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INFLUENCE OF HYDROGRAPHIC CONDITIONS ON THE INTERACTION BETWEEN ICHTHYOPLANKTON AND MACROZOOPLANKTON AT KHOR AL-ZUBAIR LAGOON, IRAQ, ARABIAN GULF

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تأثير الظروف الهايدروغرافية على العلاقة بين الهائمات السمكية والحيوانية في خور الزبير / العراق / الخليج العربي

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تمت دراسة يرقات الاسماك في خور الزبير (شمال غرب الخليج العربي) خلال الفترة من سبتمبر ١٩٨٩ وحتى أغسطس ١٩٩٠ ، سجلت اعلى سيادة ليرقات Gobiidae و Engraulidae وذلك نتيجة لتأثير الظروف الهيدرولوجية للخور . ان مجتمع اليرقات السمكية في الخور تمثل بالأنواع المقيمة والأنواع الزائرة. تمثلت يرقات الأسماك الاقتصادية بالعوائل التالية :

Clupeidae و Mugilidae و Sparidae و Sciaenidae و Soleidae وكانت وفرتها قليلة في الخور ، وعند دراسة الهائمات الحيوانية في الخور فقد كانت مجذافية الارجل Copepoda هي السائدة ، وسجلت أكبر كتلة حية للهائمات الحيوانية الكبيرة مع مجذافية الارجل Copepoda خلال شهر مارس ١٩٩٠ مقارنة ببقية اشهر السنة . كانت هناك علاقة ارتباط موجبة ما بين الهائمات السمكية والهائمات الحيوانية والتي تعكس العلاقة الغذائية ما بين هاتين المجموعتين .

Key words : Ichthyoplankton, Macrozooplankton, khor Al-Zubair, Iraq.

ABSTRACT

The ichthyoplankton of Khor AL-Zubair lagoon consisted of 17 families and dominated by Gobiidae and Engraulidae, due to the hydrological situation of the Khor. The larval fish community of the Khor consisted of resident and transient species. Larvae of commercially important families e.g. Clupeidae. Mugilidae and Sparidae occured in the Khor but in a very low numbers.

Copepoda in the Khor are the predominant type of zooplankton. Macrozooplankton and copepoda biomass was higher during March than the rest of the year. There was a positive association between icvhthyoplankton and zooplankton which reflects the trophic relationship between these groups.

INTRODUCTION

The coast line of is Iraq characterized by three main features : Shatt Al-Arab estuary, extensive mudflats and Khor Al-Zubair lagoon, (Fig. 1).

In the Arabain Gulf, ichthyoplankton studies are linited to those of Nellen (1) and Houde *et al.* **(2)**. These studies were conducted in open, non-estuarine waters of the Gulf. Grabe *et al.* **(3)** examined the spatial and temporal variations of ichthyoplankton in Kuwait bay and Khor Al-Sabiya.

The present investigation is aimed at monitoring the composition, abundance and seasonal distribution of fish larvae and Macrozooplankton in the coastal estuarine Lagoon of Khor Al-Zubair in the northwestern Arabian Gulf.

MATERIALS AND METHODS

Study area

Khor Al-Zubair is an estension of the Gulf waters in the lower reaches of Mesoptamica, It has an approximate length of 42 km, a width of 1 km at low tide, and an average depth of 10-20 m, During 1983 this water body was connected to an oligohaline marsh (Hor Al-Hammar, Fig.1), changing the environment of the Khor from a hypersaline lagoon to an estuarine one. The topography of Khor Al-Zubair look like a spindle with tapering ends, at the northern and southern ends. The northern end recieves fresh watar influx of average 700 m^3/sec throughout-the tidal cycle **(4)**. The current in the Khor is characterized by one direction throughout the tidal cycle towards the southern end (Arabian Gulf), with velocity exceeding 2m/sec during ebb tide and 0.66 m/sec in flood tide. At the southern end, the water discharge reaches 10000 m^3/sec with the velocity range 0.8-5.78 m/sec **(4)**, with big tidal range at Umm Qasir reaching 4.3 m. Due to the low profile of the shore-line, the tidal flood penetrates the mudfatds to a further distance, depending on the state of the tide, covering the halophytic vegetation (e.g. *Salicornia herbacea* and *Halocremon strobilaceum*).

