



A concise review of lobster utilization by worldwide human populations from prehistory to the modern era

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Spanier, E., Lavalli, K. L., Goldstein, J. S., Groeneveld, J. C., Jordaan, G. L., Jones, C. M., Phillips, B. F., Bianchini, M. L., Kibler, R. D., Díaz, D., Mallol, S., Goñi, R., van Der Meeren, G. I., Agnalt, A-L., Behringer, D. C., Keegan, W. F., and Jeffs, A. A concise review of lobster utilization by worldwide human populations from prehistory to the modern era. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv066.

Received 9 November 2014; revised 18 March 2015; accepted 25 March 2015.

Lobsters are important resources throughout the world's oceans, providing food security, employment, and a trading commodity. Whereas marine biologists generally focus on modern impacts of fisheries, here we explore the deep history of lobster exploitation by prehistorical humans and ancient civilizations, through the first half of the 20th century. Evidence of lobster use comprises midden remains, artwork, artefacts, writings about lobsters, and written sources describing the fishing practices of indigenous peoples. Evidence from archaeological dig sites is potentially biased because lobster shells are relatively thin and easily degraded in most midden soils; in some cases, they may have been used as fertilizer for crops instead of being dumped in middens. Lobsters were a valuable food and economic resource for early coastal peoples, and ancient Greek and Roman Mediterranean civilizations amassed considerable knowledge of their biology and fisheries. Before European contact, lobsters were utilized by indigenous societies in the Americas, southern Africa, Australia, and New Zealand at seemingly sustainable levels, even while other fish and molluscan species may have been overfished. All written records suggest that coastal lobster populations were dense, even in the presence of abundant and large groundfish predators, and that lobsters were much larger than at present. Lobsters gained a reputation as "food for the poor" in 17th and 18th century Europe and parts of North America, but became a fashionable seafood commodity during the mid-19th century.

High demand led to intensified fishing effort with improved fishing gear and boats, and advances in preservation and long-distance transport. By the early 20th century, coastal stocks were overfished in many places and average lobster size was significantly reduced. With overfishing came attempts to regulate fisheries, which have varied over time and have met with limited success.

Keywords: Africa, Americas, ancient era, Australia, Europe, fisheries, human utilization, lobsters, Mediterranean, middle ages, modern era, New Zealand, prehistory, zoo-archaeology.

Introduction

Lobsters have been a part of the world's seascape for millions of years with their origins (likely Polychelida) appearing in the Devonian [~ 409 – 372 million years ago (MYA)]. Early forms were probably deep water species, much as living polychelids are today (Bracken-Grissom *et al.*, 2014). The Achelata appeared ~ 391 – 351 MYA, but did not diverge into the palinurid and scyllarid lineages until the Permian (~ 250 MYA) (Patek *et al.*, 2006; Bracken-Grissom *et al.*, 2014). Palinurids underwent a rapid diversification in the Upper Jurassic (~ 200 – 160 MYA), which coincided with the breakup of Pangea and formation of many new habitats (George and Main, 1967; Patek and Oakley, 2003; Bracken-Grissom *et al.*, 2014). Fossil remains of scyllarids date back to the mid-Cretaceous (~ 100 – 120 MYA; Glaessner, 1969; Webber and Booth, 2007) and those of nephropids to the Lower Cretaceous (Wahle *et al.*, 2012). Nephropids may have been more common in shallow shelf waters during the Cretaceous than at present, because of the subsequent invasion of these environments by predatory fish and competing brachyuran crabs (Vermeij, 1977; Wahle *et al.*, 2012).

Most lobster stocks are currently exploited by humans, some to the point of overexploitation, and management schemes often seek to restore natural populations and their ecosystems. Therefore, understanding the history of human impacts on lobster stocks might provide valuable information to guide restoration and fishery practices. Erlandson and Rick (2010) suggested that modern views of ancient human impacts on marine fauna are biased by the belief that humans were not populous enough, nor technologically

advanced enough to significantly deplete exploited species. Yet more recent case studies from around the world (reviewed in Erlandson and Rick, 2010) demonstrate that humans modified pre-historical marine ecosystems by removing keystone predators, reducing the size of finfish and shellfish, and causing local extinctions of seabirds and marine mammals. This review seeks to reconstruct how humans came to exploit lobsters as they dispersed throughout the world and tries, when possible, to point out areas where fishing practices were seemingly sustainable and where overexploitation happened early on, before more modern fishing techniques. It follows the chronological migratory patterns of humans into specific regions to discuss the practices of the indigenous peoples and then covers how European colonization altered traditional fishing methods, the local seascapes, and, ultimately, lobster populations. The time line is divided into sections for prehistoric, ancient, middle age, and up to the introduction of modern fisheries. This is done by examining archeological data in the form of midden findings, ancient artwork and rituals, oral traditions, and written records.

A brief review of human dispersal

Current dispersal models based on dated remains suggest that archaic, anatomically modern humans (AMHs) left the African Rift Valley in several pulses and migrated west- and southward to the coasts of Africa, and then eastward to the Levant (Armitage *et al.*, 2011; Figure 1). From there, migrants continued eastward along the Indian coast to colonize various Asian Pacific islands, Australia, and the Chinese coast. Others migrated inland to colonize

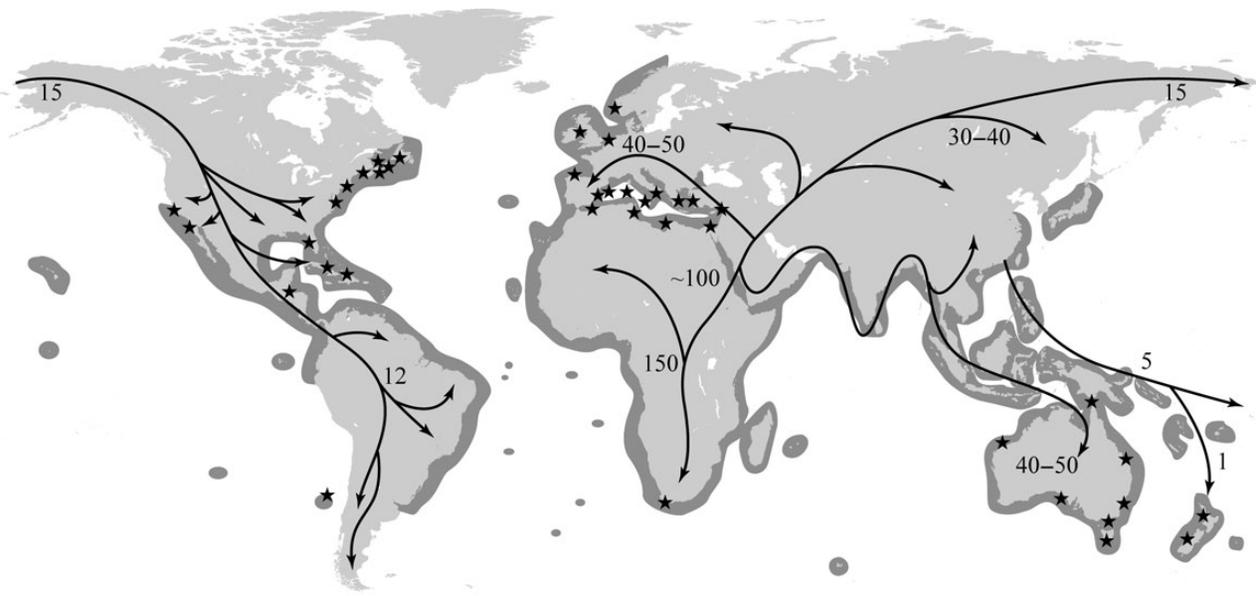


Figure 1. Migratory pattern of AMHs (arrows with dates based on DNA evidence) overlaid with coastal species of lobster distribution (dark grey area, present-day depth distribution of 10 m or less of commercial species of lobster according to Holthuis, 1991). Stars indicate areas where we have evidence of use of lobster by indigenous peoples.

the interior regions of China and Siberia. Migrating Levantine peoples also hugged the Mediterranean coastline to colonize modern-day Turkey, Romania, and southern Europe. The Americas were only recently colonized when ice sheets extending over much of Canada receded. Peoples from Siberia and Asia moved across Beringia, with some moving along the northwest coast of North America to Central and South America, and others spreading over the North American plains (Eriksson *et al.*, 2012). Movements in South America followed the Pacific coastline, until reaching the Patagonian glaciers, whereupon migrants crossed the Andes and continued southward along the Atlantic coast (de Sainte Pierre *et al.*, 2012).

