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Spatial and Temporal Distribution of Zooplankton Biomass in the Northeast Persian Gulf

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Abstract
The zooplankton biomass and distribution were studied during two oceanographic cruises in NE part of the Persian Gulf in autumn 2012 (November) and summer 2013 (August) with 300 µm-mesh net. Zooplankton samples were analyzed for biomass content. Zooplankton biomass expressed as mg m^{-3} dry wt., was greatest during summer cruise (mean of 18.8 ± 4.6 mg m^{-3} dry wt.). The mean zooplankton biomass during summer cruise was slightly higher than autumn cruise (mean of 16.2 ± 1.7 mg m^{-3} dry wt.). Higher zooplankton biomass values (mean of 127.7 mg m^{-3} dry wt.) occurred in the central part of the Persian Gulf, between NW of Kish and Hendourabi Islands. Zooplankton biomass was not higher in near-coastal waters than in the offshore. Zooplankton biomass was not spatially and temporally significant ($p>0.05$).

Keywords: *Zooplankton, Copepods, Biomass, Distribution, Persian Gulf*

1. Introduction

The Persian Gulf is a semi-enclosed marginal sea, separated from the Indian Ocean by the narrow (approximately 42 km) Strait of Hormuz (Sheppard et al., 1992). Due to its shallow depth and restricted water exchange with the wider Indian Ocean, SSTs vary by over 25°C annually (Sheppard et al., 1992). The Persian Gulf waters are also hyper-saline, with fauna surviving >48 psu, approximately 10 psu higher than ambient in tropical oceanic waters and in excess of lethal limits for fauna on Atlantic and Pacific reefs (Coles, 2003).

Notwithstanding that zooplankton biomass is an index to the fertility of the sea, it would provide information on the fishery potential. High zooplankton biomass is an indication of food abundance and/or low predation or advection (Paffenhöfer, 1980).

Given its importance for the fisheries, much attention has been given to zooplankton in the Kuwaiti waters in the Persian Gulf (Michel et al., 1983, 1986b, Bakr et al., 2004, Dorgham and Hussein 1991), and ROPME Sea Area (Yamazi, 1974, Al-Yamani et al., 1998, Dorgham et al., 2008). However, information on the zooplankton biomass distribution on the Iranian side of the Persian Gulf is limited (Rezai et al., 2010).

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In this study, the spatial and temporal variations in total zooplankton biomass on the northeast of the Persian Gulf, over the Iranian side, were investigated during two oceanographic expeditions in 2012 and 2013. Of equal interest was a comparison of the plankton biomass found in the Persian Gulf with other coastal areas around. These comparisons may be useful in assessing the likelihood of other pelagic and demersal fisheries that are not yet exploited.

2. Materials and Methods

Zooplankton sampling and general oceanographic surveys were conducted at 35 stations (Fig. 1) during 2 oceanographic cruises (Nov. 2012 and Aug. 2013) along the northeastern part of the Persian Gulf. The stations were selected in accordance with depth and close proximity of the station location to previous cruises in the same area. Details of depth of hauls and geographic coordinates are shown (Table 1). Samples were obtained from coastal waters of Bandar Abbas to Assaluyeh aboard the R/V *Ja Nay Band*. The number of sampling stations were equal during each cruise, though not necessarily the same stations were sampled during each cruise.

