselves in knowing where along the extensive coastline the most suitable mussel (*Mytilus* spp.) gathering spots were located (Gusinde 1990). In this regard, recent ethnoarchaeological research among contemporary groups in southwest Alaska has shown that Yup'ik knowledge of productive berry picking locations was transmitted by women through the use of descriptive place-naming (Fienup-Riordan 2011), while the identification and collection of dense clusters of littorinid snails on wave-sheltered high intertidal shorelines proves particularly rewarding among the Unangan of Sanak Island, which explains the abundance of this species in the archaeological shell midden sequences of the island (Maschner et al. 2009). Grasping the outcome of these intangible knowledge networks in the archaeological record often depends on the nature of site formation processes. Shellfish remains tend to preserve remarkably well in the archaeological record, and many coastal sites in western Alaska and along the Beagle Channel feature prominent shell middens (e.g., Fitzhugh 2016; Orquera and Piana 2009; Yesner 2004). In contrast, berries and other plant resources do not tend to be retrieved from archaeological sites in Tierra del Fuego, due to a combination of preservation bias and ethnographically-documented procurement patterns that favored consumption upon procurement (Gusinde 1990, 537). Nonetheless, in certain parts of Alaska, the highly-conducive preservation conditions have allowed the retrieval of berry seeds from archaeological sites under waterlogged or permafrost conditions, such as at the Nunalleq site in the Yukon–Kuskokwim Delta (Ledger and Forbes 2019).

Dietary diversification, encompassing the procurement of resources with year-round availability—such as fish or shellfish—would have enhanced food security during periods when core staples were scarce, since marine mammals or terrestrial ungulates (i.e., caribou [*Rangifer tarandus*] or guanaco [*Lama guanicoe*]), tend to be available to coastal hunter-gatherers only at specific times and places throughout the year (Anderson 1972; Fienup-Riordan 2007; McCartney 1975; Oceana and Kawerak 2014; Orquera and Piana 1999; Zangrando 2009). The temporality of such dietary shifts could have been restricted to the intra-annual scale, due to seasonal unavailabilities—e.g., during the late winter or early spring (McCartney 1975)—or result from the long-term interplay of population densities and local resources, as perhaps reflected in the increased exploitation of shellfish documented in the Aleutian Archipelago and at Tierra del Fuego around 4000 BP (Yesner 2004). In this regard, maritime-oriented adaptations tend to offer a higher threshold of minimal resource availability than inland areas with comparable climatological conditions, and thus circumpolar coastal landscapes can often support relatively dense populations. In this paper, we explore the paleoecological and cultural context for the emergence of specialized maritime adaptations in the circumpolar landscapes of western Alaska and southern Tierra del Fuego.

“I like those odds”: Risks and rewards of marine mammal procurement strategies in circumpolar coastal landscapes

Circumpolar coastal hunter-gatherer-fishers would have had at least seasonal access to a wide range of resources: berries, littoral fish, migratory birds and their eggs, marine mammals, shellfish, and terrestrial ungulates (McCartney 1975). The optimal foraging relationship between manufacture costs and net returns as a driver of technological investment have been studied extensively (e.g., Bettinger, Winterhalder, and McElreath 2006; Ugan, Bright, and Rogers 2003), and are relevant in the study of technological adaptations in circumpolar environments. While the procurement costs of shellfish and berries at patches of aggregated resources would have been minimal, the collection of eggs from cliff-nesting birds is potentially hazardous, and the acquisition of other marine resources benefited from technological investment. For example, crab-fishing among the Yámana involved a specialized four-tined long fork (Gusinde 1990), and the acquisition of marine birds is made easier by the use of blunt-tipped projectiles, nets, spears, and/or floating bolas made of light wood, facilitating retrieval (Chapman 1986; Fitzhugh and Kaplan 1982; Gusinde 1982; Sheppard 1986). Nevertheless, access to these resources would still have involved lower acquisition costs than those required for actively hunting marine mammals in open waters and/or terrestrial ungulates.

While the emphasis on the targeting of high-ranked resources would have proven particularly rewarding in circumpolar coastal landscapes, where large and energy-dense marine mammals are plentiful (Gusinde 1990; McCartney 1975), the active hunting of marine mammals in open waters involves a high degree of risk and uncertainty. In the absence of specialized toolkits, the hunting of pinnipeds would have to focus on sea-ice gaps acting as breathing holes or targeting onshore reproductive colonies, while the search and capture of whales would have been restricted to the procurement of stranded individuals. Technological investment, primarily in the form of watercraft and detachable harpoons, would have enabled a greater reliance on marine mammal hunting by enhancing the predictability of prey encounter, by reducing the costs associated with the search and capture of marine mammals in their aquatic medium beyond the sublittoral zone, and by increasing hunting success rates (Fitzhugh 2016; Orquera and Piana 2009).

Site distribution patterns on circumpolar landscapes on islands or near natural harbors along the coastline highlight the logistical importance of watercraft use in this environment (Bjerck 2009; Bjerck and Zangrando 2013). Small watercraft are important for navigating the often-treacherous waters, from turbulent open seas to narrow rivers and creeks, and precarity of life in polar environments, thus creating an entangled relationship of co-dependence between people and their boats (see Bjerck 2017). The morphology and uses of watercraft among cultural groups in western Alaska are well-attested-to in ethnographic accounts. For example, amongst the Yup'ik, *umiak* were a type of large, open-top canoe of around 8–10 m used for transporting people, resources, and only rarely for hunting (Krupnik and Chlenov 2009; Legge 2010). Conversely, the *qayaq* (i.e., kayak) was a more streamlined, single-person vessel of around 4.6 m in length, purposefully built for hunting marine mammals in rough seas, where maneuverability and speed were crucial (Bjerck 2017; Fienup-Riordan 2007). It was tailored to the body measurements of its intended pilot, and was imbued with a high degree of cultural

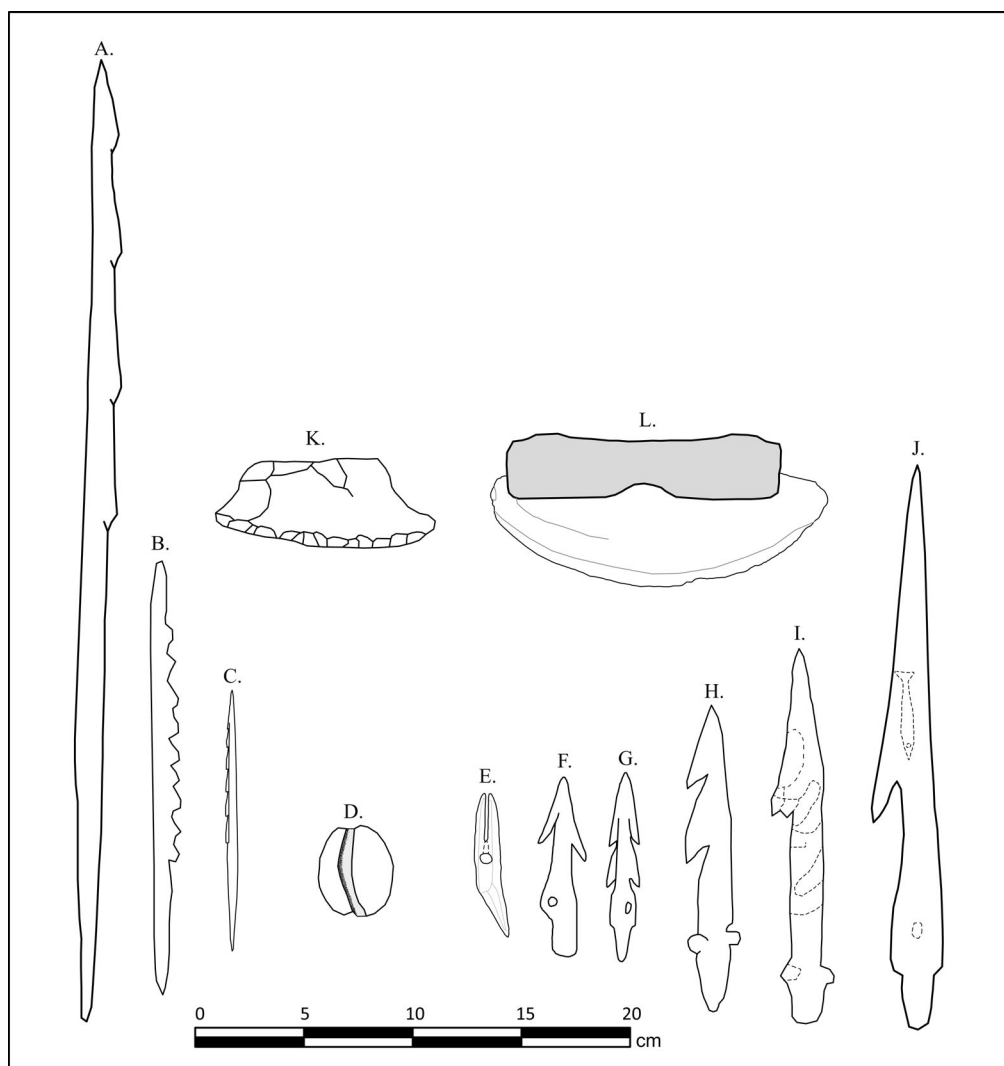


Figure 4. Composite figure depicting elements of material culture associated with maritime-oriented adaptations in circumpolar coastal landscapes. (A,B) Multi-barbed harpoon heads made on bone from the Middle Holocene site of Túnel I, Second Component (Beagle Channel, Tierra del Fuego), after Orquera, Legoupil, and Piana (2011); (C) one of two barbed prongs of a fish arrow collected from a Yup'ik community on Nunivak Island (southwestern Alaska), ca. 1890, after Fitzhugh and Kaplan (1982, 93); (D) stone net sinker from the Second Component of Túnel I (Beagle Channel), after Orquera and Piana (2009); (E) sketch of a typical pre-contact Yup'ik toggling harpoon head; (F) bilateral harpoon with off-center line hole, Hot Springs Village site (southwestern Alaska; 1500–1400 BP), after Maschner (2016, 188); (G) sketch of a typical precontact Yup'ik detachable barbed harpoon made of antler; (H,I) detachable harpoon heads with cross-shaped base made on bone, from the Second Component of Túnel I (Beagle Channel, Tierra del Fuego), after Orquera, Legoupil, and Piana (2011); (J) A large, decorated fish spear head from a Yup'ik community on the Koyuk River, Norton Sound, ca. 1890. Note the carving of a fish. After Fitzhugh and Kaplan (1982, 92). (K) Multi-purpose side-scraper from Túnel I, Second Component (Beagle Channel), after Orquera and Piana (2009). Note the morphological resemblance with the Alaskan *uluag*. (I) Sketch of a typical precontact Yup'ik *Uluag* (fish-processing knife) with a wooden handle and ground-slate blade.

symbolism—its frame parts were spoken of in terms of bones (*enret*) and the covering as skin (*amiq*), and deceased hunters were buried with the *qayaq* that they used in life (Fienup-Riordan 2007). In southern Tierra del Fuego, the Yamana employed open-top bark canoes (ca. 4–7 m long) for both transport and resource procurement, which enabled a high degree of residential mobility (Bjerck 2017; Orquera and Piana 1999; Vairo 1995). While care was taken to minimize damage to the canoes, such as tying them to the near-shore kelp bed instead of landing on rocky shores, or using kelp as padding when landing was necessary, the Yamana watercraft had an inherently short lifespan (<1 year). As such, the ability to make and own canoes was considered an essential dimension in Yamana conceptualizations of male personhood, which highlights their cultural relevance, while women were primarily responsible for paddling and canoe maintenance (Gusinde 1990; Vairo 1995).

