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ASSESSMENT OF THE ENVIRONMENT OF EAST AL-HAMMAR MARSH AFTER ADVANCING THE SALINITY INTRUSION USING THE INTEGRATED BIOLOGICAL INDEX (IBI)

Prof. Dr Kadhim H. Younis [1] , Basim M. Hubain Al-Thahaibawi [2] , Prof. Dr. Ghassan A. Al-Nagar [3], Prof. Dr. Ahmed Ch.Al-Shamary [4] , Prof. Dr. Ali A. Douabul [5] , Prof. Dr. Sajed S. Al-Noor [6]

Abstract

The environment of the eastern Al-Hammar marsh in southern Iraq was assessed using the Integrated Biological Index (IBI), the period of sample collection was divided into before the salinity intrusion, which includes the period from January 2018 to July 2018 (first period) and the salinity intrusion which includes the period from August 2018 Until December 2018 (second period) The three selected stations' average values for the Integrated Biological Index (IBI)., Harir, Al-Salal, and Al-Barka were included under poor rating (<60). The average evidence in the first period for the three stations, respectively, reached 58.2, 55.9, and 56.9, and were included under poor assessment, while the average evidence in the second period was 54.8, 54.4, and 48.5 for the three stations, respectively, and were included under poor assessment as well.

Keywords: (IBI), Al-Hammar marsh, salinity intrusion. Assessment Environment

Affiliations of Authors

[1,3,4,5] Marine Science Centre, University of Basrah, Iraq, Basrah, 61004

[2] Directorate Environment of Maysan, Ministry of Environment, Iraq, Maysan, 57000

6 College of Agriculture, University of Basrah, Iraq, Basrah, 61004

[1] younis.kadhim@yahoo.com
[2]basim.althahaibawi74@gmail.com
[3] ghssanadnan@yahoo.com
[4] a_kaseb@yahoo.com
[5] adouabul@hotmail.com
[6] saged55@yahoo.com

[4] Corresponding Author

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تقييم بيئة هور شرق الحمار بعد تقدم الجبهة الملحية باستعمال دليل التكامل الحياتي(IBI)

ا. د. كاظم حسن يونس [1] ، م. باسم محمد هبان الثهاباوي [2] ، ا. د. غسان عدنان النجار [3] ، ا. د. احمد جاسب الشمري[4] ، ا. د.علي عبد الزهرة دعيبل [5] ، ا. د. ساجد سعد النور [6]

المستخلص

تم تقييم بيئة هور الحمار الشرقي باستعمال دليل التكامل الحياتي، اذ تم جمع العينات خلال فترة قبل ارتفاع الجبهة الملحية والتي تتضمن الفترة من كانون الثاني 2018 الى تموز 2018 (المدة الأولى) وفترة ارتفاع الجبهة الملحية من اب 2018 الى كانون الأول 2018 (المدة الثانية) . تم اختيار ثلاثة محطات وكان معدل تقييم دليل التكامل الحياتي للمحطات (حرير، الصلال، البركة) تحت تقييم فقير (<60) وكان معدل تقييم للمدة الأولى 58.2، 55.9، 56.9 للمحطات الثلاثة على التوالي. وتحت تقييم فقير، بينما كان معدل التقييم للمدة الثانية 54.8، 54.4، 48.5 للمحطات الثلاثة على التوالي وتحت تقييم فقير أيضا".

الكلمات المفتاحية: دليل التكامل الحياتي، هور الحمار،الجبهة الملحية، التقييم البيئي

انتساب الباحثين

[5,4,3,1] مركز علوم البحار، جامعة البصرة، العراق، البصرة، 61004

[2] مديرية بيئة ميسان، العراق، ميسان، 57000

[6] كلية الزراعة، جامعة البصرة ،العراق، البصرة، 61004

[1] younis.kadhim@yahoo.com
[2]basim.althahaibawi74@gmail.com
[3] ghssanadnan@yahoo.com
[4] a_kaseb@yahoo.com
[5] adouabul@hotmail.com
[6] saged55@yahoo.com