The mudflats surrounding the Khor are occupied by large population of two species of mud skippers (Gobiidae). which can be seen scuttling about - on the exposed mud at low tide. The feeding habits of these two species have little in common. *Periphtalmus koelreuteri* (Pallas) is carnivorous, while *Boleophthalmus boddarti* (Pallas) is herbivorous, feeding on diatoms and other algae. Several species of crabs may also be seen associated with these mud skipper. These are *Cleistostoma dotilleforme*, *Macrophthalmus grandidieri*, *M. depresus* and *M. pectinipes*.

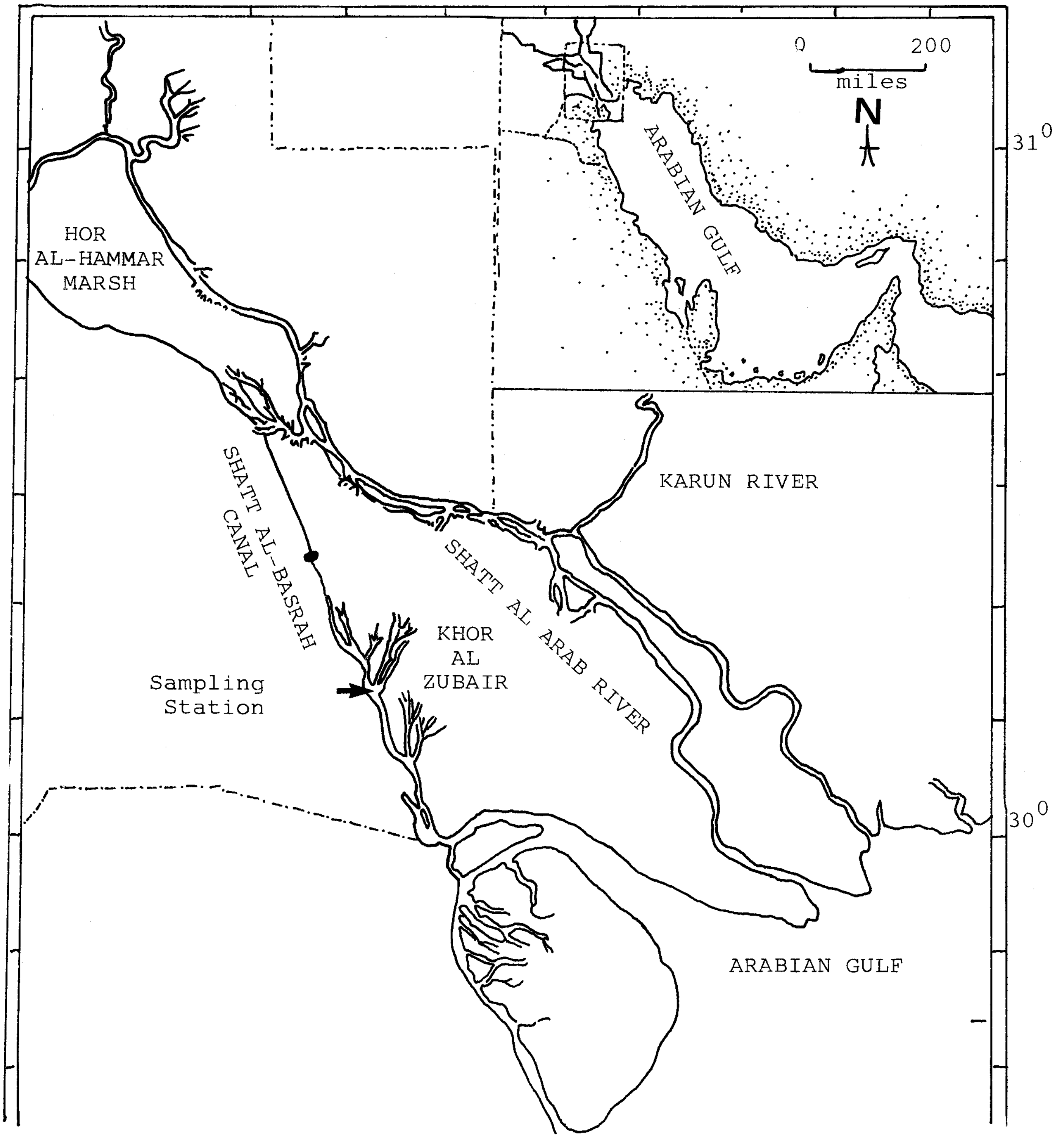

Fig. 1 Sampling station at Khor Al - Zubair NW Arabian Gulf.

