



**HAL**  
open science

## 'The numerous islands of Ichthyophagi': Neolithic fisheries of Delma Island, Abu Dhabi Emirate (UAE)

Kevin Lidour, Mark Jonathan Beech

### ► To cite this version:

Kevin Lidour, Mark Jonathan Beech. 'The numerous islands of Ichthyophagi': Neolithic fisheries of Delma Island, Abu Dhabi Emirate (UAE). Proceedings of the Seminar for Arabian Studies, 2019. hal-03418248

**HAL Id: hal-03418248**

**<https://hal.science/hal-03418248v1>**

Submitted on 6 Nov 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**‘The numerous islands of Ichthyophagi’: Neolithic fisheries of Delma Island, Abu Dhabi Emirate (UAE)**

**Kevin Lidour<sup>1, 2</sup>, Mark Jonathan Beech<sup>3</sup>**

1. Université Paris 1 Panthéon-Sorbonne, UMR 7041 (ARSCAN), 21 allée de l’Université, 92023, Nanterre, France.

2. Muséum National d’Histoire Naturelle, UMR 7209 (AASPE), CP 56, 55 rue Buffon, 75005 Paris, France.

3. Historic Environment Department, Department of Culture and Tourism (DCT), Nation Towers Corniche, PO Box 94000, Abu Dhabi, UAE.

Corresponding author: Kevin Lidour, [lidour01@gmail.com](mailto:lidour01@gmail.com)

---

**Abstract**

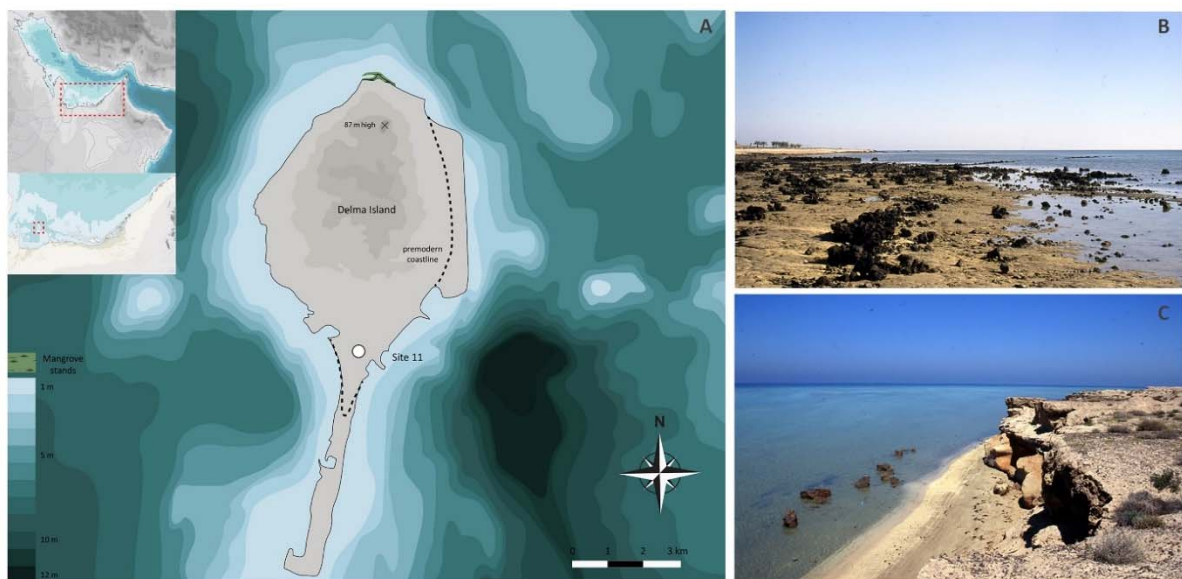
This paper presents the results of a study of nearly 55,000 fish bones from the Neolithic settlement of Delma Island, Abu Dhabi Emirate (UAE). The analysis has outlined the predominance of small coastal taxa such as seabreams and needlefish in the bone assemblage, indicating the use of non-selective fishing techniques such as small seines or coastal barrier traps. The installation of baited cage traps in deeper reef areas is also suggested by the importance of large groupers. The exploitation of the open sea is likewise documented by the catch of many kawakawas (a regional tuna species) and large sharks. Pelagic schools were probably exploited with purse seines or drift nets since the first shell hooks only emerge from the mid-fifth millennium BC onwards in the northern UAE. Fishing expeditions in open sea, however, require the use of boats at Delma. As Delma (50 km offshore), in the Arabian Gulf, and Masirah Island (20 km offshore), in the Arabian Sea, were already occupied several thousand years ago, Neolithic seafarers from eastern Arabia were thus already capable of long-distance travel. Boating technology is now directly asserted by the discovery of bitumen-coated fragments at as-Sabiyah H3, Kuwait. At Delma, the discovery of Mesopotamian pottery sherds (‘Ubaid wares) and carbonized date stones raises the issue of regular contacts with continental groups. The present archaeo-ichthyological study provides the opportunity to document and discuss the singular features of subsistence strategies in an insular environment during the Neolithic.

**Keywords:** fishing, Neolithic, eastern Arabia, Arabian Gulf, archaeo-ichthyology

---

## Introduction

During the past thirty years, many zooarchaeological studies have pointed out that Neolithic groups from eastern Arabia are characterized by subsistence economies principally focused on marine resources and small-scale husbandry. Agriculture remained uncertain, however, until the Bronze Age (c.3000 BC). In the words of S. Cleuziou (2005), the Arabian Peninsula has followed 'its own path' within the Neolithic phenomenon in the Middle East. While the significance of marine shellfish is regularly outlined for diet and specialized technologies (personal ornaments and tooling) during the Neolithic, only a few studies have been conducted on fish bone assemblages in comparison to the number of settlements and archaeological shell middens documented at this time. Fish, however, constitutes 60–90% of recovered vertebrate remains. In many respects, very little is known about the diversity of fishing grounds, strategies, and techniques engaged by Neolithic fishermen, although they raise key issues for archaeological studies such as subsistence behaviours and strategies, seasonality, and mobility. This paper presents the results of the complete analysis of the fish bones collected during the course of five seasons (1994–1995, 1998, 2014–2015) of excavations at the Neolithic site of Delma (c.5300–4700 BC, Fig. 2), Abu Dhabi Emirate, United Arab Emirates.



**Figure 1.** A. A map of the Delma island with the location of the Neolithic site © K. Lidour 2018; B-C. Different views of the Delma seashores © M. Beech

Context	Material	Lab code	Radiocarbon age BP	Calibrated radiocarbon date BC (2 $\sigma$ , 95.4% enclosed)
Trench 2, context 1043	ashy sand/charcoal	AA-52544 (GU-10609)	6395 +/- 60	5480-5293 cal. BC (0.968)
Trench 2, context 1027	ashy sand, small bits of charcoal	AA-52545 (GU-10610)	6230 +/- 45	5308-5191 cal. BC (0.541) 5184-5057 cal. BC (0.459)
Trench 2, context 1053	charcoal fragments : humified organic remains	AA-52543 (GU-10608)	6220 +/- 45	5302-5055 cal. BC (1)
Trench 1, context 15	carbonized date stone ( <i>Phoenix dactylifera</i> )	AA-32032	6165 +/- 55	5230-4962 cal. BC (0.962)
Trench 2, context 1014	carbonized date stone ( <i>Phoenix dactylifera</i> )	AA-32031	5830 +/- 55	4801-4545 cal. BC (0.992)
Trench 1, context 14	charcoal fragments : humified organic remains	AA-52546 (GU-10611)	5830 +/- 45	4790-4577 cal. BC (0.969)

**Table 1.** Radiocarbon datations from Delma. Calibration for terrestrial material according to Calib Rev 7.0.4 – IntCal13 (Stuiver & Reimer 1993)

### **Site location and archaeological settings**

The site (24°30'38'N; 52°18'37'E) is located on Delma Island (Fig. 1/A), which lies about 50 km off the coastline of the Emirate of Abu Dhabi and 30 km off the northern coastline of Sir Bani Yas Island. The central part of the island is the rocky core of a salt-dome reaching about 100 m above sea level. The shoreline of Delma has changed considerably during the past decades with significant infilling of the southern and eastern coasts of the island. Brackish and fresh sources of water are accessible from many artesian aquifers (King 1998). The coastline slope is gentle and composed of mixed assemblages of rocky colluvium and marine sediments (Fig. 1/B–C). The foreshore is wide and delimited by shallow rocky flats and fringing reefs. Deeper reefs are accessible on the nearshore, especially to the south-east. These environments offer a wide range of habitats for marine life. Stony coral assemblages in the area are mainly composed of *Porites* and *Acropora*. Modern fisheries principally specialize in the catch of groupers (local Arabic: *hāmūr* and *seman*) and grunts (local Arabic: *farsh*) (Environment Agency Abu Dhabi 2015–2016).

The site was discovered during a survey campaign conducted in 1992 by the Abu Dhabi Islands Archaeological Survey (ADIAS) project (King 1998). It is situated on a former children's playground, within the former compound of the Women's Association, in the city centre of Delma town. The Neolithic occupation was first suggested by the occurrence, on the surface, of lithic industries and pottery sherds attributed to Mesopotamian 'Ubaid wares. Systematic sieving of surface collections as well as two test trenches were excavated in 1994–1995 (Flavin & Shepherd 1994). Since 1998 excavations have focused on Trench 1, where a well-preserved circular post-hole structure was found (Beech & Elders 1999; Beech et al. 2016). The archaeological layers continue from the surface up to a depth of 1.70 m, in the deepest part of the sequence.

