The Prehistoric Fisheries of Akab Island (United Arab Emirates): New Insights into Coastal Subsistence during Neolithic in Eastern Arabia

Article *in* The Journal of Island and Coastal Archaeology · January 2019

DOI: 10.1080/15564894.2018.1531330

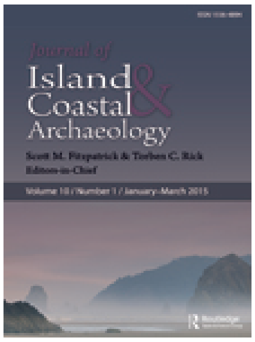
4 authors:

Kevin Lidour
Department Culture and Tourism Abu Dhabi

Philippe Béarez
French National Centre for Scientific Research

Vincent Charpentier
Institut national de recherches archéologiques préventives

Sophie MERY
French National Centre for Scientific Research



The Journal of Island and Coastal Archaeology

ISSN: 1556-4894 (Print) 1556-1828 (Online) Journal homepage: http://www.tandfonline.com/loi/uica20

The Prehistoric Fisheries of Akab Island (United Arab Emirates): New Insights into Coastal Subsistence during Neolithic in Eastern Arabia

Kevin Lidour, Philippe Béarez, Vincent Charpentier & Sophie Méry

To cite this article: Kevin Lidour, Philippe Béarez, Vincent Charpentier & Sophie Méry (2019): The Prehistoric Fisheries of Akab Island (United Arab Emirates): New Insights into Coastal Subsistence during Neolithic in Eastern Arabia, The Journal of Island and Coastal Archaeology, DOI: 10.1080/15564894.2018.1531330

To link to this article: https://doi.org/10.1080/15564894.2018.1531330

Published online: 15 Jan 2019.

The Journal of Island and Coastal Archaeology, 0:1–21, 2019

ISSN: 1556-4894 print/1556-1828 online
DOI: 10.1080/15564894.2018.1531330

The Prehistoric Fisheries of Akab Island (United Arab Emirates): New Insights into Coastal Subsistence during Neolithic in Eastern Arabia

Kevin Lidour,[1,2] Philippe Béarez,[2] Vincent Charpentier,[3] and Sophie Méry[4]

[1]*UMR 7041 ARSCAN, University Paris 1 Panthéon-Sorbonne, Paris, France*

[2]*UMR 7209 Archéozoologie & Archéobotanique, Muséum National d'Histoire Naturelle, Paris, France*

[3]*Institut National de Recherches Archéologiques Préventives, Paris, France*

[4]*UMR 6566 CREAAH, University Rennes 1, Campus de Beaulieu, Rennes, France*

ABSTRACT

The Neolithic period in Eastern Arabia (especially from 5500 to 3100 BC) is better understood due to recent excavations of stratified sites stretching from Kuwait to the Sultanate of Oman. When oasis agriculture developed from the Bronze Age onwards, herding, shellfish gathering, and fishing became the primary modes of subsistence, and despite strong regional aridity, coastal shell middens provide the best preservation conditions in the Persian Gulf. Akab, one of the many Neolithic shell middens of the United Arab Emirates coastline, is situated in the Umm al-Quwain lagoon. This settlement is dated to the second part of the fifth millennium BC and has provided more than 37,000 fish remains, derived from over 50 fish species. Ichthyofaunal analysis underlines the predominance of coastal pelagics, such as kawakawas and trevallies, and the exploitation of several coastal fishes, mostly seabreams and emperors. Inhabitants fished over a wide aquatic territory, which included shallow-water biotopes, situated inside the lagoon, and the open sea. The associated fishing gear, composed of stone sinkers and shell fishhooks, indicates that nets and lines were used. Here, we review the seasonal organization of activities and mobility schemes from an archaeo-ichthyological perspective.

KEYWORDS archaeoichthyology, Eastern Arabia, fishing, neolithic, Persian Gulf

Received 16 May 2018; accepted 14 August 2018.
Address correspondence to Kevin Lidour UMR 7041 ARSCAN, Université Paris 1 Panthéon-Sorbonne, Maison de l'Archéologie et de l'Ethnologie, 21 allée de l'Université, 92023 Nanterre, France. Email: lidour01@gmail.com
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uica.

INTRODUCTION

Archaeological research—which for a long time concentrated on the Bronze Age and the relationship between Mesopotamia, Iran, and the Indus Valley—has recently developed a particular interest in the Late Prehistory and Neolithic of Eastern Arabia. However, only a few Neolithic sites, mostly shell middens, have been excavated between Kuwait and the Sultanate of Oman during the last few decades.

Fishing and shell harvesting have long been an important subsistence activity among Arabian coastal societies, being first documented by classical Graeco-Roman authors such as Diodorus Siculus, Ptolemy, and Pliny who described them as 'fish-eaters' or *ichthyophagi*. This reliance on marine resources is still highlighted by contemporary authors (e.g., Beech 2004; Charpentier 2002), and has been corroborated by recent zooarchaeological investigations (Beech 2010a; Beech and Glover 2005; Mashkour et al. 2016; Von den Driesch and Manhart 2000).

Akab is a famous archaeological site in the United Arab Emirates (UAE) known for its unprecedented ceremonial structure made of dugong bones, presented as one of the oldest ritual sites in Arabia (Méry et al. 2009). Excavation of the settlement area has provided dense occupation layers containing a huge amount of faunal deposits, mostly seashells, crabs, and fish remains. The site is dated from the Late Neolithic (ca. 4500–3100 BC), which is a period currently under-represented in the Persian Gulf (Uerpmann 2003). Therefore, Akab is a cornerstone for understanding the regional Neolithic, and the study of Akab fish bones provides an opportunity to investigate Late Neolithic fisheries and compare them with what is known for the Middle Neolithic (ca. 5500–4500 BC), especially at the nearby site of Umm al-Quwain 2 (Mashkour et al. 2016).

Two preliminary studies were done on the fish bones of Akab: one concerning a small sample from the 1990–1992 excavations (Jousse et al. 2002) and one concerning the material collected in 2002 (Beech et al. 2017; Méry et al. 2008). This study presents a complete analysis of all the material from that site focusing on the detailed identification of the fish remains, the potential fishing techniques used and on the probable fishing grounds and seasons.

SITE DISCOVERY AND LOCALIZATION

In 1989, the former French Archaeological Mission in Umm al-Quwain conducted a series of surveys (Boucharlat et al. 1991). During these surveys, the site of Akab (25°34′9.94"N; 55°34′31.67"E) was discovered on Jazirat al-Ghallah, a small island situated in the Khor al-Beidah, a vast lagoon bordering the modern city of Umm al-Quwain (Figure 1). The surface of the site, on the top of the flattened sand dune forming the central part of the island, was covered with lithic flakes, shell beads, and faunal remains, which mostly included seashells, fish, and dugong bones.

The lagoon formation dates back to the Early Holocene (Sanlaville and Dalongeville 2005). During this period, a marine transgression cut through the preexisting dunes aligned along the coast to form some large sheltered embayments. This longshore drift subsequently established a sand barrier, which enclosed the lagoon. Nowadays, this lagoon comprises an important mangrove whose brackish waters are maintained by continuous infiltrations of the water table into the sea. However, due to the wetter climate in the Early Holocene (Berger et al. 2013; Preston et al. 2015), the seasonal surface streams (sing. *wadi*, pl. *wudiyan*) were probably able to flow more continuously. And while the lagoon was also probably smaller than today, the presence of the mangrove is well attested since the middle sixth millennium BC. Many mudcreeper shells (*Terebralia palustris*) were discovered in the earliest levels of the UAQ2 settlement site (Figure 1), dated from ca. 5500–5300 BC (Méry 2015:360). This gastropod is known as a typical symbiont of the Indo-West-Pacific mangals.

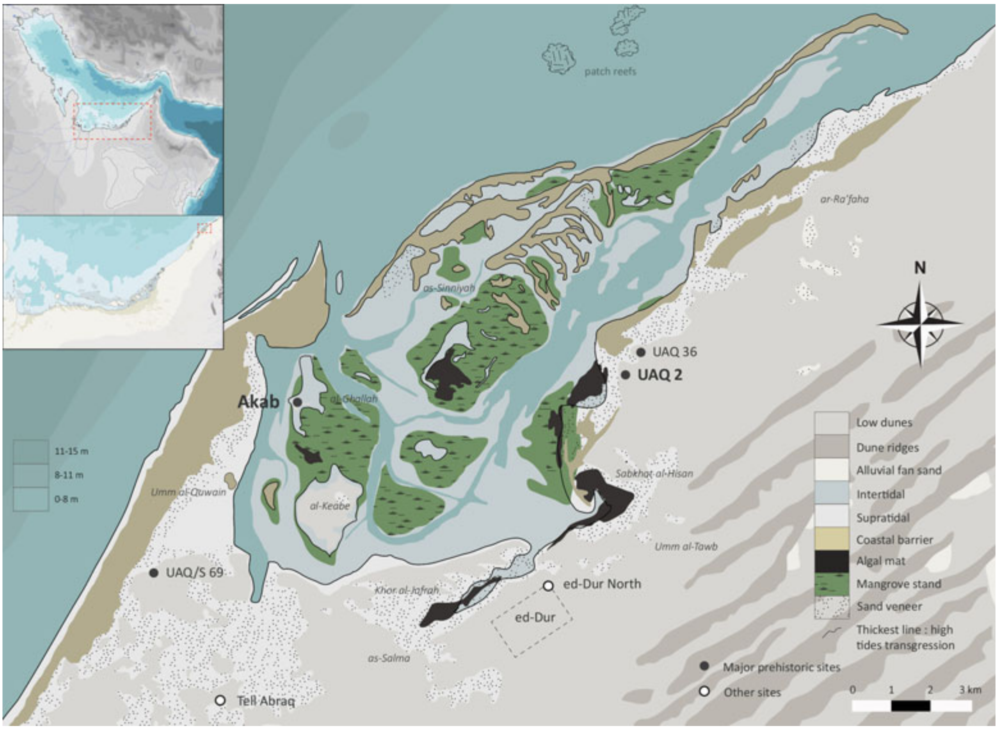


Figure 1. *Map of the Umm al-Quwain lagoon (Khor al-Beidah) and localisation of the major archaeological sites (modified from Ministry of Energy, UAE, 2006)*

The lagoon itself is shallow (max. depth: 10 m) and provides profitable habitat for marine life: seagrass beds grow over the soft bottom areas and sparse corals are established on the subtidal rocky flats. Locally called *farush*, the beach rocks result from the slow cementation of fine sediments. The tidal range is low (between 0.2 m and 1.5 m) but the foreshore slope is gentle, exposing a wide bare area during low tides, which could be particularly suited to traditional fish trapping devices. Nowadays, the water temperature range inside the lagoon is 18–20 °C during winter, increasing to 25 °C in mid-spring and frequently exceeding 30 °C during the summer. For that reason, salinity may exceed 40 ppt during the hotter months (>45 ppt in the shallowest areas), whereas it remains roughly close to the Persian Gulf mean during the rest of the year (Ali and Cherian 1983; Shriadah and al-Ghais 1999; UAQ Fisheries 1984). Because high temperatures and salinities can become limiting factors for the occurrence of certain fishes in the lagoon, modern fishermen have turned to deeper waters for their year-round activities. The Persian Gulf is also shallow (35 m mean). Just off the coast of Umm al-Quwain, the depth is about 7.3 m at 450 m offshore, and about 15 m at 2 nautical miles offshore (Service Hydrographique de la Marine 1904:111–112).

