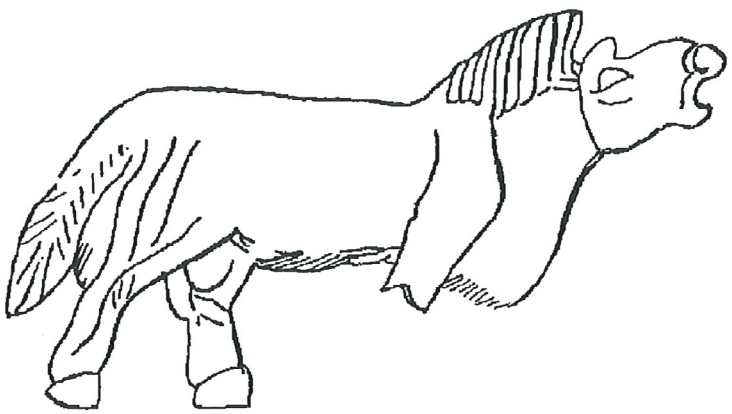
ARCHAEOZOOLOGY OF THE NEAR EAST IV B

Proceedings of the fourth international symposium on the archaeozoology of southwestern Asia and adjacent areas

edited by

M. Mashkour, A.M. Choyke, H. Buitenhuis and F. Poplin



ARC - Publicatie 32
Groningen, The Netherlands, 2000

Cover illustration:
Przewalski from Susa (nacre – mother of pearl)
Dated to 2500 – 2000 BC, identified by F. Poplin

Printing: RCG -Groningen

Information: Centre for Archeological Research and Consultancy
Poststraat 6, 9712 ER Groningen, The Netherlands

ISBN 90 – 367 – 1243 - 2
NUGI 644 - 134

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VOLUME A

FISH BONES FROM AL MARKH, BAHRAIN

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Abstract

The present study analyses the fish remains excavated in Al Markh, Bahrain during the 1973-1975 campaigns. The Neolithic material dates from two phases of occupation during the late fifth or fourth millennium BC. The sample analysed comprises a total of 138,515 bones, of which 32,278 from some 31 different species could be identified. The MNI was estimated for a better comparability because of the different taphonomic parameters of different skeletal parts in the fish groups. The distribution of the bones according to the various parts of the skeleton shows, that the whole fish skeleton was discarded, and the fish were prepared and consumed at the site. The lesser material of the upper level had been dry-sieved, that of the lower water-sieved with a finer mesh. The latter method provided evidence for the overwhelming presence of small young fish which prefer habitats in shallow coastal waters. Differences between the upper and lower layers may be due to methodological and taphonomic factors as well, but certainly show changes in the methods of fishing. The complete absence of the bones of fish that live exclusively on coral reefs may support the suggestion, that the present day reefs next to the coast did not yet exist during the time Al Markh was occupied.

Résumé

Cet article présente l'analyse de l'ichtyofaune découverte dans les fouilles d'Al Markh à Bahrein pendant les campagnes 1973-1975. Le matériel néolithique est daté de deux phases d'occupation de la fin du 5^{e} ou du 4^{e} millénaire. L'échantillon analysé comprend un total de 138515 os dont 32278 se rapportant à 31 espèces différentes ont pu être identifiés. Le NMI a été estimé en vue d'une meilleure comparaison en raison des divers paramètres taphonomiques des différentes parties du squelette des différents groupes de poissons. La répartition des os selon les différentes parties du squelette des poissons montre que la totalité du corps était dépouillée et qu'ils étaient préparés et consommés sur le site. Le matériel des niveaux plus récents, quantitativement moindre, a été tamisé à sec, celui des niveaux plus anciens à l'eau et avec une maille plus fine. Cette dernière méthode à mis en évidence l'abondance de jeunes petits poissons qui préfèrent les eaux côtières peu profondes. Bien que les différences entre les niveaux récents et anciens puissent être dues à la méthodologie utilisée, de même qu'aux facteurs taphonomiques, des changements apparaissent dans les méthodes de pêche. L'absence totale d'os de poissons vivant exclusivement sur les récifs coralliens peut étayer l'hypothèse que les récifs actuellement présents à proximité des côtes n'existaient pas à l'époque.

Key Words: Fish Exploitation, Neolithic, Arabian Gulf

Mots Clés: Exploitation des poissons, Néolithique, Golfe Arabique

Introduction

Al Markh lies about 1400 m from the west coast of Bahrain, about six kilometres south of the village of Zallaq. The site is named after the region of al-Markh three kilometres to the northeast. Today there is easy access to it but in the fourth millennium BC the site was situated on the east coast of an island to the west of the main island of Bahrain. There were two phases of occupation at Al Markh. The earlier economy was based on fishing and gathering shellfish. The later phase relied both on fishing and on the capture of dugong and the herding of goats" (Roaf 1976: 144 ff.).

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Table 1. Numeric distribution of the fishbones among the sections of the trenches J19, J21/22, and K 19

Trench	Layer	Square	Number of bones	Phase	Status
J19	31.2	AC	135	upper	sinter-encrustations
J19	31.2	AD	49	upper	partly encrusted
J19	31.2	AE	59	upper	partly encrusted
J19	31.2	BC	40	upper	sand-encrustations
J19	31.2	BD	11	upper	sand-encrusted
J19	31.2	BE	3	upper	sand-encrusted
J19	31.2	CC	21	upper	sinter-encrusted
J19	31.2	CD	14	upper	partly encrusted
J19	31.2	CE	8	upper	sinter-encrusted
J19	31.2B	BE	17	upper	sinter-encrusted
J19	31.2B	CE	63	upper	sand-sinter-encrusted
J19	31.10	CD	1	middle	not burnt
J19	31.10A	BE	3	lower	not burnt
J19	31.10A	CE	69	lower	not burnt
J19	31.14	BC	2	lower	not burnt
J19	31.15	AE	6,430	lower	not burnt
J19	31.15	CC	1	lower	not burnt
J19	31.15	CD	55,295	lower	burnt
J19	31.15	CE	3,701	lower	partly burnt
J19	31.15F	CE	12,301	lower	partly burnt
J19	31.15H	CE	55,703	lower	heavily burnt
J21	61.3	EB	592	lower	sand-encrusted
J21	61.3	DA	12	lower	sand-encrusted
J22	61.3	AB Pit F	1,130	lower	sand-encrusted
K19	1.2		5	upper	sand-encrusted
K19	1.8		2,850	lower	burnt
Sum			**138,515**		

The collection of 138,515 fish bones discussed in this report come from three trenches, namely J19, J21/J22, and K19, at the prehistoric site of Al Markh which was occupied in the late fifth or fourth millennium BC (Table 1). In Trench J19 the remains of a midden largely consisting of fish bones was excavated. Trench J21/22 lay some 20m south of J19 and K19 lay immediately to the east of J19. Only two samples were examined from Trench K19, which was excavated in 1973/74: layer 1.2 included only 5 fragments of fish bones, while the deeper lying layer 1.8 yielded 2,850 very burnt fish bones. Only a small sample of the bones from Trench J21/J22 (excavated in 1975) was available for study (1,734 bones) and by far the majority of the material excavated in 1975 came from Trench J19.

A total of 135,660 fish bones was counted for the 1975 sample of which 133,926 came from Trench J19, which was more intensively and more carefully excavated than the other trenches. Of these bones the majority came from the lower layers where the fish midden was located (420 bones from the upper layers and 133,506 bones from the lower layers). Much of the bone material was burnt, some was covered with sand-encrustation, and some was unburnt.