Coastlines at the time of the first migrations out of Africa were more extensive than today because of the last Ice Age that ended ~18 000 years ago. Migrants using land-bridges to move from continent to continent or islands and those using coastlines as pathways would have used marine resources as a relatively accessible food source, if fishing techniques and/or swimming had been mastered. Evidence of fishing technology used by *Homo erectus* has been found in Zaire (Yellen *et al.*, 1995) and Southeast Asia (Morwood *et al.*, 1998). More evidence comes from Middle Stone Age sites in South Africa (Henshilwood *et al.*, 2004; Marean *et al.*, 2007), Neanderthal sites off Gibraltar and the Mediterranean (125 000–30 000 years ago; Garrod *et al.*, 1928; Stringer *et al.*, 2008), and Australia (40 000–30 000 years ago; Jones, 1992). Boating technology was more advanced than previously thought since pelagic fish were exploited by some Pacific islanders 40 000 years ago (O'Connor *et al.*, 2011). Based on midden analysis, fish, molluscs, sea turtles, and marine mammal (dugongs, seals) were seemingly more commonly exploited than lobsters (Klein *et al.*, 2004). However, the absence of lobster remains in middens may be due not to lack of use, but rather to differences in preservation of lobster tissue and/or differences in how lobster remains were used compared with fish, bird, turtle, mollusc, or marine mammal remains.

Sampling issues

Many extant spiny (Palinuridae), clawed (Nephropidae), and slipper (Scyllaridae) lobsters overlap the migratory pathways taken by AMHs (Figure 1). However, determining the diets of migratory hunter-gatherers is difficult, and evidence of shellfish consumption (incl. lobsters) dates only from the development of relatively permanent settlements with midden heaps (“kitchen remains”). Fish bones and mollusc shells are common in prehistorical and historical middens and have often been identified and analysed to species level. Taxa with more fragile shells, such as echinoderms and crustaceans, have been largely ignored in most of the zoo-archaeological literature (e.g. Zugasti, 2011). One reason for this is the composition of the relatively thin exoskeletons (compared with thicker mollusc shells), which degrade and dissolve over time, leaving no recognizable remains in archaeological digs. Carbonic acid, formed by the interaction of rainwater and CO₂, removes all but the thickest shell fragments, leaving behind only parts of lobster claws, mandibles, and possibly gastric mill teeth. Middens in dry sites, such as caves protected from rain, may retain fragments for thousands of years, although it is sometimes difficult to separate lobster from crab fragments without DNA analysis. Lobster mandibles also appear to be well preserved in alkaline soils, such as those found in ash layers and shell middens (Leach and Boocock, 1993).

Because of rapid decomposition in non-optimal soils, lobster remains will be rare in typical middens; however, an additional



Figure 2. Example of calcified lobster mouthpart (opposed left and right grinding plates). These are one of the few elements of the exoskeleton that survive in the archaeological record.

bias can occur during screening when objects are removed from the sieved matrix. If objects are not recognized as potentially identifiable, fragments may be discarded, and thus shell bits may fail to be set aside for further examination or even considered relevant. Leach and Boocock (1993) argue that lack of knowledge on the part of archaeologists has led to the discard of lobster shell fragments at many sites in the past. In addition, the remains may differ among lobster families. For example, slipper lobsters (Scyllaridae) have thicker exoskeleton than spiny lobsters (Palinuridae) and especially clawed lobsters (Nephropidae; e.g. Barshaw *et al.*, 2003; Tarsitano *et al.*, 2006), but they lack heavily calcified mandibles of palinurids or the claws of nephropids. Thus, evidence of their use may be difficult to assess from midden samples alone. Remains of lobster mandibles in middens can date to over 11 000 years ago (Jerardino and Navarro, 2002; Figure 2), which is far less than that of fish bones that can date up to 75 000 years ago (Yellen *et al.*, 1995). Also, the assumption that lobster remains should be found only in middens is not necessarily correct, especially for indigenous peoples who practiced agriculture. In those cultures, lobster exoskeletons may have been spread over fields as fertilizer, in which case they would have completely degraded. Furthermore, some indigenous peoples had strictures of how to treat the remains of animals from whence they obtained food, and often for marine species, this meant returning the remains to the sea (Maillard, 1863). Hence, it remains unclear whether the scarcity (or absence) of lobsters in some archaeological records is caused by their inaccessibility to ancient fishers, or avoidance by ancient peoples, or decomposition of exoskeletons, or sampling bias. This means that for some parts of the world, evidence of use may focus more strongly on written and oral records and/or artwork.

Use of lobsters worldwide

Southern Africa

The Cape west coast is influenced by the northwards flowing cool-temperate Benguella Current and nutrient-rich upwelling systems, which support abundant marine life. Rocky shores and shallow subtidal kelp forests shelter an abundance of shellfish, including dense mussel beds and the endemic Cape rock lobster, *Jasus lalandii*. These

shellfish occur in inter- and shallow subtidal habitats, where they can easily be collected by hand, without the use of specialized tools.

Prehistorical era

Early human use of marine resources in South Africa date from ~165 000 years ago, during the Middle Pleistocene (Marean *et al.*, 2007). Middle Stone Age sites along the Cape west coast also confirm that subsistence harvesting of coastal resources is very ancient, based on well-developed shell middens dated to ~70 000 years ago. Preserved calcareous mandibles in middens confirm that lobsters were exploited by early hunter-gatherers over the past 15 000 years (Jerardino *et al.*, 2008). Mandible size has been used to estimate lobster carapace length and past exploitation rates (Jerardino *et al.*, 2001, 2008; Jerardino and Navarro, 2002; Jerardino, 2010a). Middens show increasing human settlement in west coast cave sites and shelters that gathered deposits between 5000 and 3000 years ago (Jerardino, 2010b). A megamidden period (large shell middens; many marine shells; low densities of artefacts) between 3000 and 2000 years ago show an intensified reliance on marine resources, including lobster, and a full range of settlement, subsistence, and new cultural, social, and economic developments (Jerardino, 2010a, b). Human habitation in this area decreased between 2000 and 500 years ago, thus concluding the Late Stone Age lifestyle before the arrival of European settlers (Jerardino *et al.*, 2009).

Introduction of modern fisheries

The Cape was first colonized by Dutch settlers in 1652, bringing them into contact with the local Khoi-San, and “strandlopers” (beach-wanderers) or “strand bosjemans” (beach bushmen; Brink, 2004). Pappé (1853) reported that rock lobster “was easily caught in vast numbers all the year round” and that they had a proclivity for massing at the sewer outfalls in Table Bay. Colonists considered lobster to be a “regular godsend” to misers and the poor classes of the community (Melville-Smith and Van Sittert, 2005), and this negative connotation persisted until lobster meat became popular with the bourgeois in Europe. Commercial exploitation of *J. lalandii* began in 1875, when a processing plant was established in Cape Town to can lobsters for export to Europe. Weights of canned, frozen, tailed, and live lobster exported from South Africa have been reported since 1891, leaving a record of most commercial landings for over a century (Melville-Smith and Van Sittert, 2005). Growth and modernization of the fishing fleet and processing plants during and after World War II led to peak landings of 17 000 t year⁻¹ in the early 1950s. Since then commercial landings have declined to between 10 and 15% of what they were at the height of the fishery. The biomass of lobsters above the legal minimum size is currently at 3.5% of pristine levels (DAFF, 2012).

