Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E., 1995. Vol.(21) No. 2: 477-500

FEEDING HABITS OF SOLES; SOLEA VULGARIS, SOLEA AEGYPTIACA, SOLEA IMPAR AND SOLEA KLEINI; FROM ABU-KIR BAY, SOUTHEASTERN MEDITERRANEAN SEA, EGYPT.

BY

*S. M. ALLAM**

***National Institute of Oceanography and Fisheries. Kayed-Bey, Alexandria.**

Keywords: Dietary overlap; Feeding habits; *Solea* species.

ABSTRACT

*The feeding habits of four species of soles; **Solea vulgaris** Quensed, 1806; **Solea aegyptiaca** Chabanaud, 1927; **Solea impar** Bennett, 1831; **Solea kleini** Bonaparte, 1833; from Abu-Kir Bay, Southeastern Mediterranean Sea, Egypt; were studied over one year. The stomach contents were analyzed by means of frequency of occurrence, numerical percentage, volume index, preponderance index and Schoener index. Results of these analyses, showed that crustaceans and molluscs were the most frequent exploited prey for all **Solea** species. Therefore, bivalves and gastropods were the main preferable prey in the diet of **S. vulgaris** and **S. kleini** respectively, while decapods were the most preferable food item in the diet of **S. impar** and **S. aegyptiaca**. These results and the values of dietary overlap suggested a relatively little competition for food resources between the four **Solea** species.*

*Variations in the abundance of different food items with fish length and season were studied for the different **Solea** species (except **S. kleini**). Results also, showed that the feeding activity of soles has continued during the spawning season.*

INTRODUCTION

Soles are important demersal fishes to the fisheries of estuaries and inshore marine waters. Their area of distribution extends from Senegal to Norway,

along the eastern coasts of Atlantic Ocean, and Mediterranean Sea including Adriatic and the Southwestern Black Sea (Whitehead ***et al.***, 1986). In Egypt, soles are common in Abu-Kir Bay, Southeastern Mediterranean Sea, at depths ranges from 10 to 100 m (Al-Kholy and El-Wakeel, 1975). They constitute about 3% of the total landed catch at Alexandria.

The food and feeding habits of ***Solea vulgaris*** in Abu-Kir Bay have been studied by El-Gharabawy (1977). In general, there is little published information on the dietary habits of ***Solea*** species in other regions (Deiana, 1986; Costa, 1988 and Molinero and Flos, 1991 & 92).

The specific objectives of the present study were to (1) describe the general feeding habits of different soles collected from Abu-Kir Bay, (2) compare the effect of fish length and season on food items eaten, and (3) investigate the dietary overlap between the different species of ***Solea***.

MATERIAL AND METHODS

Soles were randomly collected monthly from the commercial landed catch of Abu-Kir Bay, Southeastern Mediterranean Sea near Alexandria during the whole year from January to December 1991.

According to El-Gharabawy (1991), soles from Abu-Kir Bay were identified into five species which are ***Solea vulgaris***, ***S. aegyptiaca***, ***S. impar***, ***S. kleini*** and ***S. ocellata***. The last species is very rare and only 4 specimens were collected during the summer season. Therefore, this species can not be considered in the detailed of subsequent analysis. The stomach of 246 ***Solea vulgaris*** (13-27 cm T.L), 217 of ***S. aegyptiaca*** (13-28 cm T.L), 79 of ***S. impar*** (13-25 cm T.L) and 20 of ***S. kleini*** (18-27 cm T.L) were studied. For each fish, total length was measured in cm, stomach and intestine were removed, labeled and placed separately in 10% formalin solution. Only the stomach and intestine that contained food were used in subsequent diet analyses and intended here as "stomach" and "stomach content". The content of each stomach was removed, sorted and identified to the lowest possible taxonomic level, counted and measured volumetrically by water displacement. Most of the stomach examined contained sand and small gravels, which can not be considered as a food item and therefore can be neglected. Identification of prey eaten was made using the

key of Riedl (1970) and Fischer ***et al.***(1987). The following calculations were adopted for analysis of stomach content:

1- Fullness index (F.I) : Percentage of full stomachs to total number of stomachs examined.
2- Occurrence index (O.I) : Percentage of stomachs having a specific food item (i) to the total number of stomachs containing food.
3- Volume index (V.I) : Percentage of volume of each species of a particular food item (i) to total volume of all food items.
4- Preponderance index (P.I) : was determined according to Natrajan and Jhingran (1961)as $P.I_i = (V_i O_i / \Sigma V_i O_i) \times 100$, where, V_i is the percentage volume of . food item (i) and O_i is the percentage occurrence of the same food item (i).
5- Numerical percentage (N . P) : Percentage of number of food item (i) to total number of all food items.

To assess the relative importance of the different food items as calculated by preponderance index (P.I), the following categories were established:

1- Preferential prey (P.I > 50%).
2- Secondary prey (50% > P.I > 10%).
3- Accidental prey (P.I < 10%).

The stomach contents of both sexes were combined since no significant difference in the diet was found between them. Schoener's formula (1970) was used to investigate the overlapping of food resource consumed by two length groups, two seasons, two species, as follows:

$$T = 1 - 0.5 \sum_{i=1}^{n} | Pxi - Pyi |$$

where T is the index of overlap, Pxi & Pyi are the proportions (by number) of food item "i", for the groups being compared. When the index of overlap (T) is 0.0 this means that there is no overlap, 1.0 means the same food resources are consumed and higher than 0.6 considered to be significant.

RESULTS

I- *Solea vulgaris*:

General characteristics of the diet

Analysis of stomach content revealed that 28.86% of the samples examined had food. It seems that ***Solea vulgaris*** eats mainly molluscs and crustaceans (Table 1). Results of the relative importance (preponderance index) of different food items showed that molluscs (59.03%) were considered as a preferential prey eaten by this fish species while crustaceans (33.23%) were secondary in importance.

Molluscs were found in 46.5% stomach of the studied fish and made up more than 44.2% of the total food volume. Most molluscs eaten by this fish were belonging to bivalves (53.10%). The bivalve, ***Macoma cumana*** were the dominant species followed by ***Nucula nueleus***, ***Tellina pulchella*** and ***Corbula gibba***. Gastropods occurred in 11.3% of the stomachs investigated, comprised 5.8% of the total food volume and were considered as accidental food (2.48%). Gastropods consisted of: ***Hinia limata, Nassarins gibbosulus, Gibbula magus, Turitella turbona*** and ***T. communis***. On the other hand, decapods being the most important crustaceans eaten by this fish species. Decapods were represented almost entirely by shrimps. Echinodermata (***Echinocyana*** spp.), Foraminefera and ascidian larvae of *Styla* colonies were eaten accidentally and did not represent an important part in the diet of ***S. vulgaris***.