Table 2. List of fish species or genera by trench, omitting otoliths, found among the shells from trench J19 31.10 CD, 31.14 BC, and 31.15 CC

	J19 upper	J19 lower	J19 total	J21	J22	K19
Chondroichthyes: Cartilaginous Fishes						
Carcharhinus melanopterus, Blackfinned Shark	-	11	11	1	5	-
Sphyrna zygaena, Hammerhead Shark	-	17	17	1	5	-
Pristis spec., Saw-fish	-	11	11	-	1	-
Rhinchobatus djeddensis, White-spotted Ray	1	2	3	-	-	-
Dasyatis spec., Stingray	-	3	3	-	-	-
Chondroichthyes indet.	-	-	-	7	-	-
Osteichthyes: Bony Fishes						
Family Clupeidae: Sardines						
Sardinella spec., Sardina	-	2	2	-	-	-
Family Dorosomidae: Gizzard-shads						
cf. *Nematalosa nasus*, Hairback Herring	-	1,434	1,434	-	-	-
Family Ariidae: Estuarine Catfishes						
Arius thalassinus, Giant Salmon Catfish	2	3	5	-	-	-
Family Belonidae: Needle-fishes						
Ablennes hians	-	1	1	-	-	-
Family Atherinidae: Silversides						
cf. *Atherina forskalii*	-	16	16	-	1	-
Family Platycephalidae: Flatheads						
Platycephalus cf. *indicus*, Bar-tailed Flathead	-	4	4	-	-	-
Family Serranidae: Groupers						
Epinephelus/(Cephalopholis) spec., Rock-cods	157	444	601	26	35	20
Family Carangidae: Trevallies and Jacks						
Scomeroideus spec., Leatherskin	-	1	1	1	-	-
Gnathodon speciosus, Golden Trevally	6	-	6	-	-	-
Carangoides fulvoguttatus, Golden-spotted Trevally	2	-	2	-	3	-
Carangoides chrysophrys	-	-	-	1	-	-
Carangidae indet.	-	19	19	-	-	-
Family Leiognathidae: Slimies						
Leiognathus spec., Ponyfish	-	5	5	3	-	-
Family Gerridae: Silver-biddies						
Gerres spec.	-	249	249	-	14	4
Leiognathus or Gerres	-	176	176	-	-	-
Family Lutjanidae: Snappers						
Lutjanus spec.	-	16	16	-	-	-
Family Lethrinidae: Emperors						
Lethrinus/Lethrinella spec.	8	259	267	6	4	7
Family Haemulidae: Sweetlips						
Plectorhynchus spec., Sweetlips	-	4	4	-	-	-
Pomadasys, Javelin-fish	-	1	1	-	-	-
Family Sparidae: Sea-breams						
Argyrops spec., Redfin	2	20	22	-	-	-
Acanthopagrus spec., Black Bream	52	972	1,024	8	5	12
Rhabdosargus sarba, Tarwhine	1	1,620	1,621	21	17	16
Diplodus noct	-	451	451	-	-	-
Crenidens crenidens	-	7	7	-	-	-
Sparidae indet.	41	10,400	10,441	90	223	268
Family Mugilidae: Grey Mullets						
Mugils spec.	-	13	13	-	-	-

Table 2. continued

	J19 upper	J19 lower	J19 total	J21	J22	K19
Family Sphyraenidae: Barracudas						
Sphyraena spec.	-	23	23	-	-	-
Family Siganidae: Rabbitfishes						
Siganus spec.	-	11	11	-	-	-
Perciformes indet.						
acanthotrichia, pterygophori	-	3,472	3,472	-	10	-
vertebrae	-	7,873	7,873	40	420	3
dentes	-	3,186	3,186	-	-	-
Family Scombridae: Mackerels						
Euthynnus affinis, Tuna	-	2	2	-	-	-
Sum of identified or classified fish bones	**272**	**30,728**	**31,000**	**205**	**743**	**330**
Unidentifiable bone fragments	**148**	**102,778**	**102,926**	**399**	**387**	**2,525**
Total	**420**	**133,506**	**133,926**	**604**	**1,130**	**2,855**

The samples examined

In the 1973/4 season the deposits from Al Markh were dry-sieved using a 4 mm sieve to recover artefacts, shells and bones from the excavations. This practice was continued during the excavation of the upper levels of Trench J19 in 1975. During that season Sebastian Payne suggested that, because much of the bone was being damaged in the sieves and many of the smaller bones were not being recovered, water-sieving should be used. Plastic fly-screen mesh of about 1/16 inch (1.5mm) was made up into bags and the soil was taken to the sea and the water-sieving was carried out in the shallow sea-water with much pleasure.

Samples of the much richer lower layers were water-sieved and vast numbers of bones were recovered. Some of the residues were graded through sieves and divided into fractions >5 mm, 5-1.5 mm, and <1.5 mm. All the fraction >5 mm was brought to Europe for specialist examination but sometimes, because of the vast amount of material, only a proportion of the material <5 mm was brought back. In the case of J19 31.10A CE, 31.15F CE and 31.15H CE, and J21 61.3 EB only 1/8 of the fraction <5 mm was studied and so the numbers of the smaller bones and particularly of the unidentified are too low.

Methods of investigation

The distribution of the more than 135,000 fish bones according to trench, layer and 2 by 2m square of the excavation is given in Tables 1 and 3. The majority of the material consists of complete and broken bones (including extremely small fragments) from very small to middle-sized fish. The middle-sized fish were most frequent. Remains from some larger species of fish (Table 5) were present in all trenches. The main groups of fish were distributed in different percentages in the various upper and lower layers of Trench J19 (see below).

Since the bones came from sieving, they include numerous fragments too small to be identified with the naked eye. Their classification by anatomical element and fish species was carried out using a binocular microscope with a magnification of 6.7 up to (if necessary) 40 times. In this investigation we concentrated on those skeletal elements having distinctive features which can be used to distinguish different species of fish. These are chiefly the bones of the viscerocranium (such as the *praemaxillare*, *maxillare*, *palatinum*, *dentale*, *articulare*, *quadratum*, *hyomandibulare*, *epi-*, *kerato-*, *hypo-* and *urohyale*), but also include some characteristic parts of the neurocranium (such as oto-

Table 3. Distribution of the fishbones per species/group in the different sections. J19 only. Upper layers and middle layer (31.10 CD)

	31.2 AC	31.2 AD	31.2 AE	31.2 BC	31.2 BD	31.2 BE	31.2 CC	31.2 CD	31.2 CE	31.2B BE	31.2B CE	31.10 CD
Chondroichthyes	-	-	-	-	-	-	-	-	-	1	-	-
Arius	-	2	-	-	-	-	-	-	-	-	-	-
Serranidae	26	22	19	21	6	3	14	10	8	13	15	1
Carangidae	-	5	1	-	-	-	1	1	-	-	-	-
Lethrinus	-	2	1	3	-	-	-	1	-	-	1	-
Argyrops	-	-	2	-	-	-	-	-	-	-	-	-
Acanthopagrus	8	15	16	2	2	-	6	2	-	1	-	-
Rhabdosargus	1	-	-	-	-	-	-	-	-	-	-	-
Sparidae indet.	-	-	-	1	-	-	-	-	-	2	38	-
indet. fish bones	100	3	20	13	3	-	-	-	-	-	9	-
Sum	**135**	**49**	**59**	**40**	**11**	**3**	**21**	**14**	**8**	**17**	**63**	**1**

Table 3 (continued). Distribution of the fishbones per species/group in the different sections. J19 only. Lower layers

