Evaluation of the environment of the Shatt Al-Arab estuary and Iraqi marine waters using the Estuarine Biological Integrity Index (EBI)

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Abstract

A total of 9772 fish specimens were collected, including 91 species of bony fishes in the Shatt Al-Arab estuary and Iraqi marine waters, belonging to 72 genera and representing 48 families from January 2018 to December 2018 in three selected stations. The Estuarine Biological Integrity Index (EBI) was calculated in the current study through 13 units that included species richness units, fish community composition, and trophic guild units. The total Estuarine Biological Integrity Index (EBI) value reached 48.5, 55.9, and 57.4 for the three study stations. It was included in the impaired and marginally impaired evaluation in the different months within the study stations. The highest value of the index reached 71.42 in July at the Iraqi marine waters. It is evaluated as the marginally impaired category, and its lowest value was 41.47 in March at the Shatt Al-Arab estuary where it is assessed as the impaired category. The average total index value reached 55.61 and it is evaluated as in the impaired evaluation.

Keywords: EBI, Fish, Shatt Al-Arab estuary, Iraqi Marine waters.

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Introduction

Fish wealth is one of the sustainable natural resources that can renew itself through natural reproduction processes if adequately exploited, naturally fish stocks change due to factors such as temperature, salinity, and human activities, fishing effort is the most influential factor in fish stocks, the deterioration of fish stocks affects development and limits the benefits of fish wealth (FAO, 2009). Assessing the state of the environment by estimating fish stocks is one of the indispensable foundations for protecting fish products and exploiting them properly, which ensures their renewal. This is the correct way to manage fish stocks (Qasim, 2014). The seas are an essential source of protein food, including fish, as they consume approximately 20% of the world's population (Al-Mansi, 1999). Environmental assessment studies, including fish stock assessment studies, took an important turn in the early eighties of the last century in various countries of the world, mainly tropical and subtropical regions, to estimate growth rates and fishing effort as an alternative method to using bone parts to estimate the ages of the fishes (Branch *et al.*, 2011). Al-Khafaji (2016) confirmed that environmental factors, in addition to periodic and recurring changes the night and day, and the phenomenon of tides in the seas, which are linked to the lunar cycle, play an essential role in daily fish activity, fish-feeding behavior, fish seasonal migration, fish reproduction, and other behavioral activities.

Many studies in the world have been conducted on fish, especially in estuary and coastal areas. These areas provide nursery areas where young fish resort for protection from predators and feeding, as fish go there to benefit from the available food resources (Claridge *et al.,* 1986).

The importance of Iraqi marine waters is highlighted as they are a nursery, reproduction, and feeding area for many marine and estuary fishes, and their high primary productivity is due to the freshwater coming from the Shatt Al-Arab River (Hussain and Ahmed, 1995). Therefore, the current study aimed to evaluate this area environmentally using the Estuarine Biological Index (EBI) based on the fish composition applied to the area for the first time using standards specific to the Shatt Al-Arab estuary and Iraqi marine waters.

Description of the study area

The Iraqi marine waters are located in the northwestern end of the Arabian Gulf, and their high primary productivity enhances this feature, as they receive fresh water loaded with nutrients from the Shatt Al-Arab River (Hussain and Ahmed, 1995). Three stations were selected for the study in the Shatt Al-Arab estuary and Iraqi marine waters. The first station represents the Shatt Al-Arab estuary 29° 54' 15.93": N; 48° 41' 15.62": E, 29° 54' 15.84": N; 48° 37' 24.24": E, 29° 50' 44.04": N; 48° 41' 15.51": E :"44.12 '50 °29 N; 48° 37' 24.38": E.

This station is the most affected by the Shatt Al-Arab River discharge, and the marine channel entering the Shatt Al-Arab passes through it 29°50'17.98"N; 48°43'53.28"E، 29°50'17.86"N; 48°49'43.87"E, 29°46'48.85"N; 48°43'53.16"E"48.99'46°29 N; 48°49'43.90"E, which has a depth of 15 m (Mohamed *et al.* 2001), while the second station includes the part separating the influence of the Shatt Al-Arab at the open marine waters 29°43'33.41"N; 48°43'43.46"E ، 29°43'33.38"N; 48°49'34.85"E; 29°40'04.13"N; 48°43'43.39"E"04.02'40°29 N; 48°49'34.96"E.

This area is characterized by steady environmental properties at depths from 4 m to 10 m and the bottom has some grooves at depths of up to 20 m. It is considered a transitional area between the Shatt Al-Arab and marine waters. This station is characterized by the spread of medium and small fishing boats (wooden and fiberglass boats), as bottom trawl nets are used by large wooden boats and gill nets drift by small fiberglass boats. The third station represents marine waters; this station is characterized by great depths ranging from 10-20 meters. This area is characterized by the presence of fishing boats, large commercial ships, oil tankers, and some trenches with a rocky bottom. Its blue color and high transparency character of the water. These conditions have allowed the formation of some coral reefs (Jawad *et al.*, 2018) (Fig. 1), the map was made using the GIS V 10 program.

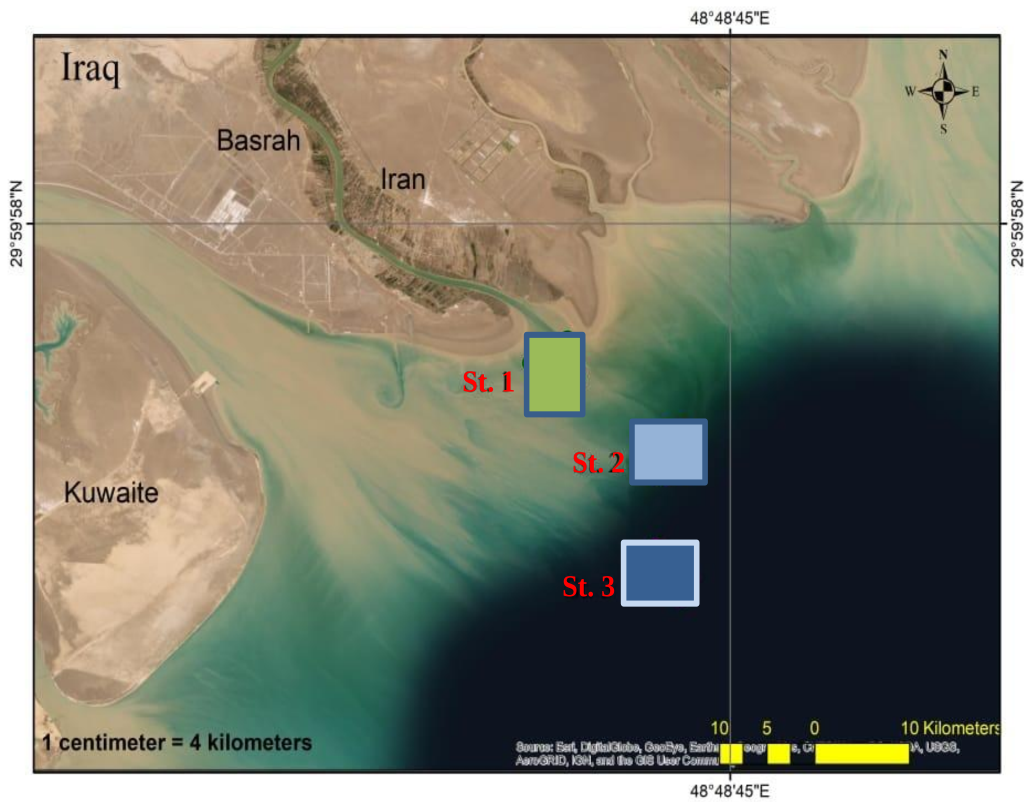

Figure 1: Represents the selected study stations in the Iraqi marine waters and the Shatt Al-Arab estuary.

