Kuwait J. Sci. Eng. **24**(1) 1997

Distribution of zooplankton in offshore waters of the west coast of the united arab emirates

GIBREEL M. SHARAF AND SAIF M. AL-GHAIS

Desert and Marine Environment Research Center, United Arab Emirates University, Al-Ain, UAE.

ABSTRACT

Seasonal fluctuations in the composition and abundance of zooplankton of the west coast of the UAE were investigated in 1993–1994. Zooplankton populations peaked in late spring and summer. The monthly numerical average of total zooplankton was about 2740 m^{-3}, with a biomass equal to 412 $mg.m^{-3}$. Copepods dominated zooplankton counts accounting for about 51% of the total. Tunicates, cladocerans, mollusc larvae and chaetognaths were also dominant groups during the study, and together comprised about 31% of zooplankton. Spatial variations in abundance of almost all zooplankton species and groups were not significantly different, indicating a homogeneity in composition among stations. Nine new geographical records, mostly copepods, were identified for the region. Species-diversity and evenness in species distribution were generally low compared to the Gulf of Oman and the Indian Ocean.

INTRODUCTION

In spite of their fundamental importance for marine ecosystem studies, few plankton surveys have been conducted in the Arabian Gulf (Enomoto 1971; Yamazi 1974; Al-Kaisi 1976; Gibson *et al.* 1980; Michel *et al.* 1981; Michel *et al.* 1986a; Michel *et al.* 1986b; Houde *et al.* 1986). Several of these studies were of short duration (Yamazi 1974; Gibson *et al.* 1980; Michel *et al.* 1986a) and in waters off the United Arab Emirates (UAE), sampling was restricted to December, February and March. Other investigations were either localized or focused on a particular taxonomic group (Bohm 1931; Furnestin & Codaccioni 1968; Weigmann 1970; Fenaux 1973).

The present work is the first study of UAE offshore zooplankton covering all seasons. The main purpose of this paper is to report species composition and their distribution at three sites in UAE waters. The results has provided a good overview of the UAE offshore zooplankton and are expected to be of use to other research projects being carried out in the area.

MATERIALS AND METHODS

Using a 0.4 m diameter plankton net of 250 micron mesh and equipped with a digital flowmeter, zooplankton samples were collected monthly from three sites off the UAE's Arabian Gulf coast from October 1993 through September 1994. Sampling consisted

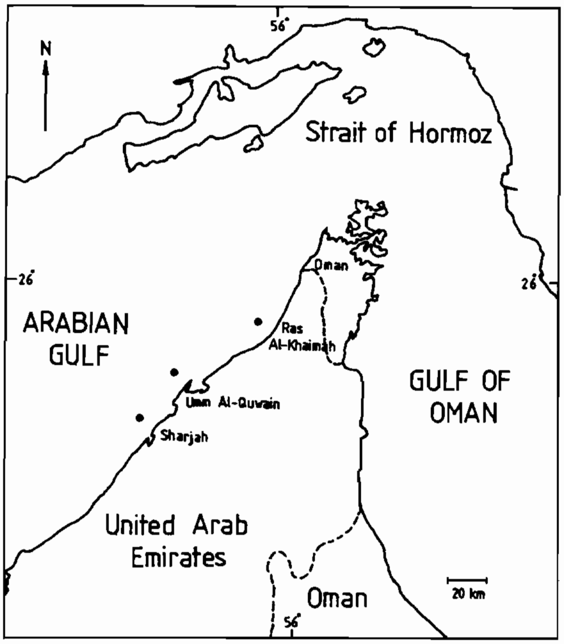

Fig. 1. Map showing sampling stations (●) located about 5 km off Sharjah, Umm Al-Quwain and Ras Al-Khaimah.

of a 10–15 minute horizontal tow during daylight about 1 m below the surface 5 Km WNW (300°) off each of the municipalities of Ras Al-Khaima (RAK), Umm Al-Quiwain (UAQ), and Sharjah (Fig. 1). We recorded temperature to the nearest 0.1°C, salinity to the nearest 0.1 ppt with a digital salinometer, and transparency to the nearest 1m with a Secchi disk. Zooplanktons were preserved with a 4% neutralized formalin solution prior to return to the laboratory for processing.

Depending on zooplankton density, we analyzed 2–15 ml aliquots using a stereo-zoom dissecting microscope and a Bogorov counting chamber. The density was expressed as numbers per m^3 seawater. Wet weight was determined after removing as much surrounding water as possible by vacuum filteration and then weighing the samples. Wet weight values were expressed in mg m^{-3}. An ANOVA in a randomized-block design without replication analyzed monthly zooplankton density by location (Sokal & Rohlf 1987). To reduce variance and because treatment effects were proportional rather than additive which does not comply with ANOVA assumptions), the data were log-transformed after adding a value of 1 to each sample to allow for zero samples. Seasons consisted of the following months: winter = December, January and February; spring = March, April and May; summer = June, July and August; fall = September, October and November. The diversity indices D (Margalef 1968) measured species richness (i.e. number of species), and E (Help 1974) species evenness (i.e., how equally abundant).