Sampling

Thirty two samples were collected from September 1989 to August, 1990. An average of three samples per month were collected during the day time at high and low tides. Sampling was done using a conical net (75 cm diameter, 175 cm in length 505 μm mesh size). The net was equipped with a flowmeter (General Oceanics). Stepoblique tows were made at speed of 0.5-2 knots, for approximately 10 minutes (ecluding wire pay out time). After each tow, the contents of the net were rinsed thoroughly into the cod-end.

Samples were preserved in the field in 10% neutralized formaldehyde - seawater. Fish larvae were sorted out and transferred to 4% neutralized formaldehyde. Macrozooplanktons were also sorted from the sample and transferred to 4% neutralized formaldehyde and then identified to the class level.

Fish larvae were identified to family and subsequently counted. Sources of information for larval identification include: Russel **(5)**, Leis and Rennis **(6)**, Moser *et al.* **(7)**, Okiyama **(8)**, Leis and Trunski **(9)** and Houde *et al.* (2).

Abundance was calculated according to the formula of Smith and Richardson (10).

$$A = (N.D.\ 10)/v$$

where : A = Abundance under 10 m^2 of sea surface.

N = Number of collected larvae

D = Depth of tow

V = Volume of filtered water

Surface temperature and salinity were measured monthly with bucket thermometer and digital salinometer respectively.

RESULTS :

1) Occurence of fish larval families :

A total of 28674 larval fish, representing 17 families were collected. Gobiidae larvae (25080 individuals) were present the year around except in winter monthes (Table 1). Engraulidae (2664 larvae) occurred in the summer months and were absent from October to April, Several families were truely rare, only occuring in samples from three or fewer cruises. Of the 17 families encountered during the study period, the two predominat families for 96.7% of all larvae collected were: Gobiidae (87.4% of all larvae collected) and Engraulidae (9.3%). Neither of these two families are commercially important.

Larvae of commercially important families occured in the Khor but in very low numbers (Table 1) including: Clupeidae. Mugilidae, Soleidae, Pomadasyidae, Sparidae, Cynoglossidae and polynemidae.

2) Seasonal trends in fish larval diversity :

The mean total fish abundance was 251/10 cm^2, The general larval abundance was during March to June. However. when all species are averaged, it is evident that larval abundance is generally higher between March and July (Spring-early Summer) (1226.6-755.8/10m^2) than during the rest of the year (16.86-1.8/10m^2).

Seasonal abundance pattern varied between familiies (Table 1). All but Gobiidae and Engraulidae showed a major peak in March-June and a minor one in May-June. Engraulidae experienced one peak in May.

Gobiidae larvae were present during the period March to November and absent in Winter months (Dec.-Feb.) The highest density occurred in March (1224/10 m^2).

Engraulid larvae appeared in the Khor from May to September, with a peak in May (180/10 m^2). The average abundance during this period was 54/10 m^2.

Scianenid larvae comprised 1.7% of total number of larvae and attained peak abundance in june (25/10 m^2).

Mugilidae, Soleidae, Leiognathidae and Clupeidae larvae also found frequently but in low numbers (Table 1).

Mugilidae and Soleidae larvae appeared in winter months, Leiognathidae and Clupeidae were present in June and July.

Sillaginidae, Syngnathidae, Scorpaenidae, Sparidae, Trichiuridae, Pomadasyidae, Centriscidae, Polynemidae and Cynoglossidae larvae were rare (one larvae/10 cm^2). occurring in less than five samples.

Table (1) : The abundance of fish larvae (No. 10m^2) in Khor Al-Zubiar from September 1987 to August 1990, Families were erranged according to their abundance