[4] المؤلف المراسل

معلومات البحث
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INTRODUCTION

The Southern Iraqi marshes are characterized by their high productivity in addition to being a natural refuge for many aquatic organisms and a significant source of inland fisheries [1,2], and a

permanent home for millions of waterfowls and a migration route between Europe and Africa [3]The marshes region is divided into three main groups: the marshes east of the Tigris and Al-Hawizeh Marsh, whose area is estimated at 3000 km2, Al-Hammar marsh and whose area exceeds 2440 km2. The third group is called the central marshes, increasing its area by 265 km2 [4]. The area of Al-Hammar region has gained many studies that have dealt with most of the biological and environmental aspects of fish, including them [5,6,7,8,9,10].

Many researchers have applied the Integrated Biological Index using fish in different areas of the marshes in Iraq [11,12,13,14,15,16]. The present study seeks to re-evaluate the environment of Al-Hammar marsh using (IBI) after the incursion of the salt front.

MATERIALS AND METHODS

The largest body of water in southern Iraq is Al-Hammar Marsh. It is situated between latitudes (30 o 33' and 30 o 58'N) and longitudes (46 o 24' and 47 o 39'E) on the right bank of the Euphrates River. It stretches from the western borders of Al-Nasiriyah City to the eastern edge of Basrah City along the Shatt al-Arab River. Saline lakes and the Southern desert's sand dune belt encircle it to the south. Historically, this marsh area has a permanent lake and marsh that encompasses around 2800 km2, although it can grow to more than 4500 km2 during seasonal and sporadic inundation periods. The marsh's length and width were roughly 120 km and 25 km, respectively, with a maximum water depth of 1.8 to 3 m**.** [17].

Al-Hammar Dike divides Al-Hammar Marsh into two halves. While the eastern portion of the Al-Hammar Marsh is within Al-Basrah City and is fed by the tidal phenomenon through the Shatt Al-Arab River, the western portion is situated in Thi-Qar Province with an area of 1326 km2, extending from close to Al-Nasiriyah to the northwest of Basrah Province in southern Iraq as shown in Figure (1).