Australia

Because Australia is bounded by the Indian, Pacific, and Southern oceans, its oceanography is quite complex. Currents running along the west and east coasts bring warm, nutrient-poor waters that flow south; these currents mean that the west and east coasts of Australia have a warm climate with coastal waters that support tropical species at what would normally be considered a temperate latitude. Hence, coral reefs are well supported along both coasts, bringing with them a rich diversity of species, including a variety of lobsters: at least 11 palinurids, 14 scyllarids, and 8 nephropids (Holthuis, 1991). The human population of around 23 million comprises Aboriginals (from ~40 000 years ago), Torres Strait

Islanders (from ~3000 years ago), and other groups that settled after 1788, when the first European colony was established.

Prehistorical and historical eras

Aboriginals possessed no literacy, and their history was communicated to successive generations through stories, art, and dance. They lived with a strong dependence on the land and water, within groups or tribes that developed skills (usually hunting, fishing, or gathering) for their specific environment. Most Aboriginals inhabited southern and eastern Australia, particularly along the larger permanent rivers, and fewer lived along the coast or gained sustenance from it. Archaeological and ethnographic records indicate that lobsters formed part of the diet of coastal Aboriginals (Anonymous, 2004). The few references that mention lobster use or European paintings depicting fishing by Aborigines suggest that fishing was typically conducted along the coastal fringe from rock platforms or shallow rocky reefs, by diving or using small canoes.

Aboriginal middens older than 4000 years in Tasmania (Flood, 1995) contained species that could be collected along rocky shores or by wading. Substantial consumption of subtidal shellfish and crustaceans (including lobsters) began when people started to dive and swim, around 3500–3000 years ago. The most significant animals to Aboriginal people were often depicted in paintings rendered on bark or rock surfaces, but there are few records of lobsters being depicted in such paintings. Only Sonkkila (2013) mentions rock art in northwestern Australia that includes images of crayfish (sic) among many other animals.

The inhabitants of Torres Strait Islands, located between Cape York, in northern Queensland, and Papua New Guinea, are a “sea people”, without a recorded history until European contact. Historical accounts suggest that lobsters formed an integral part of their diet (primarily seafood), equal to other marine species. McNiven *et al.* (2009) recorded evidence of lobster (possibly *Panulirus ornatus*) in rock art on Dauan Island, but such paintings are rare, known from only two sites. Europeans settled at Cape York in 1863. Trade with native Torres Strait Islanders was mostly for pearls and beche-de-mer, with lobsters being less important (Loban, 2007).

Introduction of modern fisheries

Lobster fishing in Australia developed as an industry during the late 1800s, simultaneously in southwestern Australia for *Panulirus cygnus*, South Australia, Victoria, and Tasmania for *Jasus edwardsii*, and New South Wales for *Sagmariasus verreauxi*. Regulations accompanied the earliest developments of lobster fishing, and although they varied among the different jurisdictions and species, they generally included size limits, prohibition against taking ovigerous females, and some spatial and/or temporal closures. For recreational fishers, the regulations focused on gear and bag limits per person. From the late 1880s through to the mid-1900s, the lobster fisheries remained relatively small and non-mechanised, but after World War II, the broad adoption of diesel engines and development of refrigeration allowed for expanded local and foreign markets. Consequently, fishing effort and catches increased steeply, necessitating fisheries management controls such as individual transferable quotas (Phillips, 2013).

Mediterranean basin

The Mediterranean is mostly landlocked with only a narrow connection to the Atlantic Ocean. The cold, low salinity water from the

Atlantic flows eastward and is warmed along the way. Evaporation in this region exceeds precipitation, so the surface water increases in salinity as it moves and eventually sinks when it reaches the Levant and then travels westward at depth, exiting back into the Atlantic at the bottom of the Strait of Gibraltar. Continental shelves in the basin are narrow and the basin is thus mostly deep sea and nutrient poor compared with the Atlantic. Nevertheless, it supports a high diversity of species, many of which are endemic to this sea. While the Mediterranean today is connected to the Red Sea via the Suez Canal, these seas were separated for most of human history. The Red Sea is an inlet of the Indian Ocean and is extremely salty and warm, being situated between desert and semi-desert land with high evaporation rates. Water exchange occurs between the Indian Ocean and Arabian Sea which helps to ameliorate the effects of high salinity and allows for extensive reef development. Partly due to the species richness of the Mediterranean and Red Seas, several ancient coastal and maritime civilizations originated along their coasts. Edible lobster species important to inhabitants along these coasts included at least two Mediterranean clawed lobsters, five spiny lobsters (two in the Mediterranean; three in the Red Sea), and five slipper lobsters (three in the Mediterranean; two in the Red Sea; [Holthuis, 1991](#)).

Prehistorical and ancient eras

The earliest depiction of a lobster is from a mural on a temple wall in Deir el-Bahari, Egypt, commemorating the trade voyage of Egyptian Queen Hatshepsut to the southern Red Sea ~3500 years ago (e.g. [Glenister, 2008](#)). It appears to be a spiny lobster (possibly *Panulirus pencillatus*) carved together with other Red Sea marine animals. Recently, only a partial claw (chela) of *Homarus gammarus* (Figure 3) was found among other kitchen refuse (mostly marine), dating ~2700 years ago (early Iron Age) in northern Sardinia (B. Wilkens, pers. comm.). The considerable size of the crushing teeth on this claw indicates a sizeable lobster. Perhaps large European lobsters were common in shallow Mediterranean waters during ancient times, and were exploited by coastal peoples.

Patchy archaeological and historical information of lobster utilization by Mediterranean and Red Seas civilizations indicate a



Figure 3. The end of a claw of *H. gammarus* found in an excavation of a seventh century BCE nuragic village of Sant’Imbenia near Alghero, northern Sardinia. Unearthed by Stefano Masala (under the supervision of Dr Barbara Wilkens, Department of Environmental Sciences, University of Sassari, Italy). Used by special permission of the copyright owners and the Soprintendenza ai Beni Archeologici di Sassari e Nuoro, Italian Ministry for the Cultural Heritage.

variable attitude towards lobster consumption, ranging from complete religious prohibition for Jews (and Christians) to epicurean status in the Hellenistic-Roman world. Consequently, lobsters are either completely absent from artwork and literary expression, or they appear quite prominently. While rare, lobsters were depicted on Roman coins, rings, terracotta vessels, tableware, wall drawings, and reliefs. However, the bulk of the information on Mediterranean lobsters comes from written text and mosaics ([Charmantier, 2014](#)).

Decorative mosaics contribute to understanding the role of marine organisms to humans in ancient times. Mosaics are often not accurate enough to allow for identification to species level, and in some cases, only parts of animals are depicted. A good example is a ~2300-year-old illustration of Pontus (“Oceanus”, a pre-Olympian sea-god) on Roman mosaic from Neapoli, Tunisia, that shows antennae and claws (presumably of a lobster) emerging from his forehead ([Fradier, 1982](#)). Another mosaic from the same period, the “Unswept Floor”, from Pergamon depicts legs and an antenna of a spiny lobster ([Orange and Nordhagen, 1966](#)). The accuracy of images increased during the Hellenistic period, such that a lobster appearing in a Roman mosaic from Thugga (Dougga of today) in the “House of Dionysus and Ulysses” ([Poinssot, 1965](#)) some 600 years later (Figure 4) is easily identified as *Palinurus elephas*. Other mosaics where lobsters can be recognized are associated with representations of fishing activities.