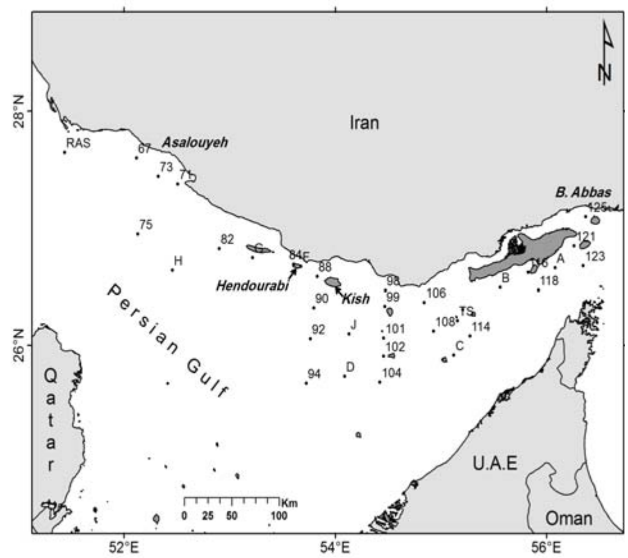

Fig. 1: Sampling stations

Table 1. Sampling stations

Stn.	Position		Depth (m)
67	27° 35' 54.6"N	052° 07' 08.7"E	72.0
71	27° 21' 07.5"N	052° 30' 27.1"E	65.0
73	27° 09' 25.6"N	052° 19' 29.0"E	81.0
75	26° 56' 49.2"N	052° 07' 49.1"E	56.0
82	26° 35' 48.4"N	052° 54' 04.4"E	81.0
84	26° 41' 23.7"N	053° 28' 08.8"E	59.0
88	26° 35' 07.1"N	053° 50' 03.3"E	50.0
90	26° 18' 27.9"N	053° 48' 06.4"E	86.0
92	26° 02' 28.7"N	053° 47' 01.5"E	75.0
94	25° 46' 39.4"N	053° 43' 32.5"E	60.0
98	26° 27' 26.9"N	054° 28' 22.8"E	25.0
99	26° 19' 23.9"N	054° 29' 17.4"E	72.0
101	26° 03' 27.8"N	054° 27' 32.1"E	50.0
102	25° 54' 10.2"N	054° 27' 25.9"E	38.0
104	25° 40' 48.6"N	054° 25' 23.5"E	34.6
106	26° 21' 40.0"N	054° 50' 30.5"E	15.4
108	26° 07' 10.0"N	054° 55' 47.0"E	10.5
112	26° 18' 06.1"N	055° 12' 26.5"E	50.0
114	26° 04' 41.1"N	055° 16' 35.5"E	76.2
116	26° 37' 11.7"N	055° 49' 31.4"E	13.0
118	26° 28' 03.0"N	055° 55' 24.6"E	60.0
121	26° 50' 35.1"N	056° 15' 13.0"E	45.0
123	26° 40' 34.9"N	056° 20' 53.5"E	37.0
125	27° 05' 44.8"N	056° 22' 14.2"E	31.0
126	27° 00' 31.1"N	056° 23' 20.2"E	30.0
A	26° 39' 21.5"N	056° 04' 56.4"E	59.0
B	26° 29' 28.9"N	055° 33' 41.9"E	60.7
C	25° 55' 19.1"N	055° 06' 57.0"E	71.0
D	25° 43' 15.6"N	054° 00' 30.8"E	63.0
F	26° 40' 09.2"N	053° 40' 30.5"E	17.0
G	26° 44' 34.8"N	053° 12' 58.3"E	84.0
H	26° 38' 15.6"N	052° 27' 25.9"E	70.0
J	26° 05' 39.5"N	054° 07' 48.6"E	85.0
TS	26° 13' 14.6"N	055° 09' 17.4"E	75.0
RAS	27° 38' 38.5"N	051° 26' 09.7"E	26.0

Samples were towed vertically at speed of ~1m/s using bongo net (300 μm mesh net) from near bottom to the surface at each station. Zooplankton samples were removed from the nets and fixed immediately in 4%-5% neutral formalin, buffered with sodium tetraborate (borax). One sample was measured for biomass analysis, while the other for quantitative counting and for microscopic analysis. The total zooplankton biomass (excluding gelatinous zooplankton) were determined by concentrating the sample on a pre-weighed 100 μm mesh filter net, rinsed with 10 ml of 70% alcohol to remove interstitial water and drained under a slight vacuum for 5 seconds (Böttger, 1982). Biomass was estimated as dry weight and expressed as mg m^{-3}. Measurements of temperature and salinity were made synchronously with the zooplankton samplings using CTD (Idronaut, model Ocean Seven).

3. Results

During autumn cruise, the temperature fluctuated between 20.5 and 29.6 °C, and salinity varied between 36.2 and 40.8 psu. However, during summer cruise, the temperature fluctuated between 20.9 and 35.0 and salinity varied between 36.8 and 40.8 psu. In this shallow tropical coastal environment vertical gradients in the temperature and salinity were negligible suggesting that the water column was well mixed.