We used the following references for species identification: copepods (Giesbrecht 1892, Mori 1937; Silas & Pillai 1973); tunicates (Thompson 1948), siphonophores (Daniel & Daniel 1963); chaetognaths (Silas & Srinivasan 1969); and general (Tregouboff & Rose 1978).

RESULTS

Hydrographic conditions

Spatial differences in temperature, salinity, and transparency were not found to be significant, so data for each of the variables from the three locations were pooled for monthly averages (Fig. 2). Annual surface water temperature averaged 27.7°C with a maximum in August of 32.8°C, significantly greater ($P < 0.001$) than the 21.5°C minimum in February. Surface salinities fluctuated between 38 ppt in November and 41 ppt in July, but seasonal differences were not significant. Monthly transparencies averaged from 7.2m in July to 11.5 m in April. Correlations between transparency and total zooplankton, and between transparency and biomass were significant for Sharjah only ($r = 0.73$, $P < 0.05$ and $r = 0.83$, $P < 0.05$, respectively).

Zooplankton community

ANOVA failed to find significant seasonal and spatial differences in either biomass values or numerical counts. In spite of the absence of significant differences, zooplankton distributions were not uniform. Mean biomass values peaked in May (2838 $mg.m^{-3}$), whereas minimum values were recorded in November (3 $mg.m^{-3}$). Regionally, RAK exhibited the highest overall mean biomass with a monthly average of 876 $mg.m^{-3}$, UAQ was second with 305 $mg.m^{-3}$, and Sharjah ranked last with only 96 $mg.m^{-3}$. The highest biomass recorded during the study occurred at RAK in May (8145 $mg.m^{-3}$), due mostly to the presence of large numbers of tunicates (1344 m^{-3}).

Numerically, zooplankton varied considerably throughout the study, ranging from a low of 98 m^{-3} (UAQ, June) to a high of 16,833 m^{-3} (RAK, May), and seasonal densities at all stations appeared to be bimodal with peaks in May and August (6977 and 5693 m^{-3}, respectively; Fig. 3). Standing numbers were highest at RAK and UAQ where monthly counts averaged 3656 m^{-3}. Sharjah showed the lowest average density with 907 m^{-3}. The lowest mean seasonal values (Fig. 3) occurred at the end of autumn (November, 471 m^{-3}) and again at the beginning of summer (June, 209 m^{-3}). We found significant correlations between total counts of zooplankton and biomass at RAK ($r = 0.93$, $P < 0.05$) and Sharjah ($r = 0.83$, $P < 0.05$), but not at UAQ ($r = 0.51$, $P > 0.05$).

From our samples, we identified 63 taxa of zooplanktons in addition to larval stages of almost all invertebrate phyla (Table 1).

Dominant zooplankton groups

Protozoa:

Only 2 protozoans were found during the study: *Favella campanula* and *Tretomphalus bulloides*, in addition to unidentified radiolarians. Together they comprised about 1% of the total zooplankton count (Table 1). The presence of these minute animals in a 250 micron net catch was accidental, probably due to some clogging of the net caused by phytoplankton blooms.

T.bulloides was the dominant species while *F.campanula* was found occasionally. *T.bulloides* appeared only in April-June samples, with the largest density recorded in Sharjah in April (846 m^{-3}).

Coelenterata and Ctenophora:

Coelenterata were mainly represented in the study area by 5 species; a few specimens belonging to Hydromedusae and Scyphomedusae need further identification.

The siphonophore *Diphyes chamissonis* was the most important and dominant coelenterate, accounting for 1.7% of the total zooplankton (Table 1). We observed two peaks of abundance in October and August in UAQ, but these variations were not significant (Table 2). The other 4 species occurred irregularly. A single specimen of *Chelophyes contorta* represents a new record in the Gulf.

Ctenophora were represented by only 2 species: *Beroe ovata* and *Pleurobrachia pileus*. Most (57%) of the *P.pileus* specimens were found in November at UAQ.

Chaetognatha:

We identified four species of arrow worms: *Krohnitta sp.*, *Sagitta enflata*, *S.ferox* and *S.robusta*. Together, they accounted for 3.5% of the total zooplankton. Adult and juvenile individuals of *S.enflata*, a cosmopolitan species, were the major contributors to the total chaetognatha (more than 90%). Although found in high numbers during April–May at RAK and UAQ, these variations were not statistically significant.

Cladocera:

Cladocerans formed about 7% of the total zooplankton count, and were represented by *Evadne tergestina* and *Penilia avirostris*. *E.tergestina*, the dominant species, showed two seasonal peaks (Fig. 4), the major one in May and the other in September. Seasonal differences ($P < 0.05$) in *E.tergestina* numbers were significant (Table 2).