Family	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	%	Total No.
Gobiidae	7.51	3.43	1.43	-	-	-	1223.7	106.5	513.20	671.1	114.10	16.60	87.64	25080
Engraulidae	2.50	-	-	-	-	-	-	-	179.30	53.7	29.30	5.86	9.3	2664
Sciaenidae	2.12	1.56	-	2.13	-	-	-	-	7.2	24.4	12.39	2.82	1.7	483
Mugilidae	-	-	-	0.63	3.00	3.7	1.3	1.7	-	1.9	-	-	0.44	125
Soleidae	0.25	-	-	-	3.10	1.5	0.5	0.4	1.75	0.4	0.20	0.20	0.29	84
Leiognathidae	0.62	-	-	-	-	-	-	-	-	0.8	3.69	2.17	0.23	67
Clupeidae	1.25	-	-	-	1.62	1.2	-	-	-	3.0	-	-	0.2	65
Silliginidae	1.81	1.56	-	-	-	-	-	-	-	0.1	0.10	0.10	0.1	28
Syrigriathidae	-	0.78	0.43	-	-	-	-	-	0.1	0.2	0.20	0.80	0.07	21
Sparidae	0.50	-	-	-	-	-	0.4	0.4	0.1	-	-	-	0.04	13
Pomadasyidae	-	-	-	-	-	-	0.7	0.5	-	-	-	-	0.01	13
Polynemidae	-	-	-	-	-	-	-	-	-	-	0.50	-	+	5
Trichiuridae	-	-	-	-	-	-	-	-	0.2	0.2	-	-	+	4
Scorpaenidae	-	-	-	-	-	0.1	-	0.2	-	-	-	-	+	3
Centriscidae	-	0.30	-	-	-	-	-	-	-	-	-	-	+	2
Hemirhamphidae	-	-	-	-	-	-	-	-	-	-	-	0.20	+	2
Cyrioglossidae	0.01	-	-	-	-	-	-	-	-	-	-	-	+	1
Unidentified														14
	135	49	13	22	76	72	11007	991	7006	7558	1478	267		28674

3) Correlation of fish larval abundance with temperature and salinity:

Surface salinity were less variable than temperature (Fig. 2). It ranged from 28.5% in March to 33.5% in January. Water temperature varied from 11.0°C in February to 32.0°C in September. In general, larval abundance was positively correlated with water temperature ($r=0.78$, $P < 0.05$) and number of families ($r = 0.803$, $P < 0.05$) and negatively correlated with salinity ($r = - 0.67$, $P < 0.05$).

Fig. (3) exhibits the association of the 12 families with temperature and salinity. Two families were positively correlated with both temperature and salinity (Gobiidae and Clupidae), and seven families were positively correlated with salinity and negatively correlated with temperature; (Engraulidae, Saciaenidae, Sillaginidae, Sparidae, Syngnathidae, Trichiuridae, and Leiognathidae), Pomadasyidae was negatively correlated with both temperature and salinity. Two families (Mugilidae and Soleidae) were negatively correlated with salinity and positively with temperature.

Table (2) shows that 93% of the larvae were collected in Spring when water temperature ranged from 16-27°C, Few larvae (0.5%) were collected in winter when water temperature ranged from 11-15°C. Nearly two thirds of the larvae were collected at salinities more than 30%.

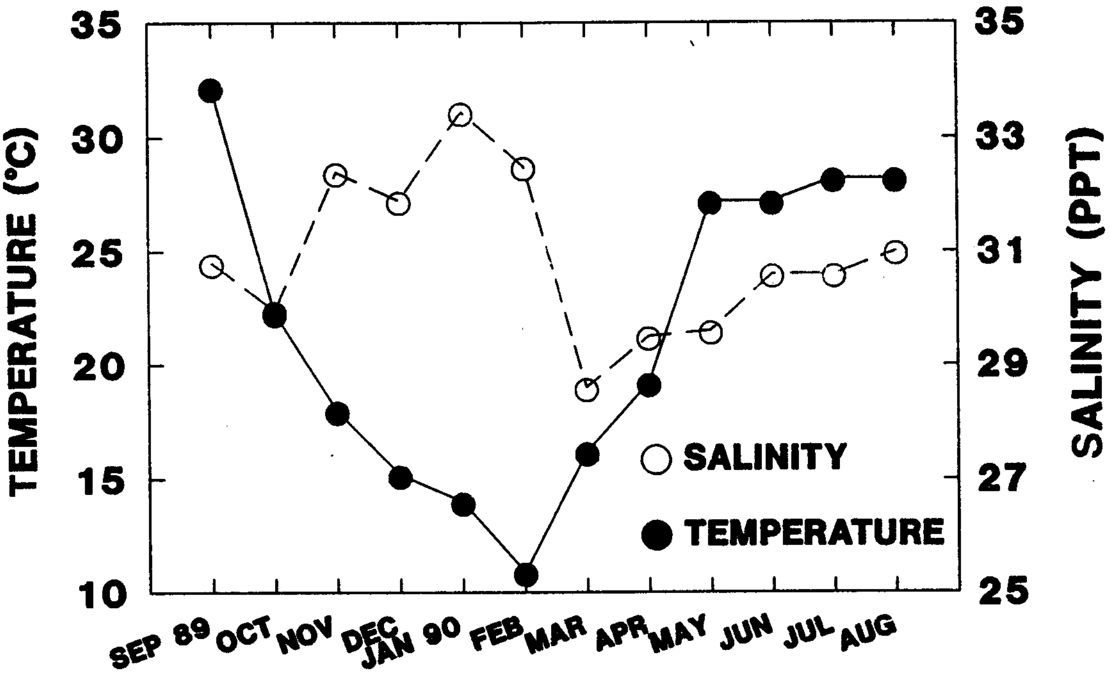

Fig. 2 Monthly changes in water temperature and salinity in Khor Al-Zubair lagoon, september 1989 - August 1990.