Materials and methods

The fish were collected on a wood fishing boat (Anwar 2), which is 16 m long and 3.5 m wide and has a horsepower of 150 hp. Its fishing speed is 2.5 knots, using a bottom trawl net with a vertical rope length of 16 m and a ground rope length of 18 m, the size of the net holes at the ends (5x5) cm and at the bag (3x3) cm, the length of the net pulling rope ranges between 75-100 m through regular monthly field trips for the period from January to December 2018, the time to pulling period of the net in the water takes three hours and each sea trip takes 6-4 days, the relative abundance of each species of fish was calculated after each fishing operation according to the equation used by Odum (1970) as follows:

Relative abundance (%) = (ni/N) 100
Where ni = number of individuals of the species in the monthly sample.
N = total number of individuals in the monthly sample.
The value of the diversity index was calculated from the equation by Shannon and Weaver .(1949)
$H=-\Sigma\ pi\ \ln pi$
Where:
H = diversity index
Pi = the proportion of individuals of each species in the catch sample
ln = the natural logarithm

Fish eggs and larvae samples were collected monthly using planktonic nets with a circular upper opening of 50 cm diameter, a cone length of 1.25 m, and a mesh size of 100 microns at a speed of 0.5 m/s for 10 minutes, A general oceanic flow meter was fixed in the middle of the distance between the center of the upper net opening and the edge of the ring to estimate the volume of water filtered through the planktonic net. Samples were collected using the oblique pulling method so that the net was lowered from one side of the boat and tied to the net with a weight weighing 10 kg under the net frame.

Then, the pulling begins near the bottom of the surface, and the difference between the flow meter readings before and after the pulling process is recorded to calculate the amount of water entering the net. After the pulling period ends, the net is pulled to the surface directly. The net is washed from the outside to ensure that planktonic organisms and small larvae do not stick to the net fabric; then, Samples are placed in a one-litre plastic bottle and preserved in a 10% formalin solution. Fish were classified according to their species based on Kuronuma and Abe (1986), Fischer and Bianchi (1984), Carpenter *et al.* (1997), and verified according to Froese and Pauly (2024). Fish eggs and larvae were classified according to (Nellen and Sohnack, 1974, Smith and Richardson, 1977; and Robinson *et al.,* 1996).

Estuarine Biological Integrity Index (EBI)

Thirteen parameters were used to calculate the Estuarine Biological Integrity Index (EBI) were selected based on Deegan *et al.* (1997) from the following major group species richness units, fish community composition units, and trophic guilds units to assess the Iraqi marine water and Shatt Al-Arab estuary, northwest Arabian Gulf. The EBI value was calculated based on the method described by Minss *et al.* (1994).

Results

Thirteen units were applied to calculate the Estuarine Biological Integrity Index (EBI) as follows:

A- Species richness units

1- Total number of species

A total number of species was 91 and species were recorded from all stations. The third station recorded the largest number of species (86), equivalent to 94.4% of the total number of species. The smallest number of species was (58) in station one, which is comparable to (64.4%) of the total number of species in the first station (Fig. 2). The results of the t-test showed significant differences (P<0.05) in the number of species caught between the months and stations of the study.

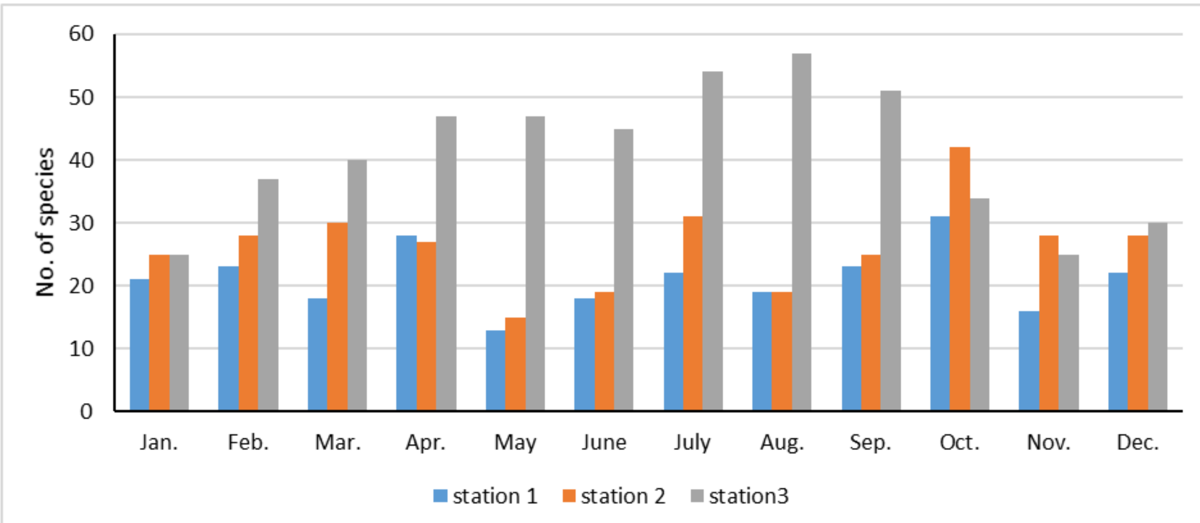

Figure 2: Monthly changes in the total number of species at the three study stations during the sampling period from January 2018 to December 2018

2- Total number of fish larvae

A total of 1154 larvae were collected belonging to nine fish families, namely Clupeidae, Cynoglossidae, Bothidae, Engraulidae, Gobiidae, Polynemidea, Scianidae, Soleidae, and Syngnathidae. The largest number of larvae (85) was obtained in April at the third station, while no larvae were obtained at the three stations during January, February, and December (Fig. 3). The statistical test (t-test) results showed no significant differences (P< 0.05) in the total number of fish larvae at the three stations.

3- The number of fish species that appeared at all stages of life

This unit included (21) species, equivalent to 23.3% of the total species (Table 1). The largest number of species from this group was obtained at the second station in October, reaching (14) species and the lowest occurrence was four species in May at the second station (Fig. 4). The statistical test (t-test) results showed no significant differences (P<0.05) in the total number of species that appeared at all stages of life at the three stations.

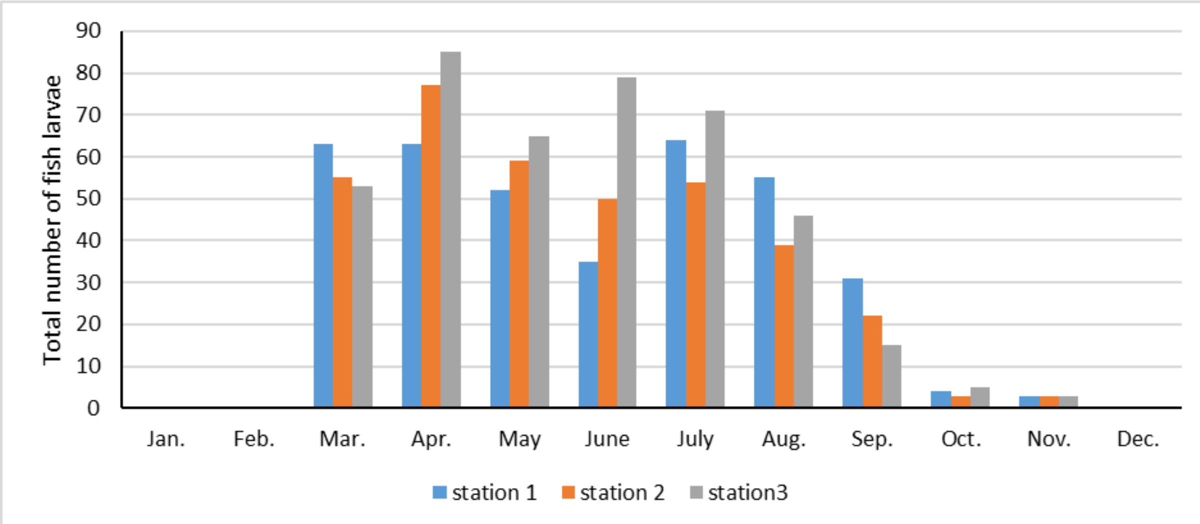

Figure 3: Monthly changes in the total number of larvae at the three study stations during the sample collection period