Variations of diet with fish length

Fish samples were grouped into 4 length groups (at 5 cm length intervals) and the preponderance index of each was calculated and represented in Fig.1. This figure showed that, decapods were the most important preferential crustacean prey eaten by this fish for all length groups especially for fish longer than 20cm. Gastropods, bivalves and cehalopods were secondary in importance for all length groups except for16-20cm group where as gastropods and cephalopods were taken accidentally. Cephalopods were absent for length group 21-25cm. It seems that, diet composition varies with fish length. Therefore, molluscs which regarded as preferential prey for smaller fish (≤15 &16-20cm) became secondary in abundance for larger fish (21-25 & 26-30 cm). However,

Table 1: Numerical percentage (N.P), Occurrence index (O.I), Volume index (V.I) and preponderance index (P.I) of different food items found in the stomachs of *Solea vulgaris*, *S. aegyptiaca*, *S. impar* and *S. kleini*.

Food items	*S. vulgaris*				*S. aegyptiaca*			
	N.P	O.I	V.I	P.I	N.P	O.I	V.I	P.I
Foraminefera	3.2	8.5	0.6	0.19	21.9	13.0	0.6	0.16
Annelida						5.2	3.3	0.23
Oligochaeta					0.3	0.9	0.8	0.01
Polychaeta					1.4	4.3	2.5	0.22
Crustacea		28.2	34.1	33.23		85.2	48.0	83.13
Isopoda	1.4	2.8	1.4	0.15	0.6	1.8	0.8	0.03
Amphipoda					7.5	4.4	2.0	0.18
Decapoda	22.4	26.8	32.7	33.08	27.4	89.5	45.2	82.92
Brachurua								
Mollusca		46.5	44.2	59.03		33.0	32.1	12.12
Gastropoda	5.6	11.3	5.8	2.48	13.5	8.7	11.4	2.03
Bivalvia	54.4	39.4	35.7	53.1	15.2	26.1	18.4	9.84
Cephalopoda	1.4	5.6	2.7	0.57	1.1	5.2	2.3	0.25
Echinodermata	11.2	9.9	7.7	2.88	9.1	14.6	10.0	2.99
Ascidiacea	0.4	1.4	0.2	0.01	1.1	3.5	0.1	0.01
Teleostean fertilized ova					0.9	1.7	0.4	0.01
Detritus		7.0	3.7	0.98		13.9	3.4	0.97
Unidentified food		18.3	9.5	6.56		8.7	2.1	0.37
Number of fish examined	246				217			
Number of full stomachs	71				115			
Fullness index (%)	28.86				53.0			

continued

Table 1: continued.

Food items	*S. impar*				*S. kleini*			
	N.P	O.I	V.I	P.I	N.P	O.I	V.I	P.I
Foraminefera	3.4	18.0	0.6	0.22	0.3	6.3	0.1	0.01
Annelida								
Oligochaeta								
Polychaeta								
Crustacea		58.9	54.2	61.76		59.5	13.9	9.64
Isopoda	0.3	1.6	0.1	0.00	16.8	56.3	13.0	9.57
Amphipoda	0.4	3.2	0.4	0.03				
Decapoda	5.2	55.7	53.6	61.73	0.3	6.3	0.9	0.07
Brachurua	0.3	1.6	0.1	0.00				
Mollusca		39.3	41.1	36.82		100.0	56.9	61.83
Gastropoda	2.4	10.2	4.6	0.97	40.6	100.0	37.7	49.28
Bivalvia	83.1	47.5	36.5	35.85	15.7	50.0	19.2	12.55
Cephalopoda								
Echinodermata	2.8	14.8	3.3	1.01	26.3	75.0	29.1	28.52
Ascidiacea	1.8	21.3	0.4	0.18				
Teleostean fertilized ova	0.3	1.6	0.1	0.00				
Detritus		1.6	0.3	0.01				
Unidentified food								
Number of fish examined	79				20			
Number of full stomachs	61				16			
Fullness index (%)	77.21				80.0			

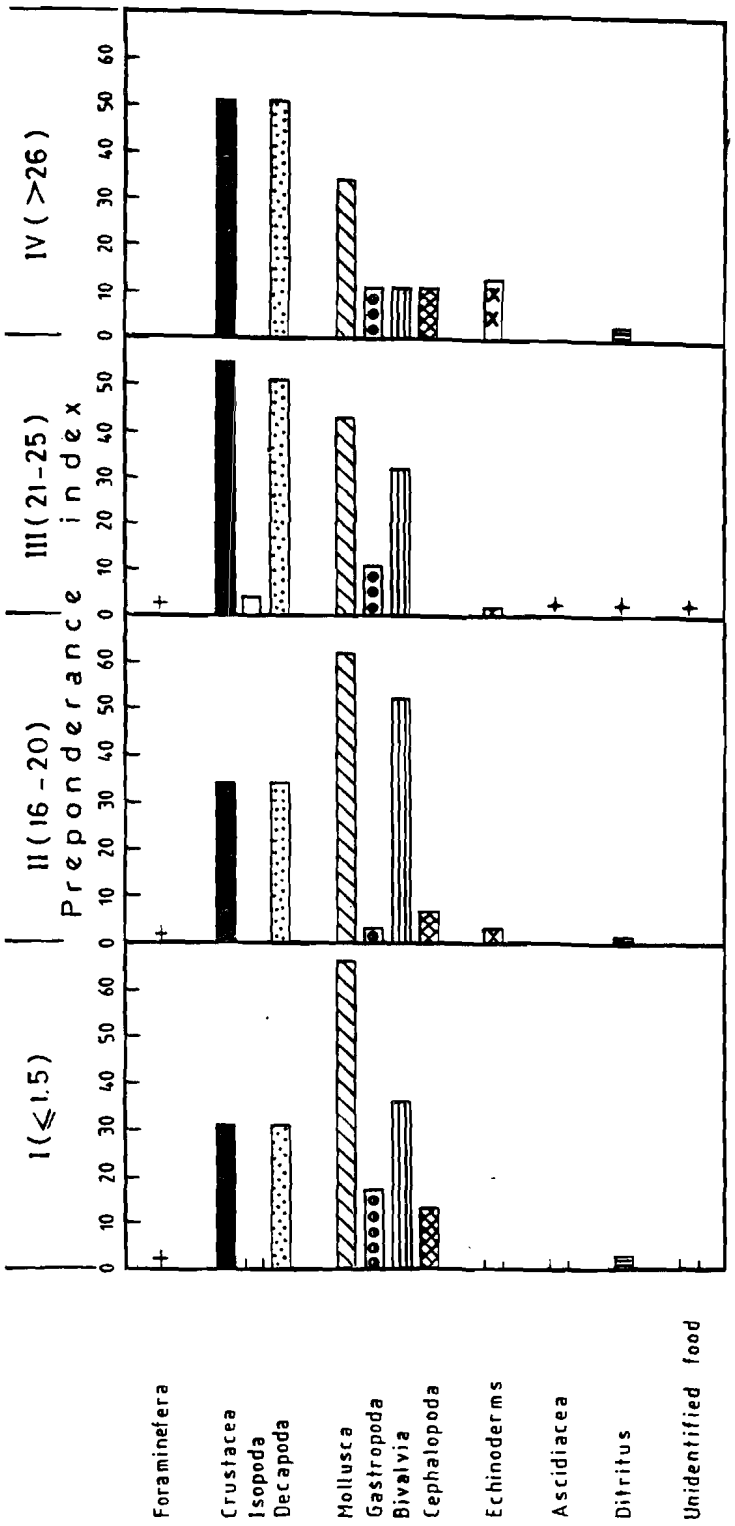

Figure 1. Variations in the diet composition with fish length of ***Solea vulgaris*** from Abu-Kir Bay (food items < 1.0% = +).

a decreasing trend in the consumption of molluscs with the increase in fish length was noted coupled with an opposite trend for crustaceans (Fig.1). So, it can be concluded that as fishes grow in length they take more crustaceans and less molluscs. Echinoderms were not found in stomachs of fish smaller than 15 cm, whereas they found in larger fish, hence they were considered as secondary prey (12.5%) for fish >26 cm and accidental for the smaller length groups. Foraminefera was accidental for all length groups.