Maritime-oriented polar hunter-gatherers used a number of specialized tools for fishing and hunting marine mammals. Detachable barbed points were designed as such to prevent the point from dislodging once it hit the prey. They are found in the Middle Holocene archaeological record of Tierra del Fuego (Figure 4H–I) and were widely used amongst Yup'ik communities on the Bering Sea, where they were known as *kukgarat* (Figure 4G). *Kukgarat* were secured with cordage to shafts that often had a seal-bladder float attached (*aklegaq*), and were launched with spear-throwers (*nuqaq*), giving them an impressive range on the open sea (Fienup-Riordan 2005). However, Yup'ik hunters also made use of toggling harpoon points (*cavek*). This type of harpoon head was designed to turn horizontally after penetrating the skin of a marine mammal, and the cord was attached to a float or large object, preventing the carcass from sinking; a sharp lithic endblade would have been slotted into the gap (Figure 4E), and attached to the harpoon shaft via a cord threaded through the central hole. Toggling harpoons offered a far more secure attachment to the prey than barbed harpoons and were suitable for larger seals and beluga in the sea-ice ecotone. However, they required far more power to penetrate successfully, limiting their range (Fitzhugh and Kaplan 1982). Neither of these points were designed to kill the prey outright but rather to wound them and slow them down, allowing them to be dispatched at close range with a lance or club (Fienup-Riordan 2007).

The higher labor investment demands involved in the manufacture of these specialized technologies, often involving recurrent costs of production, would have been readily offset by the high and reliable returns derived from the exploitation of these energy-dense animals (Orquera 2005; Orquera and Piana 1999, 112–3). Furthermore, careful crafting and curation ensured the longevity of these implements, of paramount socio-economic and cultural significance for circumpolar hunter-gatherers (Fienup-Riordan 1995; Fienup-Riordan, Rearden, and Knecht 2015).

“[But] I’m not leaving my fate up to chance”: Cultural enhancement and reinforcement of marine mammal hunting behaviors among Yup’ik communities of southwestern Alaska

The ethnographic record of indigenous Arctic communities highlights the ritual elaboration of marine mammal hunting practices and associated material culture, aiming to

increase prey encounter rates and to maintain or restore cosmological balance after a successful chase (Fienup-Riordan 1990; McGhee 2005; Nuttall 2000; Tyrrell 2005). Hunting seals and whales in open waters transcends the identification, chase, and killing of prey to become a dynamic and polycentric inter-species process, deeply imbued with symbolic meaning. This is reflected in the ways in which circumpolar hunter-gatherer-fishers enforce cultural behaviors through a respectful deference toward the personhood of marine mammals as a way to ensure that their spirits will return to the physical realm and that further encounters will continue to occur.

Examples of this are evident in Fienup-Riordan's (1995) ethnographic accounts of the Yup'ik people. There are a series of *qanruyutet* regarding the respectful treatment of prey animals, to guarantee their spirits are coaxed to return from the spirit world so that they might be reborn and hunted at a later time. In many cases, these actions were often rooted in the practicalities of traditional lifeways: modern Yup'ik groups still adhere to the teaching that animals should be hunted upon being encountered, to ensure that they are reincarnated and return to be hunted (Fienup-Riordan et al. 2020); this *qanruyun* could be read as a warning against wasting chances to capture prey opportunistically, given the importance of animal fat and protein in circumpolar environments (Masson-MacLean et al. 2020). This culturally mediated behavior also extended to the processing of carcasses. For example, respect for prey dictates that seals were dispatched quickly, as a moral obligation to reduce suffering, but also because the meat of seals that have died slowly becomes saturated with blood and turns bad to the taste. Indeed, it was widely believed that seals would approach worthy hunters of their own volition, partly because they were attracted by the prospect of fresh water and the smell of terrestrial land. As such, hunters would ritually provide dispatched seals with sips of fresh water, and would also fumigate their own bodies prior to the hunt by burning tundra vegetation in order to "smell like the land" (Fienup-Riordan 1995, 95). It is conceivable that the latter practice may have indeed actively contributed to masking the hunters' scent from their prey.

Another cultural component that assisted hunters in stalking seals on the ice were "seal scratchers." These pronged instruments were used to scratch the ice, to mimic the sound of a seal emerging from its breathing hole (Fienup-Riordan 2007). In describing such an implement collected in the late nineteenth century from a Yup'ik community in the Yukon-Kuskokwim Delta, Fitzhugh and Kaplan (1982, 78) observe that it "exudes sealness": the scratcher physically resembles the flipper of a seal, its prongs are made from three bearded seal claws, and it is decorated by an inlaid beluga-tooth figurine depicting a seal emerging from the ice. This way, it combines "spiritually compatible materials and appropriate imagery" with its fine craftsmanship and artistry marking the bearer as being sufficiently respectful and worthy of being bestowed with the prey at hand. From the same collection, a set of bird-hunting bolas from St Lawrence Island had balls of conifer wood, cords of animal sinew and, notably, a handle made from bird-bone (Fitzhugh and Kaplan 1982, 75), perhaps another example of invoking the essence of the prey it was intended to capture.

These considerations of respect for prey extended to the esthetic decoration of hunting implements. Hunters crafted "new and attractive hunting equipment" during the winter months, to "attract and please" the seals, displaying their respect for their would-

be prey (Fienup-Riordan 1995, 91). This is exemplified by the intricate harpoon designs in the archaeological record of western Alaska: consider the elegant ivory toggling harpoon heads recovered from the ca. seventeenth century Yup'ik site of Nunalleq, which are often marked with ownership/family symbols (Fienup-Riordan, Rearden, and Knecht 2015), and also the “stylistically exuberant” barbed points of the Amaknak phase in the Aleutian Islands (Davis, Knecht, and Rogers 2016, 158). Gusinde (1982) describes how Selk'nam guanaco hunters would wear a triangular ornament (*Kóoel*) on their forehead, which rendered the prey immobile, while the evidence for artistic decoration on detachable bone harpoons found in the archaeological record of Tierra del Fuego (e.g., Orquera and Piana 2009) suggests that marine mammal hunting among maritime-oriented Holocene hunter-gatherers may have also been deeply imbued with cultural significance here too.

In this context, we argue that it is particularly relevant to explore and understand the patterns underlying the independent and autochthonous development of specialized marine mammal hunting toolkits among Mid-Late Holocene coastal hunter-gatherer-fisher communities of western Alaska and Tierra del Fuego, comparing and contrasting the mosaic of adaptations between and within these two large circumpolar regions.

“I can bring you in warm ... or I can bring you in cold”: Pathways to coastal specialization and climate change in the Holocene archaeological record of circumpolar regions

Early Holocene populations in southern Patagonia and western Alaska were pioneers exploring a new environmental setting and were characterized by high mobility and ephemeral sites, which quickly allowed the identification of high-ranked resources and habitation sites through landscape habituation (Borrero 1999, 2001; Fitzhugh 2016). Given the importance of landscape habituation for the planning of subsistence strategies, we argue that relatively abrupt climatic anomalies or substantial marine transgressions would have been particularly relevant for hunter-gatherer communities living in circumpolar latitudes, since they could easily disrupt existing knowledge networks through a spatio-temporal dislocation of resource diversity and availability, often forcing a considerable restructuring of resource procurement behavior. This is consistent with Grove's (2018) observations that demographic variables among hunter-gatherers are primarily affected by increases in climatic variability rather than by variations in mean values, since variability leads to changes in the standard deviations of temperature and precipitation which render the environment less predictable. Middle-to-Late Holocene climatic variability in the Arctic was characterized by the onset of a cold episode of glacier regrowth (Neoglacial) following their maximum shrinkage during the Hypsithermal interval (Porter 2013). While multi-proxy evidence shows that the timing of an Arctic-wide onset of Neoglacial conditions was not radically abrupt nor spatially homogeneous (Kaufman et al. 2016), rapid regional increases in long-term cooling rates are appreciable (McKay et al. 2018). In Alaska and the Yukon, warm conditions around 7000–5000 BP due to high summer insolation were followed by glacier advances in a context of increasing cooling beginning around 4500–4000 BP, the first pulse of Holocene Neoglaciation (Kaufman et al. 2016; McKay et al. 2018; Solomina et al. 2015).

Evidence of early Neoglacial activity (4500–4000 BP) in this region is found in glacier cores from the Brooks Range and lake cores from coastal Alaska (Badding, Briner, and Kaufman 2013; Barclay, Wiles, and Calkin 2009; McKay and Kaufman 2009; Porter 2013). Three extensive and high-resolution isotope records from the northern Gulf of Alaska also show significant shifts in mean $\delta^{18}\text{O}$ values after 3900 BP (Anderson et al. 2005; Kaufman et al. 2016; Liu et al. 2014). An inflection point toward colder conditions around 4500–4000 BP is also reflected in dinocyst-based reconstruction of Holocene sea-ice cover, summer sea-surface salinity, and summer sea-surface temperature values in the eastern Chukchi Sea (see de Vernal and Hillaire-Marcel 2000; McKay et al. 2008).

Scenarios of unpredictability tend to foster the adoption of settlement and subsistence strategies able to buffer risk and uncertainty, since hunter-gatherer societies are generally able to adaptively address and navigate climatic constraints and opportunities (Ingold 1981; Kelly 1995). In the Northern Arctic, the rapid spread of the Arctic Small Tool tradition (ASTt), characterized by the presence of microlithic technology, took place around 5000–4500 BP. In northern Alaska, these cohesive lithic assemblages are referred to as the Denbigh Flint Complex (Giddings 1964; Anderson 1970), and offered a versatile approach for the creation of composite tools suitable for a multiplicity of purposes, including caribou hunting at inland sites of the Seward Peninsula or Punyik Point, near Etivlik Lake (Irving 1964; Kunz 2005; Larsen 1968). Coastal Denbigh sites in Cape Krusenstern also show some exploitation of seals using small harpoon end blades (Giddings and Anderson 1986). High mobility alongside standardized lithic reduction strategies increased prey encounter rates and facilitated inter-group connectivity, supporting the transmission of relevant technological innovations and enhancing the demographic viability of colonizing hunter-gatherer populations (Ellis 2008; Grove 2018; Tremayne and Winterhalder 2017).