Table (2) : Total number and percentage of fish larvae collected at three different temperature ranges and two different salinity ranges.

Families	Temperarture ranges (°C)			Salinity	ranges %
	< 15	16 - 27	> 28	< 30	> 30
Gobiidae	0	23815	1265	8008	17072
Engraulidae	0	2326	344	881	1783
Sciaenidae	0	326	157	411	72
Clupeidae	25	0	40	65	0
Leiognathidae	0	42	25	67	0
Mugilidae	78	47	0	77	28
Soleidae	34	44	6	44	40
Silliginidae	0	11	17	28	0
Pomadasyidae	0	13	0	0	13
Sparidae	0	9	4	4	9
Syngnathidae	0	11	10	20	1
Trichiuridae	0	4	0	4	0
Scorpaenidae	1	2	0	1	2
Centriscidae	0	2	0	2	0
Polynemidae	0	0	5	5	0
Hemirhamphidae	0	0	2	2	0
Total	138	26646	1876	9638	19022
%	0.5	93.0	6.5	33.6	66.3

4) Abundance and densities of mecrozooplankton:

The highest zooplankton density was in March and the lowest in December (Table 3). The highest biomass observed was in March (53.04 mg/m^2).

Monthly changes in densities and percentages of the major groups of zooplankton, Coepoda and Chaetognatha are shown in Table (3). The highest abundance of Copepoda occurred in February through April and the lowest in November. Brachyuran larvae showed peak density in March.

The association between temperature and zooplankton density was not statistically significant. Fig, (4) illusrtrates the seasonal changes in Copepods, the major component of the zooplankton standing crop. Table (4) showes the monthly changes in density of three species of copepoda, *Eucalanus subcrassus* was the overall numerically dominant and attained peak abundance in April, *Temora discaudata* showed a peak in February (Table 4).

Table (3) : Monthly changes in the densities (ind/m^3) and biomass (mg/m^2) of the macrozooplankton in Khor Al-Zubir lagoon during the period November 1989 to August 1990

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Copepoda	5.71	8.00	10.75	95.00	73.97	94.11	40.91	50.00	30.10	10.75
	65.57	92.85	42.66	76.18	31.55	86.72	66.28	50.25	78.18	68.47
Chaetognathe	0.57	0.37	5.50	3.30	5.00	0.88	0.51	10.15	0.40	0.30
	6.55	4.34	21.56	2.91	2.13	0.81	0.82	10.20	1.04	1.91
Shrimp larvae	1.85	0.00	8.00	10.40	0.90	0.00	8.87	18.00	2.50	2.40
	21.31	0.00	31.37	8.40	0.42	0.00	14.47	18.09	6.49	15.28
Brachyure	0.57	0.25	1.25	15.00	154.54	13.55	11.42	21.00	5.50	2.25
larvae	6.55	2.89	4.90	12.10	65.92	12.48	18.51	21.10	14.28	14.33
Total (ind/m^3)	8.71	8.62	25.20	123.70	234.43	108.50	61.75	99.50	38.50	15.70
Biomass (mg/m^2)	1.23	1.07	0.52	3.88	53.04	6.92	3.24			

Table (4) : Monthly changes in the densities of the daminant Copesoda species (ind/m^3) during the period November 1989 to May 1990 in Khor Al - Zubair lagoon.

Copepoda	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
E. subcrassus	5.14	—	2.12	35.0	72.04	94.0	40.91
T. discuadata	0.57	8	8.62	37.5	1.81	0.11	—
T. tubinata	—	—	—	22.5	0.11	—	—

5) Ichthyoplankton and macrozooplankton relationship

Statistical analysis showed a statistically significant positive correlation between the densities of ichtyollankton and macrozooplankton ($r = 0.741$, $P < 0.01$). Fish larvae densities were also positively correlated with Copepoda abundance.

The most productive season (February / April) for macrozooplankton generally coincides with the spring and early summer spawing peak of gobiies and engraulids in the area.