Schoener index (Table 2) showed a slight significant dietary overlap between fishes less than 15 cm and fishes longer than 21 cm. No significant dietary overlap exists between fishes of length group (16-20 cm) and ≤15, 21-25 and 26-30 cm. Generally, it can be concluded that ***S. vulgaris*** showed a slightly dietary change as they grow in length.

Variations of fish diet with season

Based on the seasonal variations of feeding of ***S. vulgaris*** (Fig.2), it can be observed that the food of this fish in winter consisted mainly of crustacea (40.1%) and mollusca (47.4%), while in spring and autumn the fish preferred to take mainly decapods (69.3% and 72.0% respectively). In summer, the decapods were taken accidentally (2.2%) and fish fed mainly on bivalves (66.5%). Cephalopods were considered as secondary prey only in spring. Foraminefera and Echinodermata were also taken accidentally during the four seasons. Detritus were shown as secondary in importance only in summer and accidental for other seasons. These results are verified by the values of Schoener index (Table 3) which show slightly dietary overlap among all seasons except for spring and autumn, where the overlap was significant. Seasonal variations of fullness index for ***S. vulgaris*** showed a lowest value in spring (20.69%) and a highest value in winter (32.5%) and summer (31.65%). Thus the feeding intensity increased in winter and summer.

II- *Solea aegyptiaca*:

General characteristics of the diet

Results of investigation showed that 53.0% of fish examined had full stomachs. In terms of relative importance (preponderance index), crustaceans (83.13%) were the preferential group taken by ***Solea aegyptiaca*** (Table 1). They occurred in 85.2% of stomachs and constituted 48.0% of food volume.

Table (2): Schoener indices between different length groups of *Solea vulgaris*, *S. aegyptiaca* and *S. impar*.

Length groups range (cm)		*I*	*II*	*III*	*IV*	*V*
Solea vulgaris						
I	≤ 15	-	0.45	0.81	0.62	
II	16 - 20		-	0.47	0.18	
III	21 - 26			-	0.52	
IV	26 - 30				-	
Solea aegyptiaca						
I	≤ 15	-	0.67	0.61	0.50	0.52
II	16 - 20		-	0.63	0.45	0.59
III	21 - 25			-	0.66	0.50
IV	26 - 30				-	0.47
V	≥ 31					-
Solea impar						
I	≤ 15	-	0.13	0.17		
II	16 - 20		-	0.33		
III	21 - 25			-		

Table (3): Schoener indices between different seasons of *Solea vulgaris*, *S. aegyptiaca* and *S. impar*.

Seasons	*Winter*	*Spring*	*Summer*	*Autumn*
Solea vulgaris				
Winter	-	0.56	0.43	0.55
Spring		-	0.30	0.81
Summer			-	0.28
Autumn				-
Solea aegyptiaca				
Winter	-	0.40	0.47	0.36
Spring		-	0.67	0.25
Summer			-	0.54
Autumn				-
Solea impar				
Winter	-		0.18	0.23
Summer			-	0.89
Autumn				-

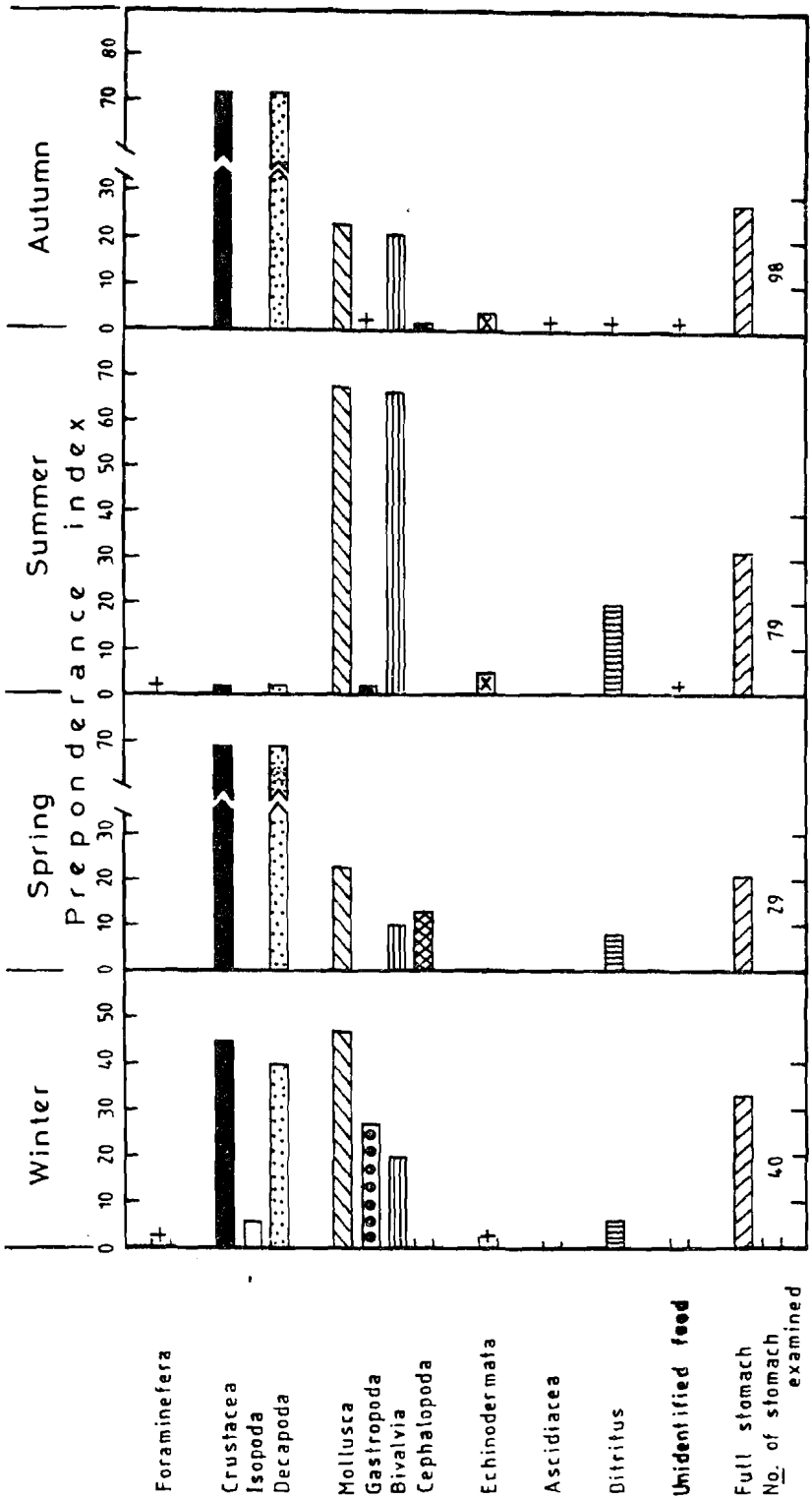

Figure 2: Seasonal variations in the diet composition of *Solea vulgaris* from Abu-Kir Bay (food items < 1.0% = +).