Throughout western Alaska, the advent of these cold climatic conditions led to a long-lasting southward expansion of the sea-ice front in the Bering Sea, seasonally reaching up to the eastern Aleutian Islands until early summer (Crockford 2008; Crockford and Frederick 2007). These conditions decisively impacted the distribution patterns of fish and marine mammals within this highly productive ecosystem (Grebmeier et al. 2006; Nelson 1969), since, for example, the persistence of pack ice would have prevented whales from migrating northwards through the Bering Strait (Crockford 2008, 122). Nonetheless, the protracted duration of the Neoglacial appears to have granted hunter-gatherer-fisher groups of the Arctic ample opportunities to incorporate the socio-economic implications of these climate-driven landscapes into their extensive knowledge networks, as illustrated by the cultural sequence from Kodiak Island.

Kodiak Island was colonized during a period of warm conditions and reduced storminess in the early Middle Holocene (ca. 7500 BP) by maritime hunter-gatherers from the eastern Aleutian Islands (Knecht and Davis 2001). The initial settlement was characterized by communities living at ephemeral seasonal sites using generalized toolkits ascribed to the Ocean Bay Tradition (composite bone fish hooks, barbed harpoons, chipped stone lances; Fitzhugh 2016). The onset of the Neoglacial led to a period of settlement and resource ranking reconfiguration, followed by the consolidation of landscape knowledge networks after climatic stabilization led to a series of regional

innovations that fostered population growth and resource processing capabilities during the Early Kachemak Period (4000–2700 BP). Toggling harpoon technology improved acquisition rates when hunting marine mammals while fishing nets allowed for the mass-capture of salmon and herring along beaches and streams from the late spring to fall (Fitzhugh 2003). The sudden availability of large quantities of resources with short shelf life and high processing costs led to the development (or adoption) of the semi-lunar-bladed fish processing knife (*ulukaq*), the use of which entails greater efficiency and lower wrist strain than the typical generalist stemmed knives of the preceding Ocean Bay II phase (Fitzhugh 2003). Net sinkers, ulus, and processing pits dominate the archaeological assemblage of Bruhn Point, a small Early Kachemak locality by the mouth of a salmon stream (Steffian, Saltonstall, and Yarborough 2016). More broadly, Early Kachemak toolkits show an increasing specialization to more effectively attend all the different tasks associated with fish resources. At Zaimka Mound, a large site located within a bay, the assemblage is predominantly comprised of plummets, slate points, split cobble scrapers, and U-shaped abraders, evidencing the harvesting, processing, and storage of aquatic resources (Steffian, Saltonstall, and Yarborough 2016). These technological investments would have granted hunter-gatherer-fisher communities the time and surplus needed to shift from a needs-based procurement strategy to the preparation and storage of fish resources to mediate the food shortages of the long winter seasons that characterized the Neoglacial Period (Steffian, Saltonstall, and Yarborough 2016). The subsistence basis for year-round occupation of the island during this cold period was complemented further by the construction of permanent semi-subterranean houses (Partlow 2000).

The eastern Aleutian Islands exhibit a similar pattern of successful maritime-oriented adaptations to the Neoglacial and its aftermath (Davis, Knecht, and Rogers 2016, 164; Lefèvre 2008; West et al. 2012). For example, Crockford (2008) reports how the well-preserved faunal record of Amaknak Bridge (3500–2500 BP), a shell midden site in Unalaska Island, features temperate marine mammals available seasonally, such as the northern fur seal (*Callorhinus ursinus*, 40% of NISP [Number of Identified Specimens]) or year-round, such as the harbor porpoise (*Phocoena phocoena*; 10%), as well as pagophilic (“ice-obligate”) and only seasonally available pinnipeds, such as ringed seals (*Phoca hispida*; 32%); porpoise remains were also abundant at the nearby site of Margaret Bay Level 4 (ca. 4700–4100 BP; Davis 2001). This pattern suggests that specialized marine mammal hunting techniques and mechanisms, such as toggling harpoons, canoes, bilaterally barbed harpoons, and lances, were effectively mobilized to acquire the plentiful pinnipeds and porpoises inhabiting the sea-ice ecotone (Crockford 2008; Davis, Knecht, and Rogers 2016). Moreover, both Margaret Bay and Amaknak Bridge feature permanent semi-subterranean dwellings with fire pits and floor channels, an architectural solution to cope with the intense northerly winds of the Neoglacial Period (Knecht and Davis 2001). The material culture, with the presence of stone lamps and small-eyed needles for tightly sewing waterproof clothes, further suggests an adaptation to very cold environments.

In southern Tierra del Fuego, the development of more spatially-fragmented population clusters around the Beagle Channel in the eighth millennium BP has been suggested to stem from the aftermath of the Hudson volcano eruption, around 7700 BP

(Ozán and Pallo 2019). Another paleoenvironmental process that could have led to a restructuring of settlement patterns was the onset of the marine transgression of the Early Holocene (8300 BP). However, it appears that the subsistence strategies of hunter-gatherer communities in the Beagle Channel region were not substantially disrupted initially. The archaeological record of Layer S of Imiwaia I (7840 ± 50 BP) and Túnel I First Component (6680 ± 210 BP) reflect a terrestrial-dominated lifestyle, characterized by almost identical and elaborate lithic assemblages, involving rhomboidal or large stemmed points and tranchets (Piana and Orquera 2009).

The adoption of specialized maritime technology and a reliance on sea resources is instead documented at Beagle Channel sites during the second half of the seventh millennium BP (Orquera 2005; Orquera and Piana 2009). While the low number and diversity of dinocysts from marine plankton recorded in the palynological record of the Beagle Channel suggest lower temperatures and salinity of sea-surface water around 6000 BP than in Mid-Late Holocene or modern samples (Candel, Borromei, and Louwye 2017, 2018), it seems that there were no major climatic triggers or evidence for terrestrial or maritime resource scarcity behind the start of procurement strategies relying on coastal resources in southern Tierra del Fuego (Orquera and Piana 1999), in contrast to the evidence from the southwestern Arctic discussed above. In fact, the Beagle Channel area appears to have exhibited only relatively minor variations in temperature and humidity throughout the Holocene, with littoral adaptations gradually developing and consolidating in the sheltered shores of the Beagle Channel and the islands after the consolidation of the Early Holocene marine transgression (Mercer 1976; Orquera 2005; Pendall et al. 2001).

The maritime hunter-gatherers of southern Tierra del Fuego exhibited relatively flexible settlement patterns and subsistence strategies to accommodate predictable seasonal fluctuations in climate and resource availability amidst a cold and wet environment (Schiavini 1993; Tivoli and Zangrando 2011). Most of the sites in the Beagle Channel were isolated or small clusters of shell middens, some of which were preferentially re-occupied, thus creating important landscape loci for these mobile and relatively small communities (Orquera, Legoupil, and Piana 2011). Marine mammals, fish, mollusks, and seabirds were ubiquitous, and paramount for the subsistence strategies of these coastal communities (Piana, Vázquez, and Tivoli 2007). In contrast, the exploitation of guanaco, while also relevant, was more localized in time and space (Alunni 2013; Muñoz 2012). For example, the targeting of guanaco family groups at Túnel I (Component 2, Level D) appears to have been a relevant seasonal activity in the fall, given the presence of neonate specimens (Vázquez 2015, 255).

Fat is an essential resource for hunter-gatherer-fisher communities and other human groups, particularly in circumpolar ecosystems (McCartney 1975; Speth and Spielmann 1983). Fat-rich pinnipeds soon became a major component of the diet of human communities living in the small pebble beaches of the Beagle Channel (Orquera and Piana 2009). At the Middle Holocene site of Túnel I (Component 2), seals comprise 63% of the NISP, with a predominance of fur seals (*Arctocephalus australis*, Minimum Number of Individuals = 365; Vázquez 2015). The leather of *A. australis* was highly-prized in the region for the elaboration of clothing and hunting equipment, even though its processing was more complicated than the preparation of guanaco skins (Mansur and

Parmigiani 2014; Parmigiani et al. 2017). The Middle Holocene hunter-gatherer-fisher communities of Imiwaia I (Second Component 2) and Túnel I (Second and Third Component) developed sophisticated equipment, such as canoes and harpoons with cross-shaped based and detachable points, that allowed them to directly engage individual adult and subadult fur seals (*A. australis*) in their aquatic medium, as well as reaching the unsuspecting members of offshore resting colonies (Martinoli 2018; Orquera and Piana 2009; Schiavini 1990). Bjerk (2009, 122) considers Component 2 of Túnel I to be the oldest unequivocal evidence for a fully “maritime relations”-adapted society in the circumpolar south.

The relevance of fishing practices from the Middle Holocene in the Beagle channel is documented by the presence of multi-barbed harpoon points and stone fish-net weights at Imiwaia I, and both littoral—such as Patagonian blenny (*Eleginops maclovinus*) and silversides (*Odontesthes* sp.)—and pelagic fish taxa—such as hakes (*Merluccius magellanicus*) and sardines (*Sprattus fueguensis*)—throughout the Imiwaia I sequence (Zangrando, Ponce, et al. 2016). The considerable increase in the number of guanaco remains in the Mid–Late Holocene zooarchaeological assemblages of the Beagle Channel (such as the Early Component of Lancha Packewaia and Third and Fourth Component of Túnel I) suggests an expansion in the range of terrestrial mobility patterns (Fernández et al. 2020; Zangrando 2009), which correlates with the increasing distribution of stone points in the lithic assemblages of the Early Component of Lancha Packewaia, in the Beagle Channel, and Ponsonby, in southern Chile (Legoupil 2003; Orquera and Piana 1999). During the Late Holocene, the zooarchaeological record of Imiwaia I and other sites in the Beagle Channel exhibit an increasing and systematic reliance on the procurement of pelagic fish and sea birds—such as cormorants (*Phalacrocorax* sp.) that lived in year-round colonies, and seasonally-available penguins (Spheniscidae)—particularly from the mid–first millennium AD onwards (Tivoli 2010; Tivoli and Zangrando 2011; Zangrando 2009). Analyses of Patagonian cod (*Salilota australis*) vertebrae from Late Holocene sites in the Strait of Magellan indicate year-round fishing, with particular emphasis during the cold season (Torres et al. 2020). Bayesian modeling of stable carbon and nitrogen isotopic values have further reinforced the notion that Late Holocene communities in the Beagle Channel had predominantly marine diets, with a complementary contribution of guanaco and a small proportion of plant resources (Kochi 2017; Zangrando, Ponce, et al. 2016). These adaptations suggest the development of a more extensive marine catchment area, within the kelp belt but beyond the immediate shoreline, as a creative adaptation to local changes in coastline morphology due to sea-level variations (Zangrando, Ponce, et al. 2016).