	31.10A BE	31.10A CE	31.14 BC	31.15 AE	31.15 CC	31.15 CD	31.15 CE	31.15F CE	31.15H CE
Chondroichthyes	3	1	-	1	-	11	16	7	5
Clupeidae	-	-	-	-	-	*2*	-	-	-
Dorosomidae	-	-	-	-	-	752	-	-	682
Arius	-	1	-	-	1	1	-	-	-
Ablennes	-	-	-	-	-	1	-	-	-
Atherina	-	-	-	-	-	16	-	-	-
Platycephalus	-	-	-	-	-	3	-	1	-
Serranidae	-	1	1	24	-	146	119	63	89
Carangidae	-	-	-	-	-	1	19	-	-
Leiognathus	-	-	-	-	-	*3*	-	-	*2*
Gerres	-	-	-	-	-	120	4	23	102
Leiognathus or Gerres	-	-	-	-	-	80	1	20	75
Lutjanus	-	-	-	-	-	11	-	-	5
Lethrinus	-	2	-	7	-	57	57	15	121
Plectorhynchus & Pomadasys	-	-	-	-	-	4	-	1	-
Argyrops	-	3	-	-	-	1	4	1	11
Acanthopagrus	-	2	-	45	-	40	21	218	646
Rhabdosargus	-	13	-	56	-	605	153	323	470
Diplodus	-	-	-	-	-	263	-	14	174
Crenidens	-	-	-	-	-	3	-	-	4
Sparidae indet.	-	31	-	1,238	-	2,530	608	2,652	3,341
Mugil	-	-	-	-	-	7	-	6	-
Sphyraena	-	-	-	-	-	20	-	3	-
Siganus	-	-	-	-	-	3	-	1	7
Perciformes indet.	-	-	-	-	-	6,709	188	1,147	6,487
Euthynnus	-	-	-	-	-	-	1	1	-
indet. fish bones	-	15	1	5,059	-	43,906	2,510	7,805	43,482
Sum	**3**	**69**	**2**	**6,430**	**1**	**55,295**	**3,701**	**12,301**	**55,703**

Table 4. Distribution of the bones of the major fish groups by the different parts of the skeleton. J19 only. The three figures for each fish group are numbers of bones from the upper layers, the lower layers and the total

	Serranidae			*Argyrops*			*Acanthopagrus*			*Rhabdosargus*			*Diplodus*			*Crenidens*		
neurocrania	13	35	48	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
otolithes	20	40	60	-	-	-	-	-	-	-	372	372	-	6	6	-	-	-
praemaxillaria	40	21	61	-	8	8	35	537	572	-	665	665	-	170	170	-	1	1
maxillaria	4	12	16	-	-	-	-	16	16	-	27	27	-	2	2	-	-	-
palatina	-	3	3	-	-	-	-	66	66	-	23	23	-	24	24	-	-	-
dentalia	41	37	78	2	8	10	17	328	345	1	472	473	-	54	54	-	-	-
dentes singuli	-	90	90	-	-	-	-	-	-	-	-	-	-	178	178	-	6	6
articularia	1	14	15	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
quadrata	4	15	19	-	-	-	-	9	9	-	23	23	-	15	15	-	-	-
hyomandibularia	2	2	4	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
hyoidea[1]	4	4	8	-	-	-	-	8	8	-	30	30	-	2	2	-	-	-
operculum[2]	1	15	16	-	2	2	-	-	-	-	1	1	-	-	-	-	-	-
cleithra/scapulae	4	16	20	-	-	-	-	8	8	-	6	6	-	-	-	-	-	-
acanthotrichia/pterygophori	-	28	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
vertebrae[3]	23	109	132	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
others	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sum	**157**	**444**	**601**	**2**	**20**	**22**	**52**	**972**	**1,024**	**1**	**1,620**	**1,621**	**-**	**451**	**451**	**-**	**7**	**7**
Minimum Number of Individuals	**20**	**30**	**50**	**1**	**4**	**5**	**18**	**268**	**286**	**1**	**332**	**333**	**-**	**85**	**85**	**-**	**3**	**3**

[1] Comprising *epihyalia, keratohyalia, hypohyalia and urohyalia*
[2] Comprising *praeoperculare* and *operculare*
[3] *vertebrae paraecaudales* and *caudales*

	Sparidae indet.			*Lethrinidae*			*Lutjanus*			*Gerres*			*Siganus*			*Perciformes indet.*		
neurocrania	-	-	97	-	8	8	-	-	-	-	1	1	-	1	1	-	-	-
otolithes	4	117	121	1	2	3	-	-	-	-	9	9	-	-	-	-	-	-
praemaxillaria	4	590	594	3	53	56	-	6	6	-	13	13	-	5	5	-	-	-
maxillaria	-	379	379	-	19	19	-	1	1	-	-	-	-	-	-	-	-	-
palatina	-	318	318	-	46	46	-	-	-	-	-	-	-	-	-	-	-	-
dentalia	-	489	489	4	21	25	-	3	3	-	10	10	-	5	5	-	-	-
dentes singuli	33	2,064	2,097	-	-	-	-	-	-	-	-	-	-	-	-	-	3,186	3,186
articularia	-	185	185	-	17	17	-	6	6	-	20	20	-	-	-	-	-	-
quadrata	-	262	262	-	15	15	-	-	-	-	4	4	-	-	-	-	-	-
hyomandublaria	-	37	37	-	16	16	-	-	-	-	-	-	-	-	-	-	-	-
hyoidea[1]	-	114	114	-	35	35	-	-	-	-	-	-	-	-	-	-	-	-
operculum[2]	-	20	20	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-
cleithra/scapulae	-	19	19	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-
acanthotrichia/pterygophori	-	174	174	-	-	-	-	-	-	-	-	-	-	-	-	-	3,472	3,472
vertebrae[3]	-	5,535	5,535	-	9	9	-	-	-	-	77	77	-	-	-	-	7,873	7,873
Sum	**41**	**10,400**	**10,441**	**8**	**259**	**267**	**-**	**16**	**16**	**-**	**134**	**134**	**-**	**11**	**11**	**-**	**14,531**	**14,531**
MNI	**3**	**297**	**300**	**2**	**28**	**30**	**-**	**6**	**6**	**-**	**15**	**15**	**-**	**4**	**4**	**-**	**-**	**-**

[1] Comprising *epihyalia, keratohyalia, hypohyalia and urohyalia*
[2] Comprising *praeoperculare* and *operculare*
[3] *vertebrae paraecaudales* and *caudales*

	Dorosomidae		
vertebrae	-	1,434	1,434
MNI	**-**	**50**	**50**

liths, *basioccipitale*, *parasphenoid*, and *vomer*), bones covering the gills (*operculare* and *praeoperculare*), and of the shoulder girdle (*cleithrum* and *scapula*) (Table 4). In addition, when possible, the vertebrae were classified. All vertebrae, not just those whose species was identified, were examined. We counted only the well preserved vertebrae, but not all the small fragments of the broken ones. When we compare the number of *Praemaxillaria* of the perch-like fish (*Perciformes*), belonging to the Serranid, Sparid, and Lethrinid families with the vertebrae of the fish from these families, we get the following result. A total of 2,151 *praemaxillaria* yielded a minimum number of individuals (MNI) of 1,076 fish (2 per fish) and 13,626 vertebrae produced a MNI of 454 fish (based on an average of 30 vertebrae per fish). The MNI given by the vertebrae is half smaller than that calculated from the *praemaxillaria*. Since one can assume that vertebrae are less likely to have been preserved than the *praemaxillaria*, and for methodological reasons (not counting fragments of vertebrae), one can conclude that in Trench J19 the whole fish skeleton was discarded on the rubbish heap. In other words, the fish bones found on the site belonged to fish that were prepared and consumed on the site and do not provide evidence for the preparation of fish to be exported elsewhere. Had there been only bones from the head one could suggest that this was the result of cutting off the heads before the fish were dried, smoked or salted. The small size of most of the fish makes it unlikely that they were filleted.

Spines (*acanthotrichia*) and rays (*pterygophori*) belonging to the *Perciformes* were counted when they were identifiable (Tables 2 and 4), though only in exceptional cases could the species precisely be established.

Because the material was recovered through sieving, it included numerous otoliths (ear-bones) and particularly the largest of the three otoliths on each side (the *sagitta*). Several well-preserved otoliths have been sent to the Musée Royale de l'Afrique Moyen in Tervuren in order to investigate possible seasonality at the site. There they will be cut into thin sections and the summer and winter growth rings will be counted (Roaf, in preparation).

The identification of the species was carried out by directly comparing the morphology of the bones with fish skeletons of known species and size in the reference collection of the Institute for Palaeoanatomy.[2] At the same time, size was reconstructed either through direct comparison or through the measurement of the bones. The total length of the fish was reconstructed (Table 5 and Fig. 1). The minimum number of individuals (MNI) for each fish species or each group of fish (Table 4 and Fig. 1) was calculated, according to standard practice, by counting the most frequently occurring parts of the skeleton on one side (or vertebrae) taking the size of the bones into consideration. As a consequence of the very fragmentary condition of the bones, the calculated MNI is far too low. Furthermore the samples reported on here are only part of the bones recovered from Trench J19 and much of the site was not excavated. So even if the calculated MNI was increased a hundredfold, it still would not yield the actual number of fish consumed by the prehistoric inhabitants of Al Markh.