Greeks and Romans were knowledgeable about the biology of Mediterranean lobsters and also understood fishing techniques. Hippocrates writing around 2460–2370 years ago distinguished among clawed, spiny, and slipper lobster forms ([Lloyd and Chadwick, 1984](#)). From 2400 to 1800 years ago, Aristotle ([d’Arcy-Thompson, 1952](#)), Pliny the Elder ([Rakham, 1962](#)), and Aelian ([Scholfield, 1958](#)) classified lobsters as “animals without blood”, and supplied detailed information about their morphology, recognizing them as decapods. They provided detailed descriptions of the claws (the “astakós”), spines, thorny antennae (the “káravos”), tail, eyes, colors, and other external features. Classical naturalists such as Aristotle and Pliny the Elder described the habitats, behaviour, predators, territoriality, homing, and movements of several lobster “types” from shallow to deeper waters in winter and summer, respectively. Aspects of lobster reproduction, life cycle, moulting, and physiology were also known. Aristotle even described tiny “káravos” that were “smaller than a finger” (possibly the first benthic stage), and with Pliny the Elder and Aelian detailed the backward escape swimming (tail-flip) of lobsters when in danger. Plutarch noted that octopus prey on lobsters some 1900 years ago ([Babbit, 1957](#)). Interactions among the common octopus (*Octopus vulgaris*), a predator of lobsters, the Mediterranean moray eel (*Muraena helena*), a predator of octopus, and lobsters were not only documented by the above naturalists, but were depicted in ancient Roman mosaics. A notable mosaic from Pompeii from ~1900 years ago ([Ward-Perkins and Claridge, 1978](#); Figure 5) shows an octopus attacking *P. elephas* while being threatened by a moray eel.

Roman and Greek fishers knew the habitats, seasons, baits, and methods to catch lobsters. The Greek poet Theocritus remarked ~2400 years ago that lobsters were a superb food that could be caught with pots (traps) made of weaved reed ([Holden, 1974](#)), and pots appeared in Roman mosaics of fishing activities (e.g. [Fradier, 1982](#)). Similar weaved pots were used in Norway well into the modern era, and are known from Africa, Brazil, and Sardinia. The Romans were the first to transfer preserved fish far inland, and they built “cetariae”, to hold live lobsters, that were similar to

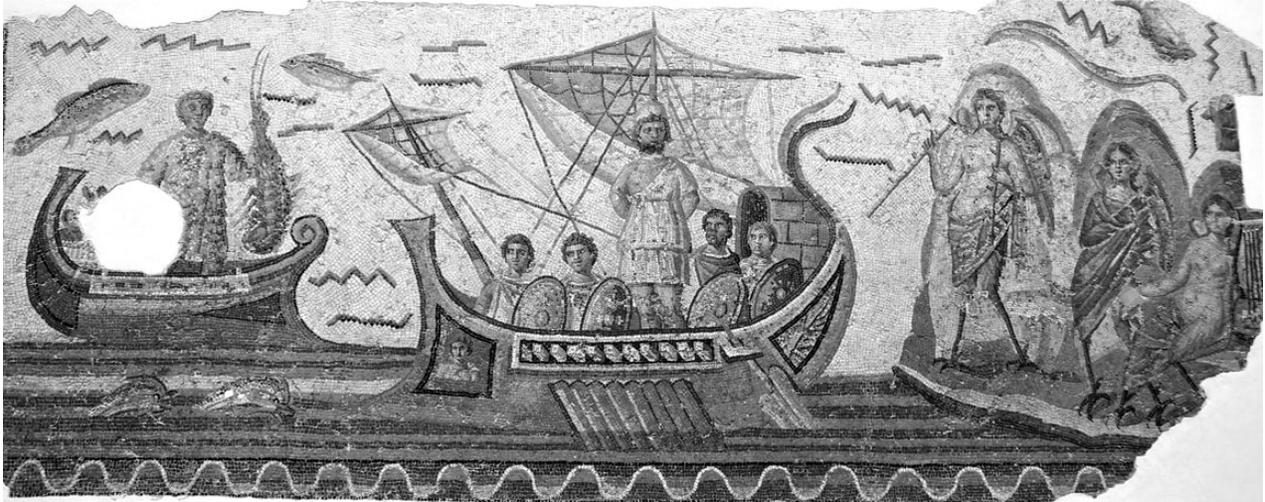


Figure 4. The common spiny lobster, *P. elephas*, in a third century CE Roman mosaic known as “Ulysses and the Sirens” from the “House of Dionysus and Ulysses” in Thugga, Tunisia. Photo by Dennis Jarvis, used with permission.

today’s holding facilities (André, 1961). “Cetariae” were built close to the sea to take advantage of natural coastal ponds fed by waves. Wealthy Roman city dwellers even had their own facilities.

Lobsters appeared in classical comedies, tragedies, and poems of Greek and Roman writers, and were described as an excellent food by the dramatist Epicharmus (Rodríguez-Noriega Guillén, 1996). They occur in recipes in cook books, including the *Deipnosophistae* (“Dinner-Table Philosophers”) by Athenaeus written between 1700 and 1800 years ago (Gulick, 1957). Lobsters were also thought to possess various medicinal properties (King, 2011) inclusive of aphrodisiacs (e.g. Pajovic et al., 2012, and references therein).

Middle ages

Few artefacts show lobster use in the Byzantine period, primarily because of the decline of non-religious art. One pavement mosaic from a Byzantine church dating to ~1400 years ago from Bet Guvrin, southern Israel (Ovadia and Ovadia, 1987), depicts two clawed lobsters, possibly *H. gammarus*, but Israel lies outside the present distribution range of any clawed lobster species (Holthuis, 1991). This discrepancy may be explained by *H. gammarus* extending into the southeastern Mediterranean during the Little Ice Age (2000–500 years ago), or the artist may have been from the western Mediterranean where this species was common or may have copied a model while visiting there.

In the Middle Ages, mosaic representations were replaced by paintings, some of which accurately depicted lobsters (e.g. Charmantier, 2014). The popularity of lobsters continued into the Renaissance and early modern era, as expressed in many paintings illustrating fish markets and luxurious table settings (see Table 1 in Charmantier, 2014) as well as in the literature (e.g. Crane, 2009).

Introduction of modern fisheries

While the yields of Mediterranean lobster declined in Roman times, they accelerated over the last two centuries, with the introduction of modern technologies and effort intensification. Fishing techniques changed from the use of pots or diving to more efficient trammel-nets, resulting in rapid stock declines during the last century (Goñi and Latrouite, 2005; Groeneveld et al., 2013). Regulation of

lobster fisheries in the Mediterranean started relatively late in the 1900s, but at-sea enforcement was difficult with the large number of vessels in the basin. Non-uniform regulations across the basin combined with poor enforcement have been cited for severe overfishing.

Europe

The North Atlantic current extends the Gulf Stream towards the northwest coast of Europe and brings warm surface water to that region, resulting in a highly productive marine ecosystem with high biodiversity. While several lobster species occur in European waters, the two main species of interest to humans are *H. gammarus* from coastal and shallow rocky habitats along the coasts of Norway south to the Azores and Morocco (and historically in parts of the Mediterranean and Black Sea), and *P. elephas* from rocky and coral-ligenous habitats of the shallow and continental shelf from Norway to Morocco and in the west-central Mediterranean. These two species have been exploited by humans for centuries, but extensive histories are only available for some regions covered herein.

Norway

Prehistorical era

Remnants of Neolithic living dating from 10 000 to 12 000 years ago are scattered along the Norwegian coast (A.K. Hufthammer, Bergen Zool. Museum, pers. comm.). Marine invertebrate remains in dry caves consist mostly of mollusc shells, with some decapod claw fragments, but it is unclear whether they represent middens from human activities or caching by animals. Stone carvings display fish and whales, but no lobsters are present in art or have been identified in middens.

Middle ages

Norse sagas and songs from 700 to 800 years ago refer to lobsters, and in medieval times, the Norse word “humarr”, today recognized as “hummer”, was acknowledged as a poetic metaphor (“kenning”) for the sea/seabed (Sturlason 1222–1231a, b; referred to in a list of sagas, e.g. Herrick, 1909 and references therein). Although the use of lobsters was not mentioned in literature at the time, the word “hummer” (which means to move or row backwards) is the root



Figure 5. Part of a Roman mosaic from Pompeii (house n. 16, insula 2, Regio VIII; first century CE) that described predator–prey interactions between an octopus, a spiny lobster, and a moray eel (Soprintendenza Speciale per i Beni Archeologici di Napoli e Pompei).

of European lobster names in 20 countries, from Scandinavia, throughout northern Europe, and as far as Russia and Armenia. The widespread use of the name “hammer” suggests that lobsters may have been traded among countries, since shared names usually imply shared goods (E. Ellingsve, NTNU, pers. comm.). Such trade does not exist in modern times, but the sharing of the expression may indicate an ancient trade, perhaps with lobsters sold and transported as frozen goods from Scandinavian middle age winter markets (Magnus, 1555).