Highlighting further the relevance of local coastline morphology in maritime adaptations, the archaeological record of southern Tierra del Fuego does not show the same emphasis on toolkit specialization for marine mammal hunting across all coastal regions. In the Moat region, just outside of the Beagle Channel, sites of the Heshkaia complex were not located in areas with easy access to seal colonies, despite their coastal location; consequently, the faunal assemblages indicate a limited, opportunistic exploitation of large adult males of sea lion (*Otaria flavescens*), who were most likely captured off-guard on the beach shore and selected anatomical parts were differentially transported back to the sites (Martinoli 2018). Not surprisingly, guanacos are therefore the

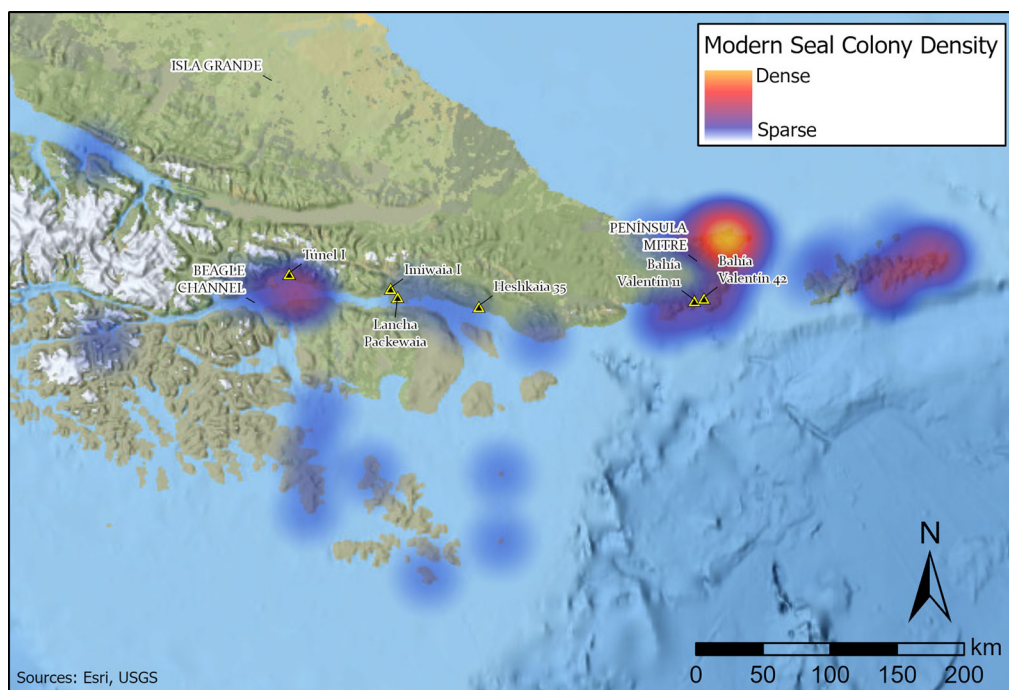


Figure 5. Distribution densities of modern seal colonies in southern Tierra del Fuego, after Martinoli (2018), presented here as a heat map for visual clarity.

most represented macrofaunal species at Heshkaia 35 and other nearby localities (Zangrando 2010, Zangrando et al. 2013), with the skeletal part profiles also suggesting a differential transport of body parts to the base camp (Alunni 2013). In Península Miter, where waves are strong and dangerous, the procurement strategies on marine mammals shifted through time and space, as a function of seasonality and proximity to the coast (Vázquez et al. 2011). Lanata (1990) suggests that spring and summer base camps would have been located near the coast, with an emphasis on the exploitation of marine resources, such as waterfowl, fish, and shellfish, with logistical exploitation of guanaco bachelor herds. During the autumn and winter, base camps would have been preferentially located at the wood-steppe ecotone instead, with an emphasis on hunting guanaco from nursery herds, ideally with an onshore seal rookery within foraging range (Lanata 1990); seal reproductive colonies are nowadays considerably more common along the shores of Península Miter than elsewhere in Tierra del Fuego (Figure 5), and would have provided a predictable access to fat resources during the harsh winter months without the need to invest in open water hunting technology. The Middle Holocene layers of Bahía Valentín 11 do suggest an active provisioning from the breeding and reproductive colonies found onshore, in the vicinity of the archaeological sites, while skeletal profiles suggest that Late Holocene human communities fully exploited the meat and bone contents of seals (Martinoli 2018). The growing number of adult females and juveniles at Late Holocene sites (Late Component of Bahía Valentín 11; Bahía Valentín 42) suggests a particular emphasis on reproductive seal colonies (Martinoli 2018), either because there was some degree of localized resource depletion

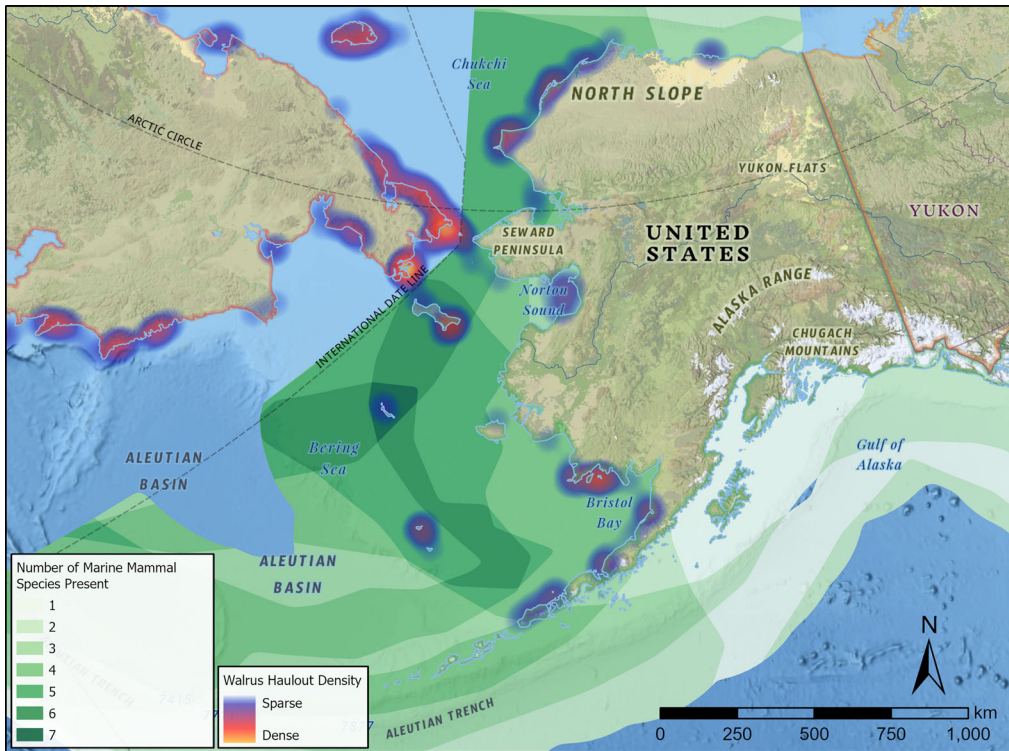


Figure 6. Overlapping areas of distribution of Alaskan marine mammal species, with a heatmap representing the distribution densities of modern walrus colonies in central Beringia. The species depicted are: bearded seal (*Erignathus barbatus*), northern elephant seal (*Mirounga angustirostris*), northern fur seal (*Callorhinus ursinus*), Pacific walrus (*Odobenus rosmarus*), ribbon seal (*Histiophoca fasciata*), ringed seal (*Pusa hispida*), spotted seal (*Phoca largha*), Stellar's sea lion (*Eumetopias jubatus*). All marine mammal distribution data were obtained from the Alaska Department of Fish and Game (2021) and the United States Geological Service (2021).

due to an intensification of hunting pressures (see Martinoli 2018), or perhaps it was primarily motivated by lower risk and procurement costs than targeting breeding colonies with larger adult males.

Returning to the Arctic, environmental stability enabled the initial occupation of the Cape Krusenstern area during the fifth millennium BP despite the cold (Anderson, Jordan, and Freeburg 2020, 95). In the Kotzebue Sound, the presence of seal bones in the ASTt (Denbigh Flint) levels at Iyatayet (Giddings 1964; Tremayne et al. 2018), as well as seal bones and consolidated seal grease at ASTt Cape Espenberg sites (Buonasera et al. 2015) evidence the exploitation of marine resources. An increasing degree of subsistence and technological specialization becomes apparent in northwestern Alaska during the first half of the third millennium BP in both coastal and inland localities, through the development of stemmed lanceolate projectile points, which were designed specifically for hunting and were selected over the versatility of microlithic technology (Darwent and Darwent 2016, 220). In terms of subsistence, the faunal assemblage at the Old Whaling site (Beach Ridge 53, Cape Krusenstern) is dominated by ringed and bearded seals which were predominantly hunted in winter, using bifacial

barbed harpoons as they approached their breathing holes, although the presence of a partially broken toggling open-socket harpoon suggests that small seals could have also been hunted during early spring and summer (Darwent and Darwent 2016; Giddings and Anderson 1986). The presence of a single bowhead whale cranium (*Balaena mysticetus*) with associated lithics, and the occasional use of whale vertebrae as furniture in semi-subterranean houses, appears to indicate the rather opportunistic exploitation of larger marine mammals (Darwent and Darwent 2016, 225). Beluga (*Delphinapterus leucas*) arrive in late spring or early summer to the Kotzebue Sound (Figure 6); ethnographically, they were driven into the shallow waters of Eschscholtz Bay and hunted without the use of specialized technology (Lucier and VanStone 1995); a similar opportunistic strategy may have been followed in prehistoric times around the Choris Peninsula (Darwent and Darwent 2016). A considerable reduction in the carrying capacity of terrestrial ecosystems, potentially due to volcanic-led ecological instability leading to a drastic reduction in caribou numbers during the second half of the fourth millennium BP may have also acted as a decisive push factor toward increasing exploitation of maritime resources in western Alaska (Barton, Shirar, and Jordan 2018; Dumond 1987; Tremayne and Brown 2017; VanderHoek 2009).