The MNI is more significant as an indicator of the relative numbers of the various fish species represented in the sample. The individual bones of the skeleton of different types of fish have varying survival rates. For example, except for a few teeth, the only bones of cartilaginous fish (*Chondroichthyes*) to survive are the calcified centra of the vertebrae. Also the only identifiable bones from members of the smaller species of the *Clupeidae* and *Dorosomidae* families are the vertebrae. From the very thin and fragile bones of the Silversides (*Atherinidae*) only the well-ossified otoliths normally survive, while as already stated, the bones of perch-like fish (*Perciformes*), particularly the very commonly found groupers (*Serranidae*), Emperor fish (*Lethrinidae*), and Seabreams (*Sparidae*) are equally distributed over the whole skeleton, so that besides vertebrae the toothbearing parts (*praemaxillare* and *dentale*) are the most frequent (Table 4). This all shows that the MNI represents the original proportions of species better than the total number of bones for each species.

As is shown in Table 3, only 420 bones were examined from the upper layers (31.2 and 31.2B) of Trench J19. The vast majority of the fish remains come from the lower layers in Trench J19 and probably date to the early fourth millennium BC (for discussion of the date see Roaf, in preparation).

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[2] We thank Michael Roaf for supplying numerous modern fish skeletons from Bahrain, which are a valuable addition to our collection.

Table 5. Variation of the reconstructed fish-sizes. J19 only

length	variation in cm	estimated mean in cm	MNI
Nematalosa nasus	8-20	13	50
Atherina	7-10	17	8
Serranidae	10-90	60	50
Scomberoideus	60		1
Gnathodon	70; 70; 75		3
Carangoides	75; 85		2
Carangidae indet.	90; 100		2
Gerres	15-25	18	15
Lutjanus	15-22	18	7
Lethrinus	10-60	28	30
Plectorhynchus	20; 25		2
Pomadasys	10		1
Argyrops	15-60	35	7
Acanthopagrus	7-15	10	54
22	15-30	220	
42	35-50	12	
Rhabdosargus	7-15	10	146
22	15-25	185	
	30; 40	2	
Diplodus	7-15	10	70
17	15-20	15	
Crenidens	<10-15	15	3
Sparidae indet.	10-40	15	300
Platycephalus	20; 30; 50		3
Siganus	15-20	17	6
Thunnus	60; 70;		2

It is statistically speaking difficult to compare the 420 bones from the upper layers with the more than 133,000 bones from the lower levels, but there appears to be a difference in the relative numbers of the most commonly occurring fishes from the two phases (Table 6). In the upper layers Serranids clearly appear to be relatively more frequent and, if less obviously, Carangids and Lethrinids also appear more common than in the lower layers. In the lower layers more than 80 % of the identified bones belong to Sparids, which only form a third of the identified bones in the upper layers. These differences may admittedly be due to statistical and/or taphonomic factors, but they may also certainly be the result of changes in the methods of fishing during the fourth millennium BC whereby more Serranids (groupers) were caught, although the Sparids (Seabream) still played a significant economic role.

Description of the individual fish groups

The only remains of members of the sardine family (*Clupeidae*) identified in the bones from Al Markh were two large damaged caudal vertebrae of *Sardinella*, whose size suggests an original length of ca. 28 cm. More common are the characteristic vertebrae of the Hairback Herrings of the *Dorosomidae* family (Gizzard-shads). These vertebrae are very small but do not come from young fish. These cannot come from the closely related *Albulidae*, *Elopidae*, and *Megalopidae*, because the members of these families are too large. Particularly distinctive are the first few precaudal vertebrae. These show on the cranial joint articulation a dorsal and ventral attachment which has left a mark which gives the articular surface the shape of a figure 8. We have only observed such an attachment mark on one species of fish, namely *Nematolosa nasus*, a member of the *Dorosomidae* family (P064/91094, on loan from the Musée de l'Afrique Central, Tervuren). The precaudal vertebrae from lower down the spine and the first caudal vertebrae have a central ridge on the ventral side. A similar feature is also found among the other members of the family *Clupeidae*, but, since the first vertebrae match those of *Nematolosa* better, we conclude that the other vertebrae also belonged to this species. The vertebrae of the closely related genera *Dussumeria* and *Thrissocles*, do not have this central ridge, so their presence can be excluded.

"Gizzard-shads are herring-like scavengers of muddy bottoms, living usually close inshore. They sometimes congregate in enormous schools" (Carcasson 1977: 44). These fish have many bones and are not very tasty thus one may suggest that the prehistoric fishermen of Al Markh, who caught a

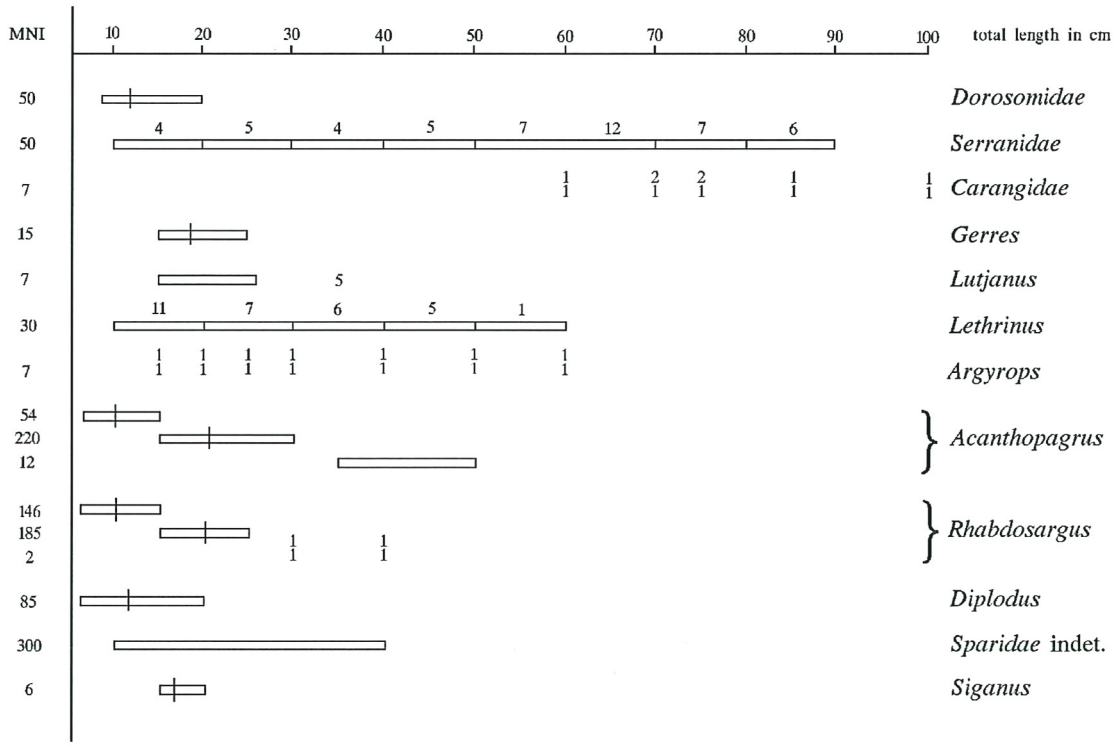

Fig. 1. Size variations of the major fish groups.

great many better tasting fish, used these small fish caught in their nets as bait for the capture of groupers and other large predatory fish (see below). The vertebrae were, however, found with the other bones and this would suggest that they too were eaten.