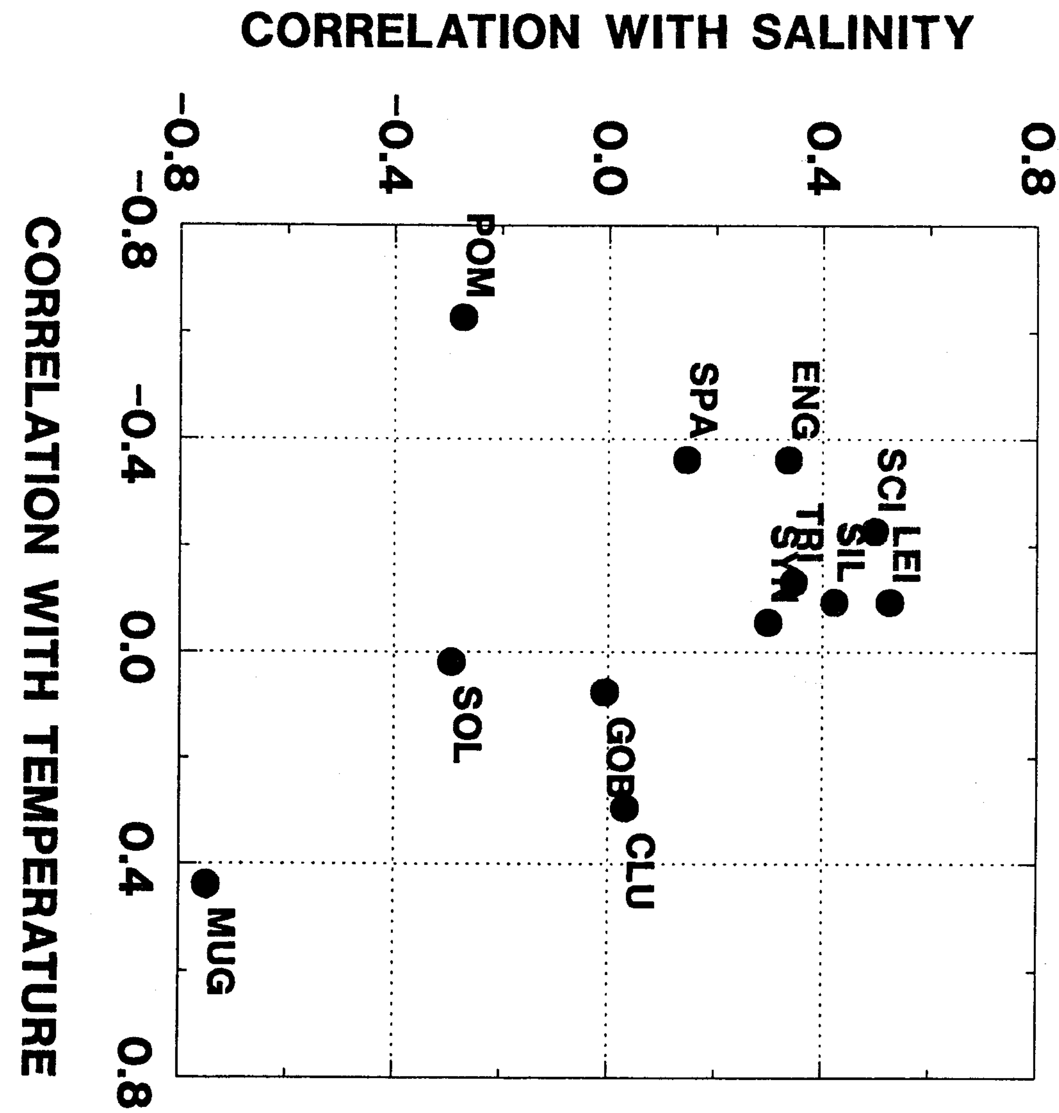

Fig. 3. Relative association of 12 families of fish larvae in Khor Al-Zubair with temperature and salinity. The plot was based on correlation coefficent (r) for both environment factors. Dashed lines represent the positive and negative significance threshold of -0.5 and +0.5. Families names are abbreviated as follows:
Engraulidae (ENG). Clupeidae (CLU), Silliginidae (SIL), Syngnathidae (SYN), Pomadasyidae (POM). Leiognathidae (LEI), Sciaenidae (SCI), Sparidae (SPA), Gobiidae (GOB), Mugilidae (MUG), Trichuridae (TRI) and Solidae (SOL).