Table (2): Schoener indices between different length groups of *Solea vulgaris*, *S. aegyptiaca* and *S. impar*.

Length groups range (cm)		*I*	*II*	*III*	*IV*	*V*
Solea vulgaris						
I	≤ 15	-	0.45	0.81	0.62	
II	16 - 20		-	0.47	0.18	
III	21 - 26			-	0.52	
IV	26 - 30				-	
Solea aegyptiaca						
I	≤ 15	-	0.67	0.61	0.50	0.52
II	16 - 20		-	0.63	0.45	0.59
III	21 - 25			-	0.66	0.50
IV	26 - 30				-	0.47
V	≥ 31					-
Solea impar						
I	≤ 15	-	0.13	0.17		
II	16 - 20		-	0.33		
III	21 - 25			-		

Table (3): Schoener indices between different seasons of *Solea vulgaris*, *S. aegyptiaca* and *S. impar*.

Seasons	*Winter*	*Spring*	*Summer*	*Autumn*
Solea vulgaris				
Winter	-	0.56	0.43	0.55
Spring		-	0.30	0.81
Summer			-	0.28
Autumn				-
Solea aegyptiaca				
Winter	-	0.40	0.47	0.36
Spring		-	0.67	0.25
Summer			-	0.54
Autumn				-
Solea impar				
Winter	-		0.18	0.23
Summer			-	0.89
Autumn				-

Crustacean prey were represented almost only by decapods (shrimp) and to lesser extent by isopods (***Idotea batica*** and ***Sphaeroma serratum***) and amphipods (Gamaridae and Eupheusiacea).

Molluscs were considered as accidental prey (12.12%). They found in 33.0% of stomachs and comprised about 32.1% of the total food volume. Most molluscs were bivalves (26.1%), gastropods (8.7%) and cephalopods (5.2%). The bivalves found in the diet of ***S. aegyptiaca*** were identified as: ***Leda pella***, ***Macoma cumana***, ***Tellina pulchella*** together with some other unidentified species. Gastropoda was represented by ***Mitra*** spp, ***Hinia limata***, ***Nassarius gibbosulus***, ***Gibbula ardens***, ***G. varia***, ***Gibbula*** **spp.**, ***Bittium reticulatum***, ***Turritella turbona***, ***T. communis*** and ***Turritella*** spp. Cephalopoda were mainly *Sepia* species. Echinodermata was *Echinocyan* sp. (2.99%) which considered accidental prey. They occurred in 14.6% of the stomachs examined and constituted only 10.0% by volume. Foraminefera, annelids, ascidian larvae of *Styela* colonial, fertilized ova of invertebrates, and detritus were also found but considered as accidental prey.

Variations of diet with fish length

The food item spectra based on the preponderance index for the five size groups of ***S. aegyptiaca*** are graphically represented in Figure 3. From the figure, it is obvious that the diet of smaller fish (≤ 15 cm) are consisted almost equally of crustacea (43.9%) and mollusca (45.5%). As the fish grows in length, the preferability of fish to take crustaceans prey increased up to length 30 cm, while molluscs prey decreased. For fish bigger than 31 cm, echinoderms (51.4%) were probably the preferential food item followed by crustaceans (25.1%) and molluscs (16.5%) come next as secondary prey. Foraminefera, oligochaetes, polychaetes, ascidians and teleostean eggs seem to be accidental food items for all length groups.

Values of dietary overlap (calculated by Schoener index) between length groups are represented in Table (2). Generally, the results showed a slightly significant overlap among prey taken by ***S. aegyptiaca*** between all length groups. Therefore, the diet of ***S. aegyptiaca*** changed with increasing fish length.