The successive occupation layers are divided into distinct chronological phases which all belong to the Neolithic period. In both trenches the uppermost part of the stratigraphy is composed of successions of sterile wind-blown sand layers and ashy lenses, which have provided quantities of artefacts and faunal remains (Phase 1–3). The layers from the lower part of the stratigraphy are the most documented, providing structures, fireplaces, and many discarded food remains (Phase 4 and 5). The earliest occupation level (Phase 6) is directly settled on an ancient sandy beach. It is likely that the site was closer to the sea than today. By 6000 BC the

marine transgression during the Neolithic is estimated to have been c.2 m above the actual modern-day sea level (Sanlaville & Dalongeville 2005).

### **Material culture**

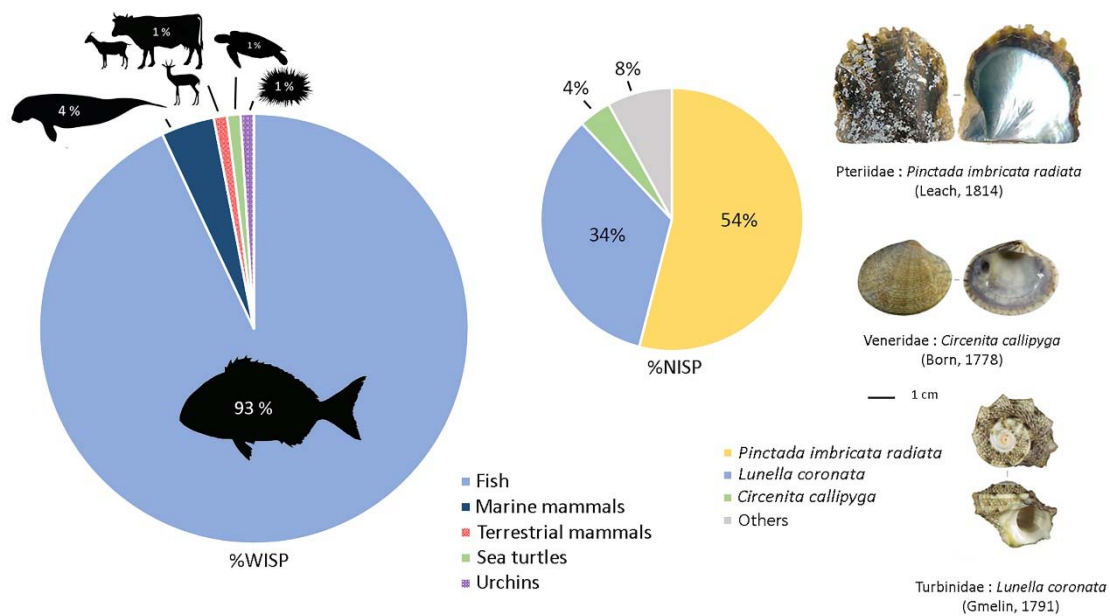
Only a few lithic tools were recovered during the excavations — the knapped assemblage includes arrowheads, drills, and knives; available flint sources are located in the north-western part of the island. Ground-stone artefacts include hammerstones and anvils or burnishing tools made from pebbles. Several unspecified perforated stone discs were also found. Their use as fishing sinkers has been suggested but remains uncertain (Beech 2004: 63). Personal ornaments include disc beads made of marine shell and soft stone, and beads made from perforated gastropods such as *Nerita* sp. and *Engina mendicaria*. Tubular beads in dark stone were also found.

Pottery at the site consists of Mesopotamian 'Ubaid wares with some Arabian coarse ware. Of particular significance is the presence of locally manufactured plaster vessels whose geometric painted decoration appears to imitate the patterns on the 'Ubaid pottery. Plaster vessels were recently also found on Marawah Island at MR11 (Beech et al. 2005). 'Ubaid sherds from Delma correspond to 'Ubaid 2 and 3 productions, dated from the last quarter of the sixth to the mid-fifth millennium BC (Méry et al. 2016).

### **General overview of the subsistence economies**

Terrestrial fauna mostly include domestic caprinids (goat, *Capra* sp.), cattle (*Bos* sp.), and wild game such as gazelle (*Gazella* sp.). The occurrence of gazelle at Delma raises the issue of their arrival during the Pleistocene, when the island was linked to continental Arabia, or of their possible later introduction. A study of the marine shellfish from Delma was previously conducted (Beech & Glover 2005: 102–105) (Fig. 3). This outlined the exploitation of close intertidal (*Lunella coronata*) and subtidal rocky flats (*Pinctada imbricata radiata* and *Hexaplex kuesterianus*). Pearl oyster banks, however, only occur in reef areas. Clams such as *Circenita callipyga* are found in intertidal coarse sands. Fishing not only includes shellfish, and bony and cartilaginous fish at Delma, but also marine mammals such as dolphins (Delphinidae) and dugongs (*Dugong dugon*). Sea turtles (Cheloniidae) were also frequently recorded. Only a few remains belong to birds (principally to the Socotra cormorant, *Phalacrocorax nigrogularis*).

Two carbonized date stones (*Phoenix dactylifera*), as well as date-stone impressions, were recovered during the excavations (Beech & Shepherd 2001). It is known that the oldest date-palm cultivation centres appear to be located in southern Mesopotamia, from fifth-millennium BC contexts (Tengberg 2012). However, populations of wild date palm have been recently discovered in Oman (Gros-Balthazard et al. 2017). The occurrence of date stones at Delma thus raises the possibility of wild date palms being harvested in eastern Arabia during the Neolithic before their regional domestication. In fact, the date stones from as-Sabiyah H3 (Carter & Crawford 2010) matched the shape of sampled wild seeds from Oman.



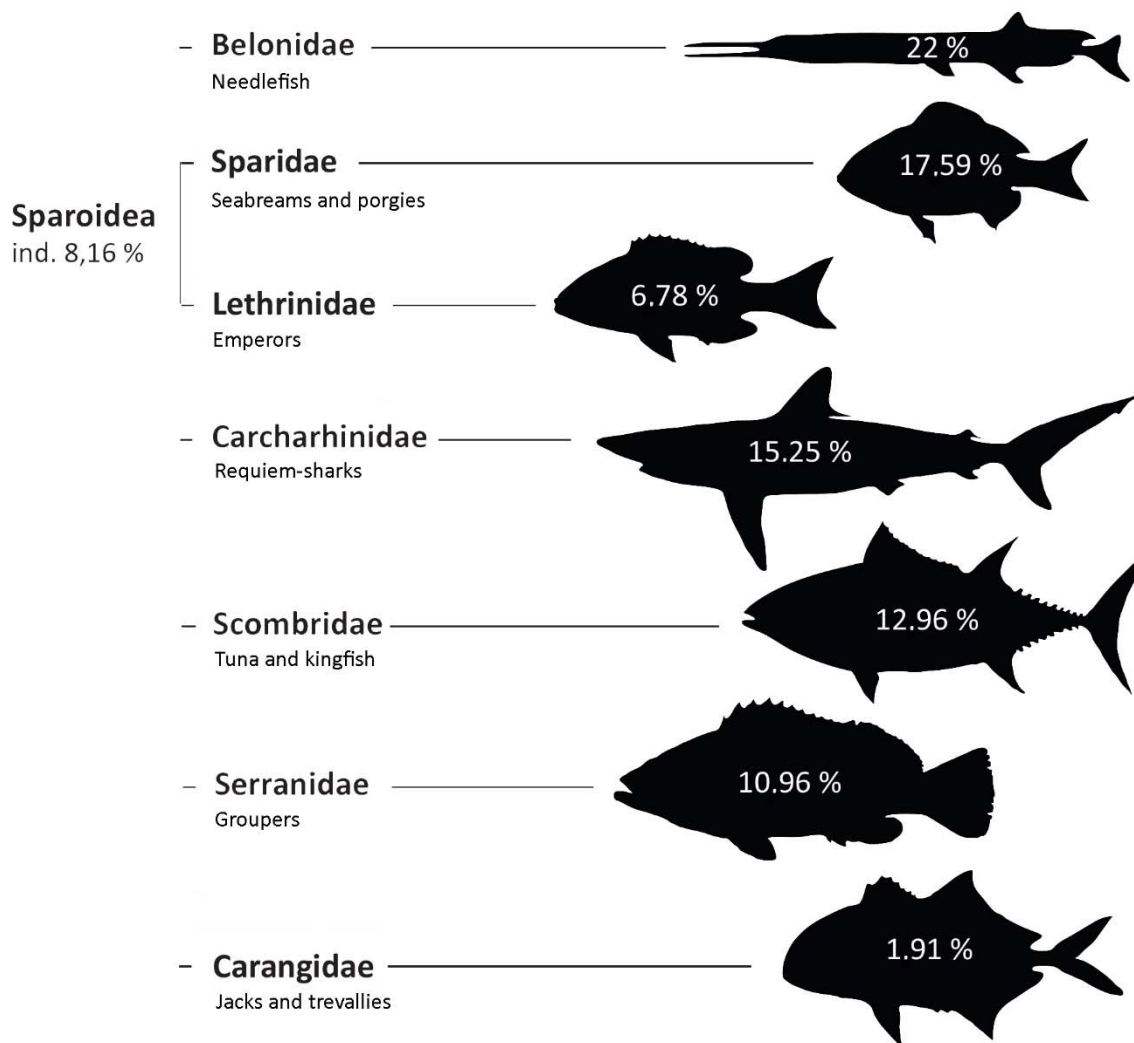
**Figure 2.** Pie charts summarising the part of different fauna categories in the diet of Delma inhabitants (according to 1994-1995 data and Beech & Glover 2005)

## Material and methods

All the excavated sediments were systematically dry-sieved using a 4 mm mesh. Additional fine sieving was also conducted with a smaller mesh (1 mm) and clusters of remains, such as connected vertebrae, were photographed, hand collected, and registered with a special number (i.e. Faunal Number #). At Delma, as at several other eastern Arabian sites (e.g. Beech 2004: 174; Mashkour et al. 2016: 199), the archaeological faunal remains are poorly preserved because of high fragmentation and the presence of salt encrustations which often obliterated the diagnostic parts (see Figs. 6 & 7).