Copepoda:

This group dominated the zooplankton in biomass as well as numbers. About 51% of the total zooplankton was comprised of copepods with a monthly average count of about 1400 m^{-3}. About 43% of the copepods were adults and 57% were larval stages (copepodites and nauplii). Calanoids numerically dominated cyclopoids which in turn dominated harpacticoids.

We identified 24 species of calanoid copepods belonging to 14 genera; 7 species of cyclopoids belonging to 5 genera, and 3 species of harpacticoids each belonging to a separate genus. Additionally, two species of parasitic copepods (both females), one belonging to Monstrilloida, the other to Caligoida, were also found. Five species represented new geographical records for the Gulf: four calanoids; *Labidocera wollastoni*, *Paracalanus parvus*, *Pontella karachiensis* and *Pontellopsis macronyx* and one cyclopoid; *Corycaeus ovalis*.

The bulk of adult copepods was comprised of only five species which accounted for 17% of the total zooplankton (Table 1). Listed in numerical order, they are as follows: *Paracalanus crassirostris*, *Corycaeus ovalis*, *Centropages orsinii*, *Temora turbinata* and *Acartia erythraea*. We failed to find any significant differences (Table 2) in abundance among stations for any species, but several species varied significantly among seasons. *P.crassirostris* (the dominant species) occurred in large numbers during December, March and August (Fig. 5) and was almost absent in October-November samples. *C.ovalis*, the second most dominant copepod, occurred throughout the year with the greatest densities being observed in January, April and September (Fig. 5).

Penaeidae:

Adult *Lucifer sp.* (a penaeid shrimp) and penaeid larvae (mostly belonging to *Lucifer sp.*) were among the common groups found (about 3% of total zooplankton) during the study. Maximum numbers occurred at RAK and UAQ stations from November to January. Variations in counts, both seasonally and spatially, however, were not significantly different.

Table 1. Species list and percentage of total zooplankton count per m^3.

Taxon	Percentage
PROTOZOA	
Tintinnida	
Favella campanula (Schmidt)	rare
Foraminifera	
Tretomphalus bulloides (D'Orbigny)	0.99
Radiolaria	rare
COELENTERATA	
Trachymedusae	
Liriope tetraphylla (Chamisso & Eysenhardt)	0.35
Narcomedusae	
Solmundella bitentaculata Quoy & Gaimard	0.15
Siphonophora	
*Chelophyes contorta** (Lens & van Riemsdijk)	rare
Diphyes chamissonis Huxley	1.66
*Sulculeolaria turgida** (Gegenbaur)	0.09
CTENOPHORA	
Beroe ovata Eschscholtz	rare
Pleurobrachia pileus Vanhoffen	rare
CHAETOGNATHA	
Krohnitta sp.	rare
Sagitta enflata Grassi	3.39
S. ferox Doncaster	rare
S. robusta Doncaster	rare
Polychaeta	
polychaete larvae	0.26
Sagitella sp.	rare
Tomopteris sp.	rare
CRUSTACEA	
Cladocera	
Evadne tergestina Claus	6.60
Penilia avirostris Dana	0.59
Ostracoda	
Conchoecia sp.	0.18
Copepoda	
copepodites and nauplii	30.62
Calanoida	
Acartia erythraea Giesbrecht	1.03
Acrocalanus gibber Giesbrecht	0.48
Calanopia elliptica (Dana)	0.15
Candacia bradyi A. Scott	rare
Canthocalanus pauper (Giesbrecht)	0.66
Centropages furcatus (Dana)	0.41
C. orsinii Giesbrecht	2.65
C. yamadai Mori	rare
Eucalanus subcrassus Giesbrecht	0.07
Euchaeta marina (Prestandrea)	rare
Labidocera acuta (Dana)	rare
L. kroyeri (Brady)	rare
L. minuta Giesbrecht	0.26
L. pavo Giesbrecht	rare
*L. wollastoni** (Lubbock)	0.04

Table 1. Continued.