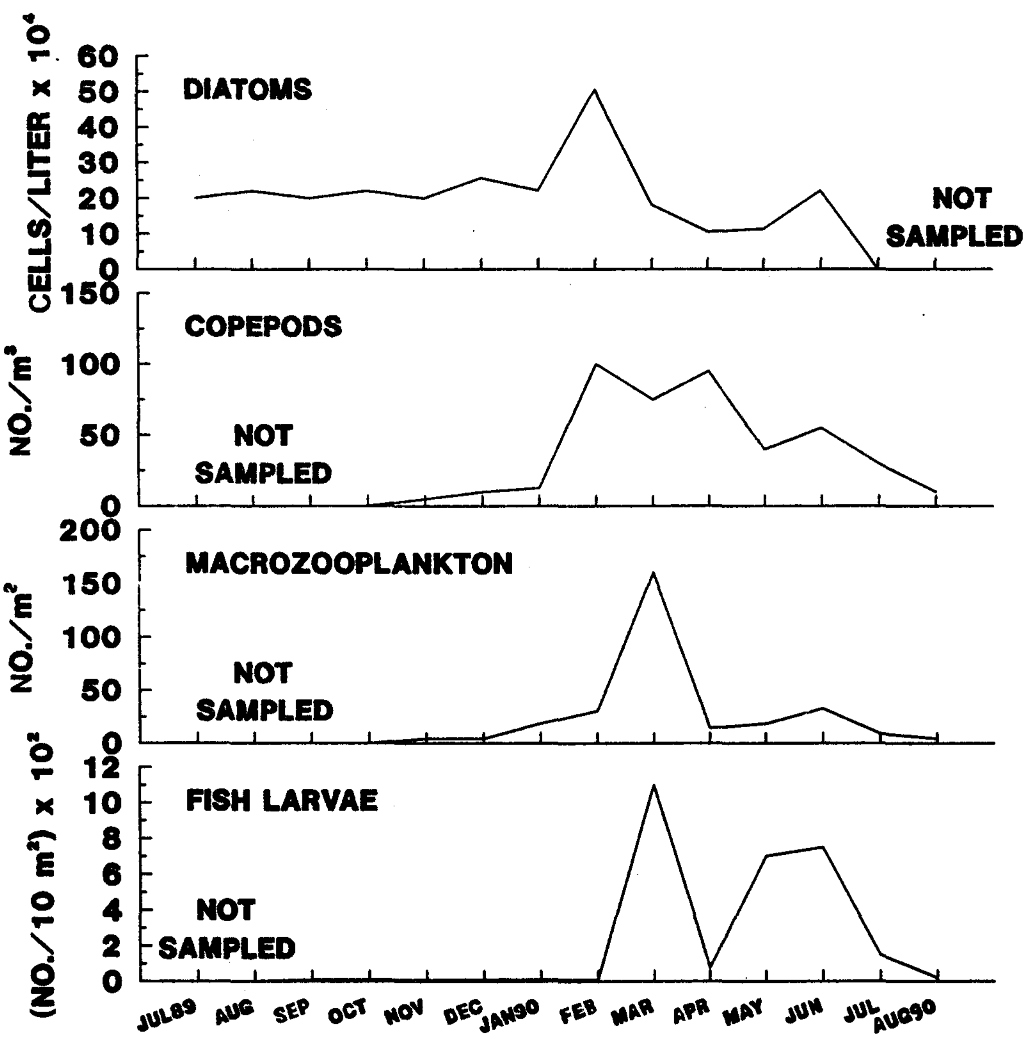

Fig. 4. Mean abundance of Diatoms, Copepoda, Macrozooplankton and Ichthyoplankton in Khor Al-Zubair lagoon, July 1989 - August 1990.

Discussion

The topography of Khor Al-Zubair is characterized by a narrow connection with the Arabian Gulf. This restricts circulation between these two water bodies. The one directional current of Khor Al-Zubair beside the huge discharge at Umm Qasser (10000 m^3/sec) (4) blocked the intrusion of Arabian Gulf water to the Khor, resulted in high tidal range at Umm Qasser (4.4 m) (4).

The resident species belonging to families that are known to be euryhaline are reported by Shubnikov (11). These factors led to the ichthyolankton of the Khor being dominated by Gobiidae and Engraulidae which are resident in the Khor.

Of the 17 families identified from the Khor, eight contained fish species of commerical value. However, as a nursery ground for commercially important species the Khor may be more important than the figures had indicated, especially after the connection with the oligohaline Hor Al-Hammar marsh.