Anatomical and taxonomic identifications were conducted according to the methods of comparative anatomy, using M. Beech's personal comparative osteological collection of Arabian Gulf fishes. The 1993–1994 material was previously studied and published (Beech 2004: 97–109). The 1998 and 2014–2015 material was studied by one of us (K.L.) during a two-month visit to Abu Dhabi in 2017.

NISP stands for the 'number of identified specimens', MNI for 'minimum number of individuals', and WISP for 'weight of identified specimens'. MNI quantifications are calculated according to the combination method: the frequency of bones is combined with laterality and size estimations (Chaplin 1971). However, the NISP is commonly preferred because of the significant bias in MNI calculation. We estimated the relative size and fresh weights of fishes after visual comparisons of archaeological bones with the reference collection.

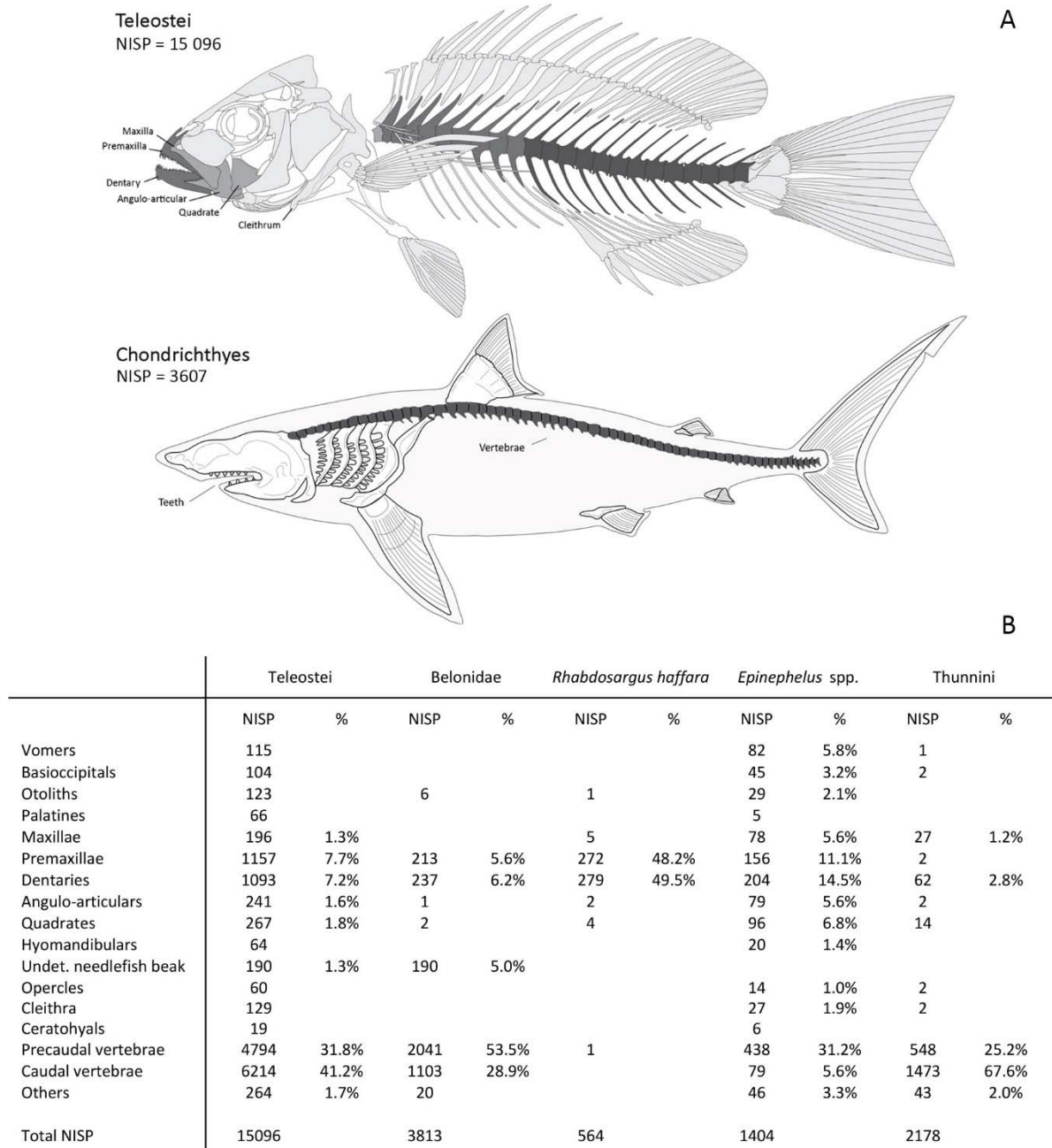


**Figure 3.** Proportions of the main families identified at Delma. NISP = 17 354; other fish taxa = 4.39 %

## Results

A total of 54,846 fish bones fragments were retrieved and recorded of which 17,354 could be identified to the level of family, genus, or species — the superfamily Sparoidea includes Nemipteridae, Lethrinidae, and Sparidae (see Fig. 9). Remains attributed to fishes clearly represent by far the greatest bulk of the vertebrate assemblage. Indeed, the total weight of fish bones nearly reaches 20 kg while the mammalian assemblage only amounts to a few hundred grams. The identifications could be attributed to different periods of the occupation of the site, which all belong to the Neolithic. A total of six families of cartilaginous fishes and twenty families of bony fishes are represented at Delma including requiem-sharks, hammerhead sharks, sand-tiger sharks, sawfish, stingrays, eagle rays, sea catfish, mullets, silversides, needlefish, flatheads, groupers, jacks and trevallies, snappers, grunts, threadfin breams, emperors, seabreams, goatfish, wrasses, parrotfish, rabbitfish, barracudas, tuna and kingfish, pomfrets, and pufferfish (some remains are illustrated in Figs. 6 & 7). This included at

least forty genera and forty-six species. Non-fish remains were also retrieved during this study including sea urchins, cuttlefish, and crabs. Sea urchin remains are represented by numerous spines and shell fragments which all belong to the same taxa: rock-boring urchins (*Echinometra* sp.). It is likely that rock-boring urchins also had an important role in the diet of *Delma* inhabitants.