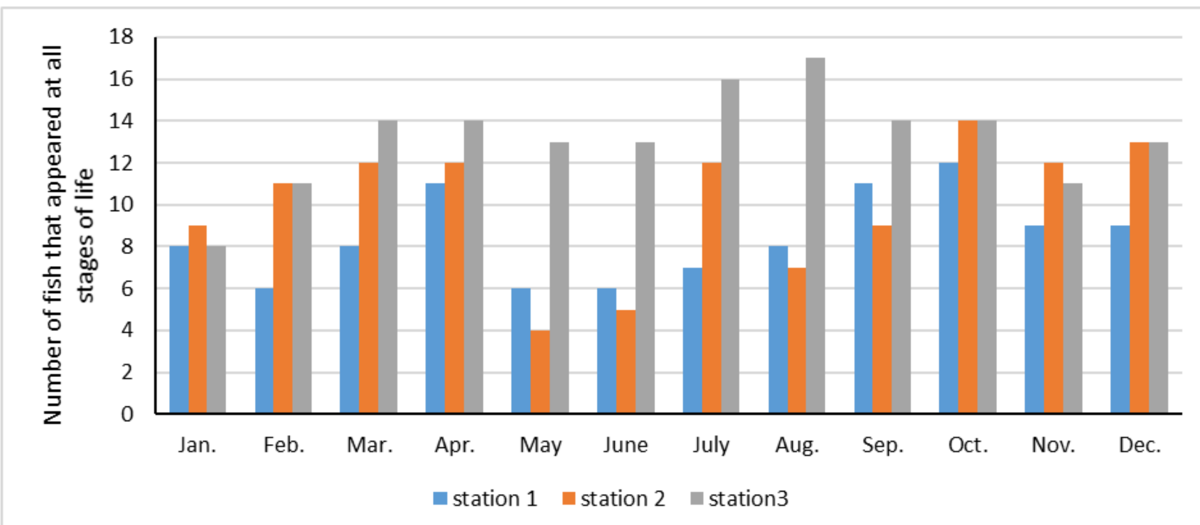

Figure 4: Monthly changes in the number of fish species that appeared at all life stages at the three study stations.

4- Number of coastal marine species

This unit included (13) species (Table 1), equivalent to 14.4% of the total number of species. The largest number of species was eight in October at the second station, while the lowest occurrence of this group was in July, with one species at the first station (Fig. 5). The statistical test (t-test) results showed no significant differences ($P< 0.05$) in the total number of coastal marine species at the three stations.

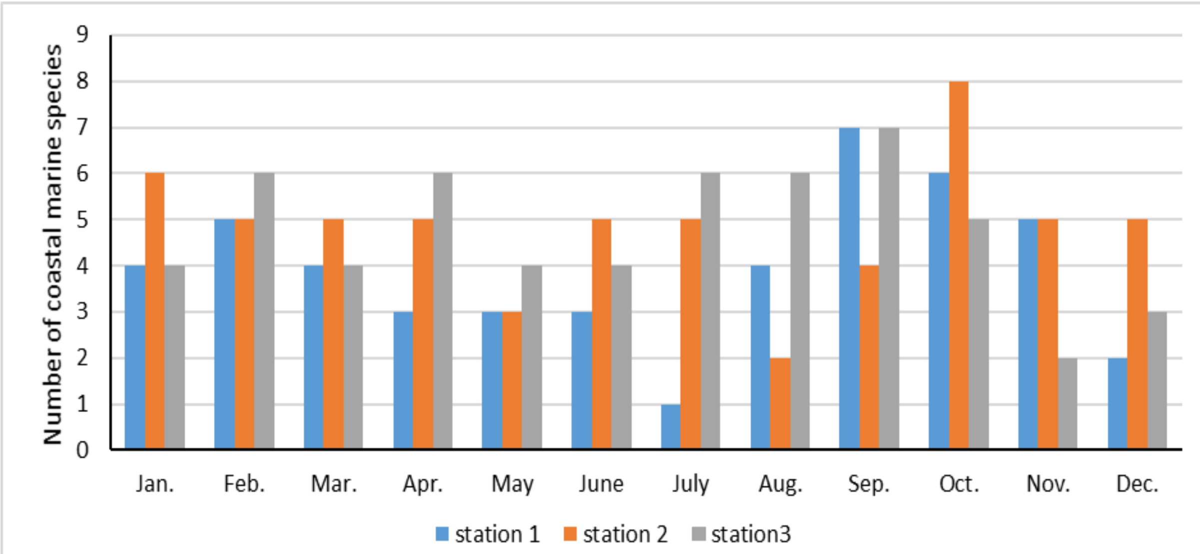

Figure 5: Monthly changes in the number of coastal marine species at the three study stations during the sampling period from January 2018 to December 2018.

5-Number of resident species

This unit included (23) species (Table 1). The number of resident species was 7, 9, and 22 species in the three study stations, respectively. The highest occurrence of these species was 22 in June, July, and August in the third station. The lowest occurrence of species in this unit was in May, (4) in the first station (Fig. 6). The statistical test (t-test) results showed a significant difference ($P < 0.05$) in the total number of resident species at the three stations.

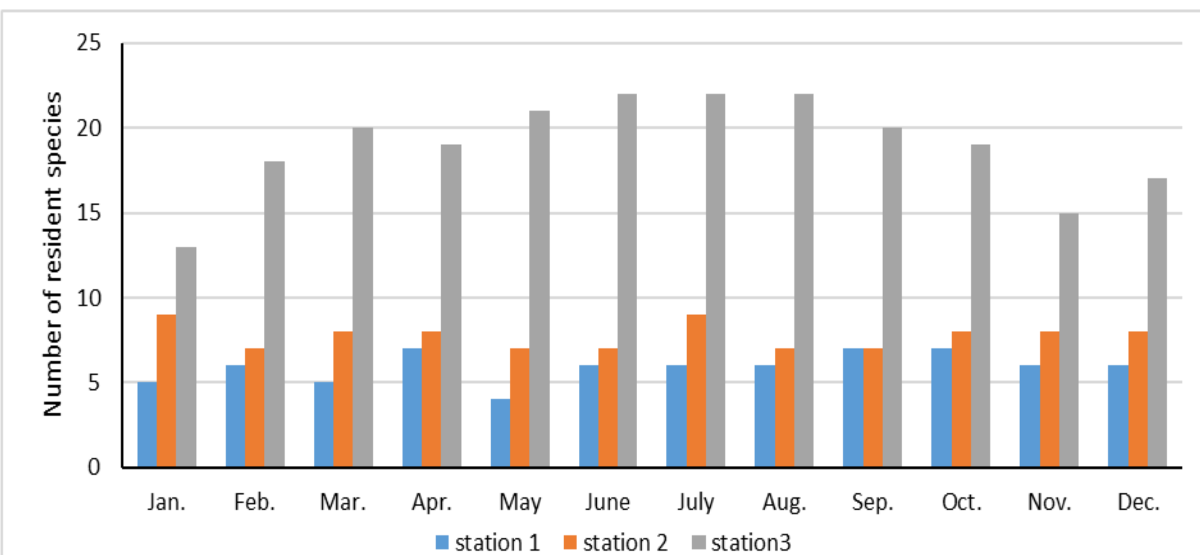

Figure 6: Monthly changes in the number of resident species at the three study stations during the sample collection period.