The Giant Salmon Catfish (*Arius thalassinus)* live today in the coastal waters of the Gulf in great numbers. They are predators and bottom feeders. They are unattractive fish to look at but their flesh is delicious. It is probably on account of their ugly appearance that today they are only offered very rarely for sale in fishmarkets. Often these fish are thrown away on the shore when they are caught and one commonly sees their desiccated bodies or bones lying on the beach. Amongst the fish bones from Al Markh only 5 examples of this species have been identified. Four are otoliths, one used as a bead (see Roaf 1976: Pl. 2G), and the other a precaudal vertebra of a very small representative of this species. The unmistakable granulated surface of the skull roof bones of this species of catfish actually survive well and it is therefore surprising that such bones were not present in the bone material from Al Markh. Perhaps the people of Al Markh valued this species as little as the present day inhabitants of the Gulf coast, or perhaps they had a taboo against the ugly catfish and threw the fish back into the water when they caught one.

Only one short section of a lower jaw of *Ablennes hians*, a member of the Needle-fish family (*Belonidae*) with narrow pointed teeth, was found. The rare occurrence of members of this species is not surprising as they are primarily "pelagic surface predators often congregating in large schools" and only in exceptional circumstances do they seek out shallow coastal waters (Carcasson 1977: 62).

As already noted, only the otoliths of the Silverside family (*Atherinidae*), have been found amongst the bones from Al Markh. These are most similar to those of the species *Atherina forskalii*. The otoliths of Silversides, growing to a maximum of 12 cm, are relatively large in proportion to their body size even in young fish. We do not dare to reconstruct the length of the fish of this family caught by the fishermen of Al Markh.

The vertebrae of members in the Flathead family (*Platycephalidae*) are elongated and unmistakable, so that their identification is not difficult. The four vertebrae from J19 agree very well with the corresponding vertebrae of the Bar-tailed Flathead (*Platyrhynchus indicus*), the most common

Table 6. Distribution of the major fish groups found in the upper and lower levels of Trench J19 at Al Markh compared with those found in the Temple at Saar, in Qala'at al-Bahrain and Shimal. The figures are the numbers of identified bones and the percentages of all bones identified to family

	Al Markh J19 upper		Al Markh J19 lower		Saar Temple		Qala'at al-Bahrain		Shimal	
	N	%	N	%	N	%	N	%	N	%
Dorosomidae	-	-.--	1,434	8.85	-	-.--	-	-.--	-	-.--
Gerres and *Leiognathus*	-	-.--	430	2.65	-	-.--	-	-.--	-	-.--
Lethrinidae	8	2.94	259	1.60	380	36.97	888	30.63	18	0.84
Serranidae	157	57.72	444	2.74	99	9.63	1,041	35.91	21	0.98
Carangidae	8	2.94	20	0.12	72	7.00	428	14.76	770	35.98
Sparidae	96	35.29	13,470	83.16	216	21.01	450	15.52	260	12.15
Sphyraenidae	-	-.--	23	0.14	190	18.48	2	0.07	24	1.12
Total identified to family	**272**	**98.89**	**16,197**	**99.26**	**1,028**	**93.09**	**2,899**	**96.89**	**2,140**	**51.07**

Note *Dorosomidae* bones are vertebrae and have not been identified on the other sites.

species of Flathead found in the Gulf today. "These fishes spend most of their time buried in the sand or mud of the bottom with just the eyes exposed ready to snap at any unwary fish of suitable size that may come within range" (Carcasson 1977: 247). Even though the normal habitat of this species corresponds well with the immediate environs of Al Markh, it was rarely found amongst the fish bones from Al Markh. This may have been because it is seldom caught in nets, as a result of its habit of burying itself in the sand.

After the *Sparidae* the fish most frequently represented amongst the finds from Al Markh are the Groupers (*Serranidae*). The morphological features of the better preserved bones mostly fit with the corresponding bones of the genus *Epinephelus*. Since, however, bones from very small fishes are also present (Table 5), representatives of other genera, such as the genus *Cephalopholis*, which is equally common in the Gulf, cannot be ruled out with certainty. All in all, lengths from 10 to 90 cm were calculated for these fish. The way individual size groups were distributed over a large range is indicated in Figure 1. Middle-sized and large examples predominate.

Ten species of *Epinephelus* and at least as many more species of *Cephalopholis* are known from the Gulf. Most species prefer rocky bottoms or coral reefs, where they lead solitary lives especially when they are older (*Epinephelus*). Some species live in waters from a few to ten metres deep and others are found only in deeper waters (see below).

Amongst the finds the 33 bones of the rarely recorded members of the *Carangidae* family (Trevallies and Jacks) belonged only to larger fish. Because, as well as vertebrae which can be identified only in exceptional cases, typically shaped bones of the viscerocranium are present, it is possible to identify at least 4 species or genera: *Scomberoideus* (*vertebra praecaudalis*), *Gnathodon speciosus* (4 *praemaxillaria*, 2 *dentalia*), *Carangoides fulvoguttatus* (2 *dentalia* in J19 and 3 *vertebrae* in J22), and *Carangoides chrysophrys* (a *supraoccipitale* with hyperostosis (abnormal swelling of the bone) in J21(for hyperostosis in fish bones see von den Driesch 1994). The Carangid bones whose species could not be identified include 2 very damaged *maxillaria* and 17 vertebrae. The sizes of the fish from Trench J19 are shown in Figure 1. One of the fish was over one metre long.

One may ask how the fishers from Al Markh were able to catch such large species of fish in the fourth millennium BC, since Carcasson (1977: 91) described the *Carangidae* as "a large group of fast swimming surface predators of moderate to large size. They usually run in fairly large schools in the vicinity of coral reefs." Thus there must have been coral reefs or rocky areas in the neighbourhood of Al Markh or the men were able to reach such areas in boats (for further discussion of the possible presence of coral reefs see below).

Fish of the genera *Gerres* (Ponyfish) and *Leiognathus* (Silver-biddies) taken together form the third most common group among the identified fish bones from Al Markh. Both genera are closely related (Carcasson 1977: 138) and therefore it is not surprising that they are not clearly differentiated

osteologically. Apparently *Gerres* is more common than *Leiognathus*. Without exception the bones belonged to smaller fish, which were rarely more than 20 cm long (Table 5). The bones classified as *Gerres* or *Leiognathus* in Table 2 include only vertebrae and a few *mesethmoidea*. All these bones also belonged to smaller fish.

"Ponyfishes and silver-biddies are small to moderate predatory fish of the tropical Indo-Pacific. They occur in shallow sheltered waters and sandy areas, often in tidal pools" (Carcasson 1977: 138). Such habitats are likely to have existed around Al Markh in the past as they do today.

A total of 16 frontal skull bones, which are typical of the species, demonstrate the presence of members of the genus *Lutjanus* (Tables 2 and 4). These bones belong to smaller fish from 15 to 25 cm long (Fig. 1). Members of the *Lutjanidae* grow considerable larger. They are, like the *Lethrinidae* (see below), active, flesheating fish, which are present in all warm oceans. They are bottom dwellers who live in small schools and feed on small fish and crustaceans. Mostly they are found on coral reefs lying some distance from the coast, but some species are also found in the intertidal zone, in lagoons, and even in mangrove swamps (Fischer and Bianchi 1984).

Bones of the members of the *Lethrinidae* (Emperor-fish) family are quite common (Tables 2 and 4). This fish family is the fourth best represented amongst the bones from Al Markh. Their way of life and their preferred living grounds are the same as those mentioned above for the *Lutjanidae*. Because of the great similarity of the individual species in this family, identification to species is not possible.

The reconstructed fish lengths (Fig. 1) range from 10 to 60 cm. These 18 examples of smaller fish between 10 and 30 cm long are more common than fish over 30 cm long of which there were 12 examples. Observations about the age of fish of particular sizes are not available. However, investigations on *Lethrinus nebulosus* (Spangled Emperor) in the Egyptian part of the Red Sea by Sanders and Kedidi (1984) show that 50 to 80 % of the catch of this species was made during the spawning season between April and July. During this period of their life the fish are particularly easy to catch. "Success of capture during the spawning season appears at least partly due to the migrations to mass spawning sites which the species undertakes. These areas are well-known to local fishermen and are targeted seasonally. For example, the area adjacent to the western tip of the Sinai peninsula, close to Ras Mohammed, is an important spawning ground and Sanders and Kedidi (1984) report that this area is fished almost exclusively between April and July" (Sheppard *et al.* 1992: 265).