Taxon	Percentage
P. crassirostris Dahl	7.70
*P. parvus** (Claus)	rare
*Pontella karachiensis** Rehman	rare
Pontellopsis herdmani Thompson and Scott	rare
*P. macronyx** A. Scott	rare
Temora discaudata Giesbrecht	0.11
T. turbinata (Dana)	2.32
Tortanus forcipatus (Thompson and A. Scott)	rare
Cyclopoida	
Copilia mirabilis Dana	rare
*Corycaeus ovalis** Claus	3.17
Oithona nana Giesbrecht	0.77
O. plumifera Baird	rare
Oithona sp.	rare
Oncaea media Giesbrecht	0.74
Sapphirina nigromaculata Claus	rare
Harpacticoida	
Euterpina acutifrons (Dana)	0.18
Macrosetella gracilis (Dana)	rare
Microsetella rosea (Dana)	rare
Monstrilloida	
Caligoida	
Caligus sp.	rare
Amphipoda	
Hyperia sp.	0.04
Gammarids	rare
Decapoda	
Lucifer sp.	1.18
Crustasean larvae	
cirriped, penaeid, caridean (alpheid, hippolytid and processid), anomuran (porcellanid and galatheid), brachyuran, astacid and stomatopod.	8.70
MOLLUSCA	
bivalve and gastropod larvae	7.89
Atlanta sp.	0.07
Cavolinia longirostris (Lesueur)	rare
Creseis acicula Rang	0.52
EchinodermATA	
ophiopleuteus larvae	0.55
Chordata	
Doliolida	
*Doliolum denticulata** Quoy and Gaimard	0.41
*D. gegenbauri** Herdman	rare
Salpida	
Salpa cylindrica (Cuvier)	rare
Thalia democratica Tokioka	1.47
Larvacea	
Oikopleura dioica (Fol)	11.05
Ascidiaceae	
ascidian larvae	rare
VERTEBRATA	
fish eggs and larvae	2.28

New records for the Arabian Gulf are marked with an asterisk *

Table 2. Results of ANOVA performed on data for abundance of species and groups found during the study. NS = not significant, * = significant at 5%, ** = significant at 1%, *** = significant at 0.1%

TAXON	Among Stations	Among Months	*Maximum Abundance*	
			Station	Month
Acartia erythraea	NS	NS		
Acrocalanus gibber	NS	***		SEP
Atlanta sp.	NS	NS		
Bivalve larvae	NS	NS		
Brachyuran larvae	*	NS	UAQ, RAK	
Calanopia elliptica	NS	*		OCT–NOV
Candacia bradyi	NS	***		NOV
Canthocalanus pauper	NS	*		APR,SEP
Centropages furcatus	NS	NS		
C. orsinii	NS	NS		
C. yamadai	NS	NS		
Cirriped larvae	NS	NS		
Corycaeus ovalis	NS	*		APR,SEP
Creseis acicula	NS	NS		
Diphyes chamissonis	NS	NS		
Doliolum denticulata	NS	*		MAR–APR
Eucalanus subcrassus	NS	NS		
Euterpina acutifrons	NS	NS		
Evadne tergestina	NS	*		APR–MAY
Gastropod larvae	NS	*		JUL–SEP
Labidocera acuta	NS	NS		
L. minuta	NS	***		OCT–DEC
L. pavo	NS	NS		
L. wollastoni	NS	*		OCT
Lucifer sp.	NS	NS		
Oikopleura dioica	NS	*		APR–MAY, JUL–SEP
Oithona nana	NS	NS		
Oncaea media	NS	NS		
Paracalanus aculeatus	NS	NS		
P. crassirostris	NS	**		DEC,MAR
P. parvus	NS	NS		
Penilia avirostris	NS	NS		
Pontellopsis herdmani	NS	*		OCT–NOV
Sagitta enflata	NS	NS		
Salpa cylindrica	NS	**		JUN
Temora discaudata	NS	NS		
T. turbinata	NS	**		JAN–MAR
Thalia democratica	NS	*		MAY
Tretomphalus bulloides	NS	NS		

Cirripede larvae:
We found barnacle larvae to be present throughout the year, accounting for 2.7% of the total zooplankton. Although densities at RAK and UAQ were much higher than those at Sharjah, these differences were not significant ($P > 0.05$).

Brachyuran larvae:
Accounting for about 3.3% of zooplankton numbers, crab zoeae and megalopae occurred throughout the year, especially at the RAK and UAQ stations. The only group whose densities differed significantly among stations was brachyuran larvae.

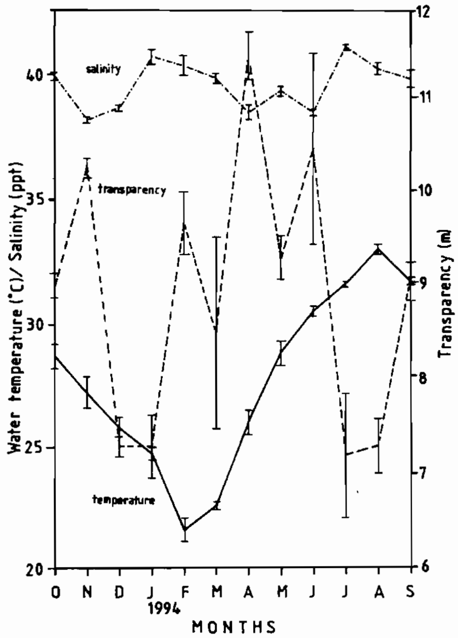

Fig. 2. Monthly averages with standard errors of salinity, temperature and transparency in the study area.