In his *Carta Marina* map of northern Europe (1539) (Figure 6a and b), giant lobster-like monsters catch a sailor and fight a “rhinoceros”. These lobster illustrations were later copied by other naturalists (Gesner, 1558). Magnus (1555) also mentions lobsters in his descriptions of the natural history and social structure of Scandinavia. Lobsters (carabii) are here connected to octopuses and moray eels, as depicted in Greek and Roman mosaics. Since moray eels and large octopuses are not present in Scandinavia, these observations may have been adopted from Pliny the Elder, whom Magnus mentions. However, Magnus (1555) describes cephalopods (Di Polypis) in a chapter illustrated by man-hunting lobster-like creatures, so it is unclear if his illustrations actually represent lobster or octopus. The first actual mention of lobsters and crabs for human consumption was made by Clausson Friis (1599, published by Storm, 1881) who described how lobsters could be caught in the intertidal zone, how cooking or drying

changed their colour, and that they avoided traps containing live crabs.

Introduction of modern fisheries

During the Enlightenment in Europe (1650–1750), wealthy and royal classes could afford lobsters, as depicted in still life paintings (details in Charmantier, 2014). In Norway, lobsters were not commonly accepted as food by privileged classes; instead, “heaps of oyster and lobster shells laying outside their shacks” showed the popularity (or the necessity of consumption) among the poor (Pontoppidan, 1752–1753). Lobsters and their shells were also used for fertilizer, and not served to farmhands and servants more than thrice weekly up until the last century (E. Nøstvold, Kvitsøy, pers. comm.).

While not popular with Norwegians, the privileged classes of England and the Netherlands created a strong demand for lobsters 400–500 years ago. Dutch traders established a trade for Norwegian lobsters around 1650, but were eventually replaced by a British trading monopoly. By 1700, the export industry expanded from a few southwestern fishing communities to cover most of southern Norway. Local reports on social and biological trends relevant to lobster exploitation and export exist since the late 1600s and trade is described in contemporary books on Norwegian natural resources and social life in the 1700s, including that by Pontoppidan (1752–1753).

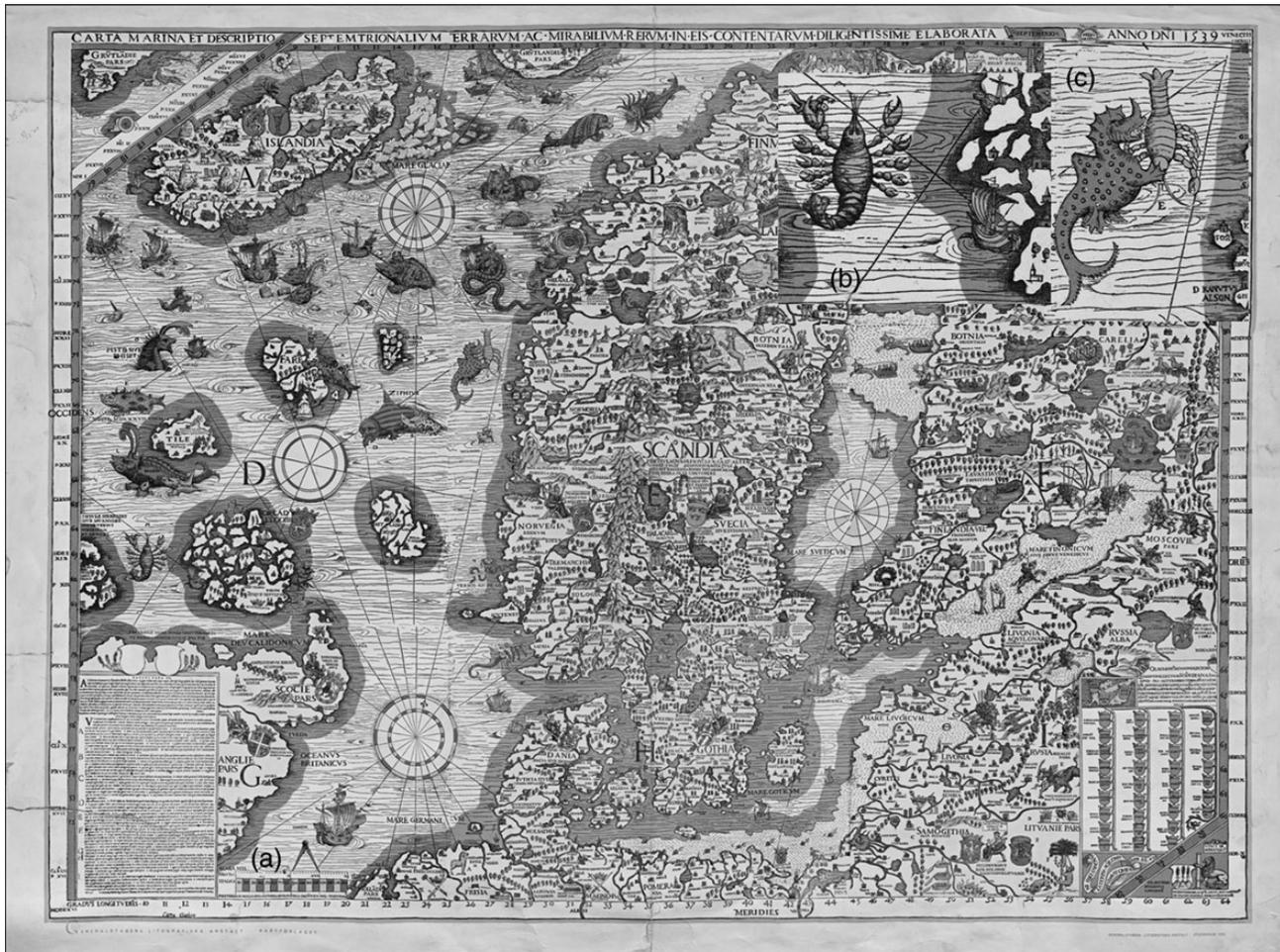


Figure 6. (a) The Olaus Magnus Carta Marina (1539 version) and the (b) and (c) “lobsters”, which may or may not be actual lobsters, but misrepresentation of cephalopods. High-resolution copy kindly provided by the Norwegian National Library, Oslo.

As lobster export became more lucrative in Norway, landowners extended their claims into the sea, attempting to privatize access rights (Sunde, 1991, and references therein). Strong disputes over fishing rights arose, culminating in a royal decree on 23 April 1728, stating that lobsters and all other marine organisms, except salmon, were common property. Increased exploitation since 1650s rapidly led to reductions in local lobster stocks, which subsequently fluctuated as a result of the wars in Europe, climate changes, market demands, and technological developments. Fishing regulations were first introduced in 1849 with little effect. At present, the Norwegian lobster stock is at a record low, showing little or no signs of recovery (Kleiven et al., 2012).

Spain

The first spiny lobster fishing grounds exploited by Spanish boats for export markets were along the northern Iberian coast, in the late 1800s. Live *P. elephas* and *P. mauritanicus* were transported in boats with seawater tanks to cities in France and the UK, where profits from their sales were four times higher than if sold domestically (Montesinos, 1905). Spanish vessels also caught clawed lobster, *H. gammarus*, in the Atlantic and Mediterranean Sea, but not as a target species.

When yields of spiny lobster from northern Spain began to decline, fleets moved to fishing grounds in West Africa. The

evidence of overexploitation noticed by them triggered the implementation of seasonal restrictions and a special fishing tax. Despite these measures, overfishing worsened in the 1900s with dramatic changes in the mean lobster weight declining from 2 kg per lobster at the start of the century to 0.6 kg today.