This recent observation, when applied to the finds from Al Markh, may, under the reasonable assumption that the spawning period of the Spangled Emperor and other Lethrinid species has not significantly changed during the last 5 to 6 thousand years, indicate that here also the main fishing period was between April and July.

Only 5 *praemaxillaria* attest the presence of members of the *Haemulidae* family (Sweetlips, *Plectorhynchus,* and Javelin-fish, *Pomadasys*), which also live in a similar habitat to the *Lutjanidae* and *Lethrinidae*.

By far the largest number of bones from Al Markh belonged to the Silver Bream or Seabream family, the *Sparidae*. Most frequently attested is the genus *Rhabdosargus*, of which only one species is found in the Indo-Pacific region, namely *R. sarba* the Tarwhine. Three species of the next most numerous genus, *Acanthopagrus*, are found in the region. These are *A. berda*, *A. bifasciatus*, and *A. latus*. Their skeletons are very similar and the bones of these three species cannot be distinguished.

Amongst the remains of *Acanthopagrus* and *Rhabdosargus* found at Al Markh three size groups stand out (Table 5). The smallest consists of fish between 7 and almost 15 cm long with an average of 10 cm (*Acanthopagrus* MNI 54 and *Rhabdosargus* MNI 146). Although it is known that "most of the seabreams grow slowly, and it is not unusual for them to reach an age exceeding 20 years despite their relatively small size" (Penney et al. 1989: 221), the smallest size group must largely consist of young immature fish (see also Fig. 21,8 in Penney et al. 1989: 223). *Praemaxillaria* and *dentalia* of *Rhabdosargus* are distinguished by plates consisting of several rows of teeth, amongst which in the back part of these bones larger, oval, molariform teeth predominate (Fig. 2). Amongst the bones from Al Markh such oval teeth are not found on jaws of fish less than 13 cm long, in which two smaller almost equally sized teeth take the place of each of the larger oval teeth (Fig. 2). The oval teeth are, however, already present (though not erupted) and cause a characteristic structure on the outside of

the *praemaxillare*, so that this size group can be identified. The change to large oval teeth occurs, as far as can be seen, when the fish is about 13 cm long. This observation in the dental development of *Rhabdosargus sarba* admittedly does not help to establish the exact age, because no study has yet been made to determine at what age and at which size this species of fish becomes mature, but at least at this point attention may be drawn to the phenomenon.

The second size group consists of *Acanthopagrus* between ca. 15 and 30 cm long (average 22 cm; MNI 220) and of *Rhabdosargus* between 15 and 25 cm long (average 20 cm; MNI 185). Finally there are groups of larger fish belonging to these two genera. The lengths of at least 12 examples of *Acanthopagrus* were reconstructed as between c. 35 and 50 cm long and at least 2 examples of *Rhabdosargus* were between 30 and 40 cm long. According to Carcasson (1977: 137) the maximum length given for *Rhabdosargus* is 45 cm, while *Acanthopagrus berda* can grow up to 75 cm long, *Acanthopagrus bifasciatus* up to 50 cm long, and *Acanthopagrus latus* up to 45 cm long.

In summary, all age groups of *Rhabdosargus* and *Acanthopagrus* are present amongst the bones from Al Markh. It is probable that in prehistoric times spawning grounds of these fish were located in the coastal waters of Bahrain and in particular along the coast near Al Markh, and this is the reason that their bones occur in such great quantities at that site.

Other species or genera of *Sparidae* identified amongst the bones from Al Markh include *Argyrops* (probably *spinifer*, the so-called Redfin), with a total of at least seven individuals of various sizes up to 60 cm long (Fig. 1), and *Diplodus noct* (Arabian Pinfish), which always stays quite small, with lengths from less than 7 to 20 cm (average 12 cm). The small *Crenidens crenidens* is attested except for one *praemaxillare* only by its shovel-like front teeth which have on the right and left two adjacent lobules. Under the microscope the unmistakable form of these teeth (see Fischer and Bianchi 1984: sheet SPARIDAE) is easily recognisable. This species, whose maximal length is 20 cm long, is certainly underrepresented in the finds from Al Markh.

Seabreams in general congregate along the coast in shallow water and so it is not surprising that they are so frequently encountered among the finds from Al Markh, which in the fourth millennium lay closer to the sea than today (Roaf, in preparation). As primarily carnivores, which eat crustaceans, molluscs, sea-urchins etc., they are very well suited to such a habitat. Some species, above all *Diplodus noct* and *Rhabdosargus sarba* also eat algae. *Diplodus noct* "feeds mainly on *Sargassopis*, which provides 66 % of its diet, with *Eckonia* providing another 12 %. This grazer also appears to time its breeding to permit the young to find optimum shelter in the macroalgae" (Sheppard *et al.* 1992: 137).

Mullets (family *Mugilidae*) are "small to medium-sized littoral fishes which usually occur in shallow weedy areas" (Carcasson 1977: 83). They live on algae, but also catch insects from the surface of the water, and therefore stay close to the surface. For this reason they are rarely caught in ground nets. The 13 finds from Trench J19 are all vertebrae of smaller fish, which give no more detailed information.

Adult Barracudas (family *Sphyraenidae*) are fast swimming, predatory fish primarily found around coral reefs. As they follow shrimps when they migrate, the barracudas also travel from the coral reefs to the seagrass beds (Crossland et al. 1987). In our case only a fragment of a *praemaxillare* and 22 loose teeth (Table 2), which also belonged to very small and therefore young fish, were found.

Of the externally very distinctive Rabbitfishes (family *Siganidae*) one fragment of a *frontale* and 10 *praemaxillaria* were preserved in the material from Trench J19. The bones represent small fish from 15 to 20 cm long (Table 5). Most members of this family grow over 25 cm long and some even over 30 cm (Carcasson 1977: 230). These fish are plant eaters, who stay in small schools "in weedy areas in shallow water, where they may be seen nibbling at the vegetation with their heads pointing downwards" (Carcasson 1977: 230).

Two vertebrae, which correspond very well with vertebrae of the tuna (*Euthynnis affinis*) prove that middle-sized tuna were occasionally caught by the prehistoric fishers of Al Markh in the coastal waters, where small groups of tuna hunt small fish, above all varieties of herring and silversides (Fischer and Bianchi 1984). The two vertebrae come from different individuals, of which one was approximately 60 cm and the other approximately 70 cm long.

The presence of teeth and calcified vertebral centra of cartilaginous fish shows that these fish were also caught. At least five species are represented. It is difficult to state anything about the size of the fish on the basis of the size of the preserved vertebral pieces, because unlike the vertebrae of bony fishes the vertebral centra become smaller towards the tail according to their position in the back bone, and if one does not know from which part of the spine the vertebral centra came from, the size of the fish cannot be reconstructed. Occasional larger vertebrae attest to the presence of larger sharks up to 1 m long. Eleven teeth of *Carcharhinus melanopterus*[3] are very small and thus come from a young fish. The vertebral centra of the Hammerhead Shark (*Sphyrna zygaena*) and of the Sawfish (*Pristis spec.*) are small. The same is true for the White-spotted Rays (*Rhinchobatus djeddensis*) and the Stingrays (*Dasyatis spec.)*, which are only attested by vertebrae.