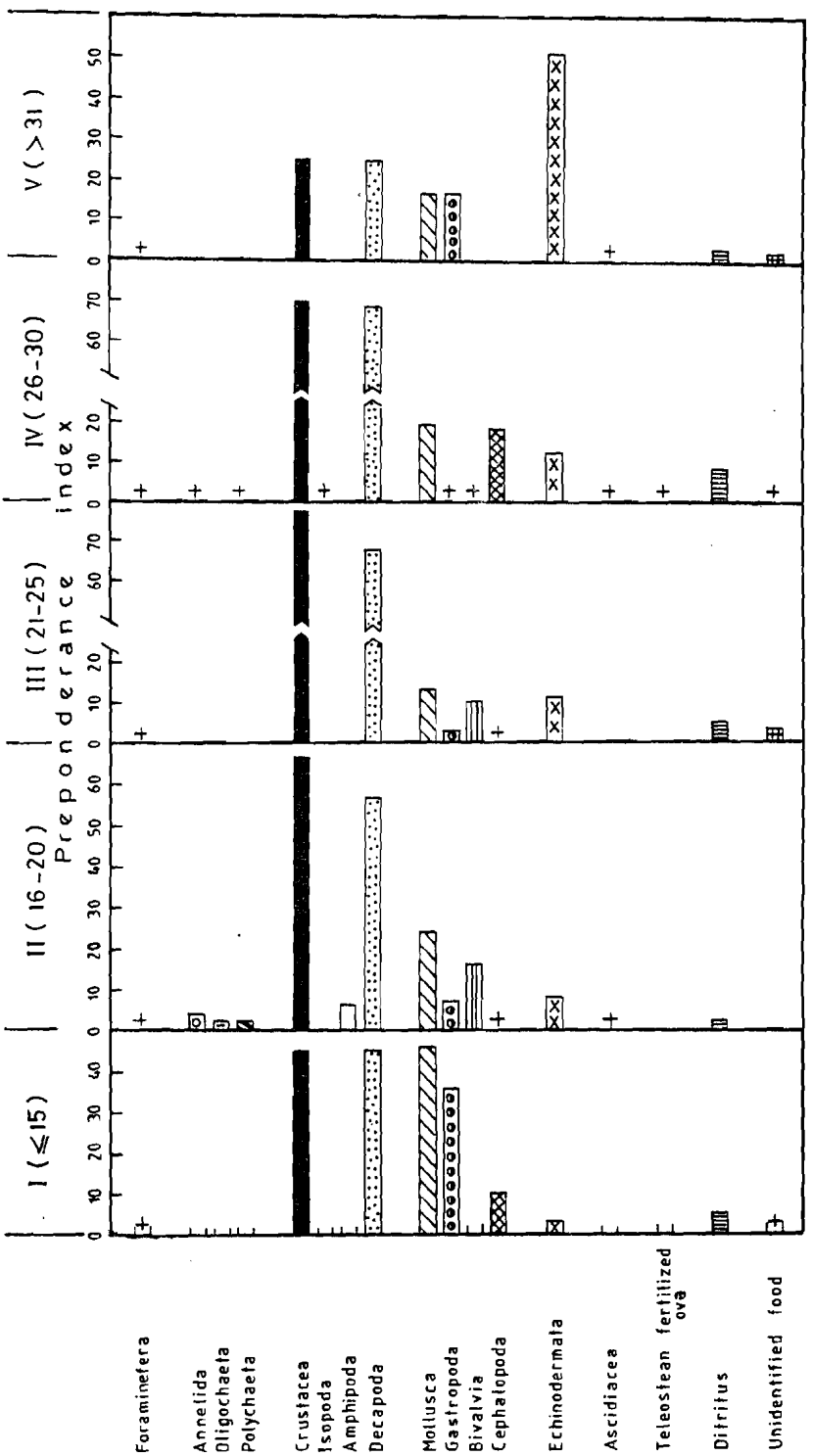

Figure 3: Variations in the diet composition with fish length of ***Solea aegyptiaca*** from Abu-Kir Bay (food items < 1.0% = +).

Variations of fish diet with seasons

The seasonal change in the relative importance (preponderance index) of the diet of ***Solea aegyptiaca*** (Fig.4) showed that decapods were the preferential prey in autumn (77.1%) and winter (77.5%) and were secondary prey in spring (47.6%) and summer (37.0%). Molluscs were accidental in winter (5.3%) and increased during spring till they became the preferential prey in summer (56.2%) and then decreased again in autumn. Most molluscs were represented by bivalves prey in autumn whereas for other seasons, both gastropods and bivalves were present. Echinoderms reached high value in spring (27.8%) but still existed as secondary prey and disappeared from the diet in autumn. Foraminefera, oligochaetes, polychaetes, isopods, ascidians and teleostean fertilized ova showed seasonal variations but of lesser importance and considered as accidental prey.

The dietary overlap among seasons for ***S. aegyptiaca*** as shown in Table 3 revealed a slightly significant value for spring and summer (0.67). The least dietary overlap existed between autumn & winter (0.36) and autumn & spring (0.25), may be due to increased molluscs and echinoderms prey during autumn and spring respectively. So, ***S. aegyptiaca*** change their food with season. The present results showed that the fullness index was lowest in spring (35.9%) and highest in autumn (63.64%). Thus the maximum predator activity over the year was in autumn.

III- ***Solea impar*** :

General characteristics of the diet

The stomachs of 77.21% of specimens analysis had full stomachs. The relative importance of different food items (Table 1) showed that crustaceans (61.76%) were the preferential prey for this species. Decapods occurred in 55.7% of the stomachs examined and constituted 53.6% of the total food volume. Decapods (mainly shrimps) were the most important crustacean prey eaten, while isopods, amphipods and Brachurua (small crabs) were of minor importance. Molluscs (36.82%) came next in importance in the diet of ***S. impar*** and considered as secondary prey. Molluscs were mainly bivalves as they constitute 36.50% of the total food volume. The most important bivalvian prey were ***Tellina pulchella*** and ***Leda pella***, while ***Macoma cumana*** and

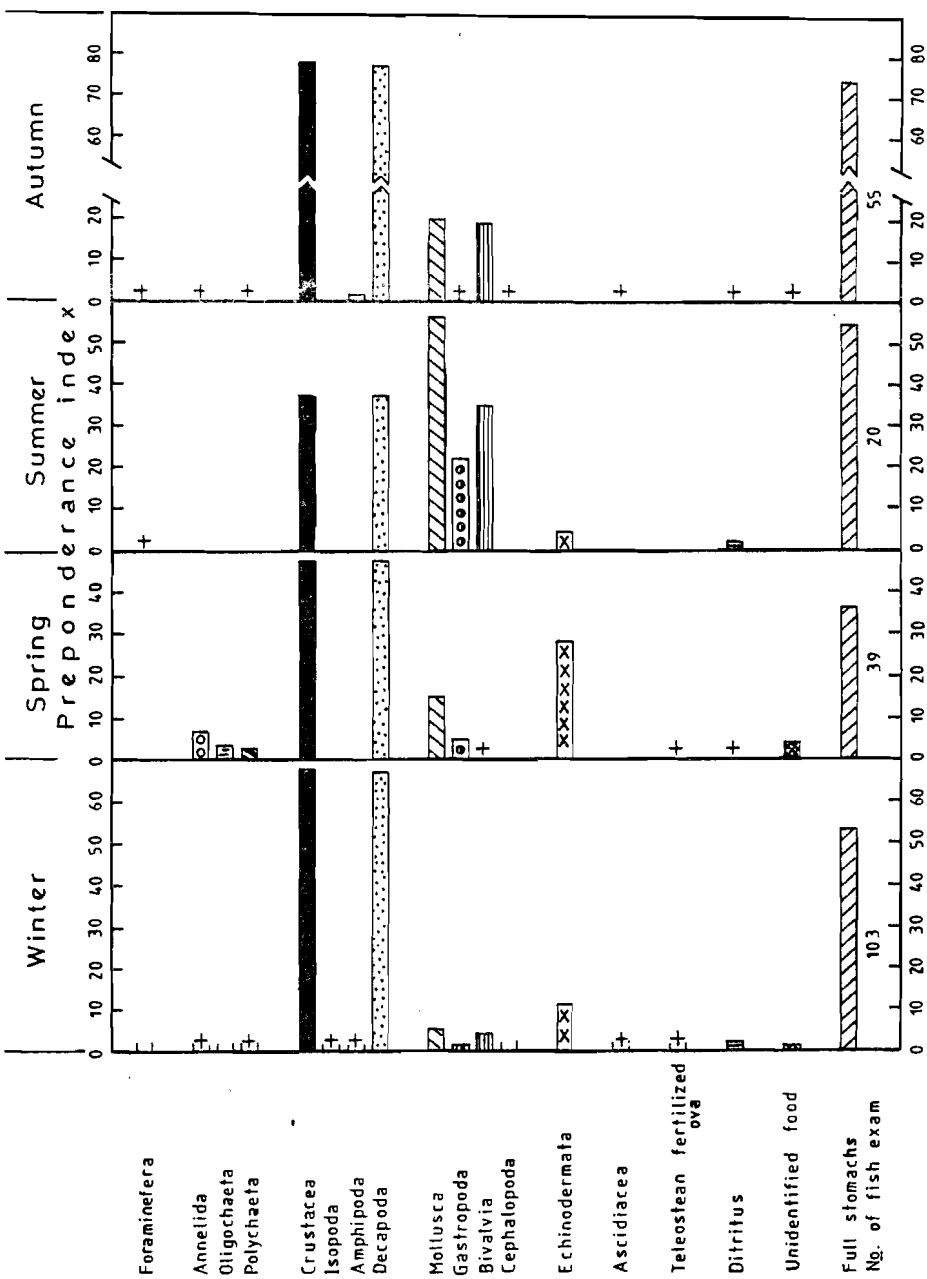

Figure 4: Seasonal variations in the diet composition of *Solea aegyptiaca* from Abu-Kir Bay (food items < 1.0% = +).