Consistent pattern in the geographic variations of biomass was not observed throughout the study period. An appreciable part of the zooplankton consisted of copepods, which mainly contributed to the overall biomass. Zooplankton biomass showed subtle variations between stations during the autumn cruise (3.86 to 40.15 mg m^{-3} dry wt.) (Fig. 4), but showed high variations (2.22 to 127.66 mg m^{-3} dry wt.) during summer cruise with highly localized concentration at certain stations (Stn. 88).

The distribution of zooplankton biomass fluctuated slightly at two cruises (Figs. 3 and 4). Mean zooplankton biomass during summer cruise (mean of 18.8 ± 4.6 mg m^{-3} dry wt.) was slightly higher than autumn cruise (mean of 16.2 ± 1.7 mg m^{-3} dry wt.). However, Mann-Whitney *U* test showed no significant difference (p>0.05) in biomass concentrations between seasons.

The mean biomass of samples collected at each station showed that some areas were more productive than others, i.e., the waters around NW of Kish Island and Hendourabi Island. Stn. 88 in particular showed maximum concentration during summer cruise, whereas Stn. F was highest during autumn cruise. However, one-way Kruskal-Wallis test showed no significant difference (p>0.05) in zooplankton biomass among stations. Moreover, biomass did not differ significantly between near-coastal and offshore waters. In another word, spatio-temporal variation of biomass was not significant.

Samples were dominated by copepods (including copepodites) during autumn and summer cruises, accounting for 57.5% (537 ± 138.7 ind. m^{-3}), 53.5% (828 ± 204.4 ind. m^{-3}), respectively.

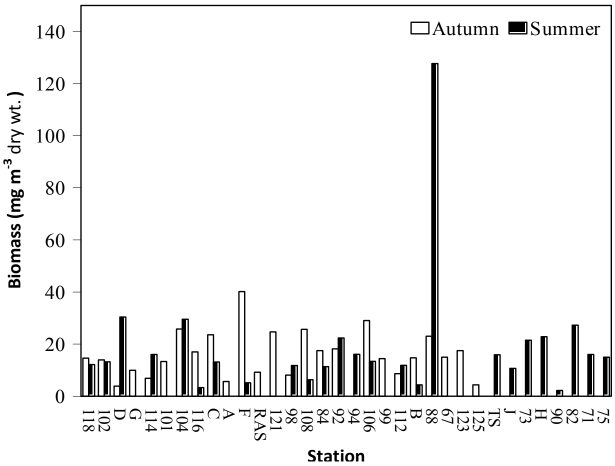

Fig. 2: Variation of zooplankton biomass in different stations

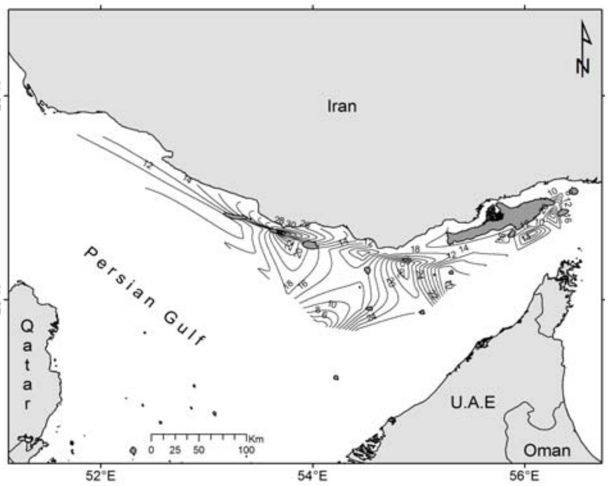

Fig. 3: Distribution of zooplankton biomass (mg m^{-3} dry wt.) during autumn cruise