Concluding remarks

"The southern Gulf coast along the UAE is low-lying, often swampy and rich in seagrasses. Offshore the water is very shallow but while it is generally muddy and unsuitable for most corals, there are numerous patch reefs dominated by *Acropora*. Fringing reefs grow around numerous low islands, as well as along the east and north coast of Qatar. These areas tend to have high coral cover, but a low diversity of perhaps less than 20 species. Their lack of success is probably because of high sedimentation and periodic decimation in near freezing winter air temperatures" (Sheppard *et al.* 1992: 69). Sheppard (1985) found a row of coral reefs in Bahrain and west of Qatar. The reefs lying close to the coast are flat and are not characterised by steep drops, which are typical of reefs lying further from the coast and which therefore accommodate a greater variety of fish species. The question may be asked whether during the time that Al Markh was occupied coral reefs had already formed near Bahrain since it is thought that the Gulf reached its present level only in about 5000 BC (e.g. Nützel 1975). One thousand years might not have allowed sufficient time for extensive coral reefs to have formed. The complete absence of the bones of fish that live exclusively on coral reefs, such as Parrotfish (family *Scaridae*), amongst the finds from Al Markh, which are present in small numbers in the Barbar period (ca. 2000 BC) sites (e.g. Saar, Moon and Irving 1997: 82) and Diraz East (identification by von den Driesch and Manhart) may support this suggestion.

The results of the analysis of the fish bones from Al Markh provide evidence for the overwhelming presence of small fish, whose preferred habitats are in shallow coastal waters with sandy or muddy bottoms. These small fishes include species such as the Hairback Herrings, Silversides, Slimies, Silver-biddies, etc. but Seabreams form by far the majority of these fish. Even if it is not possible to state the exact ages of the fish, the finds include young or immature animals which hatched in the coastal region and remained there for some time until they were large enough to swim to other areas. This statement refers above all to the various species of *Acanthopagrus*, to *Rhabdosargus sarba* and to *Diplocus noct*, which are the most frequently encountered species or genera of fish identified from Al Markh. Juveniles are also attested among the bones of Emperor fish (*Lethrinidae*), which at least indicates the presence of the fish during spawning and thereby limits the time of the fish capture for Al Markh in certain respects. The main spawning period lasts from April to July in the Indo-Pacific (see for example Sheppard *et al.* 1992: 265). It seems almost certain that the fishers of Al Markh, knowing exactly the time and place of spawning, stayed at the site in late spring and early summer in order to fish. Whether they also occupied the site outside this period cannot at present be established with certainty.

The small fish would have been caught with ground nets (seine nets), basket traps, and perhaps also barrier traps (Arabic *hadrah*), into which fish were driven by men wading slowly through the shallow waters and were trapped or else were directed by fences into the trap as the tide receded (see von Brandt 1984: 10).

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[3] We are grateful to Dr. Wim Van Neer, Tervuren, for the identification of these teeth.

The evidence for several larger species of fish, such as Groupers (*Serranidae*), Trevallies and Jacks (*Carangidae*), and Tuna (*Euthynnus affinis*), as well as Redfin (*Argyrops*) and the larger examples of Emperor fish (*Lethrinidae*) indicates that other fishing techniques were also practised. *Serranidae* and *Carangidae* are best caught using a rod and line. Although no hooks were found at this site, wooden or bone hooks could have been used if copper was not available at this date in the Gulf. Since the larger groupers prefer rocky bottoms and the *Carangidae* live primarily in open water, it must be considered that the fishers also used boats in order to fish with rod and line or with nets on the rocky reefs.

Considering the different sizes of the members of individual fish groups it is clear that despite the much greater number of bones of Sparids in comparison, for example, with the Serranids, a larger percentage of the flesh of the larger fish must have been eaten than the numbers of bones or minimum numbers of individuals appear to show. A gutted Trevally 60 cm long, for example, weighs 3 kg. A Sparid 20 cm long weighs only 120 g. A fish weighing 3 kg can provide enough flesh to satisfy six people, while six people must eat 24 Sparids of the given size to get the same amount of nourishment.

Among the bones from Al Markh some 31 different species of fish have been identified. This number is small when compared with the number of species of fish in the Gulf today. It is, however, more than the 22 identified in Qala'at al-Bahrain (Van Neer and Uerpmann 1994: 445, even though these levels were not sieved) or the 14 from the temple at Saar (Moon and Irving 1997: 80-81). But this is not surprising as the total number of identified bones from Al Markh is much greater. It should also be noted that in the lower levels of J19, 24 of the 31 species are represented by less than 24 identified bones each (i.e. less than 0.15 % of the bones identified) and 12 species were identified by 5 bones or less (i.e. 0.03 %). Had the sample been smaller most of these species would not have been recognised. On the other hand the bone material from the Bronze Age site of Shimal near Ras al-Khaimah (ca. 2300-800 BC) yielded more than 46 fish species although it was not sieved (von den Driesch 1998).

Looking at the more commonly represented species from Al Markh, Saar, Qala'at al-Bahrain and Shimal[4] (Table 6), the species from Al Markh and the proportions are quite different. Some differences may be related to different collection methods, some may be attributed to differential preservation of certain species or to the conditions in certain sites, and some may be due to different catching methods used by the ancient peoples. In the case of Al Markh the sieving of the samples has resulted in a great number of very small fish which without sieving would not have been recovered. But overall the exceptional number of Sparids from the lower layers at Al Markh can only be explained by the fact that this was the chief species present in the waters near the site.

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[4] Several of the common species identified at this site (especially in Phase 1 dated to 2300-2000 BC) were relatively rare in the bone material from Al Markh: *Ariidae* (161 identified bones 7.52 %), *Mugilidae* (193, 9.02 %), *Carangidae* (707, 50 %) and *Scombridae* (567, 30 %). This demonstrates that in some sites of the later periods in the Gulf region more specialised catching methods were practised and a wider range of habitats was exploited.

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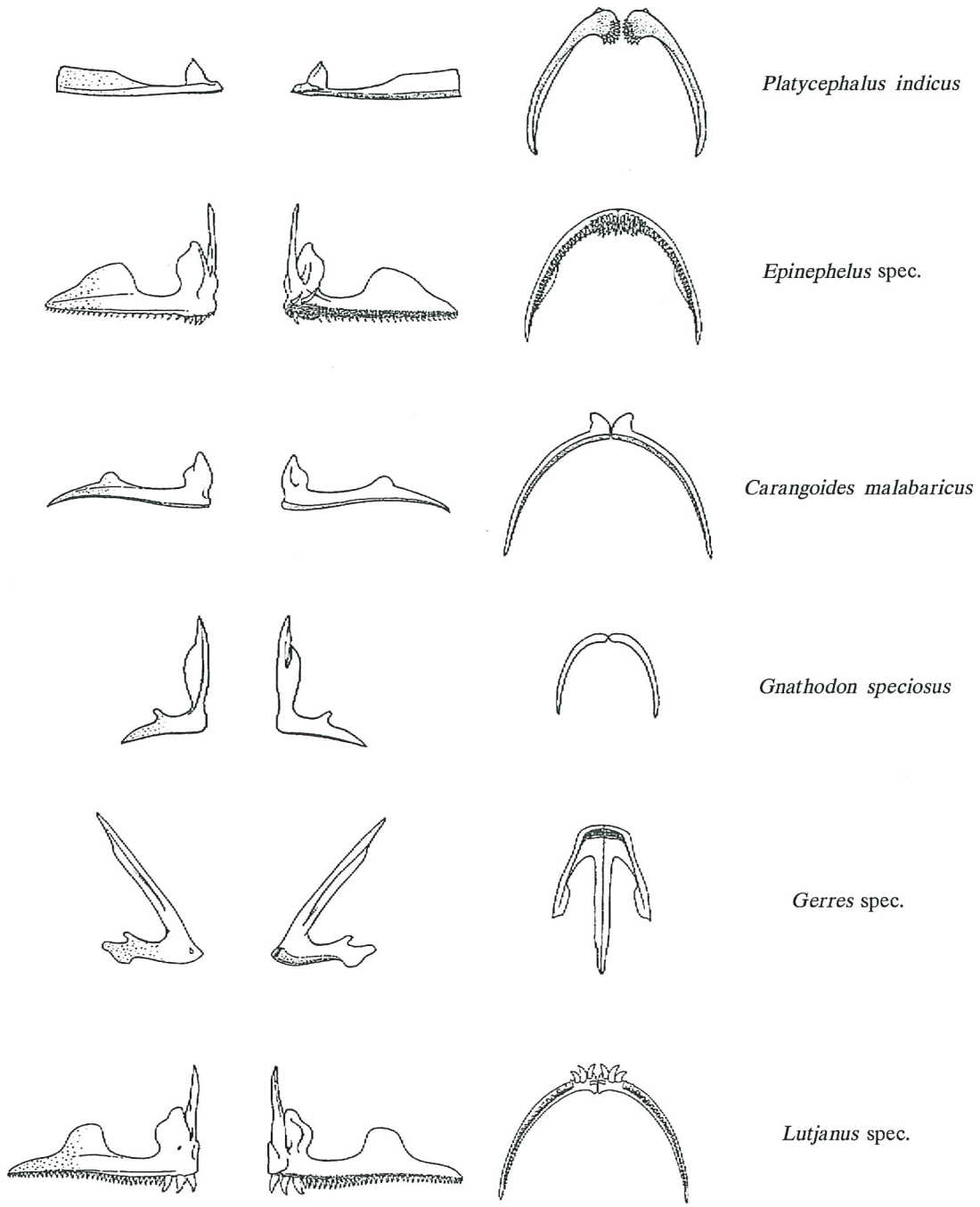