6- Number of dominant species

This unit included 17 species, equivalent to 18.68% of the species, and the number of dominant species reached (7, 8, and 15) in the three study stations, respectively. The maximum number of dominant species reached (15) species in March, June, July,August, and September, and their lowest appearance (4) in May in the first station(Fig.7). The statistical test (t-test) results showed significant differences ($P< 0.05$) in the total number of dominant species at the three stations.

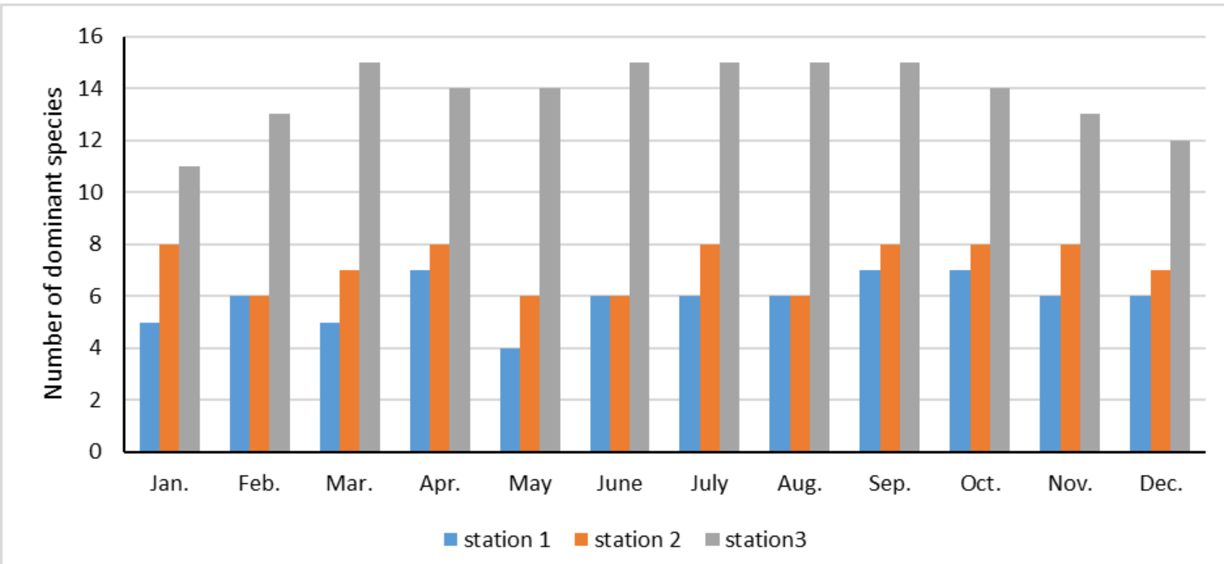

Figure 7: Monthly changes in the number of dominant species at the three study stations during the sampling period from January 2018 to December 2018.

B- Fish community composition units:

7- Percentage of resident individuals

The total number of resident species that were caught was 6057 individuals, equivalent to 61.9% of the total number of caught individuals, and five species formed: *Johnius belangeri, Photopectoralis bindus, Cynoglossus arel, Thrissina whiteheadi,* and *Brachirus orientalis* 10.98 % of the total fish individuals, the maximum percentage of resident individuals was (90.2)% in November at the third station, while it reached to lowest in February 26.8% at the first station, out of the total number of individuals caught from that month (Fig. 8). The statistical test (t-test) results showed significant differences ($P< 0.05$) in the percentage of resident individuals at the three stations.

8- Percentage of dominant specific individuals

The highest percentage of dominant individuals was obtained in November 88.7% of the total number of dominant individuals at the third station. The lowest number was obtained in

September (30), equivalent to 17.1 % of the fish caught at the first station. The results of the statistical test (t-test) showed significant differences (P<0.05) in the percentage of dominant specific individuals in the three stations and months (Fig. 9).

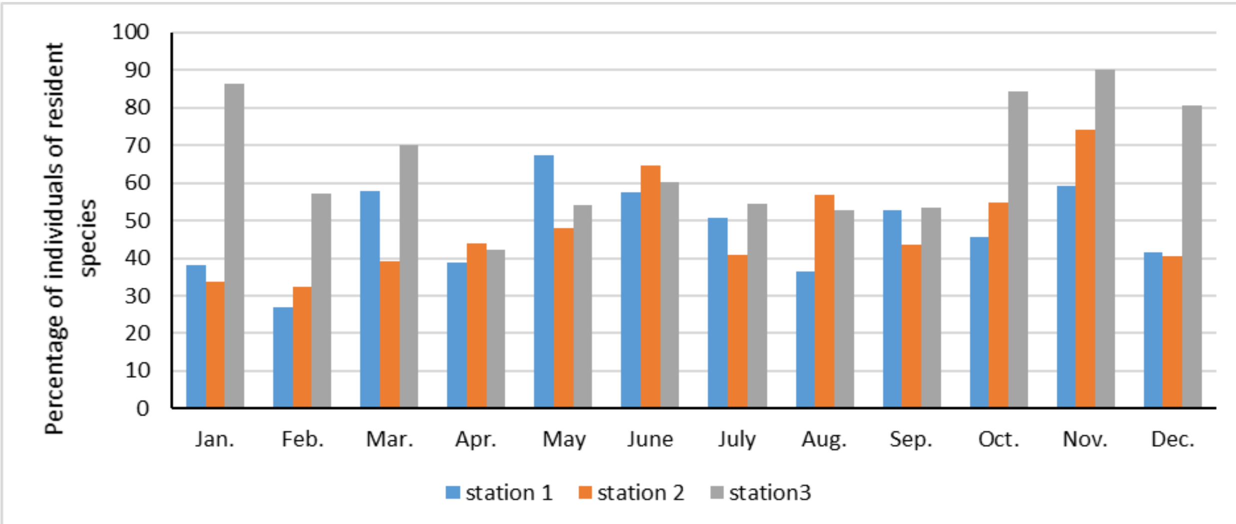

Figure 8: Monthly changes in the percentage of individuals of resident species at the stations.

9- Diversity Index

The total value of the diversity index for the three stations was 2.45, 2.62, and 2.89 respectively, and the values of the index varied clearly during the study period. The maximum value of the index was in August (3.3) in the third station, while its lowest value was in May (1.7) in the first station (Fig. 10). The results of the statistical test (t-test) showed significant differences (P<0.05) in the diversity index value in the three stations and months.