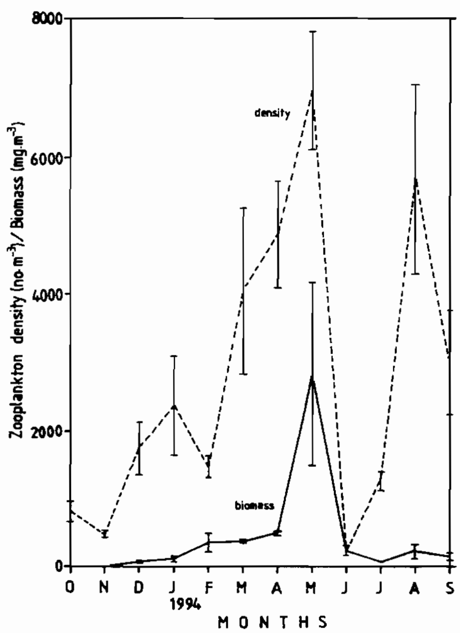

Fig. 3. Monthly averages with standard errors of biomass and total zooplankton densities from the three sampling sites.

Mollusca:

Three pelagic molluscs, *Atlanta sp.*, *Cavolinia longirostris* and *Creseis acicula*, constituted less than 1% of the total zooplankton (Table 1). The pteropod *C.acicula* dominated the more common molluscs (0.52%) with high concentrations observed in August, especially at UAQ. Bivalve and gastropod larvae outnumbered adult pelagic molluscs and formed about 8% of the total zooplankton count. We found large numbers of bivalve and gastropod veligers at the UAQ station in August.

Tunicata:

Tunicates ranked second to copepods in numerical importance, accounting for 13% of the total zooplankton. We identified five tunicate species with two dominating counts: *Doliolum denticulata* and *Thalia democratica* accounted for 85% and 11% of the total tunicates, respectively. Other species included *Doliolum gegenbauri*, *Oikopleura dioica*, and *Salpa cylindrica* as well as ascidian larvae. A significant monthly maxima of *O.dioica* occurred in May and August (Fig. 6). We also observed significant ($P < 0.05$) peaks of solitary as well as aggregate forms of *T.democratica* in May and *D.denticulata* in April. The peak abundance of *S.cylindrica* in June was even more significant ($P < 0.01$).

D.denticulata and *D.gegenbauri* are considered to be new geographical records in the area. Previous works (Michel *et al.* 1986a&b; Gibson *et al.* 1980) named the genus only.

Fish eggs and larvae:

About 2.3% of the total zooplankton consisted of fish eggs and larvae which occurred throughout the year. The highest densities of eggs were found in October and May at RAK, and egg diameter varied from 0.5 to 3 mm. Larvae (including fry) were occasionally found, especially in the July–September samples.

Species diversity

Species richness and equitability (evenness) were generally low in the UAE waters. Species richness ranged between 0.89 and 4.49, while equitability varied between 0.155 and 0.736. We found no spatial variations in these indices to be significant ($P < 0.05$), so we averaged the values from the three stations (Fig. 7). The highest richness was observed in November, and the lowest in July, whereas equitability (evenness) reached a maximum in June and a minimum in May. We found an inverse relationship ($r = -0.62$, $P < 0.05$) between species equitability and zooplankton density. As expected, the lowest values were observed in months when zooplankton populations reached the highest values due to the increase in the density of a few species.

DISCUSSION

The hydrographic parameters obtained in this study are difficult to compare with previous works (Yamazi 1974; Gibson *et al.* 1980; Michel *et al.* 1986a) for all of these sampled UAE waters for a short period of time.

It is evident from the variations in biomass and total zooplankton population that there are two major maxima in the area under consideration: a late spring maximum (May) and a summer one (August). The main cause of these peaks was the presence of large numbers of copepods (including larval stages). Copepoda in the present study

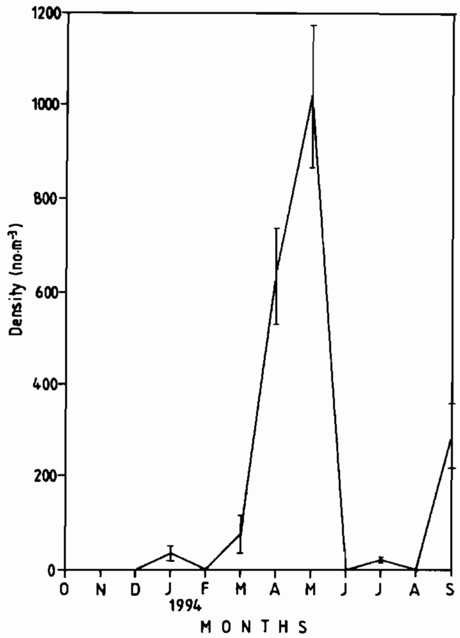

Fig. 4. Average monthly densities with standard errors of *Evadne tergestina* in the study area.