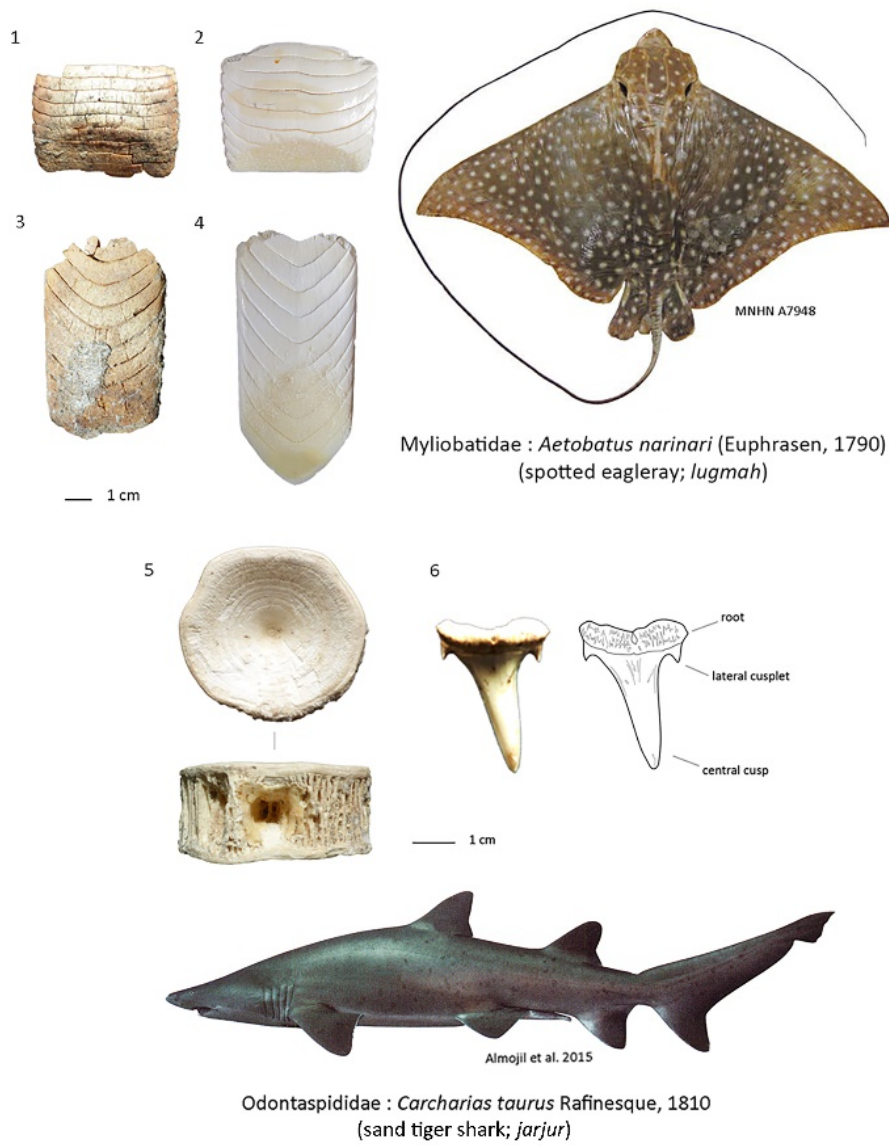


**Figure 4.** A. Anatomical representation of the fish bones from *Delma* (bony fish skeleton modified from Coutureau & Béarez 2012) B. Distribution of anatomical elements for some of the main taxa identified at *Delma*



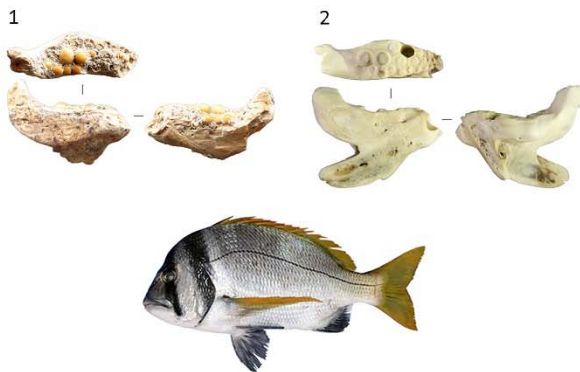
All major anatomical elements were represented among the fish bone remains (Fig. 5), including cranial, vertebral, and appendicular items. As no butchery marks were observed it is likely that fish were directly brought to the settlement and consumed in a relatively complete form. The hardest elements such as those from the mandibular arch (i.e. dentaries, premaxillae, and maxillae) as well as vertebral centra are the most common anatomical elements recorded. Tunas have strong vertebral centra which are frequently found within archaeo-ichthyological assemblages. Their cranial bones are, however, limited because of their weakness. The relative absence of their cranial bones is often misinterpreted as a result of fish beheadings. A few strong cranial elements, such as dentaries and maxillae, were recorded at Delma, however, thanks to the use of fine sieving. Sharks and rays were exclusively represented by vertebrae and dentition pieces such as teeth and tooth plates. Other parts of their skeleton are cartilaginous and generally did not preserve well.

According to the NISP data, the assemblage is mainly dominated by needlefish (Belonidae, 22%), seabreams and porgies (Sparidae, 18%), requiem-sharks (Carcharhinidae, 16%), tuna and kingfish (Scombridae, 13%), groupers (Serranidae, 11%), and emperors (Lethrinidae, 7%). Jacks and trevallies (Carangidae, 2%) are less frequent. Note that undetermined Sparoidea represent 8% of the NISP (Figs. 4 & 9). The whole percentage of Sparoidea thus average 33% of the NISP. Needlefish are almost solely represented by the genus *Tylosurus*. Seabreams are represented by at least three genera and four species of which the Haffara seabream (*Rhabdosargus haffara*) is the most common. Scombrids are represented by at least four genera but kawakawa (*Euthynnus affinis*) is prevalent. Groupers were mostly represented by the genus *Epinephelus*, while a few *Cephalopholis* remains were also recorded. Three distinct species of emperors and at least seven species of jacks or trevallies were recorded.

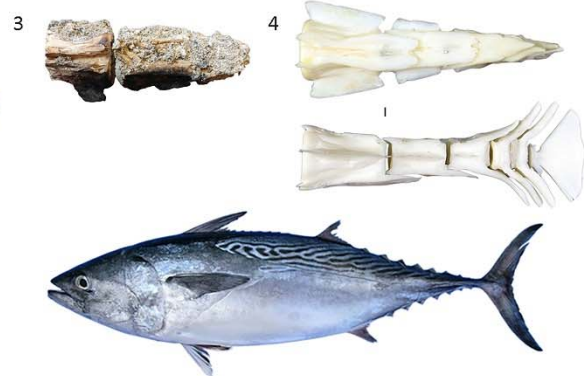


**Figure 5.** Sample of remains belonging to cartilaginous fish (Chondrichthyes) from Delma compared to analogue bones from the MNHN osteological reference collection, and corresponding live-pictures of the species. 1-2. Upper tooth plates of the spotted eagle ray, *Aetobatus narinari*. 2-4. Lower tooth plates of the spotted eagle ray, *Aetobatus narinari*. 5. Vertebral centrum of sand-tiger shark, *Carcharias taurus*. 6. Tooth (lingual side) of sand-tiger shark, *Carcharias taurus*

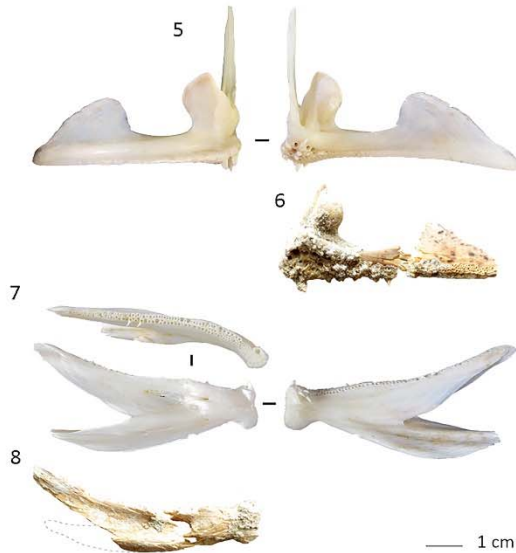
Sparidae : *Acanthopagrus bifasciatus* (Forsskål, 1775)  
(two-bar seabream; *faskar*) MNHN ICOS-00309



Scombridae : *Euthynnus affinis* (Cantor, 1849)  
(kawakawa; *şada*) MNHN ICOS-0299



Serranidae : *Epinephelus* sp. (groupers; *hamour*, *seman*)



Serranidae : *Epinephelus coioides* (Hamilton, 1822)  
(orange-spotted grouper; *hamour*)



Serranidae : *Epinephelus bleekeri* (Vaillant, 1878)  
(duskytail grouper; *seman*)



**Figure 6.** Sample of remains belonging to bony fish (Teleostei) from Delma compared to analogue bones from the MNHN osteological reference collection, and corresponding live-pictures of the species. 1-2. Right dentaries of two-bar seabream. 3-4 Series of caudal vertebrae of kawakawa, *Euthynnus affinis*. 5. Right premaxilla of duskytail grouper, *Epinephelus bleekeri*. 6. Right premaxilla of a grouper, *Epinephelus* sp. 7. Right dentary of duskytail grouper, *Epinephelus bleekeri*. 8. Right dentary of a grouper, *Epinephelus* sp.

## Discussion

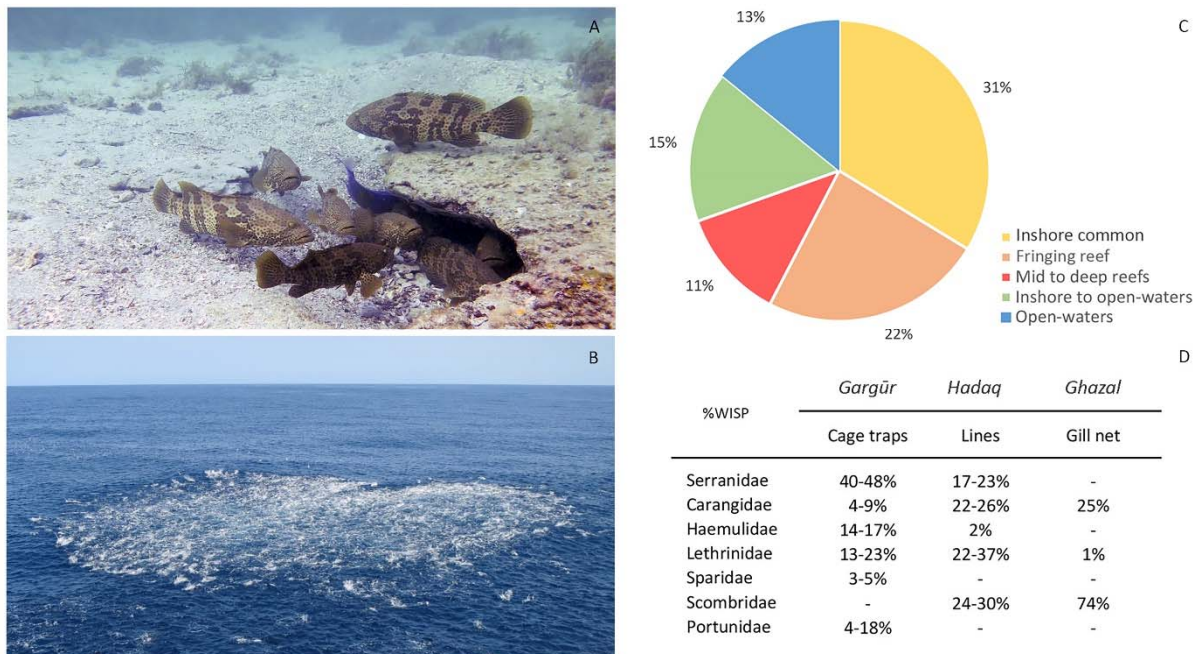
### *Fishing grounds and techniques*

All the fish taxa identified at Delma can be caught in the vicinity of the island. Fishing was essentially carried out in the close shallow waters surrounding the site (Fig. 8/C). Schools of small needlefish (100–200 g) are encountered over sandbars and fringing reefs — they usually