SITE DESCRIPTION: EXCAVATIONS AND MATERIAL CULTURE

The site was first excavated in 1990–1992 and was described as a small butchery camp which had specialized in dugong fishing (Jousse et al. 2002); it was dated to the Late Neolithic period, ca. 4500–3100 BC. From 2002 until 2009, a new series of

Table 1. **Radiocarbon and 2σ calibrated dates from the Akab site. Radiocarbone ages according to Charpentier & Méry 2008. Calibration program : Calib Rev 7.0.4. Marine13 calibration curve (Stuiver & Reimer 1993). ΔR = 163 according to Saliège et al. 2005; Southon et al. 2002.**

Sample	Type of sample	BP			2σ cal. BC			Context
Pa-2433	Dugong bone	5140	+/-	55	3522	-	3226	Dugong accumulation
Pa-2355	*Marcia* cf. *hiantina*	6275	+/-	50	4710	-	4461	Trench 2, Layer 6
Pa-2440	*Marcia* cf. *hiantina*	5970	+/-	35	4353	-	4207	Sector 1, base
Pa-2356	*Marcia* cf. *hiantina*	5900	+/-	50	4316	-	4056	Trench 5, Layer 6
Pa-2439	*Marcia* cf. *hiantina*	5710	+/-	30	4062	-	3914	A/B/C/21

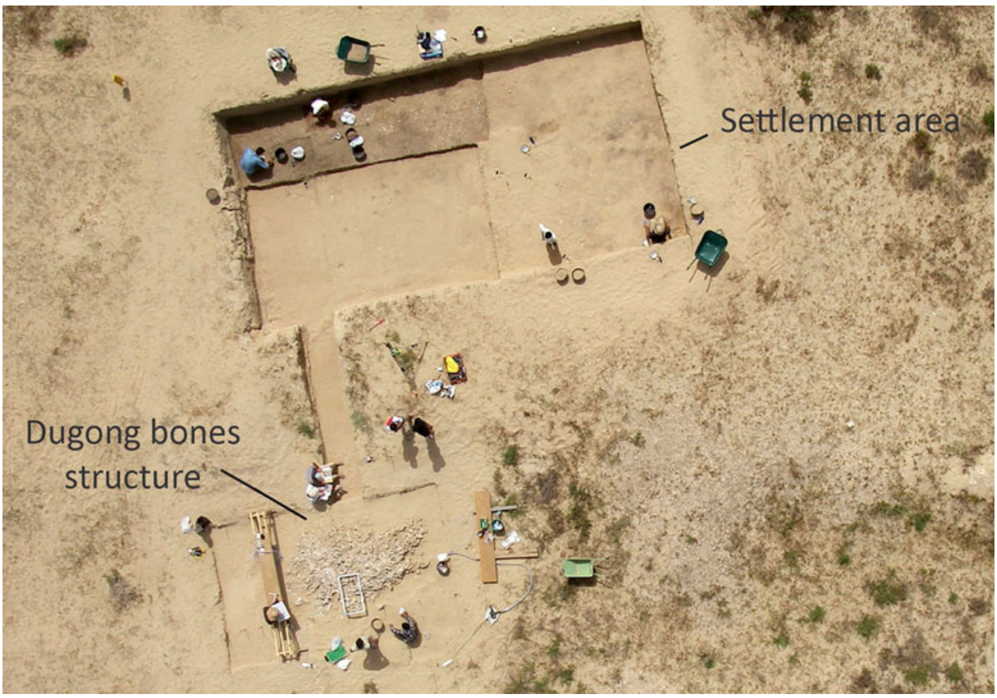


Figure 2. *Kite photo of the 2002-2009 excavations: top, the settlement area from trench 5, sector 1 & 2; bottom, the dugong bone mound © T. Sagory.*

excavations were conducted by a team from the French Archaeological Mission to the UAE (Charpentier and Méry 2008). Six test trenches (2 × 4 m) were excavated in order to define the extent of the settlement site. The excavated area represented 60 m^2.

The oldest occupation layer was dated to ca. 4600 BC in Trench 2 (Table 1: Pa-2355). Trench 5 offered well-preserved levels ranging from 4300 to 4000 BC (Table 1; Figure 2). The archaeological horizons (25–35 cm thick), directly accumulated on the Pleistocene wind-borne sand, were sealed by an uppermost layer of sterile sand more than 70 cm thick. The settlement area delivered over 250 post holes (possibly corresponding to round houses, wind barriers, and fences), numerous hearths, and domestic waste from where most of the faunal material was obtained.

Figure 3. *Neolithic fishing gear (selection of stone sinkers and shell fish-hooks) from Akab © French Archaeological Mission in UAE.*

The material culture is clearly related to the Late Neolithic period in Eastern Arabia, due to the presence of shell fish-hooks and miniature stone sinkers (Cleuziou and Tosi 1998:124–127; Méry and Charpentier 2013; Uerpmann 1992). It also comprises several "splintered pieces" and drills made from chert or flint that were primarily involved in the local manufacturing of personal ornaments: perforated gastropod beads (e.g., *Ancilla* spp.), *Spondylus* sp. and Pteriidae (pearl oysters) shells disc beads, *Conomurex persicus* or *Conus* sp. apex ring beads, and *Hexaplex kuesterianus* columella or soft stone tubular beads. Shell scrapers made from the valves of large clams (*Callista* spp.), and sheep bone points were also found, as well flint tile knives. All the pottery corresponds to the standard 'Ubaid ware (Méry et al. 2016:162) which comes from southern Iraq; a few painted sherds have 'Ubaid 3 period decoration (Charpentier and Méry 2008; Méry and Charpentier 2012).

The fishing gear of Akab is typical of the Neolithic period as defined in the Oman peninsula (see Uerpmann 1992 for a review). Several stone sinkers were found (n = 22) (Figure 3, n° 1-2). These are generally used by fishermen to weigh their nets, fishing lines, or cage traps. At Akab, we distinguished two different types. Type A sinkers are made from siliceous stone pebbles roughly fist sized (5–10 cm) and about

100–200 g (Charpentier and Méry 2008:fig. 8). Type A1 sinkers are generally rounded with a picked or grooved central waistline, used to tie a headline (Figure 3, n°1). Type A2 sinkers, less common, are flattened with notched edges—many are made in fine sandstone pebbles. Because of their moderate weights, it is likely that Type A sinkers were mostly used to weight medium-sized fishing nets such as gill nets and small seines. Type B (Figure 3, n°2) sinkers are made from small round pebbles (diameter ca. 2.5–3 cm; weight less than 20 g). A coiling waistline is generally grooved around it. These sinkers were probably used to weight light gear such as cast nets or hook-and-line (Méry and Charpentier 2012:fig. 19–20). Type B sinkers appear during the Late Neolithic. Other classifications also exist: the Akab Type B sinkers correspond well to the small thick pebbles from Saruq (Uerpmann 1992:94–95) and the fourth class from Ra's al-Khabbah 1 (Cavulli and Scaruffi 2011:fig. 2), in coastal Oman.

Shell fishhook technology has been abundantly documented in the Sultanate of Oman (Bavutti et al. 2015; Charpentier and Méry 1997) and, more recently, in the Persian Gulf (Méry et al. 2008). Few northern UAE sites provide Neolithic fishhooks: Akab, UAQ2 upper levels (Méry 2015), and out of context in Shimal (SH501 Wadi Suq tomb, Kästner 1991). At Akab, both final pieces and preforms, made from mother-of-pearl valves (mostly *Pinctada persica*) were found (Charpentier and Méry 2008:fig. 9; Méry et al. 2008:fig. 2). Complete shell fishhooks generally do not exceed 3–4 g. According to the classification suggested by Bavutti et al. (2015), the Akab fishhooks belong to various types:

- Type 1B (Figure 3, n°3-4): Fishhooks are small and slender (up to 5 cm in length) with the point curved toward the shank (Méry et al. 2008: fig. 2). A well-preserved piece shows two eyelet perforations, used to tie the line. This one is of the sub-category 1Be.
- Type 2A: One example of a large (≥ 5 cm in length), thick fishhook is attested at Akab (Méry et al. 2008: fig. 2). The point, despite being broken, seems to have been roughly parallel to the shank.

Recent excavations have also revealed that the dugong bones accumulation follows a designed structure of about 10 m^2 (Charpentier and Méry 2008; Méry et al. 2009). It was built in different stages by assembling the skulls, ribs, and mandibles of at least forty dugongs (Figure 2), and was constructed on packed sandy soil which included fragmented shells and bones reddened by ochre and artifacts similar to those found in the settlement area. Within the dugong structure, a kit of tools was also found which included a bone point, a tile knife made from tabular flint, a miniature stone sinker, and two shell fishhooks (Méry and Charpentier 2012). It was probably protected and enhanced by walls or fences, as suggested by a closed array of post holes, and dates from the end of the Neolithic period (Table 1: Pa-2433). It has no parallel in Eastern Arabia but is comparable to the dugong bone mounds in Torres Strait (Northern Australia), which, however, are not older than the fourteenth century AD (David et al. 2009; McNiven and Feldman 2003). Each of these structures are linked to totemic ceremonies and propitiatory rites (Haddon 1904–1912).

The latest levels of the settlement area and the dugong accumulation are separated by an episode of wind-blown sand, possibly corresponding to a phase of aridification. It remains unclear if the dark millennium, as defined by Uerpmann (2003), between 3800–3700 and 3300–3100 BC in the northern UAE, is due to poor preservation of the archaeological layers (owing to the sandy winds and dunal destabilization), a shift in the mobility of Neolithic populations toward a more nomadic life, or the difficulty for archaeologists in identifying low invested technologies and minimally diversified material cultures.