In the aftermath of the Neoglacial Period (ca. 2500 BP), human communities following the receding seasonal sea-ice front ecosystem colonized St Lawrence Island, and maritime-oriented hunter-gatherers quickly consolidated on Chukotka (Siberian Beringia) and western Alaska (Mason 1998; Savelle and McCartney 2003). In our view, the increasing predictability and bioavailability of coastal resource procurement in the northern half of western Alaska at the end of the Neoglacial, coupled with greater population densities and higher population connectivity (Tremayne and Brown 2017), fostered even greater technological investment through labor-intensive methods. These were reflected on a number of innovations, such as polished stone implements, thin-walled, check-stamped decorated pottery, toggling harpoons carved on caribou antlers, carved fish net sinkers, and small, side-hafted, chipped-stone blades (Dumond 2016). The sizeable and semi-sedentary coastal sites from this period, such as Iyatayet (Cape Denbigh, Norton Sound, northwestern Alaska), or Summit and Nunivak Islands (southwestern Alaska), illustrate a considerable reliance on maritime resources, with small seals dominating the faunal assemblage alongside beluga, bearded seal, saltwater mussels, and walrus, as well as some caribou remains (Casperson 2017; Giddings 1964; Tremayne 2018; Tremayne et al. 2018). At Point Hope (northwestern Alaska), the identification of a pair of toggling harpoons of a size and design suitable for whaling further emphasizes the strong maritime vocation documented for northern coastal Norton sites (Dumond 2016, 235; Jensen 2012). Alternatively, some coastal Norton sites, such as Difchahak (Norton Sound), as well as contemporary inland sites throughout western Alaska, started to rely much more heavily on mass-capture techniques for the increasingly reliable supply of salmon and other riverine fish during the warmer phase that followed the Neoglacial (see Dumond 2000, 2016; Finney et al. 2000; Miszaniec, Darwent, and Darwent 2021; Shaw 1982). As such, periods of cultural and technological innovation among hunter-gatherers in western Alaska tend to be correlated with stabilization following pronounced environmental changes, primarily due to associated demographic dynamics enabling the expansion and consolidation of landscape knowledge networks.

Conclusions

In western Alaska, the appearance and consolidation of toggling harpoons, the main element of material culture denoting the use of a specialized toolkit for hunting marine mammals, was widespread. The first consistent adoption of toggling harpoons in southwestern Alaska is documented primarily during the Neoglacial, a cold climatic context, while in the wider northwestern Alaska region they become more prominent during the warmer period that followed the Neoglacial. However, these regional differences might be partly due to taphonomic factors (Tremayne and Winterhalder 2017), since ASTt communities in Greenland possessed these technological adaptations (Grønnow 2012) and recent research is showing that communities in the Kotzebue Sound were also actively exploiting maritime resources during the Neoglacial. In southern Tierra del Fuego, detachable harpoons were only common at sites in the Beagle Channel, although their appearance does not appear to be associated with any significant climatic changes. In southern Península Mitre, hunter-gatherer-fishers mostly targeted onshore rookeries that did not demand such specialized toolkits, while those in the Moat area focused more on guanaco hunting, exploiting marine mammals only opportunistically. Constraints in navigational conditions, such as wave strength and intense tidal ranges, may have also played a role in increasing procurement risks and uncertainties, limiting the pursuit of marine mammals in open waters along the Atlantic coast of Tierra del Fuego.

Therefore, we argue that the pathways toward specialized toolkits enabling a maritime-oriented subsistence strategy in circumpolar coastal environments developed primarily as the outcome of the consolidation of landscape knowledge networks derived from the habituation of hunter-gatherer-fisher communities to predictable and conducive ecological conditions. The increasingly predictable accessibility to energy-dense marine resource patches, mediated by toolkit specialization and cultural reinforcements, created a positive feedback loop in terms of demographic growth and increased information exchange that encouraged greater technological and aesthetic investment, ensuring a continuity of use since their initial adoption.

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Conflict of interest

The authors declare that they have no known competing financial interests that could have appeared to influence the work reported in this paper.

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References

- Alunni, D. V. 2013. Estrategias de transporte, procesamiento y consumo de guanacos en la costa sur de Tierra del Fuego (Argentina) [Guanaco transport, processing, and consumption strategies in the southern coast of Tierra del Fuego (Argentina)]. Tesis de Licenciatura, Universidad de Buenos Aires (Argentina).
- Anderson, D. D. 1970. Microblade traditions in Northwestern Alaska. *Arctic Anthropology* 7 (2): 2–16.
- Anderson, D. D. 1972. An archaeological survey of Noatak Drainage, Alaska. *Arctic Anthropology* 9:66–118.
- Anderson, L., M. B. Abbott, B. P. Finney, and S. J. Burns. 2005. Regional atmospheric circulation change in the North Pacific during the Holocene inferred from lacustrine carbonate oxygen isotopes, Yukon Territory, Canada. *Quaternary Research* 64 (1):21–35. doi:[10.1016/j.yqres.2005.03.005](https://doi.org/10.1016/j.yqres.2005.03.005)
- Anderson, S., J. Jordan, and A. Freeburg. 2020. Human settlement and Mid–Late Holocene coastal environmental change at Cape Krusenstern, Northwest Alaska. *Quaternary International* 549:84–97. doi:[10.1016/j.quaint.2018.10.028](https://doi.org/10.1016/j.quaint.2018.10.028)
- Badding, M. E., J. P. Briner, and D. S. Kaufman. 2013. ¹⁰Be ages of late Pleistocene deglaciation and Neoglaciation in the north-central Brooks Range, Arctic Alaska. *Journal of Quaternary Science* 28 (1):95–102. doi:[10.1002/jqs.2596](https://doi.org/10.1002/jqs.2596)
- Barclay, D. J., G. C. Wiles, and P. E. Calkin. 2009. Holocene glacier fluctuations in Alaska. *Quaternary Science Reviews* 28 (21–22):2034–48. doi:[10.1016/j.quascirev.2009.01.016](https://doi.org/10.1016/j.quascirev.2009.01.016)
- Barton, L., S. Shirar, and J. Jordan. 2018. Holocene human occupation of the Central Alaska Peninsula. *Radiocarbon* 60 (2):367–82. doi:[10.1017/RDC.2018.2](https://doi.org/10.1017/RDC.2018.2)
- Bettinger, R. L., B. Winterhalder, and R. McElreath. 2006. A simple model of technological intensification. *Journal of Archaeological Science* 33 (4):538–45. doi:[10.1016/j.jas.2005.09.009](https://doi.org/10.1016/j.jas.2005.09.009)
- Binford, L. 1980. Willow smoke and dogs' tails: Hunter-gatherer settlement systems and archaeological site formation. *American Antiquity* 45 (1):4–20. doi:[10.2307/279653](https://doi.org/10.2307/279653)
- Bjerck, H. B. 2009. Colonizing seascapes: Comparative perspectives on the development of maritime relations in Scandinavia and Patagonia. *Arctic Anthropology* 46 (1–2):118–31. doi:[10.1353/arc.0.0019](https://doi.org/10.1353/arc.0.0019)

- Bjerck, H. B. 2017. Settlements and seafaring: Reflections on the integration of boats and settlements among marine foragers in early Mesolithic Norway and the Yámana of Tierra del Fuego. *The Journal of Island and Coastal Archaeology* 12 (2):276–99. doi:[10.1080/15564894.2016.1190425](https://doi.org/10.1080/15564894.2016.1190425)
- Bjerck, H. B., and A. F. Zangrando. 2013. Marine ventures: Comparative perspectives on the dynamics of early human approaches to the seascapes of Tierra del Fuego and Norway. *The Journal of Island and Coastal Archaeology* 8 (1):79–90. doi:[10.1080/15564894.2012.756083](https://doi.org/10.1080/15564894.2012.756083)
- Borrero, L. A. 1999. The prehistoric exploration and colonization of Fuego-Patagonia. *Journal of World Prehistory* 13 (3):321–55. doi:[10.1023/A:1022341730119](https://doi.org/10.1023/A:1022341730119)
- Borrero, L. A. 2001. *El poblamiento de la Patagonia: Toldos, milodones y volcanes* [The settlement of Patagonia: Canopies, milodons, and volcanoes]. Buenos Aires: Emecé Editores.
- Boyd, R., and P. J. Richerson. 1982. Cultural transmission and the evolution of cooperative behavior. *Human Ecology* 10 (3):325–51. doi:[10.1007/BF01531189](https://doi.org/10.1007/BF01531189)
- Bridges, E. L. 1948. *Uttermost part of the earth*. London: Hodder & Stoughton.
- Buonasera, T. Y., A. H. Tremayne, C. M. Darwent, J. W. Eerkens, and O. K. Mason. 2015. Lipid biomarkers and compound specific $\delta^{13}\text{C}$ analysis indicate early development of a dual-economic system for the Arctic Small Tool tradition in northern Alaska. *Journal of Archaeological Science* 61:129–38. doi:[10.1016/j.jas.2015.05.011](https://doi.org/10.1016/j.jas.2015.05.011)
- Candel, M. S., A. M. Borrromei, and S. Louwye. 2017. Reconstruction of the late Holocene paleo-environment of the western Beagle Channel (Argentina) based on a palynological analysis. *Quaternary International* 442:2–12. doi:[10.1016/j.quaint.2016.01.074](https://doi.org/10.1016/j.quaint.2016.01.074)
- Candel, M. S., A. M. Borrromei, and S. Louwye. 2018. Early to middle Holocene palaeoenvironmental reconstruction of the Beagle Channel (southernmost Argentina) based on terrestrial and marine palynomorphs. *Boreas* 47 (4):1072–83. doi:[10.1111/bor.12322](https://doi.org/10.1111/bor.12322)
- Casperson, M. R. 2017. Walrus, seal, and seabird faunal remains from Summit Island in Bristol Bay, Alaska: The subsistence practices of Norton peoples in an island environment (2740–980 Cal BP.). PhD diss., University of Oregon.
- Chapman, A. 1986. *Los Selk'nam: La vida de los Onas* [The Selk'nam: The life of the Onas]. Buenos Aires: Emecé editores.
- Chapman, A. 2010. *European encounters with the Yamana people of Cape Horn, before and after Darwin*. Cambridge: Cambridge University Press.
- Clark, J., and G. J. Linares-Matás. 2020. The role of landscape knowledge networks in the early Pleistocene technological variability of East Africa. *Archaeological Review from Cambridge* 35 (2):25–44.
- Collins, H. B., A. H. Clark, and E. H. Walker. 1945. *The Aleutian Islands: Their people and natural history*. Washington, DC: Smithsonian Institution.
- Crockford, S. 2008. Be careful what you ask for: Archaeozoological evidence of mid-Holocene climate change in the Bering Sea and implications for the origins of Arctic Thule. In *Islands of inquiry: Colonisation, seafaring and the archaeology of maritime landscapes*, ed. G. Clark, F. Leach, and S. O'Connor, 113–31. Canberra: ANU Press.
- Crockford, S., and G. Frederick. 2007. Sea ice expansion in the Bering Sea during the Neoglacial: Evidence from archaeozoology. *The Holocene* 17 (6):699–706. doi:[10.1177/0959683607080507](https://doi.org/10.1177/0959683607080507)
- Darwent, C. M., and J. Darwent. 2016. The enigmatic choris and old whaling cultures of the western Arctic. In *The Oxford handbook of the prehistoric Arctic*, ed. M. T. Friesen and O. K. Mason, 371–94. Oxford: Oxford University Press.
- Davis, B. L. 2001. Marine mammal hunting and the neoglacial: An archaeological study of environmental change and subsistence technology at Margaret Bay, Unalaska. *University of Oregon Anthropological Papers* 58:71–85.
- Davis, R., R. Knecht, and J. Rogers. 2016. First maritime cultures of the Aleutians. In *The Oxford handbook of the prehistoric Arctic*, ed. M. T. Friesen and O. K. Mason, 152–67. Oxford: Oxford University Press.
- de Vernal, A., and C. Hillaire-Marcel. 2000. Sea-ice cover, sea-surface salinity and halo-/thermocline structure of the northwest North Atlantic: Modern versus full glacial conditions. *Quaternary Science Reviews* 19 (1-5):65–85. doi:[10.1016/S0277-3791\(99\)00055-4](https://doi.org/10.1016/S0277-3791(99)00055-4)