swim just beneath the surface. They can be caught with small seines according to a traditional technique called *idfarah* (Arabic) which is similar to *djarifa* (Shimaore) documented in the Comoro Islands (Claro 1994; Jamon et al. 2010). Most of the seabreams identified at Delma can also potentially be caught this way, in particular small Haffara seabreams (200–300 g) which inhabit mainly soft bottoms and around coral reefs (Sommer, Schneider & Poutier 1996); two-bar seabreams occur more frequently in reef areas (Iwatsuki & Heemstra 2011).

Requiem-sharks are relatively common in these coastal environments. Blacktip reef sharks (*Carcharhinus melanopterus*) are encountered in very shallow waters and are regularly caught by inshore fisheries. They can be easily caught in nets, directly harpooned, or shot by an arrow or spear. Large specimens and some species can also swim in open waters to hunt, like the oceanic whitetip shark (*Carcharhinus longimanus*). Pelagic sharks, as well as dolphins, dugongs, and sea turtles, are frequently bycatch in drift nets.

Some remains were attributed to a large sand-tiger shark (Odontaspidae: *Carcharias taurus*) (Fig. 6/5-6).<sup>1</sup> Sand-tiger sharks generally occur in reef areas. According to Bass, D’Aubrey and Kistnasamy (1975: pl. 3) their estimated length is about 3 m but only females can reach this size (> 220–230 cm) (Gilmore, Dodrill & Linley 1983). The first record of this species in the UAE was only made in 2012 (Jabado et al. 2013), in the vicinity of Delma Island. The present study, however, demonstrates that sand-tiger sharks already occurred in the Delma area and in the Arabian Gulf 7000 years ago. Hammerhead sharks (Sphyrnidae) and large sawfishes (Pristidae: *Pristis zijsron*) are also commonly encountered around moderate-depth reef areas (Moore 2014; Jabado et al. 2017: 269).



**Figure 7. A.** A small group of orange-spotted groupers, *Epinephelus coioides* (*hamour*) near a crevice. Courtesy Abu Dhabi Marine Conservation Group. **B.** Example of a tuna bust-up off

<sup>1</sup> According to a comparison work based on Kozuch & Fitzgerald 1989.

the Ivory Coast. Creative Commons BY-NC-ND 4.0 © 2013 Wm Adams. **C.** Pie chart summarizing the different fishing grounds exploited at Delma. **D.** Fish families-associated techniques traditionally used in the Emirate of Abu Dhabi (Environment Agency Abu Dhabi 2015-2016)

The reef areas exploitation is also emphasized by the marked occurrence of large groupers (mostly between 2 and 3 kg) at Delma. Groupers are solitary and territorial fishes which generally live alone or in small groups in caves and crevices found in reefs. They could form large aggregations during the spawning season as observed for the Nassau grouper (*Epinephelus striatus*) in the western Atlantic (Colin 1992) and the camouflage grouper (*Epinephelus polyphkadion*) in the Pacific Ocean (Rhodes, Taylor & McIlwain 2011). Groupers are thus very exposed and vulnerable during this period. They always constitute a great part of the modern landings from Delma where they are quasi-exclusively caught in cage traps, called *gargūr* (pl. *garagir*) (Fig. 8/A,C). Data from Kuwait Bay indicated that cuttlefish are the best bait used for their catch in cage traps (Chen et al. 2012). Other fishes caught in this way include spangled emperors (*Lethrinus nebulosus*), king-soldier breams (*Argyrops spinifer*), grunts (Haemulidae), and rabbitfish (Siganidae). *Garagir* are traditional dome-shaped traps anciently built with palm leaves and fronds. While not mentioned by classical authors, they might have been in use for a long time. The etymology of *gargūr* is from the Old Akkadian *gigurru(m)* which means ‘basket’ and which itself comes from Sumerian (Black, George & Postgate 2000: 92). Some terms of the basic material culture have a Semitic, not Arabic, origin within regional dialects of eastern Arabia — in particular the vocabulary linked with farming and fishing. These could have been passed from Sumero-Akkadian, considering the strong contacts with Mesopotamia during the Bronze Age and the Iron Age or, more recently from Aramaic during the Sasanid period (Holes 2015: 12–18), suggesting the antiquity of the *gargūr* fish trap (2015: 14).

Lines of stones in the intertidal zone are known along the west coast of Delma Island. Previous work on these has interpreted them as the remains of ancient coastal barrier fish traps (Beech 2003), or in the case of Marawah Island, as ancient boat mooring sites (Beech & al-Shaiba 2004: 9). The dating of these features is, however, difficult although they probably belong to the Islamic period. However, simple fish traps were probably among the first techniques used by prehistoric fishermen in the area (Cleuziou & Tosi 2007: 53). Many variants exist such as *hadrah*, *meskar*, and *sakkar*. The commonest one is the *hadrah* type which consists of lines of semi-permanent intertidal fences vertically fixed and supported by stones projecting out perpendicular to the shoreline. The V shape opened to the coastline forms a funnel that encloses fish at the falling tide. Classical authors, like Diodorus (2003: 22), already attest the presence of tidal traps in eastern Arabia a few decades before our era. The antiquity of coastal barrier traps is also suggested by the etymology. The terms *meskar* and *sakkar* are constructed on the same Akkadian triconsonantic stem *sekēru(m)*, which means ‘to shut off, block up’ (Black, George & Postgate 2000: 320; Holes 2015: 14). Tidal traps are non-selective and able to catch a wide spectrum of fish taxa encountered in the shallow inshore waters, including seabream, needlefish, and small trevallies (Abou-Seedo 1992; al-Baz et al. 2007; al-Baz, al-

Husaini & Bishop 2013). Cuttlefish and pelagic crabs are also frequently caught this way (McEwan, Bell & Dvornak 2001).

While single individuals can sometimes be caught from the seashore, schools of large scombrids only occur in open waters (Fig. 8/C). Kawakawas, frigate tunas (*Auxis* sp.), and tuna (*Thunnus* sp.) tend to form multi-species schools (Collette & Nauen 1983). They feed on schools of other small pelagic fishes such as sardines (Clupeidae) and silversides (Atherinidae), which are planktivorous and thus mostly swim just beneath the surface (Fischer & Bianchi 1984). Estimated fresh weights of kawakawas from Delma are mostly between 3 and 4 kg. Epi-pelagic schools do not necessarily occur far from the shore and can be found a few hundred metres offshore, but it is necessary to use boats to catch them.

Boating technology is well attested during the Neolithic since bitumen-coated fragments were found at as-Sabiyah H3, Kuwait (Carter & Crawford 2010). Schools of scombrids are easily visible because they break the surface of the sea and attract marine birds (Fig. 8/B). Traditional techniques to fish on epi-pelagic schools are purse seines, drift nets (similar to the local *ghazal* technique), and luring (e.g. trolling and baiting with attraction food) (Fig. 8/D). As shell fish-hooks and miniature sinkers are not attested before the mid-fifth millennium BC within the Neolithic fishing kit in the Arabian Gulf (Méry, Charpentier & Beech 2008; Méry 2015), the use of hook and line techniques could not be assumed at Delma. Net fishing techniques are thus presumed. Several perforated stone discs were discovered during the excavations at Delma but their possible use as net sinkers is still unclear. Similar artefacts were found at as-Sabiyah H3 (Carter & Crawford 2010: fig. 9.14–15) and at Dosariyah, Saudi Arabia (Drechsler 2018: pl. 11.22.d). It can be assumed that other fish taxa could be caught in open waters, such as large jacks (*Caranx* spp.), trevallies (*Carangoides* spp., *Gnathanodon speciosus*), queenfish (*Scomberoides commersonianus*), torpedo scads (*Megalaspis cordyla*), king-soldier breams, and eaglerays (Myliobatidae: *Aetobatus narinari*, see Fig. 6/1–4) (Stehmann 1981; Last & Steven 1994).

### **Food habits**

About 8% of the fish bones studied were burnt (carbonization or calcination). Fire marks are concentrated on less fleshy parts of the skeleton such as the opercle series, spines, and the external tips of the jaw pieces. This distribution indicates that whole fish were probably grilled on coals.