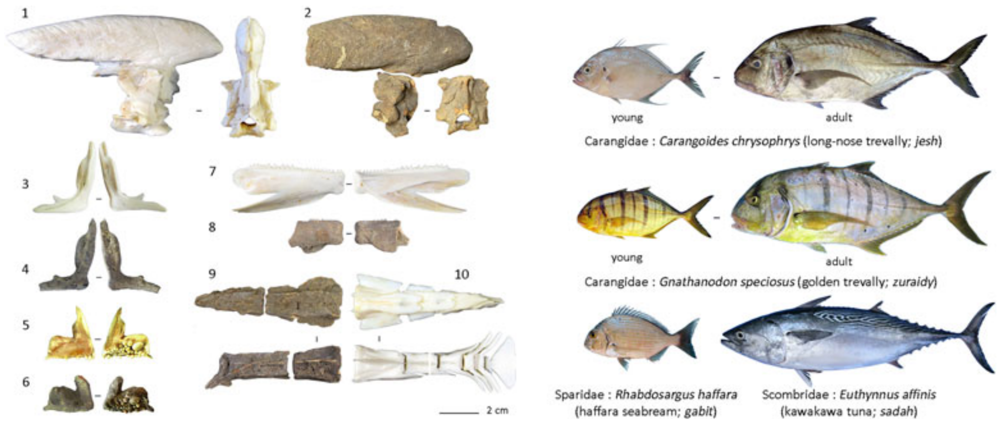


Figure 4. *Sample of the fish remains collected from Akab compared to analogue bones from the MNHN osteological reference collection, and corresponding live-pictures of the species (photos © P. Béarez and K. Lidour). 1-2. Hyperostotic supraoccipital, fused epiotics and exoccipitals of longnose trevally,* Carangoides chrysophrys*; 3-4. Right premaxillae of golden trevally,* Gnathanodon speciosus*; 5-6. Right premaxillae of Haffara seabream,* Rhabdosargus haffara*; 7-8. Right dentaries of kawakawa,* Euthynnus affinis*; 9-10. Series of caudal vertebrae of* Euthynnus affinis *(dorsal and lateral view).*

FAUNAL MATERIAL

While the inhabitants of Akab also consumed livestock (sheep/goats, cattle, and possibly dogs) and wild game (gazelles and donkeys) their food economy came essentially from the sea (Méry and Charpentier 2012:71); indeed, this settlement has provided a large amount of faunal material, of which the majority are fish bones and seashells.

Apart from fish, the marine fauna comprises dugongs (*Dugong dugon*), sea turtles (e.g., *Chelonia mydas*), crabs (mostly *Scylla serrata* and *Portunus segnis*), and shellfish, which could be directly gathered from the surrounding shores, mangal roots, or shallow patch reefs. Molluscs are mostly represented by mudcreepers (*Terebralia palustris*), murexes (*Hexaplex kuesterianus*), venus clams (*Marcia* spp.), and oysters (*Saccostrea cuccullata* and *Pinctada* spp.). Dugongs and sea turtles are slow swimmers and are not particularly difficult to catch even with simple techniques involving ropes, nets, or harpoons (Jousse et al. 2002; Zacot 2009). Other sites have provided numerous dugong bones within the Persian Gulf from Neolithic to the pre-oil era (Beech 2010b).

Because of the relatively few number of specialists working on fish osteology in Eastern Arabia, fishing practices (techniques, seasons, grounds, and the risk taking to access them) have remained poorly known until now, especially for the Neolithic period. This has been exacerbated by the underrepresentation of faunal material due to the lack of precise contextual data and the absence of sieving—a situation which is obviously problematic for the study of coastal societies. However, because the site of Akab was an open-area excavation (with a detailed stratigraphy) and all the material was sieved, a detailed study of the fish remains was possible.

MATERIAL AND METHODS

After drying, all the excavated sediments were systematically dry sieved using a 3 mm mesh. Fine sieving was also punctually conducted with a 1 mm mesh to test for the presence of small fauna. The faunal material came from the six levels (plus the

Table 2. **Table of identified fish from Akab, quantifications in NISP, MNI and WISP.**

Family	Genus	Species	NISP	MNI	WISP (g)
Carcharhinidae	*Carcharhinus*	*Carcharhinus* sp.	4	1	1.209
Dasyatidae	*Himantura*	*Himantura* sp.	1	1	?
Superorder Batoidea (ind. 'ray')			1	1	0.09
Clupeidae	*Sardinella*	*Sardinella longiceps*	3	1	0.02
	ind.		6	1	0.06
Chanidae	*Chanos*	*Chanos chanos*	1	1	0.66
Ariidae	*Netuma*	*Netuma bilineata*	191	81	318.734
		Netuma thalassina	41	27	97.315
		Netuma sp.	338	11	338.112
	Plicofollis	*Plicofollis* sp.	3	3	2.73
	ind.		21	2	9.12
Mugilidae			655	94	132.082
Atherinidae	*Atherinomorus*	*Atherinomorus lacunosus*	1	1	0.01
Belonidae	*Ablennes*	*Ablennes hians*	14	5	2.124
	Tylosurus	*Tylosurus choram*	277	17	25.069
		Tylosurus crocodylus	15	10	13.76
		Tylosurus sp.	54	10	29.077
	ind.		236	2	75.283
Platycephalidae	*Platycephalus*	*Platycephalus indicus*	16	13	5.15
Serranidae	*Cephalopholis*	*Cephalopholis hemistiktos*	1	1	0.37
		Cephalopholis sp.	5	2	0.51
	Epinephelus	*Epinephelus coioides*	17	11	41.013
		Epinephelus sp.	6	5	7.961
	ind.		3	3	1.619
Rachycentridae	*Rachycentron*	*Rachycentron canadum*	32	21	33.776
Echeneidae	*Echeneis*	*Echeneis naucrates*	1	1	0.322
Carangidae	*Alectis*	*Alectis indica*	13	6	42.93
		Alectis sp.	3	1	5.11
	Alepes	*Alepes vari*	3	2	0.45
		Alepes sp.	2		0.1
	Carangoides	*Carangoides bajad*	9	6	14.429
		Carangoides chrysophrys	827	335	2316.972
		Carangoides fulvoguttatus	7	7	11.31
		Carangoides orthogrammus	1	1	0.44
		Carangoides sp.	1705	42	1317.987
	Caranx	*Caranx ignobilis*	5	3	20.482
		Caranx sexfasciatus	163	80	141.542
		Caranx sp.	189	5	67.48
	Gnathanodon	*Gnathanodon speciosus*	632	92	541.476
	Megalaspis	*Megalaspis cordyla*	9	6	2.659
	Scomberoides	*Scomberoides commersonnianus*	74	29	55.958

(*Continued*)

***Table 2.* (*Continued*).**

Family	Genus	Species	NISP	MNI	WISP (g)
		Scomberoides lysan	1	1	0.11
		Scomberoides sp.	8	3	0.649
	Seriola	*Seriola dumerili*	1	1	0.5
	Ulua	*Ulua mentalis*	4	3	12.61
	ind.		1125	11	947.228
Lutjanidae	*Lutjanus*	*Lutjanus argentimaculatus*	4	3	3.82
		Lutjanus sp.	13	8	1.627
	ind.		1	1	1.29
Gerreidae	*Gerres*	*Gerres acinaces*	5	3	1.1
		Gerres sp.	3	1	0.29
Haemulidae	*Plectorhinchus*	*Plectorhinchus schotaf*	3	5	2.702
		Plectorhinchus sp.	4		1.912
	Pomadasys	*Pomadasys argenteus*	6	4	3.328
		Pomadasys commersonnii	1	1	0.4
		Pomadasys sp.	3	3	0.62
	ind.		1	1	0.417
Lethrinidae	*Lethrinus*	*Lethrinus borbonicus*	3	2	1.05
		Lethrinus lentjan	32	23	10.265
		Lethrinus cf. *mahsena*	1	1	2.419
		Lethrinus nebulosus	158	65	90.561
		Lethrinus sp.	508	77	95.661
Sparidae	*Acanthopagrus*	*Acanthopagrus berda*	43	22	20.56
		Acanthopagrus bifasciatus	12	5	7.356
		Acanthopagrus sp.	5	1	0.83
	Argyrops	*Argyrops* cf. *caeruleops*	1	1	0.81
		Argyrops spinifer	14	9	18.571
	Crenidens	*Crenidens indicus*	2	2	0.12
	Rhabdosargus	*Rhabdosargus haffara*	1231	439	710.329
	Sparidentex	*Sparidentex hasta*	6	4	7.94
	ind.		374	13	37.691
Superfamily Sparoidea (ind. Lethrinidae or Sparidae)			721		42.341
Sciaenidae	*Otolithes*	*Otolithes ruber*	5	2	0.392
	ind.		9	2	0.595
Mullidae	*Parupeneus*	*Parupeneus* sp.	1	1	0.12
Terapontidae	*Terapon*	*Terapon jarbua*	1	1	0.11
		Terapon sp.	3	2	0.064
Sphyraenidae	*Sphyraena*	*Sphyraena acutipinnis*	1	1	2.968
		Sphyraena jello	3	2	5.097
		Sphyraena putnamae	70	29	26.732
		Sphyraena sp.	73	8	16.458
Scombridae	*Auxis*	*Auxis thazard*	34	8	5.86

(*Continued*)

Table 2. **(*Continued*).**

Family	Genus	Species	NISP	MNI	WISP (g)
		Auxis sp.	20	2	1.294
	Euthynnus	*Euthynnus affinis*	2333	166	3094.116
	Rastrelliger	*Rastrelliger kanagurta*	2	1	0.632
	Scomberomorus	*Scomberomorus* cf. *commerson*	1	1	0.36
	Thunnus	*Thunnus tonggol*	5	4	18.686
		Thunnus sp.	7	3	15.331
	ind.		82	1	38.44
Triacanthidae	*Triacanthus*	*Triacanthus biaculeatus*	21	11	13.57
ind.			25062		6727.492
		Total determined	12550		10939.388
		Grand Total	37612	1899	17666.88

inter-level 4/5) identified in two sectors of the same settlement area (Trench 5).

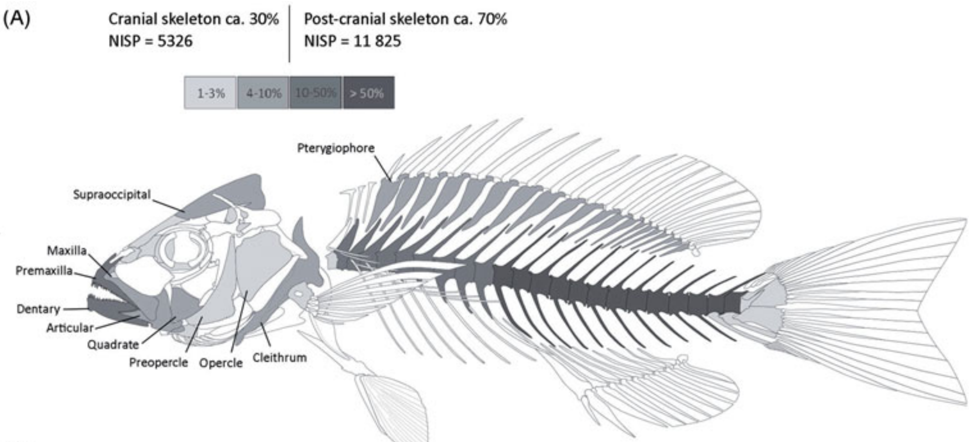
The bones were poorly preserved and often heavily encrusted with carbonates, which often obliterated their diagnostic parts; however, some anatomical connections were well preserved (Figure 4, n°9). Concretions such as these are a common phenomenon observed at several sites in Eastern Arabia (Beech 2004:174; Mashkour et al. 2016:199) and as they generally resist brushing or scrapping, acid treatments have to been used.