- Dereck, M., and R. Boyd. 2016. Partial connectivity increases cultural accumulation within groups. *Proceedings of the National Academy of Sciences of the United States of America* 113 (11): 2982–7. doi:[10.1073/pnas.1518798113](https://doi.org/10.1073/pnas.1518798113)
- Dumond, D. E. 1987. *The Eskimos and Aleuts*. London: Thames and Hudson.
- Dumond, D. E. 2000. A southern origin for Norton culture? *Anthropological Papers of the University of Alaska* 25 (1-2):87–102.
- Dumond, D. E. 2016. Norton hunters and fisherfolk. In *The Oxford handbook of the prehistoric Arctic*, ed. M. T. Friesen and O. K. Mason, 230–41. Oxford: Oxford University Press.
- Earle, T. 2000. Archaeology, property, and prehistory. *Annual Review of Anthropology* 29 (1): 39–60. doi:[10.1146/annurev.anthro.29.1.39](https://doi.org/10.1146/annurev.anthro.29.1.39)
- Ellis, C. 2008. The fluted point tradition and the Arctic Small Tool tradition: What's the connection? *Journal of Anthropological Archaeology* 27 (3):298–314. doi:[10.1016/j.jaa.2008.05.002](https://doi.org/10.1016/j.jaa.2008.05.002)
- Fernández, M., J. F. Ponce, F. J. Zangrando, A. M. Borrromei, L. L. Musotto, D. Alunni, and M. Vázquez. 2020. Relationships between terrestrial animal exploitation, marine hunter-gatherers and palaeoenvironmental conditions during the Middle-Late Holocene in the Beagle Channel region (Tierra del Fuego). *Quaternary International* 549:208–17. doi:[10.1016/j.quaint.2018.05.032](https://doi.org/10.1016/j.quaint.2018.05.032)
- Fienup-Riordan, A. 1990. The bird and the bladder: The cosmology of central Yup'ik seal hunting. *Études/Inuit/Studies* 14:23–38.
- Fienup-Riordan, A. 1995. *Boundaries and passages: Rule and ritual in Yup'ik Eskimo oral tradition*. Norman: University of Oklahoma Press.
- Fienup-Riordan, A. 2005. *Yup'ik elders at the ethnologisches museum Berlin: Fieldwork turned on its head*. Seattle: University of Washington Press.
- Fienup-Riordan, A. 2007. *Yuungnaqpiallerput: The way we genuinely live*. Seattle, WA: University of Washington Press.
- Fienup-Riordan, A. 2011. *Qaluyaarmiuni Nunamtenek/Our Nelson island stories: Meanings of place on the Bering Sea Coast*. Seattle, WA: University of Washington Press.
- Fienup-Riordan, A., A. Rearden, and M. Knecht. 2015. Irr'inarqellriit/amazing things: Quinhagak elders reflect on their past. *Alaska Journal of Anthropology* 13 (2): 37–70.
- Fienup-Riordan, A., and A. Rearden. 2016. *Anguyiim Nalliini/Time of warring: The history of bow-and-arrow warfare in southwest Alaska*. Fairbanks: University of Alaska Press.
- Fienup-Riordan, A., A. Rearden, M. Meade, D. Chanar, R. Nayamin, and C. Joseph. 2020. *Nunakun-gguq Ciutengqertut/They say they have ears through the ground: Animal essays from southwest Alaska*. Fairbanks: University of Alaska Press.
- Finney, B. P., I. Gregory-Eaves, J. Sweetman, M. S. V. Douglas, and J. P. Smol. 2000. Impacts of climatic change and fishing on Pacific Salmon abundance over the past 300 years. *Science* 290 (5492):795–9. doi:[10.1126/science.290.5492.795](https://doi.org/10.1126/science.290.5492.795)
- Fitzhugh, B. 2003. *The evolution of complex hunter-gatherers: Archaeological evidence from the North Pacific*. New York: Kluwer Academic/Plenum Press.
- Fitzhugh, B. 2016. The origins and development of arctic maritime adaptations in the Subarctic and Arctic Pacific. In *The Oxford handbook of the prehistoric Arctic*, ed. M. T. Friesen and O. K. Mason, 254–78. Oxford: Oxford University Press.
- Fitzhugh, W. W., and S. A. Kaplan. 1982. *Inua: Spirit world of the Bering Sea Eskimo*. Washington, DC: Smithsonian Institution Press.
- Friesen, T. M., and O. K. Mason 2016. Introduction: Archaeology of the north American Arctic. In *The Oxford Handbook of the Prehistoric Arctic*, ed. T. M. Friesen and O. K. Mason, 7–21. New York: Oxford University Press.
- Furlong, C. W. 1917. Tribal distribution and settlements of the Fuegians, comprising nomenclature, etymology, philology, and populations. *Geographical Review* 3 (3):169–87. doi:[10.2307/207659](https://doi.org/10.2307/207659)
- Giddings, J. L. 1964. *The archaeology of Cape Denbigh*. Providence, RI: Brown University Press.
- Giddings, J. L., and D. D. Anderson. 1986. *Beach ridge archaeology of Cape Krusenstern: Eskimo and pre-Eskimo settlements around Kotzebue Sound, Alaska*. Publications in Archeology, 20. Washington, DC: National Park Service.

- Glassow, M. A. 1978. The concept of carrying capacity in the study of culture process. *Advances in Archaeological Method and Theory* 1:31–47.
- Granovetter, M. S. 1973. The strength of weak ties. *American Journal of Sociology* 78 (6):1360–80. doi:[10.1086/225469](https://doi.org/10.1086/225469)
- Grebmeier, J., J. E. Overland, S. E. Moore, E. V. Farley, E. C. Carmack, K. E. Frey, L. W. Cooper, J. H. Helle, F. A. McLaughlin, and S. L. McNutt. 2006. A major ecosystem shift in the northern Bering Sea. *Science* 311 (5766):1461–4. doi:[10.1126/science.1121365](https://doi.org/10.1126/science.1121365)
- Grønnow, B. 2012. The backbone of the Saqqaq culture: A study of the nonmaterial dimensions of the early Arctic Small Tool tradition. *Arctic Anthropology* 49:58–71.
- Grove, M. 2018. Hunter-gatherers adjust mobility to maintain contact under climatic variation. *Journal of Archaeological Science: Reports* 19:588–95. doi:[10.1016/j.jasrep.2018.04.003](https://doi.org/10.1016/j.jasrep.2018.04.003)
- Gusinde, M. 1982. *Los indios de Tierra del Fuego: Los Selk'nam* [The indigenous communities of Tierra del Fuego: The Selk'nam]. Buenos Aires: Centro Argentino de Etnología Americana (CAEA).
- Gusinde, M. 1990. *Los indios de Tierra del Fuego: Los Yámana* [The indigenous communities of Tierra del Fuego: The Yámana]. Buenos Aires: CAEA Editorial.
- Halstead, P., and J. O'Shea, eds. 1989. *Bad year economics. Cultural responses to risk and uncertainty*. Cambridge: Cambridge University Press.
- Hawkes, K., and J. F. O'Connell. 1992. On optimal foraging models and subsistence transitions. *Current Anthropology* 33 (1):63–6. doi:[10.1086/204035](https://doi.org/10.1086/204035)
- Hayden, B. 1972. Population control among hunter/gatherers. *World Archaeology* 4 (2):205–21. doi:[10.1080/00438243.1972.9979533](https://doi.org/10.1080/00438243.1972.9979533)
- Ingold, T. 1981. The hunter and his spear: Notes on the cultural mediation of social and ecological systems. In *Economic archaeology: Towards an integration of ecological and social approaches*, ed. A. Sheridan, 119–30. Oxford: BAR Publishing.
- Irving, W. N. 1964. Punyik point and the Arctic Small Tool tradition. PhD diss. University of Wisconsin-Madison.
- Jensen, A. M. 2012. The material culture of Iñupiat whaling: An ethnographic and ethnohistorical perspective. *Arctic Anthropology* 49 (2):143–61. doi:[10.1353/arc.2012.0020](https://doi.org/10.1353/arc.2012.0020)
- Jochelson, W. 1933. *History, ethnology and anthropology of the Aleut*. Washington, DC: Carnegie Institution of Washington.
- Kaufman, D. S., Y. L. Axford, A. C. G. Henderson, N. P. McKay, W. W. Oswald, C. Saenger, R. S. Anderson, H. L. Bailey, B. Clegg, K. Gajewski, et al. 2016. Holocene climate changes in eastern Beringia (NW North America)—A systematic review of multi-proxy evidence. *Quaternary Science Reviews* 147:312–39. doi:[10.1016/j.quascirev.2015.10.021](https://doi.org/10.1016/j.quascirev.2015.10.021)
- Kelly, R. 1995. *The foraging spectrum: Diversity in hunter-gatherer lifeways*. Washington, DC: Smithsonian Institution Press.
- Knecht, R. A., and R. S. Davis. 2001. A prehistoric sequence for the Eastern Aleutians. *University of Oregon Anthropological Papers* 58:269–88.
- Knecht, R., and W. Jones. 2019. “The old village”: Yup'ik precontact archaeology and community-based research at the Nunalleq Site, Quinhagak, Alaska. *Études/Inuit/Studies* 43 (1–2): 25–52. doi:[10.7202/1071939ar](https://doi.org/10.7202/1071939ar)
- Kochi, S. 2017. Paleodietas en cazadores-recolectores del canal Beagle durante el Holoceno tardío [Hunter-gatherer palaeodiets in the Beagle Channel during the Late Holocene]. *Intersecciones en Antropología* 18:329–39.
- Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006. World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift* 15 (3):259–63. doi:[10.1127/0941-2948/2006/0130](https://doi.org/10.1127/0941-2948/2006/0130)
- Krupnik, I., and M. A. Chlenov. 2009. Distant lands and brave pioneers: Original Thule migration revisited. In *On the track of the Thule culture from the Bering Strait to East Greenland: Proceedings of the SILA Conference “The Thule Culture - New Perspectives in Inuit Prehistory Copenhagen, Oct. 26th-28th, 2006. Papers in Honour of Hans Christian Gulløv*, ed. B. Grønnow, 15:11–24. Publications from the National Museum Studies in Archaeology & History. Copenhagen: PNM.