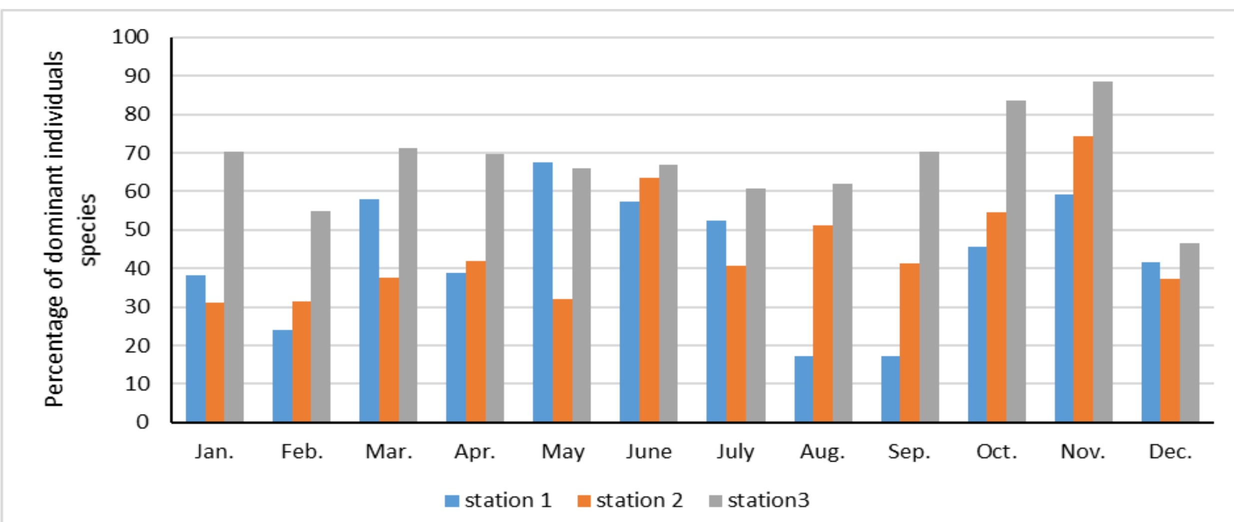

Figure 9: Monthly changes in the percentage of individuals of the dominant species at the stations.

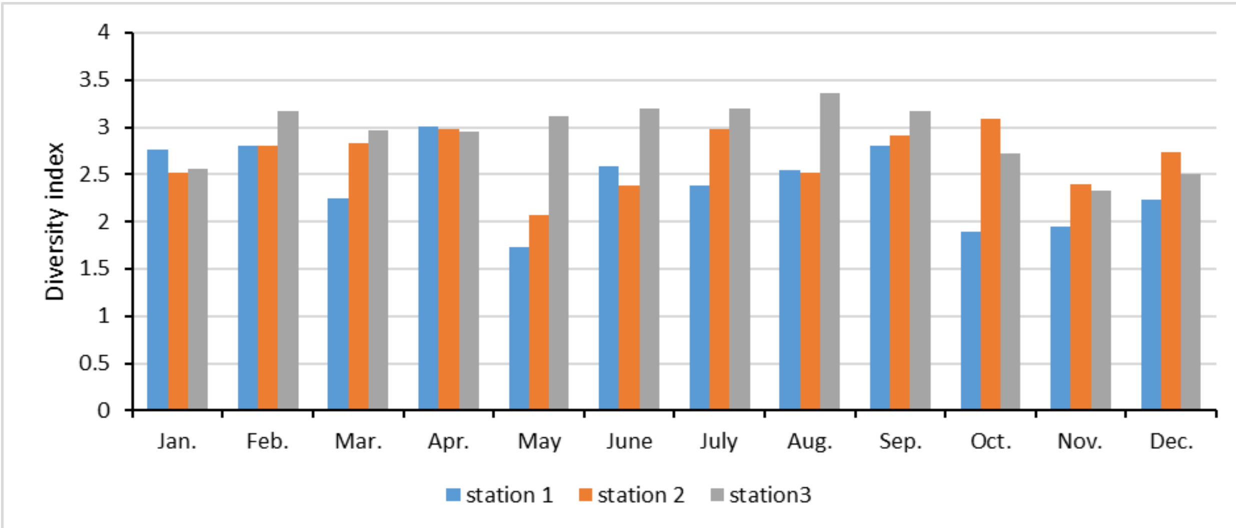

Figure 10: Monthly changes in the diversity index at the three study stations during the sampling period from January 2018 to December 2018.

C-Trophic guilds units:

10- Percentage of individuals of omnivore species

This group included 14 species, equivalent to (15.3) % of the total number of species; the omnivores include *Tenualosa ilisha, Sardinella albella, Pampus argenteus, Cynoglossus arel, Alepes djedaba, Plotosus lineatus, Trypauchen vagina, Photopectoralis bindus, Pamacanthus maculosus, Cynoglossus kopsii Crenidens crenidens, Oreochromis aureus, Oreochromis niloticus, Scomberoides commersonnianus* (Table 1). Eight species were recorded in the first and second stations, and 12 species were recorded in the third stations. The total number of mixed-feeding fish caught during the study period was 2661 individuals. The third station had the highest percentage of omnivorse fish (66.4%) during December. The lowest rate was in the first station (12.5%) during May and November in the first station (Fig. 11). The statistical test (t-test) results showed significant differences (P< 0.05) in the percentage of omnivore species at the three stations.

11- Percentage of carnivore's individuals

This group included 68 species (Table 1), equivalent to 74.70% of the total species: 39 species were recorded in the first station, 49 in the second station, and 57 in the third station. The total number of fish individuals caught in this group was 5757 fish. The highest percentage of carnivorous fish (87.1%) was obtained in March in the third station, and the lowest percentage (20.9%) in March in the first station (Fig. 12). The statistical test (t-test) results showed significant differences (P< 0.05) in the percentage of carnivorous species at the three stations.

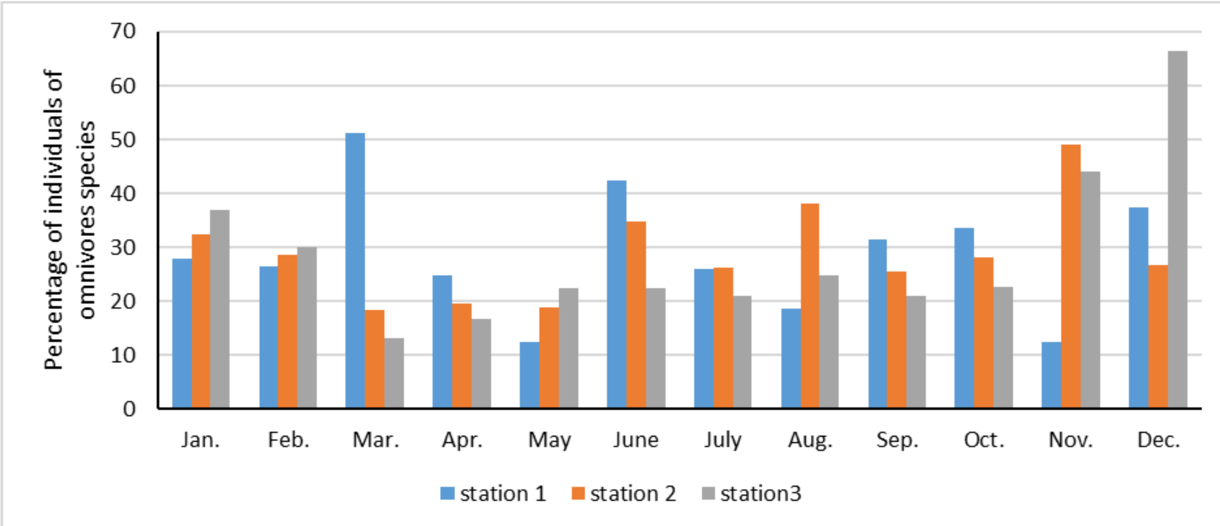

Figure 11: Monthly changes in the percentage of omnivore individuals at the three study stations.