Anatomical and taxonomical identifications were conducted according to the methods of comparative anatomy, using the reference collection of the Muséum National d'Histoire Naturelle (MNHN). Quantifications (Table 2) were based on the number of identified specimens (NISP), the minimum number of individuals (MNI) and the weight of identified specimens (WISP). Estimated fresh weights of fishes presented in Figure 5.C were obtained after visual comparisons of their bones with the reference collection. Estimated fresh weights were preferred for their particular interest in diet studies. However, fine estimates of fish sizes should be preferred for fishing techniques reconstructions or ecological interpretations (Lidour et al. 2018). The MNI (Table 2) was calculated using the frequency of bones and combined with laterality and size (Chaplin 1971; Poplin 1981). However, the NISP is commonly preferred for archaeological fish bones because of the important bias in MNI calculation, which are due to both taphonomic processes and sampling methods (Grayson 1984; Morales-Muñiz 1984). In this study, N refers to the total number of remains while NISP refers to the number of identified specimens within both taxonomical and anatomical counts.

RESULTS

A total of 37,612 fish bone remains were studied and recorded, of which 12,550 were identified to family level, at least, and to species level where possible. This fine grain identification was made possible due to the high proportion of species-diagnostic bones. In some cases, higher taxa levels have been used: the superfamily Sparoidea for seabreams (Sparidae) and emperors (Lethrinidae) and the superorder Batoidea for rays (Table 2). Only a few remains were retrieved within the 1–3 mm fraction (n = 229; NISP = 95). This low number has no impact on the >3 mm assemblage analysis or the taxonomic spectrum. From a qualitative perspective, it informs on the presence of certain taxa which could not be identified with a 3 mm mesh or larger, such as silversides (*Atherinomorus lacunosus*), indian oil sardines (*Sardinella*

(A)



(B)

	Global		*Euthynnus affinis*		*Carangoides* spp.		*Gnathanodon speciosus*		*Rhabdosargus haffara*	
	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
Supraoccipitals	311	1.8%			308	12.1%				
Epiotics	92	0.5%			92	3.6%				
Exoccipitals	48	0.3%			48	1.9%				
Quadrates	219	1.3%	6	0.3%	107	4.2%	26	4.1%	1	0.1%
Maxillae	423	2.5%	107	4.6%	118	4.6%	28	4.4%	8	0.6%
Premaxillae	1269	7.4%	21	0.9%	93	3.6%	72	11.4%	578	47.0%
Angulo-articulars	224	1.3%	21	0.9%	95	3.7%	20	3.2%	11	0.9%
Dentaries	1218	7.1%	73	3.1%	128	5.0%	74	11.7%	625	50.8%
Hyomandibulas	116	0.7%	2	0.1%	36	1.4%	26	4.1%		
Opercles	139	0.8%	9	0.1%	70	2.7%	25	4.0%	1	0.1%
Cleithra	200	1.2%	4	0.2%	35	1.4%	2	0.3%		
Ceratohyals	108	0.6%			63	2.5%	14	2.2%		
Precaudal vertebrae	2192	12.8%	420	18,0%	183	7.2%	108	17.1%	4	0.3%
Caudal vertebrae	5165	30.1%	1604	68.0%	373	14.6%	138	21.8%		
Total NISP	17151		2333		2549		632		1231	

(C)

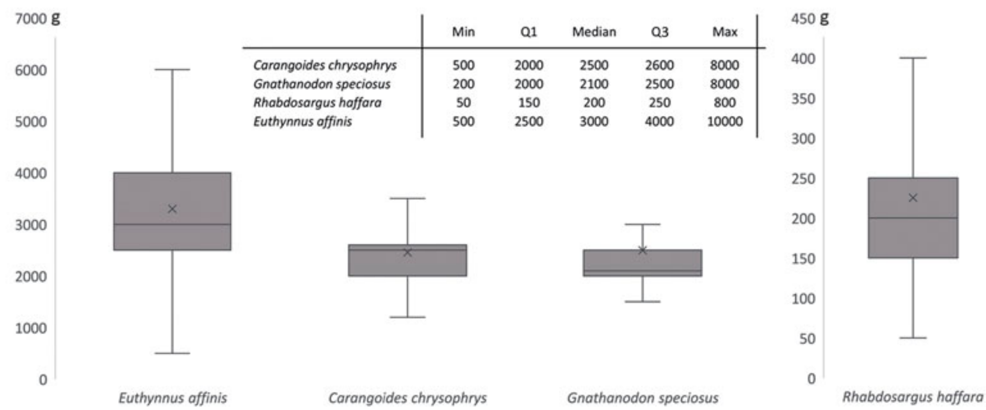


Figure 5. *A) Anatomical representation of the fish bones from Akab (modified from Coutureau & Béearez 2012). B) Detailed representations for the main taxa identified. C) Box plots of fresh weights for the main taxa at Akab (based on estimations according to visual comparisons with the MNHN Paris collection).*

longiceps), plus numerous juveniles of sparoids (grouping Sparidae and Lethrinidae), needlefishes (Belonidae), and mullets (Mugilidae). At Akab, fine sieving also captured many otoliths, in particular from mullets.

Almost all the fish bones come from the two main excavated residential areas: Sector 1 (32,493 remains) and Sector 2 (5,074 remains) and are therefore related to the Late Neolithic 1 (LN1) settlement, i.e., 4300–4000 BC (Table 1). At Akab, this period is represented by different levels of occupation for which precise dates are not yet established.

Only a few remains (n = 45) came from the dugong accumulation: the ritual structure of Akab dated to the second part of the fourth millennium BC (Late Neolithic 2 period). According to their diversity and spatial dispersion, it is unlikely that fishes were deliberately deposited here, as, for example, in the case of First Fruits ceremonies (Mauss 1967:197–204).

A total of 56 teleost species were identified, distributed across 42 genera and 22 families including, in order of importance, trevallies (Carangidae), tunas (Scombridae), and seabreams. These are followed by emperors, catfishes (Ariidae), mullets, needlefishes, and barracudas (Sphyraenidae). Few cartilaginous fishes were reported: these were identified as requiem sharks (Carcharhinidae) and stingrays (Dasyatidae). Non-fish remains were also punctually recorded, consisting of fragments of cuttlebone (*Sepia* sp.) and sea urchin shell (*Echinometra* sp.).

Anatomical representation

The systematic attribution of the fish remains was based on osteological comparisons (see part 3). Hyperostoses are species-specific swollen bones and have a special usefulness in archaeo-ichthyological analyses (Von den Driesch 1994) and figured prominently among the several keys of determination used during this study. The longnose trevally (*Carangoides chrysophrys*) shows a diagnostic hyperostosis on the supraoccipital which is elongated in the cranio-caudal axis (Figure 4, n°1–2), while hyperostoses of Indian threadfish (*Alectis indica*) and king soldier bream (*Argyrops spinifer*) are sub-triangular shaped in the lateral view. The hyperostoses of the island trevally (*Carangoides orthogrammus*) and the Indian pompano (*Trachinotus mookalee*) are more similar and might be confused with the longnose trevally; however, the latter also possesses hyperostotic epiotics and exoccipitals that tend to fuse together and are easily recognizable.

In the Akab assemblage, the anatomical representation was equilibrated with regard to the different occupation levels. The bones of the mandibular arch (in particular dentaries and premaxillae) were the most recorded cranial pieces (Figure 5.A and B), and were represented in similar proportions throughout the different settlement levels.

No evidence of a particular anthropogenic process in the fishes was observed and there were no butchery marks. A high proportion of vertebrae was prevalent in the assemblage and a number of articulated vertebrae were found during the excavation, but cranial bones were limited as they are often more sensitive to decomposition, generally because of their weakness—a typical case of differential preservation as noted at many archaeological sites. The number of vertebrae ranges from 24 to 27 for Carangidae and roughly 37 to 41 for Thunnini (tunas and kawakawas), which may explain their greater proportion in the assemblage compared to single and paired bones, especially skull bones. It is more likely that kawakawas were not headed at Akab since certain strong cranial bones, such as maxillae and dentaries (Figure 5.B), were also found. Cranial pieces from other taxa are generally well represented.

Taxonomic quantification

According to the NISP data (Table 2), the assemblage is dominated by trevallies (38%) with a high representation of the

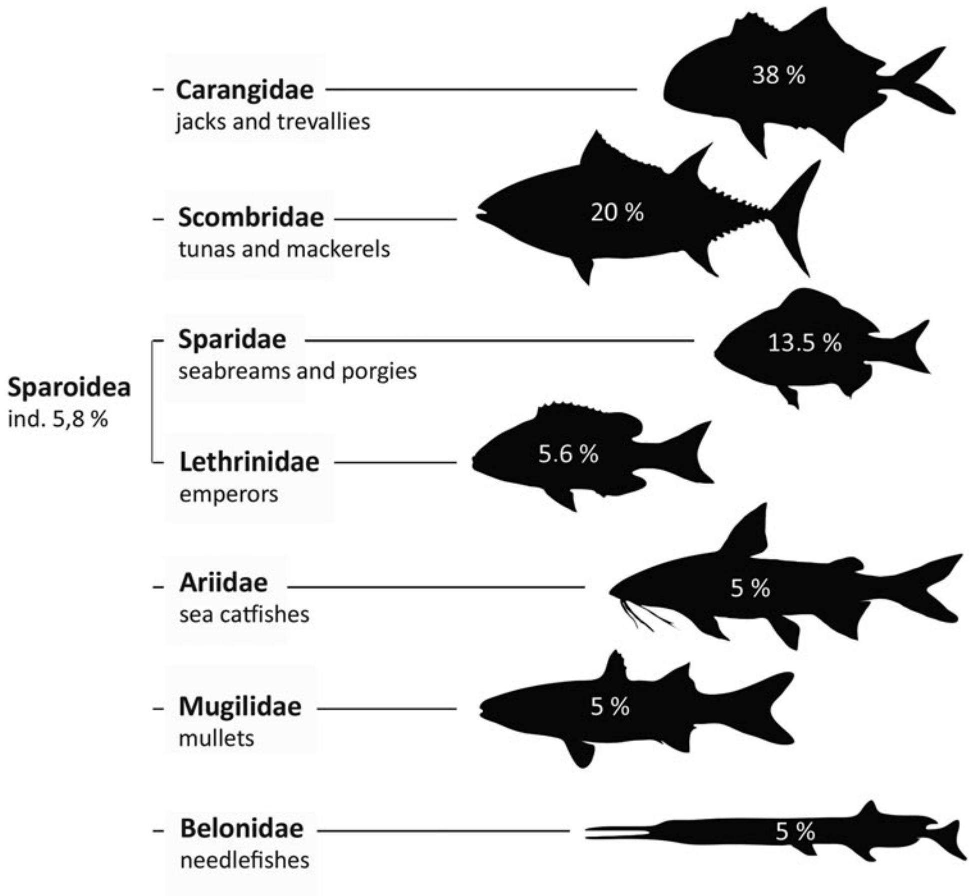


Figure 6. *Proportions of the main families identified at Akab. NISP = 12 550; other fish taxa = 2.1%.*

genus *Carangoides* (21%), mostly *Carangoides chrysophrys*. Golden trevallies (*Gnathanodon speciosus*) are less frequent (5%) and are directly followed by bigeye trevallies (*Caranx sexfasciatus*) and talang queenfishes (*Scomberoides commersonnianus*). Tunas and mackerels (20%) constitute the second most important taxon, largely dominated by kawakawas (*Euthynnus affinis*). Seabreams (Sparidae, 13.5%) are dominated by the Haffara seabream (*Rhabdosargus haffara*). Since it is often difficult to differentiate seabreams from emperors (5.6%) using some bone elements, especially caudal vertebrae, both families were grouped into the Sparoidea superfamily, which counts for ca. 25% (Figure 6).