Traditional fishing gear consisted of cotton nets until Basque fishers introduced lobster pots (Montesinos, 1905). Both gears were used simultaneously until the late 1980s, when pots were virtually abandoned for lack of effectiveness (Goñi and Latrouite, 2005).

Targeted lobster fisheries are now restricted to archipelagos and islands in the Western Mediterranean, such as the Balearic Islands in Spain, where trammel-nets are used. Here, artisanal fishers have exploited lobsters for over 150 years, and trade with the Iberian Peninsula dates back to the mid-1800s. Official statistics show much lower landings at present compared with 100 years ago.

The Americas

Pacific coast of North America

The Pacific coast of North America supports the spiny lobster *Panulirus interruptus* only at its southern-most end, from San Luis Obispo Bay, California, through the length of the Baja Peninsula (Holthuis, 1991). Paleo-Indians occupied this region around 13 000 years ago and expanded to the Northern Channel Islands

across a 7–20 km wide strait, and to the more dispersed and distant Southern Channel Islands further from the mainland when sea levels were lower than at present (Inman, 1983; Rick *et al.*, 2005). The Channel Islands and Santa Barbara Channel lie at the confluence of two major ocean currents (the cool California Current and warm Southern California Countercurrent) in a region of persistent upwelling that supports a rich diversity of habitats composed of kelp forests, rocky reefs, and eelgrass beds.

Prehistorical and historical eras

Coastal middens from the Early Holocene demonstrate that Paleo-Indians harvested a variety of marine organisms, including red abalone, giant chitons, mussels, turban snails, crabs, geese, cormorants, albatross, pinnipeds, sea otter, and a variety of finfish (Erlandson *et al.*, 2011). Active searches in well-preserved ancient middens found no lobster remains (J.M. Erlandson, pers. comm.). Middle Holocene (around 6000 years ago) middens contain a more diverse mixture of marine taxa (Rick *et al.*, 2005) from indigenous Chumash Indians (northern islands) and Tongva peoples (southern islands; Jones and Klar, 2005; Rick *et al.*, 2005). The Chumash harvested shellfish so intensively that middens illustrate declines in shell sizes of some species, suggestive of overfishing. These anthropogenic effects seem focused on abalone, but Spanish explorers in the 1700s remarked that lobsters were common in Indian villages (Fray Juan Crespi, 1769–1774; reported in McArdle, 2008), abundant in coastal waters (Sebastian-Vizcaino, 1602; reported in McArdle, 2008), and fished with devices (pots) similar to Spanish ones (Hudson and Blackburn, 1982). Less information is available for the Tongva, so it remains unclear if they used lobsters.

Introduction of modern fisheries

Chinese and Caucasian fishers replaced the island Chumash during the 1800s and fished for lobsters off Santa Barbara and Santa Cruz Island. They delivered dried tails to San Francisco's Chinatown for export to China (Rathbun, 1887; McArdle, 2008), and live lobsters for local use. Rathbun (1887) reported that lobsters were so abundant in the Santa Barbara Channel that a single person could capture around 230 kg in the space of 2 h, from the nearshore with dipnets. Spiny lobster became popular as a substitute for dwindling eastern clawed lobster, and canneries sprung up to provide a product that could withstand long-term storage and be shipped worldwide. Canneries used their own engine-powered ships to move lobster fishers between islands and along the coast, and transport catches. Industrialization increased fishing effort (both in terms of fishers and traps deployed) and landings and gradually reduced the size and weight of landed lobsters. By the early 1900s, lobster stocks were considered to be overfished and regulations were imposed. The regulations have resulted in a relatively stable catch in modern times, but at the cost of increased effort per fisher, and in a small size of fishable and reproductive lobster (McArdle, 2008).

Atlantic coast of North America

The northeastern American coast lies at the junction of the nutrient-rich, warm northward flowing Gulf Stream and the oxygen-rich, cold southward flowing Labrador Current. An abundance of fish and marine mammals have historically thrived here, including the American clawed lobster, *Homarus americanus*, which occupies a range from Labrador and Newfoundland to the shelf waters of North Carolina (Holthuis, 1991), though historically,

it has been far more abundant from northern New Jersey to Newfoundland.

Prehistorical and historical eras

Aboriginal peoples were present in Labrador some 8500 years ago, and reached Newfoundland some 4500–5000 years ago, when the climate was warmer than today (Marshall, 1996; Renouf, 1999). The Beothuk Indians occupied Newfoundland at the time of European contact in the 1400s (Tuck, 1976), although other groups may have travelled there for particular resources (Marshall, 1996). Faunal analysis suggests that Beothuk ate a wide variety of marine and terrestrial animals, including lobster, recognized from claw fragments (Howley, 1915; Marshall, 1996; Pastore, 1997). The Beothuk harvested lobster during summer (Marshall, 1996) and could store lobster tails (Tuck and Pastore, 1985) and dry the meat (Anonymous, 1987). Europeans arriving in Newfoundland in 1578 commented on the great abundance of lobsters near the shore (Parkhurst, 1578)—thus the Beothuk appear not to have fished populations down greatly.

The Mi'kmaq Indians (Canadian Maritime provinces, Gulf of St. Lawrence to the Bay of Fundy, Nova Scotia, Cape Breton, Prince Edward Island) fished for lobster when migrating from inland winter quarters in spring and summer. They used hand-collecting, spears, and hooks while wading at low tide, but also captured lobsters incidentally in fish weirs (Wallis and Wallis, 1955; Anonymous, 2012). Lobsters were used as food, fertilizer, decorations, totems, tobacco pouches, and pipes (Ganong, 1968; Anonymous, 2012).

English explorers and chroniclers of early colonies recounted how natives in Maine (probably Eastern Abenaki or Mi'kmaq) and Connecticut (Mohegan, Quinnipiac, and Pequot Indians) used lobsters (Rosier, 1605; Morton, 1632). Natives used lobster for bait to catch eel and cod, and dried them for food in winter (Wood, 1639). In Connecticut, natives were described as converging in large numbers for a month or more to harvest lobsters at low tide and dry their meat for winter (Morton, 1632). Lobster remains have been found in a Manisseean seafood processing village midden at Block Island (Rhode Island) and date to 2350–2500 years ago (K. McBride, pers. comm.; Jaworski, 1990); these may be the oldest surviving remnants in New England. Other island tribes (Wampanoags) have legends describing feasts where lobsters were boiled in pots with succotash and fish, and served with steamed clams, roast pheasant, and rabbit stew (Scoville, 1970).

Early European chroniclers also remarked on the abundance of lobsters inshore, usually by recounting how quickly lobsters could be caught via different fishing methods. For instance, Parkhurst (1578) described how with just a single gaff, he could capture enough lobsters to feed 300 men in less than a half a day in the waters of Newfoundland. Others recounted how men, with only one haul of a small draw net, caught more than 140 lobsters off Nova Scotia in 1597 (published by Brown, 1869). Wood (1639) remarked that lobsters were so plentiful that they (meat and shell) were used as fertilizer instead of food when fish were readily available. Nearly 250 years later, hoop netters were able to capture 500 lobsters in 8–10 h in waters off New Brunswick (Simmonds, 1859).

Introduction of modern fisheries

Many settlers in the 1600 and 1700s considered lobster as a suitable stand-in when other foodstuffs were unavailable, as a fertilizer for crops, or as a food for the poor (Rowan, 1876; Wells, 1986). Lobsters were often used as bait to capture the more highly prized

cod. By the late 1700s, lobster became a commodity in urban centres (Boston, New York). High demand was initially met from nearby waters, but by the early 1800s, southern New England fishers could no longer keep up (Martin and Lipfert, 1985). During this period of growing demand, the indigenous peoples were mostly excluded from lobster fishing and did not regain guaranteed fishing rights until the late 1900s (Davis et al., 2004). Live shipment gave rise to the “smack vessel” (similar to the “hummer-busser” used in Norway), and the “car” (floating box to hold lobster for sale to the smack vessel). Hand-held gaffs that typically killed lobsters were replaced by hoop nets that required constant monitoring by fishers. The inefficient hoop net gave way to the wooden trap (“pot”) that became more sophisticated in design to prevent lobster escape.