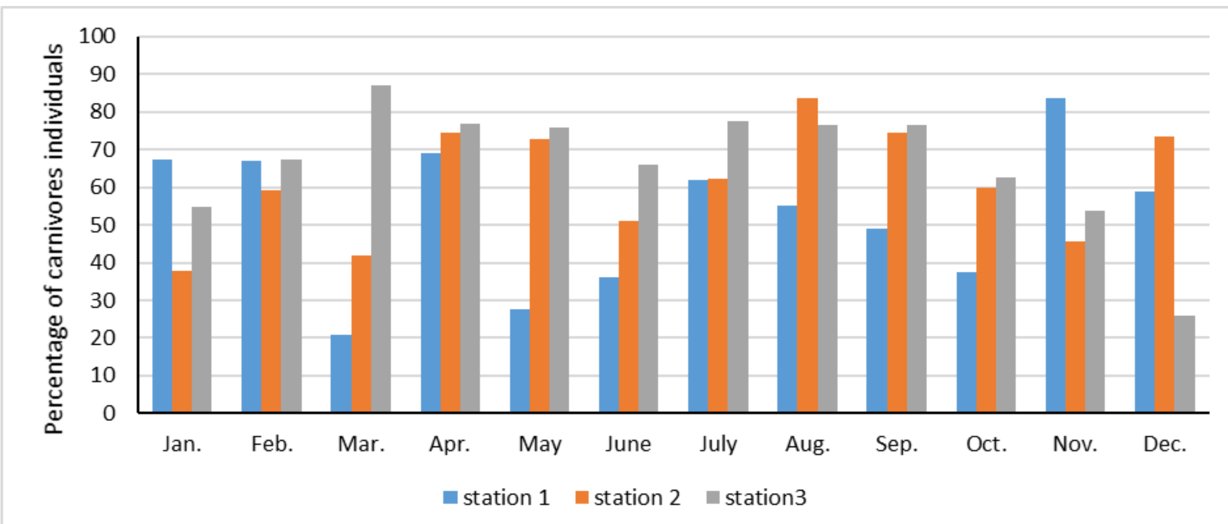

Figure 12: Monthly changes in the percentage of carnivorous individuals at the three study stations.

12- Percentage of individuals of the detritivores species

This group included (5) species, equivalent to (5.49) % of the total number of species, which are *Boleophthalmus dussumieri, Mugil cephalus, Planiliza carinata, P. subviridis, and P. klunzingeri* (Table 1). 580 fish individuals were collected from this group, representing 5.93 % of the total fish caught. The highest percentage of detritivorous fish was obtained in January, (24.5%) in the second station. The lowest percentage was in November (0.2%) in the third station. The results of the statistical test (t-test) showed significant differences ($P<0.05$) in the percentage of detritivores individuals in the study months (Fig. 13).

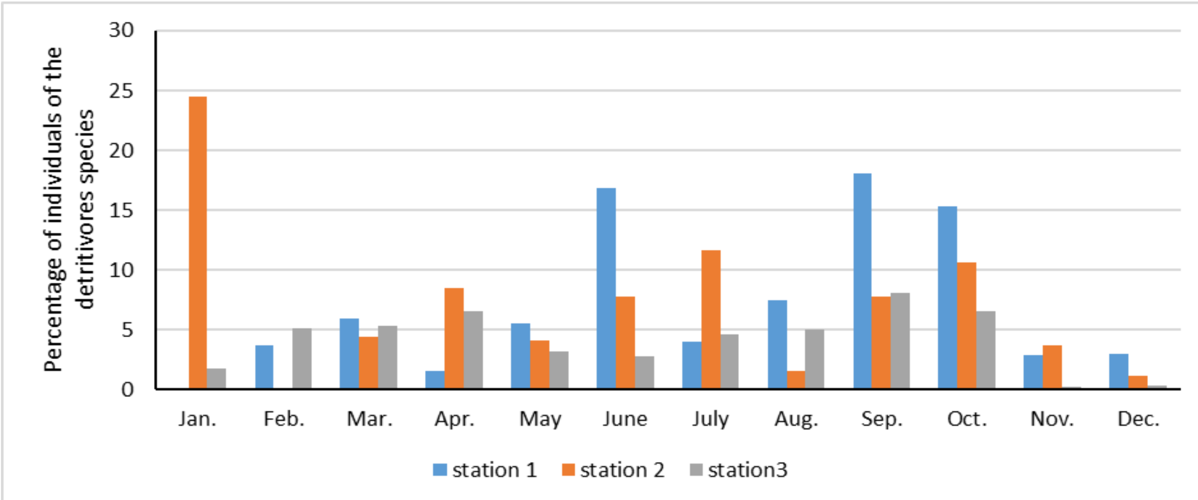

Figure 13: Monthly changes in the percentage of detritivorous fish at the three study stations during the sampling period from January 2018 to December 2018.

13-Percentage of herbivore individuals

This group included (6) species, equivalent to (6.59) % of the total number of species caught in this study, namely *Scatophagus argus, Siganus javus, S.canaliculatus, Nematalosa nasus,, Anodontostoma chacunda,* and *Acanthurus sohal* (Table 1). The total number of herbivorous fish was 107, equivalent to (1.09) % of the individuals caught (Table 1). The fishes of this group appeared to have low percentages throughout the study period. The highest percentage of fish in this group was obtained in January, at a rate of 4.4% in the first station, and the lowest percentage was 0.2% in November in station three (Fig. 14). The results of the statistical test (t-test) showed significant differences ($P<0.05$) in the percentage of individuals of herbivorous species in the months.

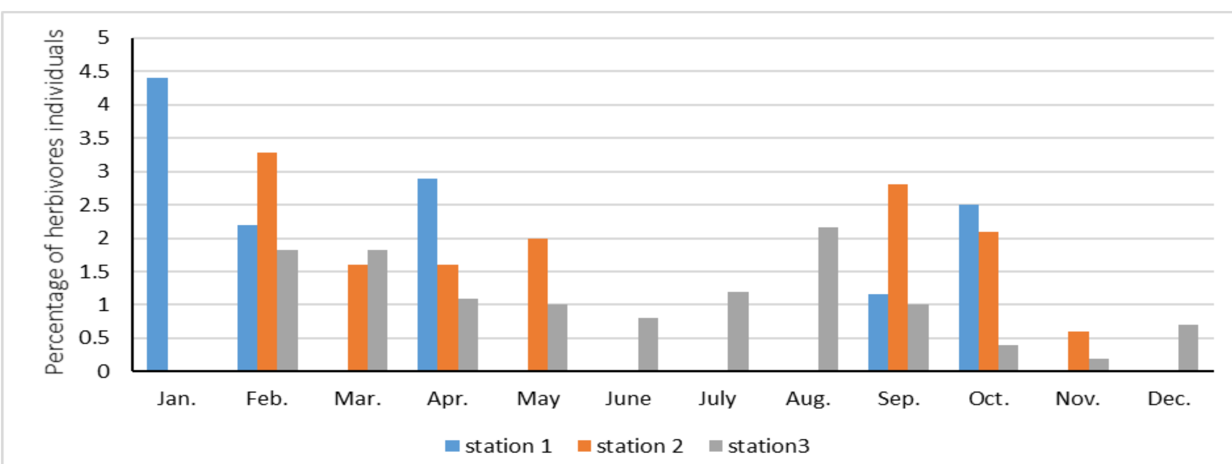

Figure 14: Monthly changes in the percentage of individuals of herbivorous species.

Table 1: Distribution of species according to the units of the Estuaries Biological Integrity Index (EBI).