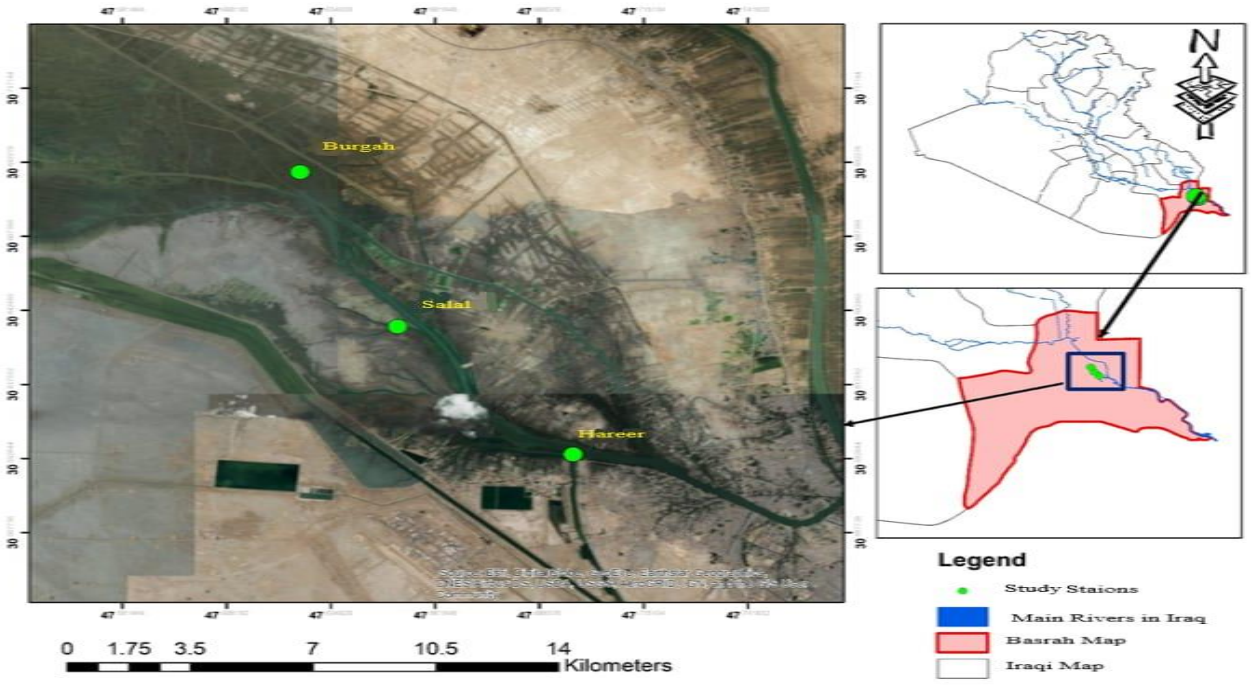

Figure (1): Shows study stations were chosen within the East Al-Hammar marshes, Southern Iraq

The results of [18].were adopted to assess the environment of East Al-Hammar marsh using the Biological Integration Index (IBI). The collection period was divided into two periods, before the salinity intrusion, which includes the period from December 2018 (first period), and the salinity intrusion, which includes the period from August to January 2018 (second period) for three selected stations from the marsh included Harir, Al-Salal, and Al-Barka.

To classify the ecosystem of East Al-Hammar marsh, twenty (20) units were selected for the Integrated Biological Index (IBI) calculation from the following primary groups:

(A) Species richness group, which includes:

1-Total number of species

2- The number of native fish species

3- The number of alien fish species

4- The number of marine fish species

5- The number of resident fish species

B -Composition of the fish community group includes the units:

6- The percentage of the native individual's species

7- The percentage of the alien individual's species

8- The percentage of the marine individual species

9- The percentage of the *Planiliza abu* individual's species

10-The percentage of the individual's Tilapia family

11-The percentage of the *Tenualosa ilisha* individual species

C-Trophic composition group includes the units:

12-The percentage of the herbivore's individual species

13-The percentage of the carnivore individuals species

14- The Percentage of detritivore individuals' species

15- The percentage of omnivores individual species

E- diversity indices, including:

16- Diversity index (H) value

17- Richness index (D) value

D- Chemical, Physical, and Biological factors:

18-The salinity values

19- The chlorophyll (A) values

20- The Biological Oxygen Demand (B.O.D.)

The approach outlined by was used to construct the Integrated Biological Index (IBI) [19].Similar to [20] the index values were separated into three groups to provide the final judgment of the marsh's degree with unit values ranging from (0-10) and IBI values ranging from (0-100).

RESULTS

Table (1) shows the species and their divisions during the study period.

Table (1): shows the distribution of fish according to the units used in estimating the Biological Integration Index (IBI) to assess the environment of East Al-Hammar marsh.

The metrics	Species
Native species	**Acanthobrama marmid ،Alburnus mossulensis ،Leuciscus vorax ،Planiliza abu ،Aphanius dispar ،Silurus triostegus ،Mystus pelusius**
Alien species	**Cyprinus carpio ،Carassius gibelio ،Oreochromis aureus ،Oreochromis niloticus ،Coptodon zillii ،Gambusia holbrooki ،Poecilia latipinna**