A disparity was noted between levels 5-6 and 4-1 due to an increase in the proportion of seabreams. This observation could not be interpreted in terms of seasonality because kawakawas and Haffara seabreams, which were abundantly represented in these levels, are today available in large amounts during the same period of the year (mostly during winter). Thus, a change in the fishing grounds, offshore fishing versus lagoon exploitation, and fishing techniques might explain this slight variation in fish proportions.

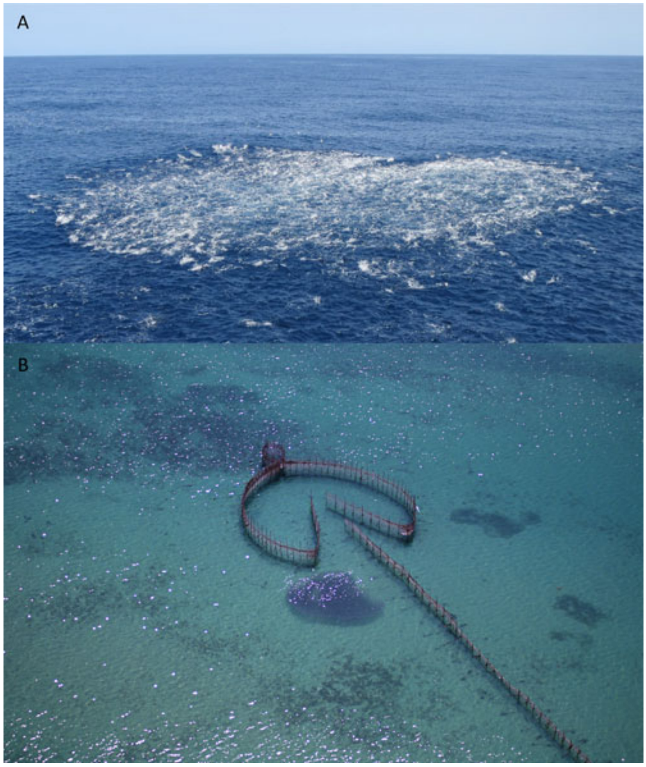


Figure 7. *A. Example of a tuna bust-up off the Ivory Coast. Creative Commons BY-NC-ND 4.0 © 2013 Wm Adams. B. Aerial view of traditional haddrah trap in Kuwait. Note the fish shoal at the trap's entrance. © 2016 Paulo Oliveira.*

DISCUSSION

The majority of fishes identified at Akab can currently be caught in the vicinity of Umm al-Quwain. An ecological survey done in 1984 (UAQ Fisheries 1984:tab. 9) permits the estimation that 90% of the taxa identified at Akab could have been directly caught inside the lagoon, including small sparoids, sea catfishes, mullets, young barracudas, and needlefishes.

Mangroves are well known to act as nurseries for many species, like young trevallies (*Carangoides* spp.); however, according to fishermen from Cairns (Queensland, Australia), even adult individuals are able to enter into shallow lagoons and coastal mangroves to hunt using the opportunity of high tides (Grant 2014; Lieske and Myers 1994). Therefore, although the longnose trevallies from Akab weigh around 2–3 kg (Figure 5.C), it is highly likely that they frequent the proximity of lagoons and coastal mangroves to feed, and that lagoon entrances or inlets were good locations to place nets or traps to catch them. Golden trevallies or *zuraidy* are principally encountered over and around offshore reefs, but they could also enter sheltered lagoons for feeding. Adults generally adopt a solitary behavior—sometimes seen among other trevally schools—while the younger ones are widespread and commensal of large fish, sharks, and even dugongs.

Kawakawas, locally known as *sadah*, are epipelagic fishes which often remain close to the shore. They tend to form multi-species schools with others scombrids (Collette and Nauen 1983) like longtail (*Thunnus tonggol*) and frigate tunas (*Auxis thazard*)—which were also identified at Akab, although in low numbers (Table 2)—and prey on small pelagics like sardines and silversides when feeding near the surface (Fischer and Bianchi 1984). These small fishes are also consumed by marine birds like seagulls whose flights fishermen track to find the fish schools. Tuna schools are also easily visible because they bust-up the surface of the sea (Figure 7.A). They are therefore an easy and profitable catch for traditional fisheries using nets or hook-and-line, as kawakawas commonly attain lengths of 60 cm to 1 m; however, it is necessary to use boats to catch them. King soldier breams or *kofar* (*Argyrops spinifer*) are bentho-pelagic fishes restricted to deep waters when adults. They could have been caught with long lines or with basket traps, locally called *gargoor* (pl. *garagir*), according to modern fisheries in the Gulf. These traditional dome-shaped traps, built in the recent past with palm leaves and fronds (Chen et al. 2012), might have been in use for a long time. Within the Sparoidea, the main taxon is the Haffara seabream or *gabit*, which is encountered in shallow coastal waters, especially over soft bottoms. Young emperors or *sheary* also form large agglomerations in mangroves and over grass beds. These small sparoids can be easily caught with a hook-and-line or *gargoor*. Tidal traps were formerly attested by classical authors like Diodorus Siculus (2003:II, 22) and were probably among the first techniques used by prehistoric fishermen in the area (Cleuziou and Tosi 2007:53). These traps, called *haddrah*, are semi-permanent intertidal fences (Figure 7.B) vertically fixed and supported by stones; this forms a bottleneck that encloses fish at the falling tide. The variant *sakkar* consists of intertidal barrier nets or net stakes which are more easily installed in lagoons or estuaries (Beech et al. 2005; Nedelec and Prado 1999:41). These techniques are non-selective and are able to catch a wide variety of fishes frequenting the shallow inshore waters; in this way they are similar to beach seines (*yaroof*) and provide similar landings (Bangsgaard and Yeomans 2016). In the Persian Gulf, the main taxa caught using the coastal barrier traps are seabreams, mullets, young barracudas, needlefishes, and trevallies, as well as moderate quantities of benthic fishes like sea catfishes, flatheads, and tripod fishes (Abou-Seedo 1992; Al-Baz et al. 2007, 2013). It should also be noted that several marine invertebrates like cuttlefishes and pelagic crabs can also be caught with tidal traps (McEwan et al. 2001), which supports the hypothesis of this technique being used by Akab fishermen.

The main fishes caught at Akab were listed and correlated with the most popular traditional fishing techniques used in Eastern Arabia (see Supplementary Information: S2). The data suggest a joint utilization of hook-and-line, gill nets, and beach seines, or barrier traps. It is likely that fishing was carried out inside the lagoon with low selective techniques like beach seines and tidal traps, allowing for a wide variety of coastal taxa to be caught, especially seagrass bed and soft bottom dwellers. In addition, at least two other specialized techniques are likely to have been used: one focusing on open water Thunnini schools, mostly kawakawas, probably caught with hook-and-lines or nets; the other focusing on trevally schools with tidal traps or gill nets deployed close to the inlets during high tides.

Seasonality

Seasonality is a recurring subject in Neolithic archaeology. It was initially suggested that Neolithic societies in Eastern Arabia followed a mobility scheme similar to that of traditional Bedouin tribes, alternating between summer and winter settlements (see Scholz 1980:fig. 2). The validity of this model was enhanced by characteristics of our modern climate: the summer is very hot and windy on the coast, making boat fishing dangerous and poorly efficient. Seasonal mobility between coastal and inland settlements has been recently suggested in the case of the study of Buhais

BHS18 site (Kutterer and Uerpmann 2017; Uerpmann and Uerpmann 2008). However, recent studies indicate that some Neolithic sites could have been inhabited throughout the year (Biagi and Nisbet 2006; Mashkour et al. 2016; Méry 2015). Moreover, other studies have demonstrated that the climate was wetter during the Neolithic (Berger et al. 2013; Preston et al. 2015) which suggests that their summers were not as harsh as one might expect. Nowadays, it is possible to fish during all seasons, although winter is clearly more productive (UAQ Fisheries 1984; Van Neer and Gautier 1993). A sedentary life, therefore, did not implicate any food storage as the local waters provided enough fish throughout the year to feed the entire settlement.

Beech (2004) analyzed the growth marks on emperor otoliths from the Neolithic site of UAQ2 (ca. 5500–4000 BC) close to Akab (Figure 1) and suggested that these fishes were caught during the spawning seasons, May–June and September–October (see also Von den Driesch and Manhart 2000). Lidour et al. (2018) also propose that Akab people took advantage of the spawning season of emperors during spring. Conversely, scombrid fishing and livestock slaughtering are considered as winter activities at UAQ2 by Mashkour et al. (2016). Indeed, within the modern climate, tunas and kingfishes (*Scomberomorus commerson*) are mostly caught during the winter months, because late spring and summer are generally too hot for these fish.

Until now, there has been little evidence of summer activities at Neolithic sites in the Gulf. According to Desse (1988) observations of otoliths from Khor P and Shagra (Qatar) indicate that fishing could have also been carried out during the summer, although less intensively than during the rest of the year. Unfortunately, the sclerochronology and ecology of fishes in Eastern Arabia and Indo-West-Pacific are not sufficiently understood to firmly extrapolate their seasonality. For example, tropical fish can spawn during a period of several months in warmer waters (Lowe-McConnell 1979) and the spawning season can vary between regional populations of the same fish species (Grandcourt et al. 2010). These biological characters, combined with the problem of applying actualist data to ancient climates, prevents any clear statement about seasonality based on fishing activities in the area being determined. To improve this knowledge, it will be necessary to embrace a broader ecosystemic view and to model the ecological studies on both ancient environments and palaeoclimatic data.

Fish processing

Current knowledge of Eastern Arabian Neolithic sites has not yet clearly provided any evidence of fish processing linked to drying, salting, or even smoking. Desse (1988) observed an overrepresentation of fish cranial elements at Khor P (Qatar), suggesting heading practices. The body, containing the rachis, could have been diffused on roads to supply inland sites (Cleuziou and Tosi 1998:125). However, the published cranial remains from Khor P were mostly composed of seabream teeth and the otoliths of seabreams and silversides. And because enameloid and dentin from teeth and aragonite from otoliths make these remains more resistant than bones in certain contexts, there could be a taphonomic bias; therefore, the hypothesis of fish processing suggested at Khor P is clearly unconvincing.