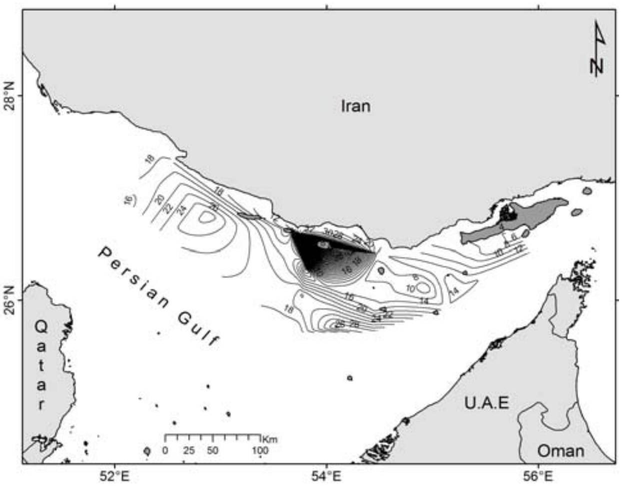

Fig. 4: Distribution of zooplankton biomass (mg m^{-3} dry wt.) during summer cruise

4. Discussion

Biomass values obtained in this study were amongst the average in the literature within the Persian Gulf waters (Table 2). This may be primarily attributed to different towing methods of the net. The earlier collections in the Persian Gulf were made using oblique tows (Michel et al., 1981, Michel et al., 1986a, b) leading to collection of more diverse organisms. Morioka et al. (1990) and Nakashima et al. (1992) showed that the whole collection and mean dry weight of their zooplankton samples usually increased as mesh size got smaller, a point indicated earlier by Michel et al. (1986a) who had indicated that the mean biomass measurements were greater for the smaller net (110 µm) than the larger mesh net (330 µm) in the Persian Gulf waters. This was mainly because smaller mesh retained the numerous minute copepods and larval forms.

The biomass values of the present study compared with findings at other parts of the Persian Gulf are not necessarily the outcome of low efficient resource use by planktonic communities, but rather be the direct result of a low surface production and low flux of organic material from overlaying layers due to shallowness of the Persian Gulf. Due to near uniformity of temperature and salinity ranges among stations, no significant variation in zooplankton biomass between stations was observed.

The present results on higher zooplankton biomass content in summer are in close agreement with that of Michel et al. (1986a) who found higher biomass in spring and summer.

This study covered the northeast part of the Persian Gulf, and expectedly differed from findings of other authors who studied the southern part and mostly the Kuwaiti waters. However, effects of other parameters such as tide, atmospheric conditions, currents, variation in the speed of hauling and the effect of wind may in part cause differences in biomass values of zooplankton.

Zooplankton biomass may be over-estimated due to contamination of inorganic materials such as phytoplankton-originated detritus (Kawamura 1986), re-suspended sediments and terrestrial runoff (Nagao et al., 2001) in near-coastal areas, especially near Bandar Abbas (Stn. 125). Phytoplankton blooms can often greatly enlarge measurements (Michel et al., 1986a). Yamazi (1974) was observed that zooplankton biomass in the Persian Gulf is formulated by mixed communities of neritic and oceanic forms of the larger size and inlet water forms of smaller size, both habitually being adapted to the environment of high temperature and salinity.

Since, copepods comprised the bulk of the total zooplankton throughout the water column, it is not surprising that the planktonic biomass profiles essentially reflect the abundance profiles of copepods.

It is obvious that the northeast part of the Persian Gulf sustains some of the highest zooplankton standing stocks in Iranian waters. Whether the high zooplankton stocks in the Persian Gulf are indicative of high secondary production is not known. The zooplankton is thus of the greatest relevance to coastal fisheries.

It is the responsibility all to preserve the health of this productive ecosystem in order to sustain fishery production in the future.

Table 2. Comparison of zooplankton biomass for various systems within the Persian Gulf

Location	Dry wt. (mg m^{-3})	Mesh size (µm)	Method of tow	References
Kuwait	34.00-290.00	330	Oblique	Michel and Herring (1984)
Kuwait	4.00	333	Oblique	Michel et al. (1986a)
Hormuz Strait	407.00	330	Oblique	Michel et al. (1986b)
Hormuz Strait	40.00-860.00	300	Vertical	Rezai et al. (2010)
NE Persian Gulf	3.86-40.15	300	Vertical	Present study in autumn
NE Persian Gulf	2.22-127.66	300	Vertical	Present study in summer

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