A few remains were attributed to the stellate puffer (*Arothron stellatus*). Pufferfish are relatively uncommon in the area and mostly occur in patch reefs and outer slopes of reefs (Lieske & Myers 1994) — they can be caught in cage traps. They are identified at several other archaeological sites from the Arabian Gulf (Marawah MR14 and MR16, Balghelam BG12) (Beech 2004: tables 104, 114, 119) including the Neolithic settlement of Umm al-Quwain UAQ2, UAE (Mashkour et al. 2016). It is noteworthy that pufferfish are usually reported as poisonous to eat (Masuda et al. 1984). Tetrodotoxin present in the internal organs leads to muscular paralysis, including of the diaphragm, and can cause death from respiratory failure in a few hours (Clark et al. 1999). These ichthyotoxins are essentially concentrated in the skin and gut (the liver in particular), implying that the flesh can be consumed if correctly prepared. The toxicity rate, however, varies considerably from region to region (Magarlamov, Melnikova

& Chernyshev 2017) and it is not clear if the pufferfish from Delma are poisonous or not. It is likely they are not because pufferfish remains recovered among other fish bones from the Delma site had not received any special treatment.

### **Seasonality**

Seasonality and mobility issues have been widely discussed in the last few years. While the pattern was essentially oriented towards semi-nomadism according to ethnographic works (Scholz 1980; Lancaster & Lancaster 1995), new results have shown that some Neolithic sites could have been inhabited throughout the year, benefitting from highly productive marine environments such as mangroves (Biagi & Nisbet 2006; Cavulli & Scaruffi 2013; Mashkour et al. 2016). In this regard, archaeo-ichthyological investigations have also suggested that fishing was not solely carried out during a limited part of the year (Desse 1988; Driesch & Manhart 2000; Beech 2004: 201–207; Wilkens 2005; Lidour, Vorenger & Béarez 2018) but at least from autumn to late spring (Mashkour et al. 2016: fig. 10). While marine waters are more productive during the winter season because of cooler seawater temperatures (Van Neer & Gautier 1993), fishing continues to be carried out at other times of the year in small fish-rich grounds such as lagoons, mangroves, and reef areas. The majority of fish identified at Delma therefore could have been caught all year round (e.g. seabream, needlefish, sharks, groupers, and emperors). According to modern environmental parameters, schools of scombrids can, however, only be exploited during the winter season in the Arabian Gulf. However, because of significant climate change since the Neolithic, the seasonal patterns of subsistence and mobility should be reconsidered.

### **Comparisons**

The Neolithic fisheries from the Arabian Gulf are essentially characterized by the exploitation of shallow and coastal environments. The main taxa identified belong to small seabream, whose proportion is generally situated between 30 and 90% of the NISP (Desse 1988; Driesch & Manhart 2000; Beech 2004; 2010; Mashkour et al. 2016). Emperors also represent a great part of the spectrum of Umm al-Quwain UAQ2 (c.36%). Sparoid fishes occur abundantly over soft bottoms and seagrass bed areas close to the shore. They can also be encountered in small lagoons and possibly reef areas. Many silverside (*Atherinomorus lacunosus*) otoliths were recorded from Khor FB and Khor P (Qatar) by J. Desse (1988). These little fish form large schools along sandy shorelines and near reef margins (Ivantsoff & Crowley 1999). Sardines (Clupeidae: cf. *Nematalosa nasus*) constitute a major group at the al-Markh J19 fisheries: this species also forms schools in coastal areas and could be found very close to the shoreline (Rainboth 1996). All these taxa can be caught with simple and non-selective techniques such as tidal barrier traps (al-Baz, al-Husaini & Bishop 2013), fixed nets, and small seines. Sea catfish (Ariidae), which are numerous at as-Sabiyah (c.7%), were probably caught with baited cage traps such as the traditional *gargūr* — according to modern landings data (Chen et al. 2012; Environment Agency Abu Dhabi 2015–2016). High proportions of large trevallies (c.38%) were recently observed at Akab in the Umm al-Quwain lagoon, where singular fishing techniques have possibly been identified (Lidour, Vorenger & Béarez 2018; Lidour et al., in press). Techniques such as firing arrows, spearing, and harpooning are possible but remain uncertain.

Fishing in open sea is suggested by the occurrence of pelagic fishes such as kawakawas, tunas, or kingfishes at several of these sites. Large sharks, jacks, trevallies, and king-soldier breams were also frequently consistent with fishing carried out in deeper waters. However, so far, high proportions of scombrids within Neolithic contexts have only been reported at sites situated in the Sultanate of Oman (e.g. RH5, RH6, RH10, and KM1) (Uerpmann & Uerpmann 2003; Wilkens 2005). The fishing of pelagic fishes along the Ja'alan and the Arabian Sea coasts is facilitated by greater depths close to the shoreline. Recent studies from Akab (Lidour et al., in press), Dosariyah (Uerpmann & Uerpmann 2018) and, now, Delma, have revealed large quantities of kawakawa and tuna remains. Techniques such as net fishing in the open sea and luring could have been utilized. It is certain that fishing expeditions in open sea were frequently carried out during the Neolithic in the Arabian Gulf to exploit scombrid schools — at least hundreds of metres from the settlement sites and involving the use of boats. Delma is actually one of the oldest sites where this kind of fishing has been documented in eastern Arabia and definitively changes our perception of fishing activities in the Arabian Gulf during the Neolithic.

Comparative assemblages are lacking in the vicinity of Delma. The closest sites are situated in Sir Bani Yas Island, c.30 km from Delma and dated to the early Islamic period (Sir Bani Yas SBY2, SBY4, SBY7, and SBY9) (Beech 2004: 109–121). The surrounding environments of Sir Bani Yas are quite similar to those from Delma, with sandy shorelines and extensive reef areas. Deeper waters are, however, far from the coast and thus more difficult to access. The proportion of scombrids is thus very reduced at these sites (only 2% at SBY9) but seabream, emperors, groupers, and requiem-sharks were frequently identified, which seems to indicate the perseverance of certain techniques such as barrier traps and cage traps. Only a few remains were attributed to needlefish. This suggests that unprofitable techniques such as small seine fishing did not continue within more specialized activities oriented towards a market logic as opposed to the subsistence economy of small Neolithic communities.

## **Conclusion**

The inhabitants of Delma were involved in a variety of subsistence economies specialized in the exploitation of marine resources: marine mammals, sea turtles, shellfish, urchins, pelagic crabs, and fish were caught and consumed. The present study has shown that fishing was essentially carried out in shallow coastal environments such as sandbars and fringing reefs, using non-selective techniques such as fixed nets, small seines, and tidal barrier traps. The exploitation of deeper reefs is suggested by the occurrence of large groupers, which were probably caught with baited cage traps. Seafaring expeditions in open sea were regularly conducted in order to exploit the pelagic schools and, additionally, to catch large sharks and dolphins. The main techniques involved were probably purse seine or drift nets since shell fish-hooks were not documented before the mid-fifth millennium in the northern UAE.

As the occupation of offshore islands such as Delma implies a mastery of seafaring technology, the latter could have also fostered open-sea fishing. However, this does not seem to be a specificity of this site in the Arabian Gulf since high quantities of large scombrids were also recently recorded at Akab (c.4300–4000 BC) during the Late Neolithic (Lidour et al., in press) and Dosariyah (c.5000–4800 BC) during the Middle Neolithic (Uerpmann & Uerpmann 2018). Further investigations on fish bone assemblages from other periods are necessary in order to



gain a better understanding of the evolution of fisheries during the prehistory of the southern Arabian Gulf.

### **Acknowledgements**

We would like to thank Rita Aoun-Abdo (Executive Director, Culture Sector) and Mohammed Amer al-Neyadi (Head of the Historic Environment Department) from the former Abu Dhabi Tourism and Culture Authority (TCA Abu Dhabi), now known as the Department of Culture and Tourism (DCT), for their support for our work on Delma Island. Our thanks also to Fathy Mohammed Abdulla (cultural landscape ranger, TCA Abu Dhabi) who provided local logistical support on the island and also assisted on the archaeological excavations.

Special thanks to Dr Philippe Béarez (CNRS, UMR 7209 AASPE – Muséum National d’Histoire naturelle, Paris) and Dr Sophie Méry (CNRS, UMR 5666 CREAAH – Université de Rennes 1) for their advice and the supervision of the PhD thesis of one of us (K.L.). We would also like to thank Michele Degli Esposti and Helen Knox for their help in correcting the text.