This hypothesis was also proposed for Akab (Charpentier and Méry 2008:131) but, unfortunately, as scombrid skull bones are particularly fragile (Béarez 1996:135–136), except for certain jaws elements, only a few were preserved. Moreover, until now, no inland site dated from the Neolithic period (e.g., Buhais BHS18) has provided fish bones. Dried fish consumption is however suggested on later sites, especially at Mleiha (second–third centuries AD), in inland UAE (Van Neer et al. 2013).

Table 3 **Comparison of proportions of the main fish families identified at Akab and different UAQ sites (data from Beech 2004; Mashkour et al. 2016; Uerpmann & Uerpmann 2005; Van Neer 2017).**

	UAQ2	UAQ2	Akab	Tell Abraq	Ed-Dur North	Ed-Dur
	Middle Neolithic	Late Neolithic	Late Neolithic	Bronze Age	Iron Age	150 BC-150/ 250 AD
NISP	5006	351	12550	14988	75	4429
Mugilidae	0.5%	1.1%	5.2%	19.4%	–	4.5%
Serranidae	2.4%	4%	0.3%	2.2%	6.7%	4.7%
Carangidae	1.5%	3.7%	38.1%	15.4%	29.3%	11.6%
Lethrinidae	37.1%	8%	5.6%	24.2%	12%	9.3%
Sparidae	49.7%	73.5%	13.5%	21.7%	32%	15.4%
Scombridae : Thunnini	2.7%	–	19.1%	0.2%	4%	29.1%
Scombridae : others	< 0.1%	–	0.7%			17.4%

Comparisons with other assemblages

The exploitation of shallow coastal environments using generalist techniques is the typical scheme of Neolithic fisheries in the Persian Gulf. Indeed, high proportions of seabreams are noted at several sites, such as as-Sabiyah H3 (36%—Kuwait, Beech 2010a), Dosariyah DOS11 (77%—Saudi Arabia, Beech 2004), al-Markh J19 (83%—Bahrain, Von den Driesch and Manhart 2000), Khor P (78%—Qatar, Desse 1988), and Dalma DA11 (34%—UAE, Beech 2004; Beech and Glover 2005). Groupers (Serranidae) are another of the main taxa identified at as-Sabiyah (17%), al-Markh (4%), and Dalma (15%), suggesting that fishing was also carried out over reefs.

Fishing in open waters is also attested by the occurrence of Thunnini—while few—at as-Sabiyah (n = 36), Dosariyah (n = 5), al-Markh (n = 2), and Dalma (n = 215). Some of these sites have also provided few remains of king soldier breams, which is consistent with fishing in deeper waters. Strikingly, until now, none of these sites has provided proportions of trevallies similar to those at Akab (i.e., 38%): remaining always lower than 10%. Proportions of pelagic fishes including Thunnini and trevallies are, however, prevalent on several sites situated in coastal Oman (>60%): Ra's al-Hamra sites 5, 6, 10, and Khor Milkh 1 (Uerpmann and Uerpmann 2003; Wilkens 2005). This area benefits from the proximity of deeper bottoms that could be advantageous for the living and the transit of pelagic fishes.

Because of the occurrence of Thunnini (n = 137), king soldier breams (n = 111), and even a tooth of tiger shark (*Galeocerdo cuvier*) at UAQ2, we know that fishing in open waters was practiced during the Middle Neolithic (MN) in the Gulf, i.e., from the mid-sixth to the end of the fifth millennium. The assemblage is, however, mainly dominated by small seabreams (ca. 90% of the MN assemblage, and mostly 10–30 cm long) (Table 3), whose proportion increases during the following periods. Mashkour et al. (2016) suggest that fishing "became even more focused on local exploitation of the shallow waters of the neighbouring lagoon." Emperors represent the other prevalent taxa at UAQ2, about 40% during the MN but only ca. 8% during LN1 at Akab. Nowadays, small emperors are numerous in the lagoon of Umm al-Quwain and are available all year round (UAQ Fisheries 1984), which raises the question of their disappearance in LN levels. Emperors were mainly identified through their otoliths at UAQ2 (85% of their remains, Beech pers. com.) but, unfortunately, before 2015, otoliths were not systemically collected due to the methods of separating material: otoliths were often confused with shell fragments. Subsequently, because the site was excavated before 2015, the upper levels of UAQ2 are otolith depleted and we can assume that the proportion of emperors is greatly underestimated at Akab. Such a bias is common in field archaeology, but it could be eradicated with the use of fine sieving and further training for field archaeologists by faunal remains experts.

LN1 is currently marked by the occurrence of the shell fishhooks and small stone sinker types (Cleuziou and Tosi 2007), which advocates for their joint use. They were mainly discovered along the coast of Oman on sites dated from the mid-fifth to the end of the fourth millennium (Bavutti et al. 2015; Charpentier and Méry 1997). Only a few were found in northern UAE, at Akab (Méry et al. 2008) and in the Late Neolithic levels at UAQ2 (Méry 2015). While the efficiency of handlines is theoretically lower than gill nets, the first technique requires less time, effort, and people (Jennings et al. 2001); the reflection of the mother-of-pearl shell makes the fishhook function as a lure that tricks surface predators, in particular Thunnini (Anell 1955:146; Béarez et al. 2012:209). Shell fishhooks represented an important innovation, and were likely the results of long and fruitful observations of the surface predator's behavior and forms of hunting. The use of shell fishhooks, therefore, was probably motivated by, and linked to, the fishing of pelagics.

Later fisheries are known from two other archaeological sites at Khor al-Beidah (Figure 1): Tell Abraq (Early Bronze Age) and ed-Dur (Early Iron Age and the Late pre-Islamic period) (Table 3). The large amount of fish remains include significant quantities of sparoids and mullets, which indicate a perseverance of fishing in the shallow coastal waters, including the lagoon (Uerpmann and Uerpmann 2005; Van Neer et al. 2017). Overall, open water fishing is attested at both sites through the occurrence of pelagic fishes such as Thunnini, king soldier breams, amberjacks (*Seriola* spp.), and eagle rays (Myliobatidae). The Iron Age and pre-Islamic site of ed-Dur provides a closer taxonomic spectrum to Akab: it is quite diversified and shows notable proportions of trevallies and kawakawas (Table 3). The occurrence of rabbitfishes (Siganidae, 3.6%) at Tell Abraq and groupers (4.7%) at ed-Dur may suggest the use of *garagir* traps in reef areas situated offshore.

Large proportions of trevallies and kawakawas are registered on later sites of the northern UAE coast: Kush, Jazirat al-Hulaylah, and Julfar, which are dated from the Islamic period. Small coastal fishes such as sparoids (mainly Haffara seabreams) and mullets were also identified in abundance on these sites (Beech 1998, 2004; Desse and Desse-Berset 2000). The presence of tuna (*Thunnus* spp.) is more important at these later sites—e.g., at Julfar (8.19%)—considering that fishermen were more able to fish in deeper waters due to an amelioration of their fishing gear and boats.

CONCLUSION

Although the local environment of UAQ has probably changed significantly during the past 7,500 years, current archaeo-ichthyological data confirms that the lagoon and its mangrove were already well established during the Neolithic, allowing a wide variety of fishes—commonly associated with the lagoonal environments as shallow sheltered bays, mangroves, and estuaries—to be caught (see Supplementary Information: S1). Fishing expeditions were also carried out by boat, in open waters, in order to catch kawakawas and other pelagic fish.

In the UAE, Neolithic offshore seafaring is well attested by the insular occupations of Marawah and Dalma (Beech 2004; Beech et al. 2016), some tens of kilometers offshore. At as-Sabiyah (Kuwait) boating technology is documented by bitumen pieces interpreted as waterproof coatings (Carter and Crawford 2010). Reed imprints on these fragments suggest that ancient boats were comparable to traditional *shoosh/shashah*: rowboats made of palm fronds and commonly operated with paddles, or less frequently with a small sail. Such small crafts could only carry a restricted fishing crew and a limited cargo, making them not particularly safe for fishing offshore schools. Net fishing can also be difficult in open waters, as an overloaded net can cause the fishermen to fall overboard, or even to sink the boat. Handlining and especially luring with shell fishhooks are much easier alternatives to catch surface predators like tunas, kingfishes, and trevallies.

In the Trobriand archipelago, Malinowski (1948) noted that open water fishing generated superstitious behaviors among the fishermen, while fishing inside the lagoon did not. Fishing and seafaring in these deep waters creates anxiety because of the fear of bad landings and drowning risks (Homans 1941; Poggie et al. 1976; Poggie and Pollnac 1988), and often produces superstitious behaviors including taboos and apotropaic or propitiatory ceremonies. Beliefs associated with totemism commonly originate from hunting or fishing stories (Leblic 1989; Mauss 1967:47–48; McNiven 2003). In some respects, fishing in open waters probably presented a high degree of risk, and therefore a certain amount of anxiety, for the Neolithic Akab fishermen; and may have resulted in superstitious behaviors or beliefs linked to the construction and maintenance of the dugong bone mound for specific ritual ceremonies. It remains impossible, however, to specify the nature of the superstitions/beliefs and their link with the belief system of the community.

Because of its predefined and predesigned structure and the specific set of associated deposits (mostly adornments), the dugong bone mound at Akab has been interpreted as a ceremonial site. And despite the fact that the parallels mentioned here reflect other cultures, countries, and periods, it is possible that at Akab these rites were probably not only dedicated to the dugong figure and its symbolism, but also to fishing and, in particular, to the expeditions carried out in the open sea.

This study provides new insights into Neolithic fisheries, regarding the marine resources exploited, the fishing gear used, and strategies developed in accordance with the natural environment of Akab. Alongside generalist fishing inside the lagoon, the fishing of trevallies was probably organized near the inlet, while kawakawas were captured in the open sea, only accessible by boat. The evidence presented here suggests that the shell fishhooks, weighted with miniature sinkers, that arose during the Late Neolithic, were specifically used as shining lures to catch selected pelagic predators.

This study also opens up the discussion on fish processing and seasonality, which was formerly oriented—based on local ethnographic data—toward semi-nomadism; it also provides evidence of a more balanced pattern, with a site occupation that extended at least from winter to late spring. Further work at Akab, especially sclerochronologic investigations, should contribute to resolve this issue. As data on the other faunal remains (seashells, crabs, terrestrial mammals, and dugongs) are still not available, the relative part of fish consumption in the Neolithic diet is unclear. Nevertheless, according to other contemporaneous sites, both in the UAE and the Sultanate of Oman, fishes have significantly contributed to the human subsistence economy here during both Neolithic and later periods.