Lobster canning grew during the mid-1800s, and by the 1880s, there were 23 plants in Maine and over 40 in Canada (Rathbun, 1887). The canneries required millions of pounds of lobster per year to supply demand, and mounting fishing pressure caused a decline in lobster size and weight (from 1.8–4.5 to <0.9 kg). The live lobster industry also impacted stocks, because fishing row-boats became larger, engine powered, then gave way to large mechanized boats, permitting fishing further from the shore. Increased demand and the industrialization of the lobster fishery led initially to regulations stipulating who could fish local waters, but by the late 1800s these stipulations included a variety of measures that differed from state to state. Some of the stricter regulations caused a decline in the Maine canneries with many closing; by the end of the 1800s, all Maine canneries had closed or relocated to the Canadian Maritimes (Martin and Lipfert, 1985).

Massachusetts and Rhode Island (later joined by Maine, Newfoundland, and other Canadian regions) opened up state hatcheries by the end of the 1800s, in an attempt to restock state waters with more than 800 million larvae hatched from egg-bearing females (Martin and Lipfert, 1985). Despite these “seeding” efforts and the imposition of additional regulations, lobster stocks continued to experience dramatic drops in abundance and shifts to smaller individuals. Today’s stocks are highly depleted in all but their most northern range (Gulf of Maine northward), and even those stocks only provide high yields with enormous fishing effort.

South Florida

The Caribbean spiny lobster, *Panulirus argus*, occurs in shallow coastal waters of southeastern Florida, along the Keys archipelago, and throughout the Caribbean Sea (Holthuis, 1991). Humans settled the area during the Archaic Period (9000–3000 years ago) and gave rise to the Glades cultures (2750–500 years ago). By the time of the European contact (–500 years ago), the descendants of the Glades culture had given rise to the Tequesta (near modern-day Miami and the Upper Florida Keys) and the Calusa (west coast of south Florida, from Fort Myers to Naples and the Ten Thousand Islands area). Both tribal societies were based on marine and estuarine resource exploitation.

Prehistorical and historical eras

Middens indicate that the tribes consumed more than 50 species of fish and 20 species of molluscs and crustaceans, sea and land turtles, ducks, and some land mammals, although these latter items accounted for <7% of their animal-based energy (MacMahon and Marquardt, 2004). The Calusa had little contact with Europeans, but one shipwreck survivor observed that lobsters were consumed regularly by both the Calusa and Tequesta (Fontaneda, 1575).

Introduction of modern fisheries

Wars between Spain and England devastated the South Florida tribes. The British took over Florida in the mid-1700s, and reported that lobsters were plentiful and quite large, but they were not highly prized as food, and were instead used as bait for fish such as snapper and grouper (De Brahm, 1772; Moe, 1991). For the next century-and-a-half, lobsters were captured by south Floridians with castnets, gillnet, haul seines, and spears, and were easily captured *en masse* when roaming over grass flats. A commercial fishing industry for lobsters arose when the Florida Keys were connected to the mainland via the Overland Railroad in 1912, but no regulations on fishing were imposed until the 1920s. Nevertheless, regulations have failed to prevent overfishing and landings have declined dramatically in the present time.

Caribbean and Mesoamerica

The tropical Caribbean Sea basin (~2 754 000 km²) supports five spiny and four slipper lobsters species. The Caribbean spiny lobster *P. argus* is the most abundant, and has been identified in pre-Columbian archaeological deposits throughout the Caribbean (Keegan, 1982, 2000).

Prehistorical and historical eras

The earliest migrants (ca. 6000 years ago) were hunter-gatherers, who transitioned from tropical forest life to coastal living, shifting from subsistence hunting to gathering shellfish (Rouse, 1989; Wing, 1989; Keegan, 2000). Archaeological evidence for this shift comes from sites in Cuba, Haiti, the Dominican Republic, Puerto Rico, and the Lesser Antilles (see review in Keegan et al., 2013). For example, middens from the pre-ceramic period (5000–3000 years ago) in the Lesser Antilles contain thousands of mollusc shells and fish bones (Wilson, 2007), demonstrating that subsistence hunting had been replaced by coastal living.

Saladoid cultures, also known as ceramic-making farmer-fishers (around 2400–1100 years ago), originated along the Orinoco River of lowland Amazonia (present-day Venezuela) and maintained subsistence strategies that included shellfish gathering (Newsom and Wing, 2004). Archaeological sites on Montserrat (2400–2200 years ago), Nevis (965–735 years ago), Turks and Caicos Islands (915–715 years ago), eastern Puerto Rico and Anguilla (815–615 years ago), and Saint Lucia (1115–515 years ago) suggest that the consumption of lobster was widespread and covered the entire Ceramic Age occupation (de France et al., 1996). However, lobster remains occurred in low frequencies at all sites, suggesting that lobsters were not commonly harvested or remains were not well preserved.

The Taino (Arawakan) civilization (6000–500 years ago) occupied the Greater Antilles and some of the northern Lesser Antilles. They were seafaring people who harvested conch, oysters, lobsters, and crabs using various methods (Rouse, 1992). The sizes and types of fish in archaeological deposits throughout the Caribbean indicate that basket traps were probably used to harvest lobsters. A test of this hypothesis by Keegan (1982) using 2 m long × 1 m wide Haitian-style basket traps (Figure 7), similar to those used by the Taino, caught lobsters of relatively small size at low frequency. This matched archaeological evidence for ubiquitous, but limited use of lobsters by the Taino (Keegan, 1982).

The Maya (Yucatan peninsula; 3800–1100 years ago) comprised a large and pervasive civilization extending from Mexico into Mesoamerica (present-day Honduras, Belize, Guatemala, El

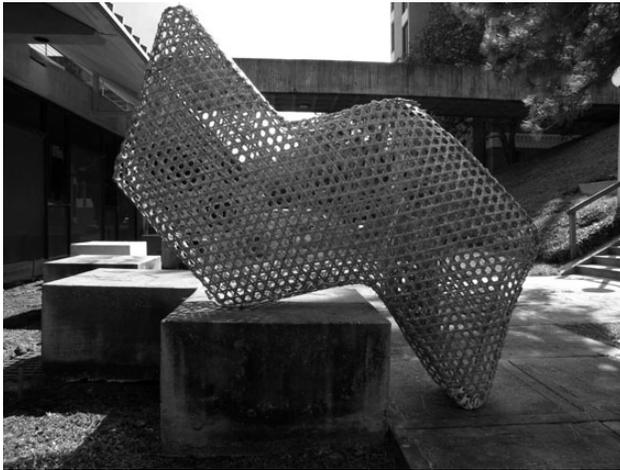


Figure 7. Haitian-style basket trap used to capture fish and lobsters (purchased in Cap-Haïtien, 1995).

Salvador, and Costa Rica). Mayans consumed many marine animals, including lobsters, which were often dried, roasted, and salted (Lang, 1971). Lobsters form part of Mayan aquatic iconography (Bonnafox, 2008), and represented the expression of maritime trade (Lang, 1971). Effigy vessels were widespread and an effigy of a Caribbean spiny lobster excavated in 2007 from Belize is one of the oldest (<http://www.belize.com/maya>).

Introduction of modern fisheries

At the time of the Spanish conquest in 1492, the Taino were cultivating crops and had evolved individual specialities including fishing and trapping. New technologies would substantially increase lobster harvests in the coming centuries. The 1600 and 1700s were marked by increased trading between Europe and the New World. New World fishing techniques that targeted both fish and lobsters included bottom netting, trapping with wooden pots, harpooning, torch fishing, and diving (Price, 1966).