Marine species	**Johnius belangeri ،Scatophagus argus ،Bathygobius fuscus ،Boleophthalmus dussumieri ،Sillago sihama ،Acanthopagrus arabicus ،Sparadnetx hasta ، Nematalosa nasus ،Tenualosa ilisha،Ilishaa compressa،Thryssa whiteheadi ، Thryssa malabarica ،Thryssa hamiltonii ،Liza klunzingeri ،Liza carinata ، Planiliza subviridis، Sardinella albella ،Netuma bilineatus ،Brachirus orientalis ،Cynoglossus arel ،Hyporhamphus limbatus**
Resident species	**Thryssa whiteheadi ،Tenualosa ilisha ،Planiliza subviridis ،Acanthopagrus arabicus ،Oreochromis aureus ،Oreochromis niloticus ،Coptodon zillii ،Poecilia latipinna ،Thryssa hamiltonii ،Sillago sihama ،Nematalosa nasus ، Hyporhamphus limbatus**
Herbivores species	**Oreochromis aureus ،Oreochromis niloticus، Coptodon zillii**
Carnivores species	**Thryssa hamiltonii ،Acanthobrama marmid ،Alburnus mossulensis ، Leuciscus vorax ،Johnius belangeri ،Scatophagus argus، Bathygobius fuscus ، Acanthopagrus arabicus ،Sparadnetx hasta ،Ilishaa compressa ،Thryssa whiteheadi ،Thryssa malabarica ،Gambusia holbrooki ،Aphanius dispar ، Silurus triostegus ،Mystus pelusius ،Netuma bilineatus ،Brachirus orientalis ، Cynoglossus arel ،Hyporhamphus limbatus ،Sillago sihama،**
Detrivores species	**Boleophthalmus dussumieri ،Liza klunzingeri ،Liza carinata ،Planiliza subviridis ،Planiliza abu،**
Omnivores species	**Cyprinus carpio ،Carassius gibelio ،Poecilia latipinna ،Nematalosa nasus ، Sardinella albella ،Tenualosa ilisha،**

The first unit: The total number of fish species

Thirty-four species within 30 genera and 19 families belonging to the Osteichthyes class were collected, all of which were presented in the first station (Harir) and the second (Al-Salal), and 20 species in the third station (Al-Barka) as shown in Figure (2).

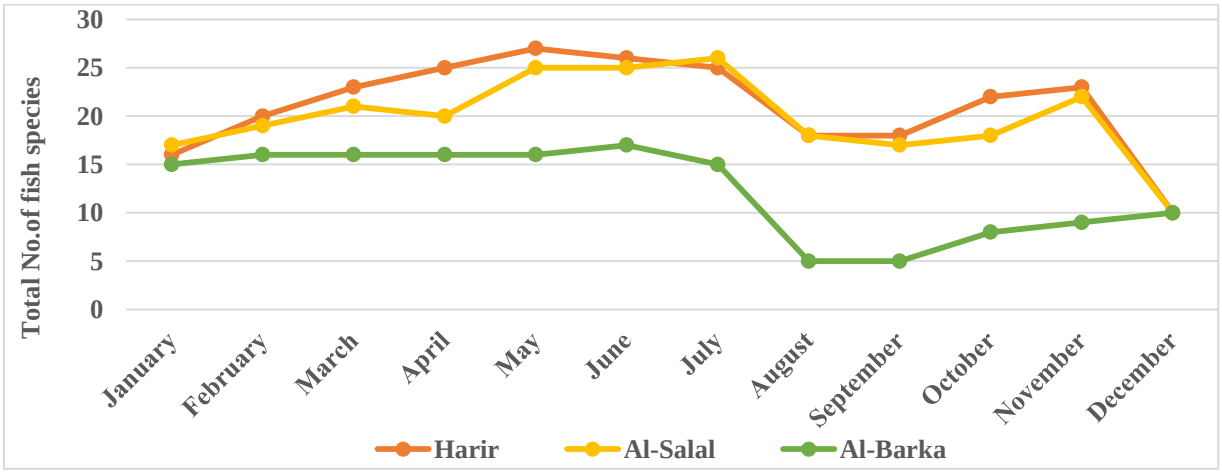

Figure (2): The total number of fish species at all study stations of East Al-Hammar marsh

The second unit: Number of native fish species

The number of native species increased to seven, or seven species, representing 20.6% of all species. The biggest number of species was observed in March at the first and second stations, totaling seven species, while no species were recorded in the second period except for the one species of *A. mento* in November in the first and second stations and in December in the third station as shown in Figure (3).