ACKNOWLEDGEMENTS

Thanks go to H. H. Sheikh Saud bin Rashid al Mualla, UAE Supreme Council Member and Ruler of Umm al-Quwain; H. E. Sheikh Khaled bin Humed al Mualla, Director, Manager of the Department of Archaeology and Heritage, Umm al-Quwain; Ms. Alyaa Mohammad al Ghufly, Director of the Museum of Umm al-Quwain; and to the French archaeological mission in UAE for access to the study materials and *accommodation in the field. The excavations at Akab were supported by the Department of Antiquities and Museums of Umm al-Quwain, the Sous-direction des Sciences Humaines, Sociales et de l'Archéologie du Ministère des Affaires Etrangères, the Institut National de Recherches Archéologiques Préventives (INRAP), and the Centre National de la Recherche Scientifique (CNRS). Special thanks go to Dr. Mark Jonathan Beech (Department of Culture and Tourism, Abu Dhabi) for his help in obtaining specific specimens and his contribution in presorting the Akab material. We are also grateful for his expert advice and kind encouragement throughout the doctoral project of one of us (K. L.). Thanks to Jill Cucchi for copy-editing. Our final acknowledgements go to the UAQ fishermen for the information they provided regarding traditional techniques and the localization of fishing spots.*

FUNDING

This study was made possible with the material and financial support of UMR 7209 (AASPE—Muséum National d'Histoire Naturelle), UMR 7041 (Arscan—Université Paris 1 Panthéon-Sorbonne), UMR 6566 (CREAAH—Université Rennes 2), and ANR NeoArabia.

ORCID

Kevin Lidour http://orcid.org/0000-0002-0252-9376
Philippe Béarez http://orcid.org/0000-0003-0397-2393

REFERENCES

Abou-Seedo, F. S. 1992. Abundance of fish caught by stake traps (Hadra) in the intertidal zone in Doha, Kuwait bay. *Journal of the University of Kuwait (Science)* 19(1): 91–99.

Al-Baz, A. F., M. M. Al-Husaini, and J. M. Bishop. 2013. Intertidal fixed stake net trap (Hadrah) fishery in Kuwait: Distribution, catch rate and species composition. *World Academy of Science, Engineering and Technology, International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering* 7(12): 1114–1119.

Al-Baz, A. F., W. Chen, J. M. Bishop, M. Al-Husaini, and S. A. Al-Ayoub. 2007. On fishing selectivity of hadrah (fixed stake trap) in the coastal waters of Kuwait. *Fisheries Research* 84(2):202–209.

Ali, R., and T. Cherian. 1983. *Environmental Conditions of the Coastal Waters of the United Arab Emirates During 1982* . Annual Report. Technical Report. Abu Dhabi: Department of Fisheries, Ministry of Agriculture and Fisheries, United Arab Emirates.

Anell, B. 1955. Contribution to the history of fishing in the Southern Seas. *Studia Ethnographica Upsaliensia* 9:1–249.

Bangsgaard, P., and L. Yeomans. 2016. Zooarchaeological perspectives on rural economy and landscape use in eighteenth-century Qatar. In *Landscapes of the Islamic World: Archaeology, History, and Ethnography* (S. McPhillips and P. D. Wordsworth, eds.):94–108. Philadelphia: University of Pennsylvania Press.

Bavutti, E., F. Borgi, E. Maini, and J. M. Kenoyer. 2015. Shell fish-hook production at Ras al-Hadd HD-5, Sultanate of Oman (fourth millennium BC): preliminary archaeological and experimental studies. *Proceedings of the Seminar for Arabian Studies* 45:1–6.

Béarez, P. 1996. Comparaison des ichtyofaunes marines actuelle et holocène et reconstitution de l'activité halieutique dans les civilisations précolombiennes de la côte de Manabi Sud (Equateur): 202. Thèse de Doctorat. Paris: Muséum National d'Histoire Naturelle.

Béarez, P., P. Gay, and R. Lunniss. 2012. Sea fishing at Salango (Manabí Province, Ecuador) during the Middle Formative Machalilla phase. *Latin American Antiquity* 23(2):195–214.

Beech, M. J. 1998. Comments on two vertebrate samples from early Islamic Jazirat al-Hulaylah (5th-9th c.AD) and Islamic Julfar (mid-14th-16th c. AD), United Arab Emirates. *Bulletin of Archaeology - University of Kanazawa* 24:197–203.

Beech, M. J. 2004. *In the Land of the Ichthyophagi modelling fish exploitation in the Arabian Gulf and Gulf of Oman from* *the 5th millennium BC to the Late Islamic period* . British Archaeological Report 1217. Oxford: British Archaeological Reports.

Beech, M. J. 2010a. The animal and fish bones. In *Maritime Interactions in the Arabian Neolithic. Evidences from H3, As-Sabiyah, an Ubaid-Related Site in Kuwait* (R. Carter and H. Crawford, eds.):129–156. American School of Prehistoric Research Monograph Series 8. Boston: Brill.

Beech, M. J. 2010b. Mermaids of the Arabian Gulf: Archaeological evidence for the exploitation of dugongs from prehistory to the present. *Journal of the National Center for Documentation and Research* 2(3):3–18.

Beech, M. J., V. Charpentier, and S. Méry. 2017. Evidence for deep-sea fishing and cultural identity during the Neolithic period at Akab Island, Umm al-Qaiwain, United Arab Emirates. In *Archaeozoology of the Near East 9* (M. Mashkour and M. J. Beech, eds.): 331–338. Oxford: Oxbow Books.

Beech, M. J., R. Cuttler, D. Moscrop, H. Kallweit, and J. Martin. 2005. New evidence for the Neolithic settlement of Marawah Island, Abu Dhabi, United Arab Emirates. *Proceedings of the Seminar for Arabian Studies* 35:37–56.

Beech, M. J., and E. Glover. 2005. The environment and economy of an Ubaid-related settlement on Dalma Island, United Arab Emirates. *Paléorient* 31(1):97–107.

Beech, M. J., K. Strutt, L. Blue, A. K. al-Kaabi, W. A. Omar, A. A. al-Haj el-Faki, A. R. Lingareddy, and J. Martin. 2016. ‘Ubaid-related sites of the southern Gulf revisited: the Abu Dhabi Costal Heritage Initiative. *Proceedings of the Seminar for Arabian Studies* 46:9–24.

Berger, J.-F., V. Charpentier, R. Crassard, C. Martin, G. Davtian, and J. A. López-Sáez. 2013. The dynamics of mangrove ecosystems, changes in sea level and the strategies of Neolithic settlements along the coast of Oman (6000–3000 cal. BC). *Journal of Archaeological Science* 40:3087–3104.

Biagi, P., and R. Nisbet. 2006. The prehistoric fisher-gatherers of the Western Coast of the Arabian Sea: A case of seasonal sedentarization? *World Archaeology* 38(2):220–238.

Boucharlat, R., E. Haerinck, C. Phillips, and D. T. Potts. 1991. Occupation humaine et environnement au 5e et au 4e millénaire sur la côte Sharjah-Umm al-Qaiwain (U.A.E.). *Arabian Archaeology and Epigraphy* 2: 93–106.

Carter, R., and H. Crawford (eds.). 2010. *Maritime Interactions in the Arabian Neolithic. Evidences from H3, As-Sabiyah and Ubaid-Related Site in Kuwait*. American School of Prehistoric Research Monograph Series 8. Boston: Brill.

Cavulli, F., and S. Scaruffi. 2011. Fishing kit implements from KHB-1: net sinkers and lures. *Proceedings of the Seminar for Arabian Studies* 41:27–34.

Chaplin, R. E. 1971. *The study of animal bones from archaeological sites*. New York: Seminar Press.

Charpentier, V., 2002. Archéologie de la côte des ichtyophages. Coquilles, squales et cétacés du site IVe-IIIe millénaires de Ra’s al-Jinz. In *Essays on the Late Prehistory of the Arabian Peninsula* (S. Cleuziou, M. Tosi, and J. Zarins eds.):73–99. Serie Orientale Romana vol. 93. Roma: Instituto italiano per l’Africa e l’Oriente.

Charpentier, V., and S. Méry. 1997. Hameçons en nacre et limes en pierre d’Océanie et de l’Océan Indien: analyse d’une tendance. *Journal de la Société des Océanistes* 105(2): 147–156.

Charpentier, V., and S. Méry. 2008. A Neolithic settlement near the Strait of Hormuz: Akab Island, United Arab Emirates. *Proceedings of the Seminar for Arabian Studies* 38:117–136.

Chen, W., A. Al-Baz, J. Bishop, and M. al-Husaini. 2012. Field experiments to improve the efficacy of gargoor (fish trap) fishery in Kuwait’s waters. *Chinese Journal of Oceanology and Limnology* 30(3):535–546.

Cleuziou, S., and M. Tosi. 1998. Hommes, climats et environnements de la Péninsule arabique à l’Holocène. *Paléorient* 23(2):121–135.

Cleuziou, S., and M. Tosi (eds.). 2007. *In the Shadow of the Ancestors. The Prehistoric Foundations of the Early Arabian Civilization in Oman*. Muscat: Ministry of Heritage and Culture, Sultanate of Oman.

Collette, B. B., and C. E. Nauen. 1983. FAO Species Catalogue. Volume 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. *FAO Fisheries Synopsis* 125(2):1–137.

David, B., I. McNiven, J. Crouch, M. Badulgal, R. Skelly, B. Barker, K. Courtney, and H. Hewitt. 2009. Koey Ngurtai: the emergence of a ritual domain in Western Torres Strait. *Archaeology in Oceania* 44(1):1–17.

Desse, J. 1988. Khor P., Khor F.B. et Shagra. Les faunes, le rôle de la pêche. In *Préhistoire à Qatar, mission archéologique française à Qatar, 2* (M.-L. Inizan, ed.): 157–166. Paris: Editions Recherche sur les Civilisations.

Desse, J., and N. Desse-Berset. 2000. Julfar (Ras al Khaimah, Emirats Arabes Unis), ville portuaire du golfe arabo-persique (VIIIe-XVIIe siècles): exploitation des mammifères et des poissons. In *Archaeozoology of the Near East IV. Proceedings of the fourth international symposium on the archaeozoology of southwestern Asia and adjacent areas* (M. Mashkour, A. M. Choyke, H. Buitenhuis, and F. Poplin, eds.):79–93. Groningen: ARC.

Diodorus Siculus. 2003. *Bibliotheca Historica, Asia. Liber II . Trans. B. Eck. Collection des Universités de France, Série grecque - Collection Budé 430*. Paris: Les Belles Lettres.

Fischer, W., and G. Bianchi (eds.). 1984. *FAO Species Identification Sheets for Fishery Purposes. Western Indian Ocean - Fishing Area 51 . 6 vols. FAO species identification guide for fisheries purposes*. Rome: FAO & Denmark Funds-in-Trust.

Glover, E., and M. J. Beech. 2005. The environment and economy of an Ubaid - related Settlement on Dalma Island, United Arab Emirates. *Paléorient* 31(1):97–105.

Grandcourt, E., T. Z. A. Abdessalaam, F. Francis, and A. T. Al Shamsi. 2010. Reproductive biology and implications for management of the spangled emperor *Lethrinus nebulosus* in the southern Arabian Gulf. *Journal of Fish Biology* 77(10): 2229–2247.

Grant, E. M. 2014. *Grant's Guide to Fishes: The Fisherman's Bible*. Scarborough: E.M. Grant Pty Ltd.

Grayson, D. 1984. *Quantitative Zooarchaeology*. Cambridge, MA: Academic Press.