Family	Genus	Species	NISP	MNI	WISP (g)	NISP	MNI	WISP (g)			
Carcharhinidae	Carcharhinus	Carcharhinus cf. plumbeus	1	1	0.14	Lutjanus	Lutjanus malabaricus	1	1	0.01	
		Carcharhinus sp.	331	45	245.5		Lutjanus sp.	6	3	0.36	
Sphyrnidae	ind.	Sphyrna sp.	2311	-	930.91	Diagramma	Diagramma pictum	6	5	2.67	
		Carcharias taurus	57	11	17.87	Plectorhynchus	Plectorhynchus schotof	10	1	2.6	
Odontaspidae	Carcharias		5	3	11.601		Plectorhynchus sp.	1	1	0.08	
	ind. Lamniformes		128	9	142.45	Pomadasy	Pomadasy sp.	2	1	0.39	
Pristidae	Pristis	Pristis sp.	95	14	83.27	ind.		10	2	3.23	
Dasyatidae	Dasyatis	Dasyatis sp.	2	1	1.25	ind.		1	1	0.02	
Myliobatidae	ind.	Acobatus narinari	1	1	0.2	Lethrinus	Lethrinus lentjan	27	22	1.77	
			2	1	34.94		Lethrinus microdon	11	8	2.75	
ind. Batoidae	Acobatus		22	3	10.3		Lethrinus nebulosus	42	27	3.02	
	ind. Chondrichthyes		41	-	3.54		Lethrinus sp.	1095	204	131.31	
ind. Chondrichthyes			638	23	110.32	Acanthopagrus	Acanthopagrus arabicus/sheim	35	27	174.8	
			<b>2996</b>	<b>89</b>	<b>1481.831</b>		Acanthopagrus bifasciatus	9	21	114.94	
		<b>Total determined Chondrichthyes</b>	<b>3634</b>	<b>112</b>	<b>1592.151</b>		Acanthopagrus sp.	212	34	94.33	
Ariidae	Netuma	Netuma bilineata	7	5	10.54	Argyrops	Argyrops spinifer	14	5	6.57	
		Netuma sp.	16	4	3.17		Argyrops sp.	8	6	0.58	
Mugilidae	ind.		12	9	5.88	Rhabdosargus	Rhabdosargus haffara	712	245	252.58	
			9	2	1.28	ind.		2059	87	221.13	
Atherinomoridae	Atherinomorus	Atherinomorus lacunosus	1	2	0.01	ind.		1417	12	134.71	
	Tylosurus	Tylosurus crocodilus	304	34	32.11	ind.		6	3	0.11	
Belontiidae		Tylosurus sp.	1790	32	143.36	ind.		1	1	0.01	
			1719	41	282.8	Scar	Scar	2	1	2.48	
Platycephalidae	Platycephalus	Platycephalus indicus	6	7	1.57	ind.		25	17	8.38	
	ind.		2	1	0.19	Siganus	Siganus javus	2	1	0.04	
Serranidae	Cephalopholis	Cephalopholis sp.	3	2	0.06		Siganus sp.	91	17	1.68	
	Epinephelus	Epinephelus bleekeri	1	1	0.2	Sphyraena	Sphyraena jello	1	1	0.36	
		Epinephelus coioides	20	12	18.8		Sphyraena sp.	15	11	1.5	
		Epinephelus cf. malabaricus	2	1	0.6	Auxis	Auxis sp.	6	4	2.48	
		Epinephelus sp.	1381	194	2274.84	Scomberomorus	Scomberomorus commerson	4	2	1.9	
			492	84	570.12	Euthynnus	Euthynnus affinis	2001	75	3697.88	
Carangidae	Carangoides	Carangoides sp.	68	30	31.35	Thunnus	Thunnus sp.	6	1	3.59	
	Caranx	Caranx sexfasciatus	3	4	8.74	ind. Thunnini		216	16	343.67	
		Caranx sp.	27	6	7.73	ind.		13	5	12.02	
	Decapterus	Decapterus sp.	8	1	0.5	Pampus	Pampus argenteus	7	2	0.1	
	Gnathanodon	Gnathanodon speciosus	100	30	32.09	ind. Perciformes		844	-	117.04	
	Megalaspis	Megalaspis corayla	3	1	1.2	Tetraodontidae	Arothron	19	3	45.8	
	Scomberoides	Scomberoides commersonianus	120	29	110.98	ind.	Arothron stellatus	4	-	2.25	
	Trachinatus	Trachinatus sp.	182	30	143.49	ind. Teleostei		36011	-	8209.9	
<b>Total determined Teleostei</b>			<b>14375</b>	<b>1436</b>	<b>8953.8</b>	<b>Total determined Teleostei</b>			<b>14375</b>	<b>1436</b>	<b>8953.8</b>
<b>Grand Total</b>			<b>54864</b>	<b>1548</b>	<b>18872.891</b>	<b>Grand Total</b>			<b>54864</b>	<b>1548</b>	<b>18872.891</b>

**Table 2.** Taxonomic list with number of identified specimens (NISP), minimum number of individuals (MNI) and specimen weight (WISP) in grams.

## 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.
- Almoji D.K., Moore A.B.M. & White W.T. 2015. *Sharks & rays of the Arabian/Persian Gulf*. London: MBG (INT) Ltd.
- Bass A.J., D'Aubrey J.D. & Kistnasamy N. 1975. Sharks of the east coast of southern Africa. IV. The families Odontaspidae, Scapanorhynchidae, Isuridae, Cetorhinidae, Alopiidae, Orectolobidae and Rhinodontidae. *Oceanographic Research Institute Investigational Report* 39: 1–102.
- al-Baz A.F., al-Husaini M.M. & Bishop J.M. 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., Chen W., Bishop J.M., al-Husaini M.M. & al-Ayoub S.A. 2007. On fishing selectivity of hadrah (fixed stake trap) in the coastal waters of Kuwait. *Fisheries Research* 84/2: 202–209.
- Beech M.J. 2003. The development of fishing in the United Arab Emirates: A zooarchaeological perspective. Pages 289–308 in D.T. Potts, H. Naboodah & P. Hellyer (eds), *Archaeology of the United Arab Emirates: Proceedings of the First International Conference on the Archaeology of the UAE*. London: Trident Press.
- 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*. (Abu Dhabi Islands Archaeological Survey Monograph, 1). (British Archaeological Reports, International Series, S1217). Oxford: Archaeopress.
- Beech M.J. 2010. The animal and fish bones. Pages 129–156 in R. Carter & H. Crawford (eds), *Maritime interactions in the Arabian Neolithic. Evidences from H3, As-Sabiyah, an Ubaid-related site in Kuwait*. (American School of Prehistoric Research Monograph Series, 8). Boston: Brill.
- Beech M.J. & Elders J. 1999. An 'Ubaid-related settlement on Dalma Island, Abu Dhabi Emirate, United Arab Emirates. *Bulletin of the Society of Arabian Studies* 4: 17–21.
- Beech M.J. & Glover E. 2005. The environment and economy of an Ubaid-related settlement on Dalma Island, United Arab Emirates. *Paléorient* 31/1: 97–105.
- Beech M.J. & al-Shaiba N. 2004. Intertidal archaeology on Marawah island: New evidence for ancient boat mooring sites. *Tribulus* 14/2: 8–16.
- Beech, M.J. & Shepherd E. 2001. Archaeobotanical evidence for early date consumption on Dalma Island, United Arab Emirates. *Antiquity* 75: 83–89.
- Beech M.J, Cuttler R., Moscrop D., Kallweit H. & Martin J. 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., Strutt K., Blue L., al-Kaabi A.K., Omar W.A., al-Haj el-Faki A.A. ... Martin J. 2016. 'Ubaid-related sites of the southern Gulf revisited: the Abu Dhabi Coastal Heritage Initiative. *Proceedings of the Seminar for Arabian Studies* 46: 9–24.
- Biagi P. & Nisbet R. 2006. The prehistoric fisher-gatherers of the western coast of the Arabian Sea: A case of seasonal sedentarization? *World Archaeology* 38/2: 220–238.
- Black J., George A. & Postgate N. (eds). 2000. *A concise dictionary of Akkadian*. (Second [corrected] printing). (Santag 5). Wiesbaden: Harrassowitz.
- Carter R. & Crawford H. (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. & Scaruffi S. 2013. Thoughts on nomadism in Middle Holocene Oman. *Arabian Archaeology and Epigraphy* 24: 15–27.
- Chaplin R.E. 1971. *The study of animal bones from archaeological sites*. New York: Seminar Press.
- Chen W., al-Baz A.F., Bishop J. & al-Husaini M.M. 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.
- Clark R.F., Williams S.R., Nordt S.P. & Manoguerra A.S. 1999. A review of selected seafood poisonings. *Undersea & Hyperbaric Medical Society* 26: 175–184.
- Claro R. 1994. Características generales de la ictiofauna. Pages 55–70 in R. Claro (ed.), *Ecología de los peces marinos de Cuba*. Instituto de Oceanología, Academia de Ciencias de Cuba and Centro de Investigaciones de Quintana Roo.
- Cleuziou S. 2005. Pourquoi si tard? Nous avons pris un autre chemin. L'Arabie des chasseurs-cueilleurs de l'Holocène au début de l'âge du bronze. Pages 123–148 in J. Guilaine (ed.), *Aux marges des grands foyers du néolithique: Périphéries débitrices ou créatrices?* Paris: Errance.
- Cleuziou S. & Tosi M. (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.
- Colin P.L. 1992. Reproduction of the Nassau grouper, *Epinephelus striatus* (Pisces: Serranidae) and its relationship to environmental conditions. *Environmental Biology of Fishes* 34: 357–377.
- Collette B.B. & Nauen C.E. 1983. FAO species catalogue. ii. 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.
- Coutureau M. & Béarez P. 2012. *Lutjanus Bloch, 1790. ArchéoZoo*. Accessed 24 March 2018. [www.archeozoo.org/archeozootheque/galleries/file\\_uploader/pdf/lutjanus\\_spp.pdf](http://www.archeozoo.org/archeozootheque/galleries/file_uploader/pdf/lutjanus_spp.pdf)
- Desse J. 1988. Khor P., Khor F.B. & Shagra. Les faunes, le rôle de la pêche. Pages 157–166 in M-L. Inizan (ed.), *Préhistoire à Qatar, Mission archéologique française à Qatar, 2*.