South America and the Juan Fernandez archipelago

It is unknown how early South America was colonized after peoples migrated through Beringia; however, human occupation sites, particularly Monte Verde in Chile and Quebrada Jaguay and Quebrada Tacahuay in Peru, have dated to around 14 600 years ago (Dillehay *et al.*, 2008) and around 12 700–12 900 years ago (Keefer *et al.*, 1998), respectively.

Prehistorical and historical eras

Faunal evidence suggests a wide use of resources, both coastal and mountainous. There is clear evidence that marine seaweeds from sandy and rocky shorelines were exploited (Dillehay *et al.*, 2008) where marine shellfish and crustaceans would also be present. In Quebrada Jaguay and Quebrada Tacahuay, knotted cordage, fish bones, and crustacean and mollusc shells have been recovered (e.g. Keefer *et al.*, 1998). Indications of lobster use on the mainland include lobster effigies from ancient Peru (e.g. of the Chimu-Inca Culture, Moche Valley, north coast of Peru, dating 585–475 years ago, Mingei Museum, CA, USA; <http://www.mingei.org/collection/object/ceremonial-sprinkler-with-lobster-effigy-2/>). This is peculiar, because no shallow water marine clawed or spiny lobsters are present along the Pacific coast of South America. More information

comes from reports by European explorers, such as Theodor de Bry's 450-year-old engraving of Incas bringing treasures, including a lobster, as ransom for their leader, Atahualpa, held by the Spanish (King, 2011). The effigies and engravings may, however, represent the freshwater prawn, *Macrobrachium brasiliense*, which is widely distributed in South America.

The spiny lobster *Jasus frontalis* is known from the Juan Fernández and Desventuradas Islands in the southeastern Pacific Ocean (Holthuis, 1991). Andrew Selkirk, a Scottish sailor, was marooned on Robinson Crusoe Island for 4 years. When he was rescued, the ship's captain described his men bringing back an “abundance of *Craw-fish*” along with Selkirk (King, 2011). Selkirk's biographer wrote that he had often captured huge lobsters that he boiled or grilled (Howell, 1829). Later travellers would write that this lobster was large (weighing 3.5 or 4 kg each), highly flavourful, and incredibly abundant (e.g. Anson, 1853).

Introduction of modern fisheries

Commercial fishing for *J. frontalis* began in the late 1800s, when lobsters were commercially harvested from shallow waters (<15 m), but as fishing pressure increased, lobsters were harvested from deeper and deeper water (Holthuis, 1991). Assessments show that the population near the island is overexploited, but fishing has expanded to new grounds (Jeffs *et al.*, 2013). The fishery continues today and provides employment for a large proportion of the archipelago inhabitants.

New Zealand

New Zealand straddles the boundary of the Pacific Ocean and the Tasman Sea midway between Antarctica and the tropics. The islands lie at the confluence of two current systems: the warm Subtropical Gyre (northwest and northeast coasts) and the cooler Antarctic Circumpolar Current (southern islands). Upwellings occur at the convergence zones of the two systems, providing nutrients for rich fishing grounds. Two spiny lobster species inhabit New Zealand waters: the widespread red spiny lobster, *J. edwardsii*, and the packhorse lobster, *S. verreauxi*, that is restricted to the northeast North Island (Kensler, 1967).

Prehistorical and historical eras

New Zealand was first settled 1200 years ago by Polynesian seafarers who initially lived along the coast and relied heavily on gathering seafood from shallow waters (Best, 1986). Archaeological evidence (mandibles) from multiple shell middens date to ~700–900 years ago and show that lobsters were exploited (Anderson, 1979; Leach and Anderson, 1979; Leach and Boocock, 1993). Written records from European explorers and Maori oral history indicate that lobsters were important seafood (Best, 1986). Apart from hand gathering in shallow waters, Maori fishers also used plant-based traps and fishing lines baited with abalone (Best, 1986). Thus far, only *J. edwardsii* mandibles have been found at archaeological sites (Leach and Boocock, 1993).

Lobsters were eaten fresh, dried, and prepared by soaking in freshwater so that the flesh separated easily from the shell without cooking (Best, 1986). Coastal Maori traded sun- and oven-dried lobsters with inland tribes (Best, 1986). Lobster fishing was highly regulated within Maori communities through cultural rituals and taboos. Chants and charms related to the process of catching lobsters were integral to fishing, reflecting a spiritual perspective towards the natural world. Tribal groups administered spatial, seasonal, or rotational harvesting strategies (Best, 1986). Even with these measures,

changes in mandible size in some middens strongly suggest that the Maori had negative impacts on *J. edwardsii* populations and drove the species to smaller sizes over several centuries (Leach and Anderson, 1979). Some archaeologists suggest that the Maori may have practiced intensive use of a resource for a time, followed by a period where they allowed the resource to recover (Leach and Boocock, 1993), but it does not appear that intensively fished populations of *J. edwardsii* rebounded.

Introduction of modern fisheries

There is now a significant commercial fishery in New Zealand, with around 2700 t of lobsters harvested a year, and with significant stakeholding by Maori descendants.

Conclusions

It is undisputed that ancient and more recent peoples around the world used lobsters for food and trade. In many cultures, lobsters were a valuable and highly prized commodity; in others, they were considered food for the poor, or a replacement when other foods were not available. However, before the modern era, knowledge of lobster use is based mainly on archaeological evidence, artwork, or historical accounts. These sources are less exact and often biased by ancient and sometimes lost cultural insights. Nevertheless, they do give important information, as long as their interpretation accounts for the cultures from which they derive. One should keep in mind that when Europeans provided descriptions of lobster stocks in new lands, they did so within the context of their own often already overfished home stocks. Therefore, when Europeans described new found stocks of lobsters as highly abundant, we should take them at their word that lobsters were as abundant as described and that these written descriptions were not exaggerations (Bolster, 2012).

Apart from the Mediterranean civilizations and possibly some Maori tribes, indigenous peoples appear to have harvested lobsters at a sustainable rate, even when other taxa (marine mammals, pelagic fish, land mammals, shellfish) in the same area may have been overexploited. Traditional hand collection methods, small baskets (pots), and gaffs limited the numbers of lobsters that could be captured at one time. As colonists increased their demand for lobster, new technologies were developed that increased the efficiency of capture.

Overexploitation typically followed a specific pattern. For example, when lobsters became sought-after seafood commodities in European and other markets during the mid-1800s, fisheries became industrialized, extracting greater quantities. International trade followed the development of preservation techniques (frozen, canned, or live lobsters) and long-distance transport of products. Some of the modern fishing methods and gear, such as trammel-nets, led to precipitous declines in lobster abundance. In some cases, indigenous peoples were pushed out of lobster fisheries during the period of economic expansion; in countries such as New Zealand and Canada, they now have traditional fishing rights.

Lobster life history, which typically progresses from pelagic and well-hidden juvenile stages to more accessible adolescent and adult stages, has allowed them to retain a part of the recruiting population out of reach of fishing gear. Nevertheless, the long lifespans, slow growth, and variable recruitment success leave many lobster species vulnerable to continued overexploitation. Despite regulatory attempts, lobster stocks around the world are currently heavily or overexploited, and it is unrealistic to expect a recovery

to the near-pristine levels reported by explorers some 400–500 years ago.

High landings of some stocks today come as a result of a highly mechanized fishing fleet, use of a large number of pots or nets, smaller sizes of landed lobster, and reductions in the age of reproduction. In addition, lobsters inhabit ecosystems where large groundfish have themselves been overfished, and where some of their prey (e.g. urchins, oysters, scallops, clams, mussels) may also have been overfished. Hence, today's lobster populations may be much more vulnerable to perturbations, such as fishing pressure and climate change than in the past. Recognizing how anthropogenic selection pressures imposed upon lobster populations have altered their demography, genetic diversity, and ecosystems in which they live is critical for future management schemes. Historical analyses, similar to those conducted by McArdle (2008) for California spiny lobster and Bolster (2012) for groundfish, may prove useful to managers and fishers alike in furthering an understanding of human impacts on worldwide lobster stocks.

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Handling editor: Carmel Finley