Haddon, A. D. 1904–1912. *Reports of the Cambridge Anthropological Expedition to Torres Straits, Volumes IV & V*. Cambridge: Cambridge University Press.

Homans, G. C. 1941. Anxiety and Ritual: the Theories of Malinowski and Radcliff-Brown. *American Anthropologist, New Series* 43(2): 164–172.

Jennings, S., M. J. Kaiser, and J. D. Reynolds. 2001. *Marine Fisheries Ecology*. Oxford: Blackwell Science.

Jousse, H., M. Faure, C. Guérin, A. Prieur, and J. Desse. 2002. Exploitation des ressources marines au cours des Ve-IVe millénaires: le site à dugongs de l'île d'Akab (Umm al-Qaiwain, Émirats Arabes Unis). *Paléorient* 28(1):43–60.

Kästner, J.-M. 1991. Interim Report of the 6th Campaign of the German Archaeological Mission to Ra's al-Khaimah 1990. Unpublished manuscript, Göttingen.

Kutterer, A., and H.-P. Uerpmann. 2017. Neolithic nomadism in south-east Arabia—strontium and oxygen isotope ratios tooth enamel from al-Buhais 18 and Umm al-Quwain 2 in the Emirates of Sharjah and Umm al-Quwain (UAE). *Arabian Archaeology and Epigraphy* 28:75–89.

Leblic, I. 1989. Notes sur les fonctions symboliques et rituelles de quelques animaux marins pour certains clans de Nouvelle Calédonie. Anthropozoologica special issue 3 "Animal et pratiques religieuses: les manifestations matérielles": 187–196.

Lidour, K., J. Vorenger, and P. Béarez. 2018. Size and weight estimations of the spangled emperor (Teleostei: Lethrinidae: *Lethrinus nebulosus*) from bones measurements elucidate fishing grounds exploited and ancient seasonality at Akab (United Arab Emirates). *International Journal of Osteoarchaeology*: 1–14. doi:10.1002/oa.2683.

Lieske, E., and R. Myers. 1994. *Coral Reef Fishes. Indo-Pacific & Caribbean including the Red Sea. Collins Pocket Guide*. New York: Harper Collins Publishers.

Lowe-McConnell, R. H. 1979. Ecological aspects of seasonality in fishes of tropical waters. *Symposia of the Zoological Society of London* 44:219–241.

Malinowski, B. 1948. *Magic, Science and Religion and Other Essays*. Glencoe: The Free Press.

Mashkour, M., M. J. Beech, K. Debue, L. Yeomans, S. Brehard, D. Gasparini, and S. Méry. 2016. Middle to Late Neolithic animal exploitation at UAQ2 (5500–4000 cal BC): an Ubaid-related coastal site at Umm al-Quwain Emirate, United Arab Emirates. *Proceedings of the Seminar for Arabian Studies* 46: 195–210.

Mauss, M. 1967. *Manuel d'Ethnographie*. Paris: Editions Sociales.

McEwan, T., S. A. F. Bell, and M. J. Dvornak. 2001. The hadra fish trap: a technique to acquire fishes for Aquaria. *Bulletin de l'Institut océanographique de Monaco* 20(1):205–208.

McNiven, I. J. 2003. Saltwater people: spiritcapes, maritime rituals and the archaeology of Australian indigenous seascapes. *World Archaeology* 35(3):329–349.

McNiven, I. J., and R. Feldman. 2003. Ritually orchestrated seascapes: hunting magic and dugong bone mounds in Torres Strait, NE Australia. *Cambridge Archaeological Journal* 13(2):169–194.

Méry, S. 2015. Mobilité et interculturalité en Arabie orientale durant la Protohistoire ancienne: modalités de formation d'un ensemble culturel et d'entités régionales. In *Les systèmes de mobilité de la Préhistoire au Moyen-Âge* (N. Naudinot, L. Meignen, D. Binder, and G. Querré, eds.):353–368. Antibes: APDCA.

Méry, S., M. J. Blackman, M. J. Beech, and K. Lidour. 2016. 5500 av. notre ère: le vase de Marawah MR11 et l'Obeid du Golfe. In *Parcours d'Orient. Recueil de textes offert à Christine Kepinski* (B. Perello and A. Tenu, eds.):155–174. Oxford: Archaeopress Archaeology.

Méry, S., and V. Charpentier. 2012. Akab Island, a Neolithic sanctuary in the Gulf. In *Proceedings of the 2nd International Conference on the Archaeology of the United Arab Emirates* (D. T. Potts and P. Hellyer, eds.):69–77. Abu Dhabi, Dubai, and London: Motivate Publishing.

Méry, S., and V. Charpentier. 2013. Neolithic material cultures of Oman and the Gulf sea-shores from 5500-4500 BCE. *Arabian Archaeology and Epigraphy* 24:73–78.

Méry, S., V. Charpentier, G. Auxiette, and E. Pelle. 2009. A dugong bone mound: the Neolithic ritual site on Akab in Umm al-Quwain, United Arab Emirates. *Antiquity* 83: 696–708.

Méry, S., V. Charpentier, and M. J. Beech. 2008. First evidence of shell fish-hook technology in the Gulf. *Arabian Archaeology and Epigraphy* 19:15–21.

Morales Muñiz, A. 1984. A renewable exploitation model for application on ichthyoarchaeological assemblages. In *2èmes rencontres d'Archéo-ichtyologie* (N. Desse-Berset, ed.): 41–60. Notes et monographies techniques 16. Valbonne: CRA-CNRS.

Nedelec, C., and J. Prado. 1999. *Definition and Classification of Fishing Gear Categories*. FAO Fisheries Technical Paper. Rome: FAO Fishery Industries Division.

Poggie, J. J., Jr., and R. Pollnac. 1988. Danger and rituals of avoidance among New England fishermen. *Maritime Anthropological Studies* 1(1):66–78.

Poggie, J. J., Jr., R. Pollnac, and C. Gersuny. 1976. Risk as a basis for taboos among fishermen in southern New England. *Journal for the Scientific Study of Religion* 15:257–262.

Poplin, F. 1981. Un problème d'ostéologie quantitative: calcul d'effectif initial d'après appariement. Généralisation aux autres types de remontages et à d'autres matériels archéologiques. *Revue d'Archéométrie* 5: 159–165.

Preston, G. W., D. S. G. Thomas, A. S. Goudie, O. A. C. Atkinson, M. J. Leng, M. J. Hodson, H. Walkington, et al. 2015. A multi-proxy analysis of the Holocene humid phase from the United Arab Emirates and its implications for southeast Arabia's Neolithic populations. *Quaternary International* 382:277–292.

Sanlaville, P., and R. Dalongeville. 2005. L'évolution des espaces littoraux du golfe Persique et du golfe d'Oman depuis la phase finale de la transgression post-glaciaire. *Paléorient* 31(1):9–26.

Scholz, F. 1980. *Sultanate of Oman, Part I Geographical Introduction*. Stuttgart: Ernest Klett Printing.

Service Hydrographique de la Marine. 1904. *Instructions nautiques. Océan Indien. Golfe d'Oman et golfe persique*. Paris: Imprimerie Nationale.

Shriadah, M. M. A., and S. M. Al-Ghais. 1999. Environmental characteristics of the United Arab Emirates waters along the Persian Gulf: Hydrographical survey and nutrient salts. *Indian Journal of Marine Sciences* 28(3): 225–232.

UAQ Fisheries. 1984. *Study on Mariculture Environment of Umm al-Quwain Lagoon and the Experimental Rearing of Shrimp, Rabbitfish and Mullet*. Technical Report 8: 1–72. Abu Dhabi: Department of Fisheries, Ministry of Agriculture and Fisheries, United Arab Emirates.

Uerpmann, M. 1992. Structuring the Late Stone Age of Southeastern Arabia. *Arabian Archaeology and Epigraphy* 3:65–109.

Uerpmann, M. 2003. The Dark Millennium. Remarks on the Final Stone Age in Emirates and Oman. In *Archaeology of the United Arab Emirates. Proceedings of the First International Conference on the Archaeology of the United Arab Emirates* (D. T. Potts, H. al-Naboodah, and P. Hellyer, eds.):73–84. Abu Dhabi: Trident Press.

Uerpmann, M., and H.-P. Uerpmann. 2003. *Stone Age Sites and Their Natural Environment. The Capital Area of Northern Oman, IIII*. Beihefte zum Tübinger Atlas des Vorderen Orients Reihe A (Naturwissenschaften), 31(3). Wiesbaden: Dr. Ludwig Reichert.

Uerpmann, M., and H.-P. Uerpmann. 2005. Fish exploitation at Bronze Age harbour sites in the Arabian Gulf area. *Paléorient* 31(1): 108–115.

Uerpmann, M., and H.-P. Uerpmann. 2008. Neolithic faunal remains from al-Buhais 18 (Sharjah, UAE). In *The Natural Environment of Jebel al-Buhais: Past and Present. The*

Archaeology of Jebel al-Buhais, II (H.-P. Uerpmann, M. Uerpmann, and S. A. Jasim, eds.):97–132. Department of Culture and Information, Government of Sharjah, UAE and the Institut für Ur- und Frühgeschichte und Archäologie des Mittelalters, Universität Tübingen, Germany. Tübingen: Kerns Verlag.

Van Neer, W., and A. Gautier. 1993. Preliminary report on the faunal remains from the coastal site of ed-Dur, 1st-4th century A.D. In *Archaeozoology of the Near East. Proceedings of the First International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas* (H. Buitenhuis and A. T. Clason, eds.):110–118. Leiden: Universal Book Services.

Van Neer, W., A. Gautier, E. Haerinck, W. Wouters, and E. Kaptijn. 2017. Animal exploitation at ed-Dur (Umm al-Qaiwain, United Arab Emirates). *Arabian Archaeology and Epigraphy* 28:11–30.

Van Neer, W., W. Wouters, and M. Mouton. 2013. Evidence of sun-dried fish at Mleiha (S.-E. Arabia) in antiquity. *Arabian Archaeology and Epigraphy* 24(2):224–321.

Von den Driesch, A. 1994. Hyperostosis in fish. In *Fish Exploitation in the Past* (W. Van Neer, ed.):37–45. Annalen, Zoologische Wetenschappen 274. Tervuren: Koninklijk Museum voor Midden Afrika.

Von den Driesch, A., and H. Manhart. 2000. Fish bones from al-Markh, Bahraın. In *Archaeozoology of the Near East IV. Proceedings of the Fourth International Symposium on the Archaeozoology of Southwestern Asia and Adjacent Areas* (M. Mashkour, A. M. Choyke, H. Buitenhuis, and F. Poplin, eds.):50–67. Groningen: ARC.

Wilkens, B. 2005. Fishing in the Arabian sea: a short note on the prehistoric sites RH6 and Ra's al-Jinz 1 in Oman. *Paléorient* 31(1): 126–130.

Zacot, F.-R. 2009. *Peuple nomade de la mer. Les Badjos d'Indonésie. Itinéraire autobiographique d'un ethnologue*. Paris: Pocket.