- Kunz, M. L. 2005. The Denbigh Flint complex at Punyik Point, Etivlik Lake, Alaska. *Alaska Journal of Anthropology* 3 (2):101–16.
- Lanata, J. L. 1990. Humans and terrestrial and marine mammals at Península Mitre, Tierra del Fuego. In *Hunters of the recent past*, ed. L. B. Davis and B. O. K. Keeves, 400–6. London: Unwin Hyman.
- Lantis, M. 1990. The selection of symbolic Meaning. *Études/Inuit/Studies* 14 (1/2): 169–189. <https://www.jstor.org/stable/42869687>
- Larsen, H. 1968. *Trail creek: Final report on the excavation of two caves on Seward Peninsula, Alaska. Acta Arctica Fascicula, 15*. Copenhagen: Ejnar Munksgaard.
- Ledger, P. M., and V. Forbes. 2019. Paleoenvironmental Analyses from Nunalleq, Alaska illustrate a novel means to date pre-Inuit and Inuit archaeology. *Arctic Anthropology* 56 (2):39–51. doi:10.3368/aa.56.2.39
- Lefèvre, C. 2008. Aleut hunters, sea otters, and sea cows: Three thousands years of interactions in the Western Aleutian Islands, Alaska. In *Human impacts on ancient marine ecosystems: A global perspective*, ed. T. C. Rick and J. M. Erlandson, 43–75. Berkeley: University of California Press.
- Legoupil, D, ed. 2003. *Cazadores-recolectores de Ponsonby (Patagonia austral) y su paleoambiente desde VI al III milenio A.C. Magallania, 31* [Hunter-gatherers at Ponsonby (southern Patagonia) and their palaeoenvironment from the sixth to the third millennium BC]. Punta Arenas: Universidad de Magallanes.
- Legge, S. S. 2010. Brief communication: Transportation and trauma: Dog-sledding and vertebral compression in Alaskan Eskimos. *American Journal of Physical Anthropology* 141 (4):632–7. doi:10.1002/ajpa.21220
- Lewis, J. P., D. B. Ryves, P. Rasmussen, J. Olsen, L. G. van der Sluis, P. J. Reimer, K.-L. Knudsen, S. McGowan, N. J. Anderson, and S. Juggins. 2020. Marine resource abundance drove pre-agricultural population increase in Stone Age Scandinavia. *Nature Communications* 11 (1):2006. doi:10.1038/s41467-020-15621-1
- Lim, J. S., S. Gleason, W. Jones, and W. Church. 2021. *Nuna Nalluyuituq* (The Land Remembers): Remembering landscapes and refining methodologies through community-based remote sensing in the Yukon-Kuskokwim Delta, Southwest Alaska. *Archaeological Prospection* 28 (3):339–55. doi:10.1002/arp.1840
- Lim, J. S., and G. J. Linares-Matás. 2021. Using open spatial data to investigate the importance of Salmon streams in the Indigenous cultural landscapes of Southwest Alaska. SocArXiv, May 26. doi:10.31235/osf.io/2ba6t
- Linares-Matás, G. J., and J. Clark. 2021. Seasonality and Oldowan behavioral variability in East Africa. *Journal of Human Evolution* :103070 doi:10.1016/j.jhevol.2021.103070. PMC: 34548178
- Liu, Z., K. Yoshimura, G. J. Bowen, N. H. Buenning, C. Risi, J. M. Welker, and F. Yuan. 2014. Paired oxygen isotope records reveal modern North American atmospheric dynamics during the Holocene. *Nature Communications* 5:3701. doi:10.1038/ncomms4701
- Lothrop, S. K. 1928. *The Indians of Tierra del Fuego*. Ushuaia: Zagier & Urruty.
- Lucier, C. V., and J. W. VanStone. 1995. *Traditional Beluga drives of the Iñupiat of Kotzebue Sound, Alaska*. Chicago: Field Museum of Natural History.
- Lycett, S. J. 2014. Dynamics of cultural transmission in Native Americans of the high great plains. *PLoS One* 9 (11):e112244. doi:10.1371/journal.pone.0112244
- Maldonado, J. K., C. Shearer, R. Bronen, K. Peterson, and H. Lazrus. 2013. The impact of climate change on tribal communities in the US: Displacement, relocation, and human rights. In *Climate change and indigenous peoples in the United States*, ed. J. K. Maldonado, B. Colombi, and R. Pandya, 93–106. Cham: Springer
- Mansur, M. E., and V. Parmigiani. 2014. Pielas y cueros [Furs and leather]. In *Cadenas operativas en la producción y uso de bienes por los pueblos originarios de Tierra del Fuego*, 89. Coyhaique: Proceedings of the IX Jornadas de Arqueología de la Patagonia.
- Martinoli, M. P. 2018. Modalidades de explotación, procesamiento y consumo de pinnípedos en la margen meridional de Tierra del Fuego [Modes of pinniped exploitation, processing and

- consumption in the southern margin of Tierra del Fuego]. PhD diss., Centro Austral de Investigaciones Científicas (Universidad de Buenos Aires, Argentina).
- Maschner, H. D. G. 2016. Archaeology of the Eastern Aleut Region. In *The Oxford handbook of the prehistoric Arctic*, ed. T. M. Friesen and O. K. Mason, 182–99. New York: Oxford University Press.
- Maschner, H. D. G., M. W. Betts, J. Cornell, J. A. Dunne, B. Finney, N. Huntly, J. W. Jordan, A. A. King, N. Misarti, K. L. Reedy-Maschner, et al. 2009. An introduction to the biocomplexity of Sanak Island, Western Gulf of Alaska 1. *Pacific Science* 63 (4):673–709. doi:[10.2984/049.063.0410](https://doi.org/10.2984/049.063.0410)
- Mason, O. K. 1998. The contest between the Ipiutak, Old Bering Sea, and Birnirk polities and the origin of whaling during the first millennium AD along the Bering Strait. *Journal of Anthropological Archaeology* 17 (3):240–325. doi:[10.1006/jaar.1998.0324](https://doi.org/10.1006/jaar.1998.0324)
- Masson-MacLean, E., C. Houmard, R. Knecht, I. Sidéra, K. Dobney, and K. Britton. 2020. Pre-contact adaptations to the Little Ice Age in Southwest Alaska: New evidence from the Nunalleq site. *Quaternary International* 549:130–41. doi:[10.1016/j.quaint.2019.05.003](https://doi.org/10.1016/j.quaint.2019.05.003)
- McCartney, A. P. 1975. Maritime adaptations in cold archipelagos. In *Prehistoric maritime adaptations of the circumpolar zone*, ed. W. W. Fitzhugh, 281–338. The Hague: Mouton.
- McGhee, R. ed. 2005. *The last imaginary place: A human history of the Arctic world*. Chicago: University of Chicago Press.
- McKay, J. L. M. L., A. de Vernal, C. H.-M. Hillaire-Marcel, C. N. Not, L. P. Polyak, and D. D. Darby. 2008. Holocene fluctuations in Arctic sea-ice cover: Dinocyst-based reconstructions for the eastern Chukchi Sea. GEOTOP Publication 2008-0023. *Canadian Journal of Earth Sciences* 45 (11):1377–97. doi:[10.1139/E08-046](https://doi.org/10.1139/E08-046)
- McKay, N. P., and D. S. Kaufman. 2009. Holocene climate and glacier variability at Hallet and Greyling Lakes, Chugach Mountains, south-central Alaska. *Journal of Paleolimnology* 41 (1): 143–59. doi:[10.1007/s10933-008-9260-0](https://doi.org/10.1007/s10933-008-9260-0)
- McKay, N. P., D. S. Kaufman, C. C. Routson, M. P. Erb, and P. D. Zander. 2018. The onset and rate of Holocene neoglaciation cooling in the Arctic. *Geophysical Research Letters* 45 (22): 12487–496. doi:[10.1029/2018GL079773](https://doi.org/10.1029/2018GL079773)
- Mercer, J. 1976. Glacial history of southernmost South America. *Quaternary Research* 6 (2): 125–6. doi:[10.1016/0033-5894\(76\)90047-8](https://doi.org/10.1016/0033-5894(76)90047-8)
- Miszaniec, J. I., J. Darwent, and C. M. Darwent. 2021. Small game, estuaries, and nets: New perspectives on Norton culture coastal adaptations from a shell midden in Norton Sound, Alaska. *The Journal of Island and Coastal Archaeology* 16 (2-4):317–41. doi:[10.1080/15564894.2019.1701148](https://doi.org/10.1080/15564894.2019.1701148)
- Muñoz, S. A. 2012. Guanaco butchering by hunter-gatherers from Isla Grande de Tierra del Fuego, Southern Patagonia. In *Bones for tools—Tools for bones: The interplay between objects and objectives*, ed. K. Seetah and B. Gravina, 75–86. Cambridge: McDonald Institute for Archaeological Research Monographs.
- Nelson, R. K. 1969. *Hunters of the northern ice*. Chicago: University of Chicago Press.
- Nuttall, M. 2000. Becoming a hunter in Greenland. *Études/Inuit/Studies* 24 (2):33–45.
- Oceana and Kawerak. 2014. *Bering Strait marine life and subsistence use: Data synthesis*. Juneau, Alaska: Oceana & Kawerak, Inc.
- Orquera, L. A. 2005. Mid-Holocene littoral adaptation at the southern end of South America. *Quaternary International* 132 (1):107–15. doi:[10.1016/j.quaint.2004.07.019](https://doi.org/10.1016/j.quaint.2004.07.019)
- Orquera, L. A., D. Legoupil, and E. L. Piana. 2011. Littoral adaptation at the southern end of South America. *Quaternary International* 239 (1-2):61–9. doi:[10.1016/j.quaint.2011.02.032](https://doi.org/10.1016/j.quaint.2011.02.032)
- Orquera, L. A., and E. L. Piana. 1999. *Arqueología de la región del canal Beagle (Tierra del Fuego, Argentina)* [Archaeology of the Beagle Channel region (Tierra del Fuego, Argentina)]. Buenos Aires: Sociedad Argentina de Antropología.
- Orquera, L. A., and E. L. Piana. 2009. Sea nomads of the Beagle Channel in Southernmost South America: Over six thousand years of coastal adaptation and stability. *The Journal of Island and Coastal Archaeology* 4 (1):61–81. doi:[10.1080/15564890902789882](https://doi.org/10.1080/15564890902789882)
- Ozán, I. L., and M. C. Pallo. 2019. Past human populations and landscapes in the Fuegian Archipelago, southernmost South America. *Quaternary Research* 92 (2):304–22. doi:[10.1017/qua.2018.157](https://doi.org/10.1017/qua.2018.157)