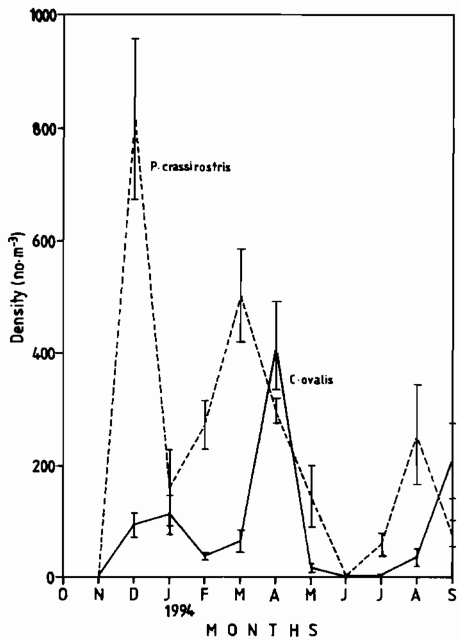

Fig. 5. Average monthly densities with standard errors of *Paracalanus crassirostris* and *Corycaeus ovalis* in the study area.

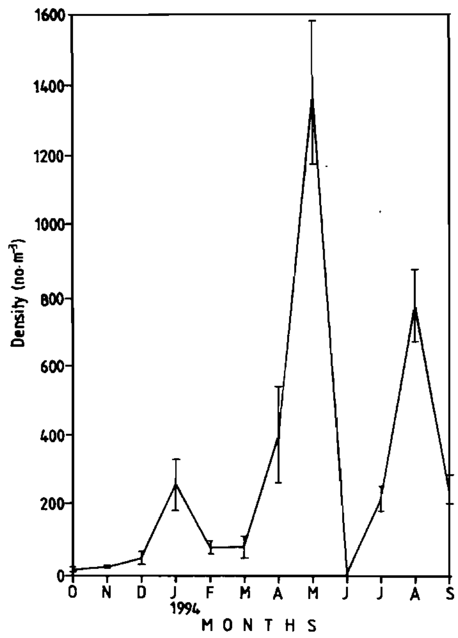

Fig. 6. Average monthly densities with standard errors of *Oikopleura dioica* in the study area.

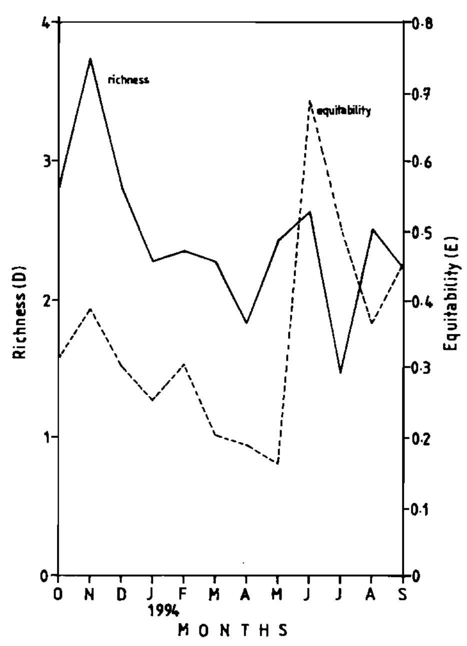

Fig. 7. Species diversity indices (species richness expressed as log number of species and equitability) in the study area.

accounted for 29% to 88% of the total zooplankton with a monthly average of 51%. Previous researchers (Yamazi 1974; Gibson *et al.* 1980; Michel *et al.* 1986a&b) also found copepods to dominate the zooplankton community in Gulf waters.

Michel *et al.* (1986b) found earlier seasonal peaks of total zooplankton abundance in Kuwaiti waters, the first in March and the second and major one in July. Numbers recorded in these peaks were very high compared to our results (about 43,000 and 72,000 m^{-3} for March and July, respectively). Yamazi's (1974) results also showed higher densities of zooplankton in Kuwaiti coastal waters than in other parts of the Gulf.

The low zooplankton density in UAE waters might be caused by a low nutrient level compared to the more fertile Kuwaiti waters which benefit from fresh water and nutrients input via the Shatt Al-Arab estuary. Silicate and dissolved oxygen measured in Kuwaiti coastal waters were found at higher levels than those of the waters off the Trucial Coast (Yamazi 1974).

Assuming dry weight is equal to 10% of the wet weight (Gibson *et al.* 1980), the average regional biomass during March in the present work can be equated to the values obtained by Michel *et al.* (1986a). Their average value of dry weight for the 5 stations off the UAE coastline (stations 79, 84, 85, 88 and 89) was about 28 $mg.m^{-3}$, while in our results, our value (375 $mg.m^{-3}$) is converted to about 37 $mg.m^{-3}$. Grice & Gibson (1978) reported similar values (46 $mg.m^{-3}$) during sampling in March.

Michel *et al.* (1986a) also found that higher biomass values exist in the UAE and adjacent waters and that these exceed other areas in the Gulf, with the exception of Kuwaiti waters. Gibson *et al.* (1980), on the other hand, found a reversed pattern where the lowest biomass values were in area 1 (UAE offshore waters), while higher values were recorded in the northwest waters of the Gulf.