Species	Units
Gobiidae, Engraulidae, Clupidae, Sciaenidae, Soleidae, Cynoglossidae, Polynemidae, Bothidae, Syngnathidae	**Fish larvae families**
Johnius belangerii [1,2,3], Tenualosa ilisha [1´2´3], Photopectoralis bindus [1´2´3], Brachirus orientalis [123], Thryssa whiteheadi[123], Cynoglossus arel[123], Netuma thalassina[123], Pampus orgenteus[23], Mugil cephalus [2], Otolithes ruber, Terapon puta, Sardinella albella, Nematalosa nasus, Acanthopagrus arabicus, Trypauchen vagina, Scomberoides commersonnianus, Pseudosynanceia melanostigma, Alepes djedaba, Sillago sihama, Sillago Arabica, Saurida tumbil1, Platycephalus indicus, Ilisha melastoma	**Resident species**
O.ruber[123], J.belangeri[1,2,3],T.ilisha[123], Johnius dussumieri[123], S.albella[123], N.nasus[123], T.vagina[123], T.whiteheadi[123], B.orientalis[123], C.arel[123], Thryssa dussumieri [123], Solea elongata [123], Cynoglossus kopsii[123], Eleutheronema tetradactylum [123], Polydactylus sixtarius[123], Baleophthalmus dussumieri[123], Anodontostoma chacunda[123], Protonibea diacantha [13], Cryptocentrus lutheri [1], Argyrosomus hololepidotus, Solea Stanalandi	**fish species that appeared at all stages of life**
T.ilisha[123], S.albella[123], A.arabicus[123], N.nasus[123], Planiliza klunzingerii[123], Planiliza subviridis[123] ,M.cephalus[123], Anodontostoma chacunda[23], Crenidens crenidens[23], Acanthopagrus berda[13], B.dussumieri[13], Planiliza carinata, Acanthopagrus bifasciatus	**Coastal marine species**
J. . belangerii[1,2,3], T.ilisha[1´2´3], Photopectoralis bindus[1´2´3], B.orientalis[123], C.arel[123],N.thalassina[12], M.cephalus[12], T.whiteheadi[23], O.ruber[3], Terapon puta[3], S.albella[3], N.nasus[3], Pampus argenteus[3], S.sihama[3], S. arabica[3],S.tumbil	**Dominant species**
J. belangerii[1,2,3], J.dussumieri[123], Sphyraena qenie[123], P.indicus[123], N. thalassina[123], S.sihama[123], S. arabica[123], Choridactylus multibarbus[123], Cephalopholis hemistiktos[123], P.sixtarius[123], A.arabicus[123], B.orientalis[123], T.dussumieri [123], Triacanthus biaculeatus[123], E.tetradactylum[123], Sphyraena obtusata[23], Megalaspis cordyla[3],T.whiteheadi[123], Alectis	**Carnivorous fish species**

indica[123],O.ruber[123],L.lunaris[123],T.puta[123], Lutjanus russellii[123], Chirocentrus dorab[123],P.melanostigma[123],S.elongata[123], Scomberomorus comerson[123], Upeneus doriae[123],S.tumble[123],M,cinereus[123], Nemipterus peronii[123],T.lepturus[123],I.melastoma[123], Ilisha compressa[123], Atropus atropos[123], Pomadasys kaakan[23],A.taeniatus[23], Ephippus orbis[23], Priacanthus tayenus[23], Allenbatrachus grunniens[23],S.taeniata[23], Drepana longimana[23], Parastromateus niger[23],P.melanostigma[23], Platax teira[23], Upeneus tragula[23],P.tayenus[23], Euthynnus affinis[23],S.stanalandi[23],E.coioides[13],N.japonicus[13],L.borbonicus[13], Protonibea diacantha[13], Rhynchorhamphus georgii[2], Pseudotriacanthus strigilifer[3],A.bifasciatus[3], Cryptocentrus lutheri[1],A.berda[12], Gobiopsis sp[3], Arnoglossus aspilos[3], Lutjanus malabaricus[3], Argyrosomus hololepid	
T.ilisha[1´2´3], S.albella[123], P.argenteus[123], C.arel[123], A.djedaba[123], P.lineatus[123], T.vagina[123], P.bindus[1´2´3], P.maculosus[23], C.kopsii[23], C.crenidens[23], O.aureus[3],O.niloticus[3],S.commersonnianus[123]	**Omnivores fish species**
Scatophagus argus[123], N.nasus[123],A.chacunda[23], Siganus canaliculatus[23], Siganus javus[23], Acanthurus sohal	**Herbivores fish species**
P.subviridis[123],P.klunsingerii[123],B.dussumieri[123],M.cephalus[12],P.carinata[3]	**Detrivores fish species**

1: Occurrence at the first station.

2: Occurrence at the second station.

3: Occurrence at the third station.

Estuarine Biological Integrity Index (EBI)

The total EBI value for the three stations was 48.5, 55.9, and 57.4 % respectively. The EBI values for the different months in the three stations were included under the evaluation of Impaired (<60) except for April (65), which was included under the assessment of marginally impaired (60-80) in the first station and 61.62, 65.22 and, 60 for March, April, and October respectively in the second station while in the third station, these months were included under the evaluation of the marginally impaired at March (66.92), April (62.1), May (62.6), June (63), July (71.42) and August (69) (Fig. 15). The statistical test (t-test) results showed significant differences ($P<0.05$) between the index values in the months.

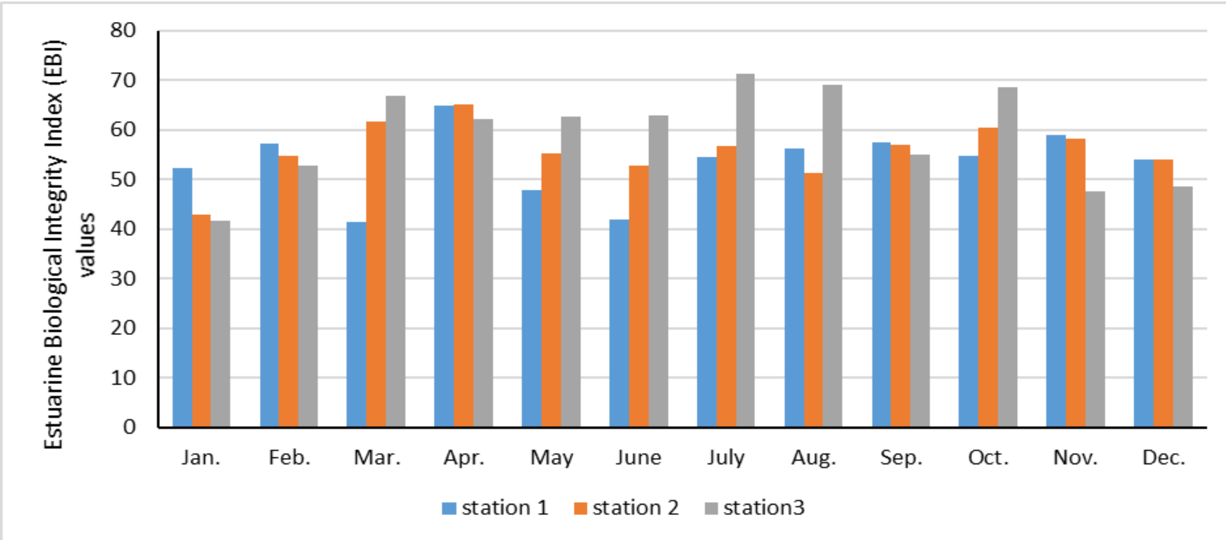

Figure 15: Monthly changes in the Estuaries Biological Integrity Index (EBI) values at the three stations.

Figure (16) shows the cluster analysis of the degree of similarity for the (EBI) using the Jaccard similarity index, which shows the presence of three main groups. The first main group, at a similarity level of 90%, included two secondary groups. The first secondary group included both October and December at a similarity level of 98%, while the second secondary group included November, February, and September at a similarity level of 98%. The second main group included only January at a similarity level of 74%. The third main group included two secondary groups at a similarity level of 84%. The first included May, June, and April at a similarity level of 98%, while the second secondary group included March, August, and July at 94%.