- Parmigiani, V., M. C. Álvarez-Soncini, M. E. Mansur, and M. P. Martinoli. 2017. El Procesamiento de Cueros de Lobo Marino (*Arctocephalus australis*) entre los Canoeros Magallánico-Fueguinos: Una Evaluación Experimental [Patagonian sea lion (*Arctocephalus australis*) leather processing among the communities of Tierra del Fuego and the Strait of Magellan: An experimental assessment]. *Boletín de Arqueología Experimental* 12:95–134.
- Partlow, M. 2000. Salmon intensification and changing household organisation in the Kodiak Archipelago. PhD diss., University of Wisconsin-Madison.
- Pendall, E., V. Markgraf, J. W. C. White, M. Dreier, and R. Kenny. 2001. Multiproxy record of late Pleistocene-Holocene climate and vegetation changes from a peat bog in Patagonia. *Quaternary Research* 55 (2):168–78. doi:[10.1006/qres.2000.2206](https://doi.org/10.1006/qres.2000.2206)
- Piana, E. L., M. M. Vázquez, A. M. Tivoli. 2007. Dieta y algo más: Animales pequeños y variabilidad del comportamiento humano en el canal Beagle [Diet and beyond: Small animals and human behavioural variability in the Beagle Channel]. En *Arqueología de Fuego-Patagonia. Levantando piedras, desenterrando huesos... y develando arcanos*, ed. F. Morello, M. Martinic, A. Prieto, and G. Bahamondes, 39–50. Punta Arenas: CEQUA.
- Porter, S. C. 2013. Neoglaciation in the American Cordilleras. In *Encyclopedia of Quaternary science*, ed. S. A. Elias and C. J. Mock, 2nd ed., 269–76. Amsterdam: Elsevier.
- Savelle, J. M., and A. P. McCartney. 2003. Prehistoric bowhead whaling in the Bering Strait and Chukchi Sea regions of Alaska: A zooarchaeological assessment. In *Indigenous ways to the present: Native whaling in the Western Arctic*, ed. A. P. McCartney, 167–84. Edmonton: Canadian Circumpolar Institute Press.
- Schiavini, A. 1990. Estudio de la relación entre el hombre y los pinnípedos en el proceso adaptativo humano del canal Beagle (Tierra del Fuego, Argentina) [Study of the relationship between humans and pinnipeds in adaptation processes at the Beagle Channel]. PhD diss., Universidad de Buenos Aires, Argentina.
- Schiavini, A. 1993. Los lobos marinos como recurso para cazadores-recolectores marinos: El caso de Tierra del Fuego [Patagonian sea lions as a resource for maritime hunter-gatherers. Tierra del Fuego as a case-study]. *Latin American Antiquity* 4 (4):346–66. doi:[10.2307/972072](https://doi.org/10.2307/972072)
- Shaw, R. D. 1982. The expansion and survival of the Norton Tradition on the Yukon-Kuskokwim Delta. *Arctic Anthropology* 19 (2):59–74.
- Sheppard, W. L. 1986. Variability in historic Norton bay subsistence and settlement. PhD diss., Northwestern University, Chicago.
- Sloan, A. 2019. Gender, subsistence, change, and resilience in Quinhagak's present and past. *Études/Inuit/Studies* 43 (1-2):243–64. doi:[10.7202/1071947ar](https://doi.org/10.7202/1071947ar)
- Solomina, O. N., R. S. Bradley, D. A. Hodgson, S. Ivy-Ochs, V. Jomelli, A. N. Mackintosh, A. Nesje, L. A. Owen, H. Wanner, G. C. Wiles, et al. 2015. Holocene glacier fluctuations. *Quaternary Science Reviews* 111:9–34. doi:[10.1016/j.quascirev.2014.11.018](https://doi.org/10.1016/j.quascirev.2014.11.018)
- Spears, J. 1895. *The gold diggings of Cape Horn: A study of Life in Tierra del Fuego and Patagonia*. New York: G. P. Putnam's Sons.
- Speth, J. D., and K. A. Spielmann. 1983. Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Research* 2:1–31.
- Steffian, A., P. Saltonstall, and L. F. Yarborough. 2016. Maritime economies of the central Gulf of Alaska after 4000 BP. In *The Oxford handbook of the prehistoric Arctic*, ed. M. T. Friesen and O. K. Mason, 304–22. Oxford: Oxford University Press.
- Tivoli, A. M. 2010. Exploitation of bird resources among prehistoric sea-nomad societies of the Beagle Channel region, southern South America. *Before Farming* 2010 (2):1–12. doi:[10.3828/bfarm.2010.2.3](https://doi.org/10.3828/bfarm.2010.2.3)
- Tivoli, A. M., and A. F. J. Zangrando. 2011. Subsistence variations and landscape use among maritime hunter-gatherers: A zooarchaeological analysis from the Beagle Channel (Tierra del Fuego, Argentina). *Journal of Archaeological Science* 38 (5):1148–56. doi:[10.1016/j.jas.2010.12.018](https://doi.org/10.1016/j.jas.2010.12.018)
- Torres, J., K. Mahé, J. L. Dufour, P. Béarez, and M. San Román. 2020. Characterizing seasonal fishing patterns and growth dynamics during the Middle and Late Holocene in the Strait of Magellan (Chilean Patagonia): Sclerochronological analysis of tadpole codling (*Salilota australis*) vertebrae. *The Journal of Island and Coastal Archaeology*, 1–20. doi:[10.1080/15564894.2020.1755393](https://doi.org/10.1080/15564894.2020.1755393)

- Tremayne, A. H. 2018. Marine resource intensification and the reorganization of lithic technologies during the Middle-Late Holocene in Northwest Alaska. *The Journal of Island and Coastal Archaeology* 13 (4):457–73. doi:[10.1080/15564894.2017.1278730](https://doi.org/10.1080/15564894.2017.1278730)
- Tremayne, A. H., and W. Brown. 2017. Mid to late Holocene population trends, culture change and marine resource intensification in Western Alaska. *Arctic* 70 (4):365–80. doi:[10.14430/arctic4681](https://doi.org/10.14430/arctic4681)
- Tremayne, A. H., C. M. Darwent, J. Darwent, K. A. Eldridge, and J. T. Rasic. 2018. Iyatayet revisited: A report on renewed investigations of a stratified middle-to-late Holocene coastal campsite in Norton Sound, Alaska. *Arctic Anthropology* 55 (1):1–23. doi:[10.3368/aa.55.1.1](https://doi.org/10.3368/aa.55.1.1)
- Tremayne, A. H., and B. Winterhalder. 2017. Large mammal biomass predicts the changing distribution of hunter-gatherer settlements in mid late Holocene Alaska. *Journal of Anthropological Archaeology* 45:81–97. doi:[10.1016/j.jaa.2016.11.006](https://doi.org/10.1016/j.jaa.2016.11.006)
- Tyrrell, M. 2005. Inuit perception, knowledge and use of the sea in Arviat, Nunavut. PhD diss., University of Aberdeen.
- Ugan, A., J. Bright, and A. Rogers. 2003. When is technology worth the trouble? *Journal of Archaeological Science* 30 (10):1315–29. doi:[10.1016/S0305-4403\(03\)00022-0](https://doi.org/10.1016/S0305-4403(03)00022-0)
- Vairo, C. P. 1995. *Los Yamana: Nuestra única tradición naval marítima autóctona* [The Yamana: Our only autochthonous maritime naval tradition]. Ushuaia: Zagier & Urruty.
- VanderHoek, R. 2009. The role of ecological barriers in the development of cultural boundaries during the later Holocene of the central Alaska Peninsula. PhD diss., University of Illinois at Urbana-Champaign.
- Vázquez, M. 2015. Guanacos en el segundo componente de Túnel I (Canal Beagle): Un enfoque tafonómico [Guanacos in the Second Component of Túnel I (Beagle Channel): A taphonomic perspective]. *Magallania (Punta Arenas)* 43 (1):251–77. doi:[10.4067/S0718-22442015000100014](https://doi.org/10.4067/S0718-22442015000100014)
- Vázquez, M., A. F. Zangrando, A. Tessone, and A. Ceraso. 2011. Arqueología de la costa meridional de Península Mitre [Archaeology of the Mitre Peninsula's southern shore]. In *Los cazadores-recolectores del extremo oriental fueguino. Arqueología de Península Mitre e Isla de los Estados*, ed. M. Vázquez, A. F. Zangrando, and A. Tessone, 203–30. Buenos Aires: Sociedad Argentina de Antropología.
- Wahl, J., and I. Trautmann. 2012. The Neolithic massacre at Talheim: A pivotal find in conflict archaeology. In *Sticks, stones and broken bones: Neolithic violence in a European perspective*, ed. R. Schulting and L. Fibiger, 77–100. Oxford: Oxford University Press.
- West, D., V. Hatfield, E. Wilmerding, C. Lefèvre, and L. Gualteri. 2012. *The people before: The geology, paleoecology and archaeology of Adak Island, Alaska*. Oxford: British Archaeological Reports.
- Winterhalder, B., and E. A. Smith. 1981. *Hunter-gatherer foraging strategies: Ethnographic and archaeological analyses*. Chicago, IL: University of Chicago Press.
- Yesner, D. R. 2004. Prehistoric maritime adaptations of the subarctic and subantarctic zones: The Aleutian/Fuegian connection reconsidered. *Arctic Anthropology* 41 (2):76–97. doi:[10.1353/arc.2011.0097](https://doi.org/10.1353/arc.2011.0097)
- Zangrando, A. F. 2009. *Historia evolutiva y subsistencia de cazadores-recolectores marítimos de Tierra del Fuego* [Evolutionary history and subsistence of maritime hunter-gatherers in Tierra del Fuego]. Buenos Aires: Sociedad Argentina de Antropología.
- Zangrando, A. F. 2010. Coastal archaeology and hunter-gatherers in Southeastern Tierra del Fuego. *The Journal of Island and Coastal Archaeology* 5 (2):288–91. doi:[10.1080/15564894.2010.487360](https://doi.org/10.1080/15564894.2010.487360)
- Zangrando, A. F., K. Borrazzo, A. Tivoli, D. V. Alunni, and M. P. Martinoli. 2013. El sitio Heshkaia 35: Nuevos datos sobre la arqueología de Moat (Tierra del Fuego, Argentina) [The Heshkaia 35 site: New data on the archaeology of Moat (Tierra del Fuego, Argentina)]. *Revista del Museo de Antropología* 7:11–24.
- Zangrando, A. F., J. F. Ponce, M. P. Martinoli, A. Montes, E. Piana, and F. Vanella. 2016. Palaeogeographic changes drove prehistoric fishing practices in the Cambaceres Bay (Tierra del Fuego, Argentina) during the middle and late Holocene. *Environmental Archaeology* 21 (2): 182–92. doi:[10.1080/14614103.2015.1130888](https://doi.org/10.1080/14614103.2015.1130888)
- Zangrando, A. F., L. Riccialdelli, S. Kochi, J. W. Nye, and A. Tessone. 2016. Stable isotope evidence supports pelagic fishing by hunter-gatherers in southern South America during the Late Holocene. *Journal of Archaeological Science: Reports* 8:486–91. doi:[10.1016/j.jasrep.2016.05.015](https://doi.org/10.1016/j.jasrep.2016.05.015)