Yamazi (1974) reported 21 genera and 30 species of copepods throughout the Gulf, whereas Michel *et al.* (1986a) recognized more than 49 species in the area south of Kuwait. During the present study, we identified 35 copepod species. The relatively low species number in UAE waters compared to Michel *et al.* (1986a) is probably because only surface daytime samples were collected in the present work, while Michel *et al.* (1986a) collected oblique samples from a large area extending from south of Kuwait to the Strait of Hormoz.

Paracalanus crassirostris was considered as the most dominant copepod by Michel *et al.* (1986a), while larvaceans, especially *Oikopleura sp.* were second in abundance to copepods, followed by cladocerans and chaetognaths (Michel *et al.* 1981). Similar results were obtained in the present study, except that mollusc larvae ranked third in abundance followed by Cladocera and Chaetognatha.

Species-diversity indices were low compared to those of the Gulf of Oman and the Indian Ocean proper. Copepod species-diversity in the Arabian Gulf was found by all authors to be less rich than that in the Indian Ocean, where a total of 147 to 153 species involving 35 to 47 genera have been recorded by Tsuruta (1957) and Chiba (1972). Weigmann (1970) recorded 24 species of Euphausiacae from the Arabian Sea, but only one species, *Pseudeuphausia latifrons*, occurred in the Gulf. Seven appendicularian species are known from the Gulf (Fenaux 1973; Yamazi 1974) compared to 19 in both the Gulf of Aden and the Oman Sea. Chaetognatha in the Gulf are represented by at least 6 species (Furenstin & Codaccioni 1968; Yamazi 1974) compared with 33 species recorded from the Indian Ocean and neighbouring seas (Silas & Srinivasan 1969).

Diversity is reported to be higher in the deep sea than in shallow waters (Omori & Ikeda 1984). Almeida Prado-Por (1983) recorded 31 species of calanoid copepods from the Gulf of Aqaba of which only 9 species were recorded in the shallower Gulf of Suez. The paucity of species in the Arabian Gulf may be attributed to the shallow depths of the Gulf which usually do not exceed 75 m and thus limit the distribution of species to neritic epipelagic forms only, whereas mesopelagic species do not penetrate the shallow waters of the Gulf.

ACKNOWLEDGEMENTS

We thank Mr. Zahir Khan, Mr. Omar El-Basheer, Mr. Richard Cooper and Dr. Mohammad Attia of the Desert and Marine Environment Research Center, UAE University, for their co-operation during the field study.

REFERENCES

Al-Kaisi, K.A. 19976. On the phytoplankton of the Arabian Gulf. Abstracts of papers presented at the Joint Oceanographic Assembly. Edinburgh, UK, 13–14 September, FAO, Rome.

de Almeida Prado-Por, M.S. 1983. The diversity and dynamics of Calanoida (Copepoda) in the Northern Gulf of Elat (Aqaba), Red Sea. Oceanologica Acta **6(2):** 139–145.

Bohm, A. 1931. Peridineen aus dem Persischen Golf und dem Golf von Oman. Archiv für Protestenkunde **74:** 188–197.

Chiba, T. 1972. Plankton of the Indian Ocean. Marine Science, **4(6)**.

Daniel, R. & Daniel, A. 1963. On the siphonophores of the Bay of Bengal I. Madras Coast. Journal of the Marine Biological Association of India, **5(2):** 185–220.

Enomoto, Y. 1971. Oceanographic survey and ecological study of shrimps in the waters adjacent to the eastern coast of the State of Kuwait. Bulletin of the Tokai Regional Fisheries Research Laboratory, **66.**

Fenaux, R. 1973. Appendicularia from the Indian Ocean, the Red Sea and the Persian Gulf. **In**: Zeitzschel, B. & Gerlach, S.A. (Eds). The Biology of the Indian Ocean, pp. 409–414, Springer-Verlag, Berlin.

Furnestin, M.L. & Codaccioni, J.C. 1968. Chaetognathes du nord-ouest de l'ocean Indien (Golfe d'Aden-Mer d'Arabie-Golfe d'Oman-Golfe Persique). Cahiers de l'Orstom, Oceanographie, **6:** 143–171.

Gibson, V.R., Grice, G.D. & Graham, S.J. 1980. Zooplankton investigations in Gulf waters north and south of the Straits of Hormoz. Proceedings of a symposium on coastal and marine environments of the Red Sea, Gulf of Aden and tropical western Indian Ocean, **2:** 501–517.

Giesbrecht, W. 1892. Systematik und faunistik der pelagischen copepoden des Golfes von Neapel und der angrezenden meeresabschinitte. Faunna and Flora of the Bay of Naples (Monograph) **19:** 1–831.