Paris: Éditions Recherche sur les Civilisations.

Diodorus/transl. B. Eck. 2003. *Bibliotheca Historica, Asia. Liber II*. (Collection des Universités de France, Série grecque). (Collection Budé, 430). Paris: Les Belles Lettres.

Drechsler P. (ed.). 2018. *Dosariyah. Reinvestigating a Neolithic coastal community in eastern Arabia*. (British Foundation for the Study of Arabia Monograph, 19). Oxford: Archaeopress.

Driesch A. von den & Manhart H. 2000. Fish bones from al-Markh, Bahraïn. Pages 50–67 in M. Mashkour, A.M. Choyke, H. Buitenhuis & F. Poplin (eds), *Archaeozoology of the Near East IV. Proceedings of the fourth international symposium on the archaeozoology of southwestern Asia and adjacent areas*. Groningen: ARC.

Environment Agency Abu Dhabi 2015–2016. *Fisheries Statistical Bulletin 2014–2015: A brief overview of the fisheries of the Emirate of Abu Dhabi*. Abu Dhabi: National Fisheries Information System.

Fischer W. & Bianchi G. (eds). 1984. *FAO Species identification sheets for fishery purposes. Western Indian Ocean – Fishing Area 51*. (FAO species identification guide for fisheries purposes). (6 volumes). Rome: Food and Agriculture Organization & Denmark Funds-in-Trust.

Flavin K. & Shepherd E. 1994. Fishing in the Gulf: Preliminary investigations at an 'Ubaïd site, Dalma (UAE). *Proceedings of the Seminar for Arabian Studies* 24: 115–134.

Gilmore R.G., Dodrill J. & Linley P. 1983. Reproduction and embryonic development of the sand tiger shark. *Odontaspis taurus*

(Rafinesque). *U.S. Fishery Bulletin* 81: 201–225.

Gros-Balthazard, M., Galimberti, M., Kousathanas, A., Newton, C., Ivorra, S., Paradis, L. ... Wegmann D. 2017. The discovery of wild date palms in Oman reveals a complex domestication history involving centers in the Middle East and Africa. *Current Biology* 27/14: 2211–2218.

Holes C. 2015. *Dialect, culture, and society in eastern Arabia*. iii. *Phonology, morphology, syntax, style*. (Handbook of Oriental Studies. Section 1: The Near and Middle East, 51/3). Leiden/Boston: Brill.

Ivantsoff W. & Crowley L.E.L.M. 1999. Atherinidae. Silversides (or hardyheads). Pages 2113–2139 in K.E. Carpenter & V.H. Niem (eds), *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*. iv. *Bony fishes part 2 (Mugilidae to Carangidae)*. Rome: Food and Agriculture Organization.

Iwatsuki Y. & Heemstra P.C. 2011. A review of the *Acanthopagrus bifasciatus* species complex (Pisces: Sparidae) from the Indian Ocean, with redescription of *A. bifasciatus* (Forsskål 1775) and *A. cateluna* (Lacepède 1801). *Zootaxa* 3025: 38–50.

Jabado R.W., al-Ghais S.M., Hamza W., Henderson A.C. & Mohamed A.A. 2013. First record of the sand tiger shark, *Carcharias taurus*, from United Arab Emirates waters. *Marine Biodiversity Records* 6: 1–4. doi: <https://doi.org/10.1017/S1755267213000043>

Jabado R.W., al-Baharna R.A., al-Ali S.R., al-Suwaidi K.O., al-Blooshi A.Y. & al-Dhaheri S.S. 2017. Is this the last stand of the critically endangered green sawfish *Pristis*

zijosron in the Arabian Gulf? *Endangered Species Research* 32: 265–275. doi: <https://doi.org/10.3354/esr00805>

Jamon A., Wickel J., Nicet J.B., Durville P., Bissery C., Fontcuberta A. ... Parc Marin de Mayotte 2010. *Évaluation de l'impact de la pêche au Djarifa sur la ressource halieutique à Mayotte*. Rapport PARETO/APNEE/LAGONIA/Parc Marin de Mayotte pour le compte de l'AAMP.

King G.R.D. 1998. *Abu Dhabi Islands archaeological survey*. London: Trident Press.

Kozuch L. & Fitzgerald C. 1989. A guide to identifying shark centra from southeastern archaeological sites. *Southeastern Archaeology* 8/2: 146–152.

Lancaster W. & Lancaster F. 1995. Nomadic fishermen of Ja'alân, Oman. *Nomadic Peoples* 36/35: 227–244.

Last P.R. & Stevens J.D. 1994. *Sharks and rays of Australia*. Canberra: Commonwealth Scientific and Industrial Research Organization.

Lidour K., Vorenger J. & Béarez P. 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: <https://doi.org/10.1002/oa.2683>

Lidour K., Béarez P., Charpentier V. & Méry S. (in press). The prehistoric fisheries of Akab Island (United Arab Emirates). New insights into coastal subsistence during Neolithic in eastern Arabia. *Journal of Island and Coastal Archaeology*.

Lieske E. & Myers R. 1994. *Coral reef fishes: Indo-Pacific & Caribbean*. (Collins Pocket Guide). New York: Harper Collins.

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

Magarlamov T.Y., Melnikova D.I. & Chernyshev A.V. 2017. Tetrodotoxin-producing bacteria: Detection and migration of the toxin in aquatic systems. *Toxins* 9/166: 1–20. doi: <https://doi.org/10.3390/toxins9050166>

Mashkour M., Beech M.J., Debue K., Yeomans L., Brehard S., Gasparini D. & Méry S. 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.

Masuda H., Amaoka K., Araga C., Uyeno T. & Yoshino T. 1984. *The fishes of Japanese archipelago*. Tokyo: Tokai University Press.

Méry S. 2015. Mobilité et interculturalité en Arabie orientale durant la Protohistoire ancienne: Modalités de formation d'un ensemble culturel et d'entités régionales. Pages 353–368 in N. Naudinot, L. Meignen, D. Binder & G. Querré (eds), *Les systèmes de mobilité de la préhistoire au moyen-âge*. Antibes: Éditions APDCA.

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

Méry S., Blackman M.J., Beech M.J. & Lidour K. 2016. 5500 av. notre ère: Le vase de Marawah MR11 et l'Obeid du Golfe. Pages 155–174 in B. Perello & A. Tenu (eds),

*Parcours d'Orient. Recueil de textes offert à Christine Kepinski.* Oxford: Archaeopress.

Moore A.B.M. 2014. A review of sawfishes (Pristidae) in the Arabian region: Diversity, distribution, and functional extinction of large and historically abundant marine vertebrates. *Aquatic Conservation* 25/5: 656–677.

Rainboth W.J. 1996. *Fishes of the Cambodian Mekong. FAO species identification field guide for fishery purposes.* Rome: Food and Agriculture Organization.

Rhodes K.L., Taylor B.M. & McIlwain J.L. 2011. Detailed demographic analysis of an *Epinephelus polyphekadion* spawning aggregation and fishery. *Marine Ecology Progress Series* 421: 183–198.

Sanlaville P. & Dalongeville R. 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.

Sommer C., Schneider W. & Poutier J-M., 1996. *The living marine resources of Somalia. FAO species identification field guide for fishery purposes.* Rome: Food and Agriculture Organization.

Stehmann M. 1981. Myliobatidae. In W. Fischer, G. Bianchi & W.B. Scott (eds), *Eastern Central Atlantic (Fishing Areas 34, 47). FAO species identification field guide for fishery purposes.* v. Rome: Food and Agriculture Organization.

Stuiver M. & Reimer P.J. 1993. Extended 14C data base and revised CALIB 3.0 14C

age calibration program. *Radiocarbon* 35: 215–230.

Tengberg M. 2012. Beginnings and early history of date palm garden cultivation in the Middle East. *Journal of Arid Environments* 86: 139–147.

Uerpmann M. & Uerpmann H-P. 2003. *Stone Age sites and their natural environment. The capital area of northern Oman, III.* (Beihefte zum Tübinger Atlas des Vorderen Orients, Reihe A [Naturwissenschaften], 31/3). Wiesbaden: Dr. Ludwig Reichert.

Uerpmann M. & Uerpmann H-P. 2018. Faunal remains and subsistence strategies. Pages 384–422 in P. Drechsler (ed.), *Dosariyah. Reinvestigating a Neolithic coastal community in eastern Arabia.* (British Foundation for the Study of Arabia Monograph, 19). Oxford: Archaeopress.

Van Neer W. & Gautier A. 1993. Preliminary report on the faunal remains from the coastal site of ed-Dur, 1st–4th century A.D. Pages 110–118 in H. Buitenhuis & A.T. Clason (eds), *Archaeozoology of the Near East. Proceedings of the first international symposium on the archaeozoology of southwestern Asia and adjacent areas.* Leiden: Universal Book Services.

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.