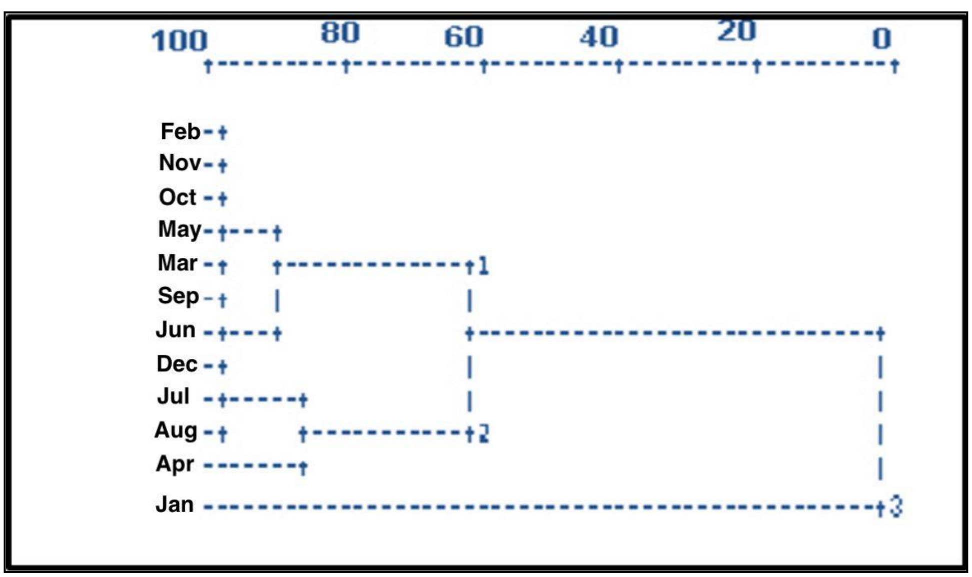

Figure (16): Cluster analysis of the degree of similarity between the study months for the total Estuarine Biological Integrity Index (EBI)

When comparing the present study of the Iraqi marine water integration index with two previous studies (Ali 1993; Mohamed *et al.,* 2001), and after applying the Estuarine Biological Integrity Index (EBI) to them, it was found that the highest value of the index was obtained in the last study and reached 76.6 and was included under the marginally impaired evaluation, while the values of the index in the Ali (1993), and the present study were included under the impaired evaluation, as they reached 59.06 and 57.6, respectively (Table 2).

Table (2) Values of the units of the Estuarine Biological Integrity Index (EBI) of this study and comparison with other studies from Iraqi marine water areas.

Index units	Ali, 1993 (1989-1990)	Mohamed *et al.* (2001) (1995-1999)	present study
Total number of species	73	116	91
Number of resident species	23	25	32
Number of dominant species	20	28	23
Number of coastal marine species	19	21	16
Number of species that have appeared at all stages of life	16	27	13
Percentage of dominant species	83.4	24.1	22
Percentage of Resident Individuals	9.3	21.5	47.48
Diversity index	2.04	2.73	4.4
Percentage of carnivore’s individuals	42.2	52.3	2.65
Percentage of individuals of the detritivoreous species	7.3	8.3	50.6
Percentage of herbivore individuals	0.01	2.1	6.08
Percentage of individuals of omnivore species	14.3	10.72	8.30
Index value	59.06	76.6	57.6

Discussion

Environmental indices, including the Estuarine Biological Integrity Index (EBI), are important in preparing environmental reports and their developmental status. They are also suitable for measuring the validity of focused environmental monitoring (Ganasan and Hughes, 1998; Karr 1981) has proven that the Integrated Biological Index (IBI) is one of the most successful biological methods for assessment. From it, he developed the Estuarine Biological Integration Index (EBI), which was developed by Deegan *et al.* (1997). This index has proven successful in many countries, as it is considered one of the most valuable and successful indexes in monitoring the environmental status of estuaries. It has been applied comprehensively in estuaries and bays by Elliott *et al.* (2007) and Franco et al. (2008). The Estuarine Biological Integrity Index can be linked to the indexes of richness, similarity, and diversity within the units included in the index. (Moyle and Marchetti, 2006) The success of this index in its application in different countries of the world requires making significant changes and modifications in the original units by deleting or adding some units included in the calculation of this index (Meng *et al* .2002).

The total Estuarine Biological Integrity Index (EBI) value in the present study was (55.61%), which is within the impaired assessment. The increase in the index value in April for the three stations that were included in the marginally impaired assessment was 65, 61, and 62 %, respectively, coinciding with a decrease in salinity values, which reached 37.1 $\%_{\circ}$, a decrease in omnivores and detrivoreous fishes, and an increase in carnivorous and herbivorous fishes in that month. This is the same as what McCormick *et al.* (2001) reached, as well as an increase in the diversity index. This confirms the association of the diversity index with an increase in the number of species and an increase in the percentage of species individuals in that month and the extent of stability of environmental and climatic conditions.

This was confirmed by Bindoff *et al.* (2019) while preparing the final report on the assessment of marine and coastal oceans using the (EBI). What increased the value of the index was the increase in the number of resident species and their proportions and the decrease in the number of dominant species and their proportions in that month because the index is sensitive to any environmental change, whether numerical or weighty. This was confirmed by Tyler (1971). In addition, the increase in the value of the index coincided with the presence of fish larvae in April as a result of the availability of suitable environmental conditions of temperature, salinity, etc.

This is consistent with the findings of Dominguez *et al.* (2013) during their study of estuaries and marine areas in Europe. The lowest value of the (EBI) was 45.7% in January, which coincides with the cold winter months, during which the number of fishes caught decreases, fish feeding on organic detritus and omnivores increase, fish feeding on plants decreases and disappear in the second and third stations. The biomass decreases at 4.69 mg/m3 and chlorophyll 0.07 mg/m3, the decrease in resident species and their proportions, and the increase in the numbers of dominant fishes. The disappearance of fish larvae in this month and the decrease in the number of coastal fishes reduced the index's value, which Meng *et al*. (2002) confirmed during their study on the Narragansett Estuary and Bay in the United States of America.

Conclusions and recommendations

1- The environmental assessment of the Shatt Al-Arab estuary and Iraqi marine waters has been reduced and classified as impaired and marginally impaired.
2- They are implementing the necessary monitoring programs to monitor the marine environment and activating control tools and law enforcement.
3- It is implementing and developing a comprehensive strategy for integrated coastal zone management, and Developing legislation and regulations in line with the principles of integrated coastal zone management.

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تقييم بيئة مصب شط العرب والمياه البحرية العراقية باستعمال دليل التكامل المصبي

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المستخلص

جمعت 9772 سمكة اشتملت على 91 نوع من صنف الأسماك العظمية في مصب شط العرب والمياه البحرية العراقية تعود إلى 72 جنسا" وتمثل 48 عائلة للمدة من كانون الثاني ولغاية كانون الأول 2018 في ثلاثة محطات منتخبة .تم حساب دليل التكامل الحياتي المصبي في الدراسة الحالية من خلال ثلاث عشرة وحدة تضمنت وحدات غنى الأنواع وتركيبة المجتمع السمكي ووحدات تركيبة التغذية، بلغت قيمة دليل التكامل الحياتي المصبي الكلية (48.5 و55.9 و57.4) لمحطات الدراسة الثلاث على التوالي وادرج ضمن تقييم ضعيف وحافة الضعيف في الأشهر المختلفة ضمن محطات الدراسة ،بلغ اعلى قيمة للدليل 71.42 في تموز في المحطة الثالثة وادرج ضمن فئة حافة الضعيف وادنى قيمة له 41.47 في أذار في المحطة الأولى وكان ضمن فئة ضعيف وبلغت معدل قيمة الدليل الكلية 55.61 وكان ضمن تقييم ضعيف.

الكلمات المفتاحية: دليل التكامل المصبي، مصب شط العرب، الأسماك، المياه البحرية العراقية.

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