Fig. 2. Praemaxillaria of the main fish species identified in Al Markh.
Left: lateral view; middle: medial view; right: ventral view

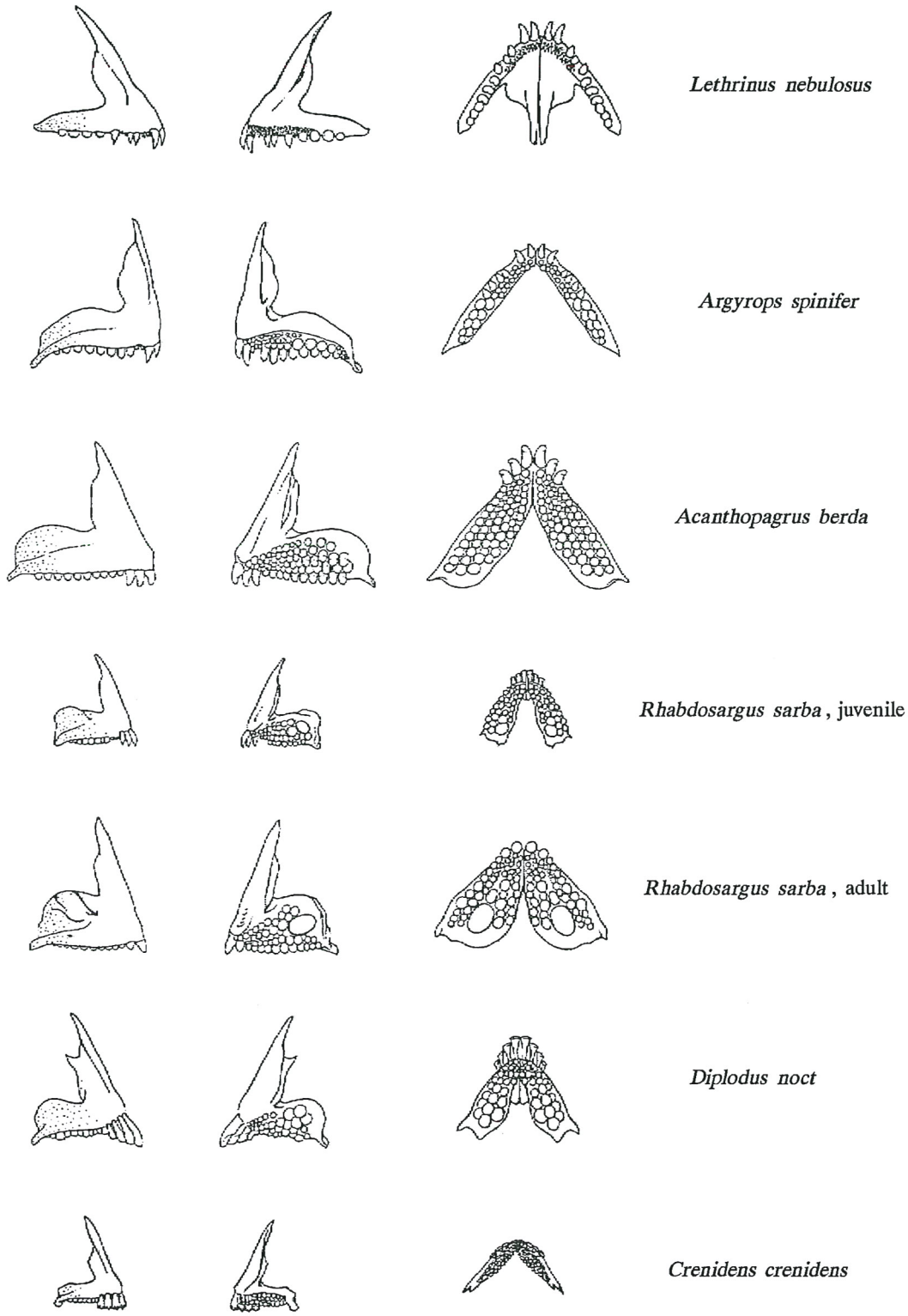

Fig. 2. continued

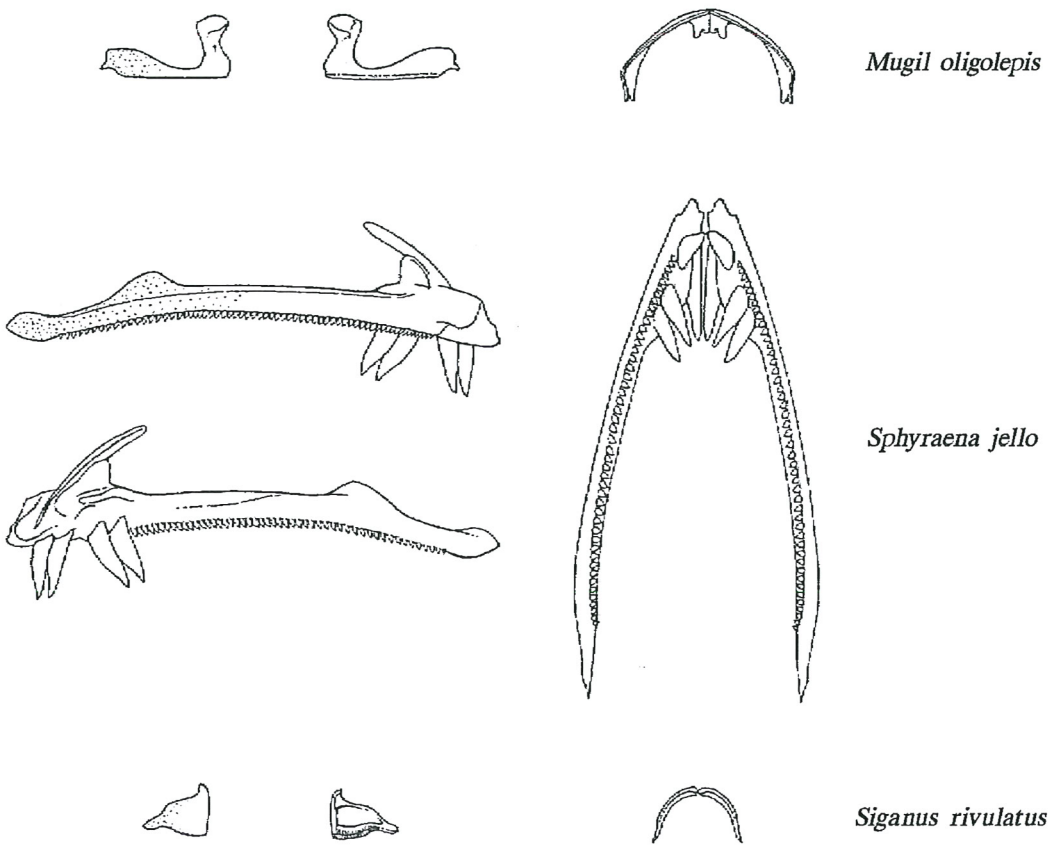

Fig. 2. continued