Grice, G.D. & Gibson, V.R. 1978. General biological oceanographic data from the Persian Gulf and Gulf of Oman. Report B, Woods Hole Oceanographic Institution, Technical Report, **WHOI-78-38**: 37, pp.

Heip, C. 1974. A new index measuring evenness. Journal of the Marine Biological Association of the United Kingdom **54:** 555–557.

Houde, E.D., Almatar, S., Leak, J.C. & Dowd, C.E. 1986. Ichthyoplankton abundance and diversity in the Western Arabian Gulf. Kuwait Bulletin of Marine Science **8:** 107–393.

Margalef, R. 1968. Perspectives in ecological theory. The University of Chicago Press, Chicago, 111, pp.

Michel, H.B., Behbehani, M. & Herring, D. 1986a. Zooplankton of the western Arabian Gulf South of Kuwait waters. Kuwait Bulletin of Marine Science **8:** 1–36.

Michel, H.B., Behbehani, M., Herring, D., Arar, M., Shoushani, M. & Brakoniecki, T. 1981. Zooplankton diversity, distribution and abundance in Kuwait waters. Kuwait Institute for Scientific Research, Kuwait, 154, pp.

Michel, H.B., Behbehani, M., Herring, D., Arar, M., Shoushani, M. & Brakoniecki, T. 1986b. Zooplankton diversity, distribution and abundance in Kuwait waters. Kuwait Bulletin of Marine Science **8:** 37–105.

Mori, T. 1937. The pelagic Copepoda from the neighbouring waters of Japan. Soyo Company, Tokyo, 150, pp.

Omori, M. & Ikeda, T. 1984. Methods in marine zooplankton ecology. Chapter 10. Wiley, New York, First Edition, 332, pp.

Silas, E.G. & Pillai, P.P. 1973. The calanoid copepod Family Pontellidae from the Indian Ocean. Journal of the Marine Biological Association of India **15(2):** 771–858.

Silas, E.G. & Srinivasan, M. 1969. Chaetognaths of the Indian Ocean, with a key for their identification. Proceedings of the Indian Academy of Science, Series B: 177–193.

Sokal, R.R. & Rohlf, F.J. 1987. Introduction to biostatistics. W.H. Freeman and Company, New York, 2nd Edition, 363 pp.

Thompson, H. 1948. Pelagic tunicates of Australia. Commonwealth Council for Scientific and Industrial Research, Australia, 196, pp.

Tregouboff, G. & Rose, M. 1978. Manuel de planctologie Mediterraneenne. Editions du Centre National de la Recherche Scientifique, Paris, I (Texte), 587, pp.

Tsuruta, A. 1957. Oceanographical and planktological studies of tuna-fishing grounds in the eastern part of Indian Ocean. Journal of Shimonoseki, College of Fisheries **7(1).**

Weigmann, R. 1970. Zur Okologie und Ernahrungsbiologie der Euphausiaceen (Crustacea) in Arabischen Meer. 'METEOR' Forschungsergebnisse, Reihe D. **5:** 11–52.

Yamazi, I. 1974. Analysis of the data on temperature, salinity and chemical properties of the surface water, and the zooplankton communities in the Arabian Gulf in December 1968. Transactions of the Tokyo University of Fisheries **1:** 26–51.

(Accepted 10 March 1996)

توزيع العوالق الحيوانية في مياه سواحل الشواطىء الغربية لدولة الإمارات العربية المتحدة

جبريل شرف و سيف الغيص

مركز أبحاث البيئة الصحراوية والبحرية
بجامعة الإمارات العربية المتحدة، العين، دولة الإمارات العربية المتحدة

خلاصة

بعد دراسة للتغيرات الموسمية وكثافة العوالق الحيوانية القاطنة للمياه المحيطية للساحل الغربي لدولة الإمارات العربية المتحدة في عام ٩٣-١٩٩٤ تبين ارتفاع أعداد العوالق الحيوانية في آخر الربيع وفي الصيف وأن المتوسط السنوي للعوالق الكلية يصل الى ٢٧٤٠ حيوان/م^{٣} بينما بلغ المتوسط السنوي للكتلة الحية ٤١٢ مجم/م^{٣}.

أظهرت الدراسة أيضا سيادة القشريات مجدافية الارجل حيث بلغت حوالي ٥١٪ من العوالق الكلية تليها المجاميع الآتية: الغلاليات، القشريات خيشومية الارجل، يرقات الرخويات والديدان شوكية الفكوك وتصل نسبتها الى ٣١٪ من العوالق وتبين أيضا وجود ٩ أنواع لم تسجل في المنطقة من قبل (جديدة جغرافيا).

بينت الدراسة أيضا وجود تجانس في تركيب العوالق في المحطات المختلفة وذلك لعدم وجود اختلافات مكانية ذات دلالة في اعداد مجاميع العوالق المختلفة وتبين ايضا قلة الانواع المتواجدة في الخليج العربي مقارنة بخليج عمان والمحيط الهندي.