Corbula gibba were of less importance. Gastropods were identified as ***Fusinus syracusanus***, ***Naticarius stercus-muscarum***, ***Melanella*** **sp.**, ***Turritella communis***, ***Bittium reticulatum*** and ***Mitra*** spp.

The results showed also that prey other than crustaceans and molluscs were considered accidental.

Variations of diet with fish length

An inspection on the different food items among length groups of ***Solea impar*** (Fig.5) showed that fishes less than 15 cm preferred mainly decapods (97.44%). For other length groups; (16-25cm); the fish still preferred decapods beside molluscs which present as secondary prey. Molluscs which found in the diet of fishes (16-20cm) were mostly bivalves (41.44%) while those for (21-25cm) were mainly of gastropods (31.02%). The other food items observed in the diet of this species were of less importance and considered as accidental prey.

The dietary overlap between different length groups (Table 2), showed that there were slightly dietary overlap between different length groups. Thus, it can be concluded that ***S. impar*** change their feeding habits with increasing length.

Variations of fish diet with seasons

Seasonal variation of the different food items, as calculated by the preponderance index in Fig.6, showed that decapods were the preferential prey eaten by ***S. impar*** during winter (98.98%) and autumn (76.15%). Whereas they considered accidental during summer (8.24%). On the other hand, bivalves were only eaten as a preferred item during summer (90.32%) and considered accidental item during winter. Comparison between spring and other seasons can not be made since in spring only one specimen of ***S. impar*** was available in the catch of ***Solea*** species. The stomach contents of this specimen contained only decapods.

Schoener index on the dietary overlap between three seasons only (winter, summer and autumn) showed a highly significant dietary overlap between summer & autumn and a slightly overlap between winter & summer and autumn & winter (Table 3). This was probably due to the high presence of

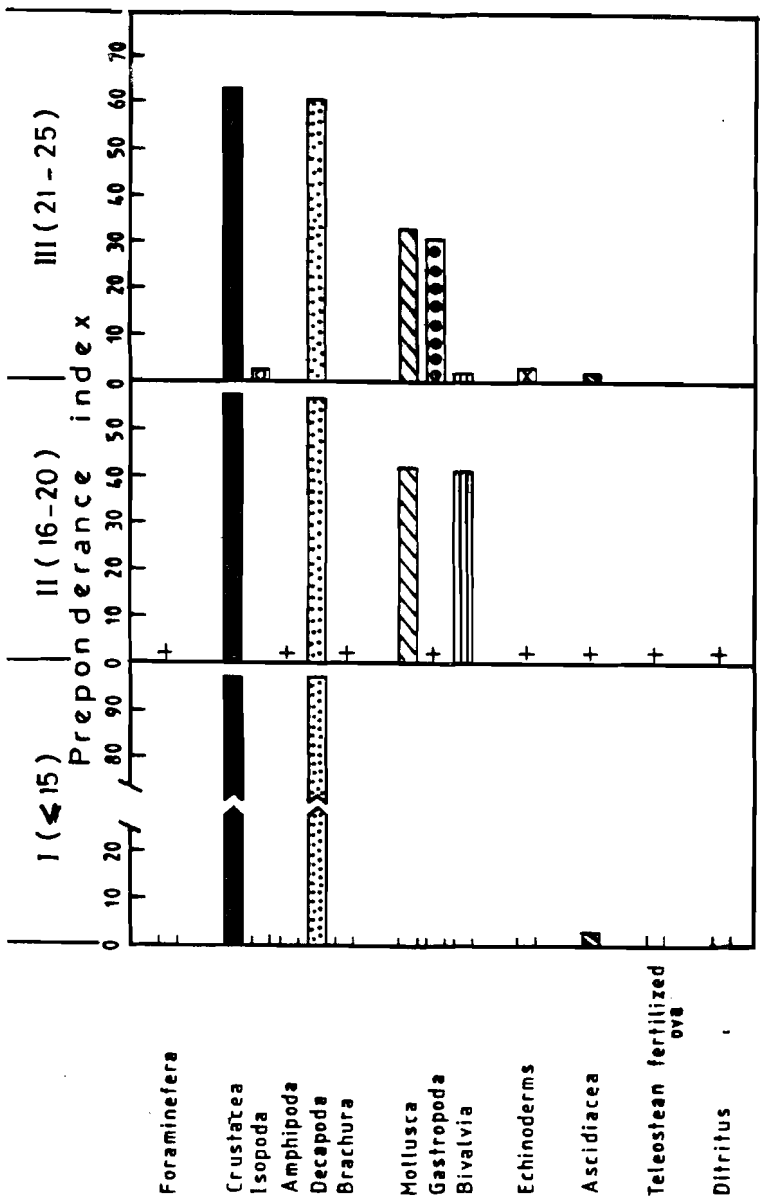

Figure 5: Variations in the diet composition with fish length of ***Solea impar*** from Abu-Kir Bay (food items < 1.0% = +).