The low density make the inchthyoplankton community of Khor Al-Zubair fall within the physically controlled type where environmental condition fluctuates widely and the organisms are subjected to a strong physical stress.

Not all larvae occurring in the Khor have actually been spawned as eggs in the Khor itself. Although many species of fish are known to spawn in the Khor (e.g. *P. koelreuteri*, and *T. mystax* and *T. hamiltoni*).

Serveral species groups are advected into the embayment from offshore areas. These include representatives of the Mugilidae, Sparidae, Soleidae and Clupeidae **(12)**.

This mechanism may explain temporal trends in larval abundance. This also points to the potential importance of the Khor as a nursery area for larvae and juveniles of fish that spend their adult life in the open waters of the Arabian Gulf. The estuarine conditions of the Khor may also prevent other marine species from spawning in the area.

The larval fish community in the Khor consisted of resident and transient species. Residents include the Gobiidae and Engraulidae, taxa that spawn in the Khor area and spend their entire life in that system. The second group consisted of species that spawn in the coastal waters (Mugilidae) as well as the Gulf proper (Clupeidae, Sciacenidae, Soleidae and Sparidae). These taxa utilize the Khor as a nursery group and include species such as *Liza subviridis, L, carinata, Ilisha indica, Ilisha megaloptera, Johnius sing, J. belangerii, Cynoglosus arel* and *Synoptura orientalis.*

The ichthyoplankton of the Khor is dominated by goby larvae which include large populations of *B. boddarti*, *P. koelreuteri* occupying the intertidal mud flats. These species release their larvae in synchronozation with the blooms of the phytoplankton and zooplankton (Fig. 4).

The spawning of *P. koelreuteri* and *B. boddarti* takes place in March and June respectively **(13)**. *Thryssa mystax* and *T. hamitoni* spawn in June **(14)** which again confirms the relationship between the fish larvae and their zooplankton prey.

There was a considerable variability in the temperature measured during sampling months. This variability contributed to a low seasonal abundance of fish larvae, especially during the summer season. The expected pattern is of increased primary production and phytoplankton biomass during the wet winter months (15).

Copedoda in khor Al-Zubair are the predominant type of zooplankton (16) Macrozooplankton and Copepoda biomass was higher in Khor Al-Zubair during March than during the dry summer months. A similar pattern was noted by Grabe *et al.* (3) in Kuwait Bay. Here again there was a considerable seasonal variability and the seasonal pattern is controlled by phytoplankton, zooplankton and coperoda interacting with temperature, low salinity and tidal currents.

The domcnance of Copepoda in the Khor is in accordance with that reported by Grabe *et al.* (3) from Kuwait Bay and Khor Al-Subyia as well as other subtropical areas. Chaetognatha abundance was also high in winter as reported by Michel *et al*, **(17)** from the Kuwait coast. The low occurrance of Decapoda and Crab zoae in the Khor could be related to the hydrographical situation and esturaine dilution. The negative association between salinity and total density of macrozooplankton agreed with Ageel **(16).** An optimum temperature appears to be near 20°C and departures from 20°C could be a factor limiting the increase of zooplankton density. Similar relationships were found by Al-Rekabi **(15)** in Khor Al-Zubair and by Grabe *et al.* (3) in Kuwait bay.

Ichthyoplankton and zooplankton densities were positively associated, as observed by Houde *et al*, (2) in Kuwait coastal waters. This positive association between ichtyoplankton and zooplankton reflects the trophic relationahips between these groups, It was reasonable to expect that areas where larval fish are typically distributed will, concide with high food resources **(18)**. Copepoda are generally a major food resource for larval fish **(19) (2)**. The coexistance of Copepoda and fish larvae in high densities in the Arabian Gulf may indicate that the spawning season of fin fish are generally well matched with the season of high food availibility (2).

Examination of the stomach contents of the larvae of *Thryssa mystax* indicated that it consisted mainly of Copepoda nauplii *(Eucalnus and Temora)* in Khor Al-Zubair lagoon during June **(20)**.

Loeb and Nichols **(21)** noticed that the strong positive correlation may indicate local aggregation of visually-feeding larvae and zooplankton taxa in response to increased food availablity.

Competition among macrozooplankton (e.g. Mysidasea and ctenophores) which require the same food (including fish larvae) is a factor in mortalities of larval fish. For example, Ali Khan (22) demosntrated that mass mortalities of *Sardinella* larvae could be caused by predation by macrozooplankton.

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