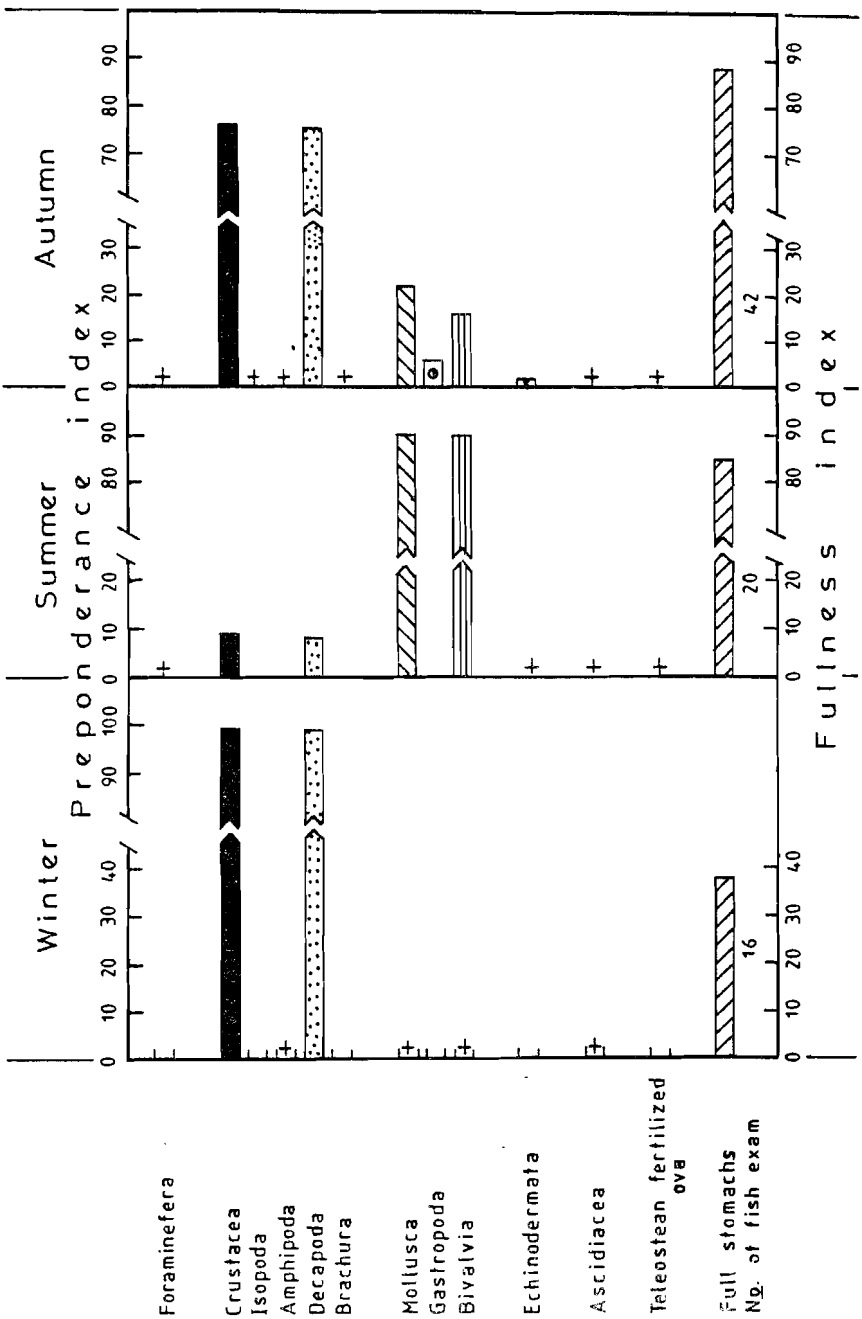

Figure 6: Seasonal variations in the diet composition of ***Solea impar*** from Abu-Kir Bay (food items < 1.0% = +).

decapods prey in winter. Generally, ***S. impar*** change their food from winter to summer while from summer to autumn the food has slightly changed. The fullness index of ***S. impar*** showed a lowest value in winter (37.56%) and a highest values in autumn (88.1%) and in summer (85.0%). Accordingly, summer and autumn considered as the active feeding seasons of this species.

IV- ***Solea kleini*** :

Results have showed that 80.0% of examined stomachs were containing food. The feeding analysis of ***S. kleini*** showed that molluscs (61.83%) were the preferable food item for this fish (Table 1). Gastropods constituted 49.28% of molluscs prey and they identified as ***Gibbula ardens, G. magus, G. varia, Gibbula*** spp, ***Caliostoma granulatum, Hinia limata, Fusinus rostratus, Nassarius gibbosulus, Nassarius*** spp., ***Naticarius stercus-muscarum, Hadriania craticuloides, Melanella*** sp., ***Pusia abenus, Turritella turbona, T. communis, Bittium reticulatum*** and ***Mitra*** sp. Bivalves constitute 12.55% and represented mainly by ***Leda pella, Cerastodeima glaucum, Nucula nucleus, Macoma cumana, Corbula gibba, Cypridine mediterranea, Tellina pulchella*** and other ***Tellina*** spp.

Echinodermata with ***Echinocyana*** spp. considered as a secondary prey (28.52%). Although isopods occurred in 56.3% of stomachs examined, they were regarded as accidental prey (9.57%). Decapods and Foraminefera were also considered as accidental prey.

Unfortunately, variations of diet with fish length and season can not be achieved herein due to the few samples which were collected only during summer and autumn.

V- The dietary overlap among different *Solea* species :

Results of Schoener index on the dietary overlap between ***Solea*** species. (Table 4) showed no significant values exist between ***S. kleini*** and other ***Solea*** species. This is may be due to the preferability of gastropods prey by ***S. kleini*** (Table 1) while other ***Solea*** spp. consumed either bivalves as in ***S. impar*** and ***S. vulgaris*** or crustaceans as in ***S. aegyptiaca***. Also no dietary overlap exists between ***S. impar*** & ***S. aegyptiaca***. This is due to the preferability of bivalves

Table 4: Values of Schoener indices between different *Solea* species.

Species	*S. vulgaris*	*S.aegyptiaca*	*S. impar*	*S. kleini*
S. vulgaris	-	0.58	0.69	0.35
S.aegyptiaca		-	0.31	0.39
S. impar			-	0.22
S. kleini				-

prey by ***S. impar***. A moderate and a slightly significant overlap exist between ***S. vulgaris*** and either ***S. aegyptiaca*** or ***S. impar*** respectively.

DISCUSSION

The present study on the diet analysis for four ***Solea*** species; ***S. vulgaris***, ***S. aegyptiaca***, ***S. impar*** and ***S. kleini***, in Abu-Kir Bay indicate that these fishes feed mainly on a mixture of macroinvertebrates which included crustaceans and molluscs frequently. Results of present study (Table 4) showed no significant dietary overlap or competition between the ***Solea*** species. This food selectivity in ***Solea*** spp. has been demonstrated before for other related flat fishes in other areas (Skalkin, 1959; Tyler,1972; Kislalioglu & Gibson, 1977; Hacunda, 1981; Macdonald & Green, 1986; Collie, 1987; Martell and McClelland, 1994). Moore and Moore (1976) stated that fish selectivity was due to prey availability, not only a function of its presence or absence but also of its size, behaviour and density in exploited habitat. Moreover, predation by each fish species was a selective process, and inter-specific diet differences are related to the morphology of the predator and the behaviour and microhabitat of the prey (Macdonald and Green, 1986).

The present diet analysis on four ***Solea*** species revealed that ***S. vulgaris*** prefer bivalves (mollusca) and decapods (crustacean) as a secondary prey; ***S. aegyptiaca*** prefer mainly decapods, ***S. impar*** prefer decapods and bivalves as a secondary prey and ***S. kleini*** prefer gastropods and echinoderms as a secondary prey.

The only available data on the feeding preference of ***S. vulgaris*** in Abu-Kir Bay was that of El-Gharabawy (1977), who found that molluscs were frequently found in the stomachs of ***S. vulgaris*** followed by polychaetes and crustaceans. Both the present results and that of El-Gharabawy confirmed the importance of molluscs as a principle or preferable prey in the diet of ***S. vulgaris*** in Abu-Kir Bay. The other differences found between the present results and that of El-Gharabawy may be due to the annual hydrographic variations which probably affect the availability of different food items (Pitt, 1973).

Other studies in the Southern North Sea have revealed that polychaetes were the principle components of the diet of ***S. vulgaris*** followed by molluscs and crustaceans (Braber and De Goot, 1973) while Costa (1988) found that the food of this species in Tagus estuary consists primarily of polychaetes followed by crustaceans and molluscs. Moreover, Le Mao (1986) found that the 0-group of ***S. vulgaris*** in the Rance Estuary, France, feed mostly on polychaetes and bivalves. On the other hand, Molinero & Flos (1991) found that the composition of the diets of ***S. solea*** from Ebro Estuary, Spain, consists of crustaceans (54.9%), polychaetes (34.1%) and molluscs (10.9%).

In the present study, the diet of ***S. kleini*** consists mainly of molluscs (61.83%) with gastropods (49.28%) predominant, then echinoderms (28.52%) and crustacea. This result differs from that obtained by Deiana (1986); on the same species inhabiting the Mediterranean Sea (Italy); in the importance of echinoderms as a preferential food followed by molluscs and then crustaceans as a secondary food.

It is well known that ***Solea*** species like other demersal fishes are opportunistic feeders and therefore the differences of food habit noted between the present study and other studies are primarily due to the variations in the available food resources at each habitat (Nikolsky, 1963; Tyler, 1972; Moore and Moore, 1976; Macdonald and Green, 1986).

The present study on variation of diet with fish length for the four ***Solea*** species indicate that ***S. impar*** completely change their feeding habits with the increase in length while ***Solea aegyptiaca*** moderately change their diet with increasing length. ***S. vulgaris*** slightly change their diet with increasing length.

El-Gharabawy (1977) observed that the feeding habits of ***S. vulgaris***, based on the frequency of occurrence, change with fish length. Also, significant differences in the basic diet of ***S. solea*** in Ebro Estuary, Spain, were observed as a function of age (Molinero and Flos, 1991). Variations in the diet with fish length have been reported in other demersal fishes (Powles, 1965; Hacunda, 1981; Martell and McClelland, 1994).

The present study, generally, showed also a relatively seasonal variation in the food consumption for ***S. vulgaris***, ***S. aegyptiaca*** and ***S. impar*** in Abu-Kir Bay. The seasonal variations in the feeding habits of ***S. vulgaris*** have been observed before by El-Gharabawy (1977). Likewise other ***Solea*** species in other areas i.e., ***S. kleini*** (Deiana, 1986), ***S. solea*** (Molinero and Flos, 1992) showed also seasonal differences in the feeding habits.

The highest feeding activity of ***S. vulgaris*** was found in winter and summer; ***S. impar*** in summer and autumn and ***S. aegyptiaca*** in autumn only. It could be mentioned herein that the spawning season of ***S. vulgaris*** in Abu-Kir Bay occurs during winter (El-Gharabawy, 1977), ***S. aegyptiaca*** in late autumn and winter while that of ***S. impar*** in spring and summer with a peak in May (Whitehead ***et al.***, 1986). Therefore, the feeding activity of these species during the spawning season reflecting the dependence of their diet on prey availability. These findings are in agreement with that obtained before by El-Gharabawy (1977), Deiana (1986) and Molinero and Flos (1992).

ACKNOWLEDGMENTS

The author would like to express her gratitude to Dr. M. M. El-Gharabawy and Mrs. H. H. Aly who provided me with the most specimens used during this study. Also, my thanks to Dr. M. El-Komi for his help during the identification of invertebrate.

REFERENCES

Al-Kholy, A. A. and S. K. El-Wakeel, 1975. Fisheries of the South-Eastern Mediterranean Sea along the Egyptian coast. Soviet-Egyptian Expedition 1970-1971. B. Inst. Ocean. & Fish. ARE. 5. 168-249.

Braber, L. and S. S. De Goot, 1973. The food of five flat fish species (Pleuronectiformes) in the Southern North Sea. Neth. J. Sea Res. 6: 163-172.

Collie, J. S., 1987. Food selection by yellow flounder (***Limanda ferruginea***) on Georges Bank. Can. J. Fish. Aquat. Sci. 44: 347- 367.

Costa, M. J., 1988. Feeding ecology of fish in the Tagus estuary (Portugal). Cybium, 12(4): 301-320.

Deiana, A. M., 1986. A study on food preferences in ***Solea kleini*** BP., 1933 (Osteichthyes Pleuronectiformes). OEBALIA, vol. XIII, N.S.: 27-32.

El-Gharabawy, M. M., 1977. Biological studies on soles in the region of Abu-Kir Bay. M.Sc Thesis, Faculty of Science, Alexandria University, 163pp.

El-Gharabawy, M. M., 1991. Identification of five sole species from the Egyptian Mediterranean waters by isoelectric focusing. Assiut - J. of Aquacult. Sci., Egypt, 22 (1): 49-64.

Fischer, W.; M. L. Bauchot, et M. Schneider (redacteurs), 1987. FAO d'identification des especes pour les besions de la pêche (Revision I). Mediterranée et Mer Noir. Zone de Pêche 37. Rome, FAO, 2: 261-1530.

Hacunda, J. S., 1981. Trophic relationships among demersal fishes in a coastal area of the Gulf of Maine. Fish. Bull., 79: 775-788.

Kislalioglu, K. and R. N. Gibson, 1977. The feeding relationship of shallow water fishes in a Scottish Sea loch. J. Fish Biol., 11: 257-266.

Le Mao, P., 1986. Feeding relationships between the benthic fauna and the dominant benthic fish of the Rance Estuary (France). J. Mar. Biol. Ass. UK. 66: 391-401.

Macdonald, J. S. and R. H. Green, 1986. Food resource utilization by five species of benthic feeding fish in Passamaquoddy Bay, New Brunswick. Can. J. Fish. Aquat. Sci., 43: 1534-1546.

Martell, D. J. and G. McClelland, 1994. Diets of sympatric flat fishes, ***Hippoglossoides platessoides, Pleuronectes ferrugineu Pleuronectes americanus***, from Sable Island Bank. Canada. J. Fish Biol., : 821-848.

Molinero, A. and R. Flos, 1991. Influence of sex and age on the feeding habits of the common sole ***Solea solea***. Mar. Biol. (Berlin) 111(3): 493-502.

Molinero, A. and R. Flos, 1992. Influence of season on the feeding habits of the common sole ***Solea solea***. Ibid, 113, (3): 499-507.

Moore, J. W. and I. A. Moore, 1976. The basis of food selection in flounders (***Platichthys flesus***) in the Severn estuary. J. Fish Biol. 9: 139-156.

Natrajan, A. V. and A. G. Jhingran, 1961. Index of preponderance; A- Method of grading the food elements in the stomach analysis of fishes. Indian J. Fish, 8: 54-59.

Nikolsky, G. V., 1963. The ecology of fishes. Academic press, London, New York, 352pp.

Pitt, T. K., 1973. Food of American plaice (***Hippglossoides platessoides***) from the Grand Bank, Newfoundland. J. Fish. Res. Board Can. 30: 1261-1273.

Powles, P. M., 1965. Life history and ecology of American plaice (***Hippoglossoides platessoides*** F.) in the Magdalen Shallows. Ibid, 22: 565-598.

Riedl, R., 1970. Fauna und Flora der Adria. Verlag Paul Parey, Hamburg und Berlin, 702pp.

Schoener, T., 1970. Non-synchronous spatial overlap of lizards in patchy habitats. Ecology, 51: 408-418.

Skalkin, V. A., 1959. Food and food interrelationships of flounders of the Il'insk Bank. Fish. Res. Board Can. Translation Series 789.

Tyler, A. V., 1972. Food resource division among northern, marine, demersal fishes. J. Fish. Res. Bd. Canada 29: 997-1003.

Whitehead, P. J. P.; M. -L Bauchot; J. C. Hureau; J. Nielsen and E. Tortonèse, 1986. Fishes of the North- eastern Atlantic and Mediterranean. UNESCO vol. III: 1308-1324.