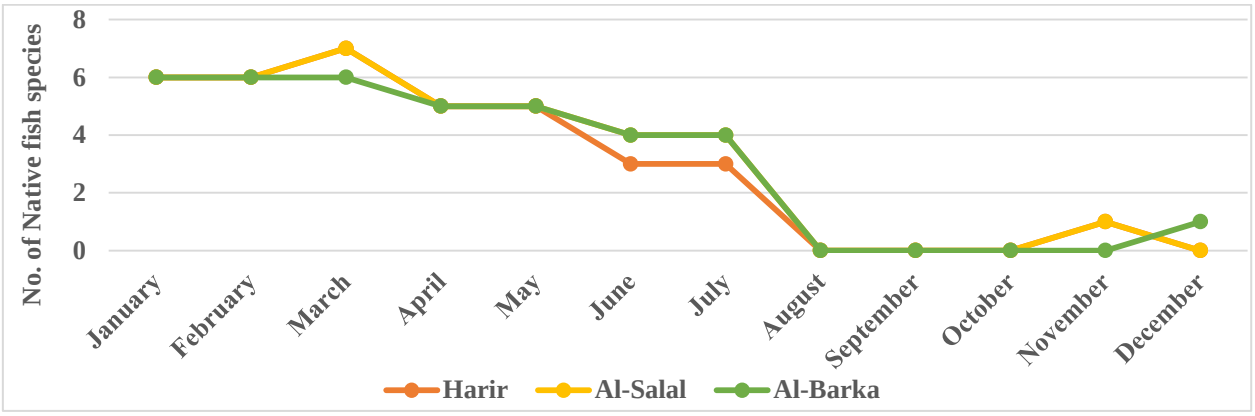

Figure (3): Number of native fish species at all study stations of East Al-Hammar marsh

The three-unit: Number of alien fish species

This group included (7) species, equivalent to 20.6% of the total number of species. The presence of all species of this group was also recorded in the first period (March to July) in the first station (January to July) in the second station and (January to June) in the third station, while these species disappeared in July and August in the second period, some species reappeared in the following months as shown in Figure (4).

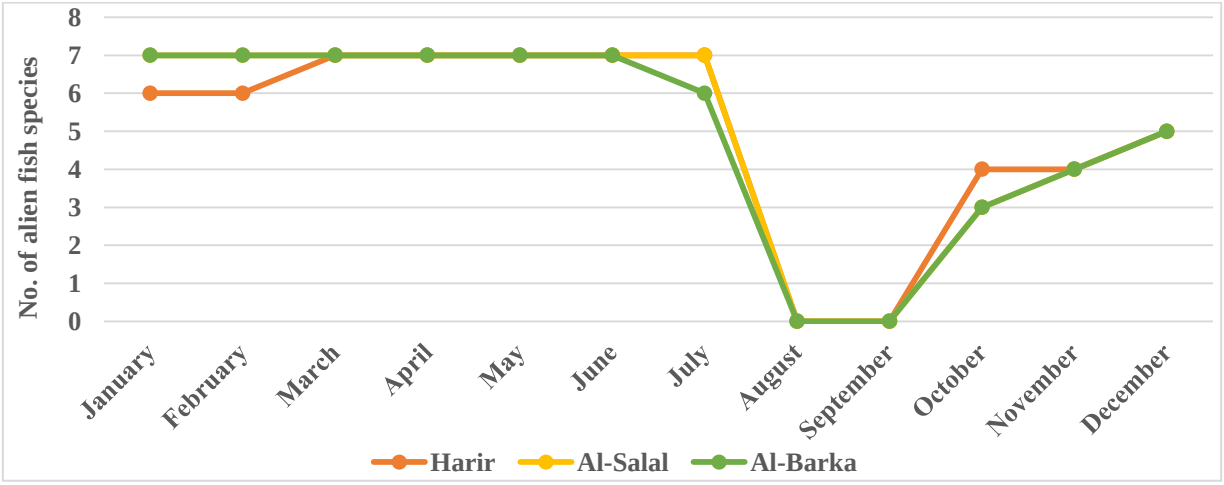

Figure (4): Number of alien fish species at all study stations of East Al-Hammar marsh

The fourth unit: Number of marine fish species

This group included (20) species, equivalent to 58.8% of the total number of species. The highest number of species of this group was recorded during the months of the salinity intrusion period and reached a maximum of (18) species from August to November in August at both the first and second stations, while the third station was characterized by a decrease in a number of marine

species in the two periods compared to the first and second stations as shown in Figure (5).

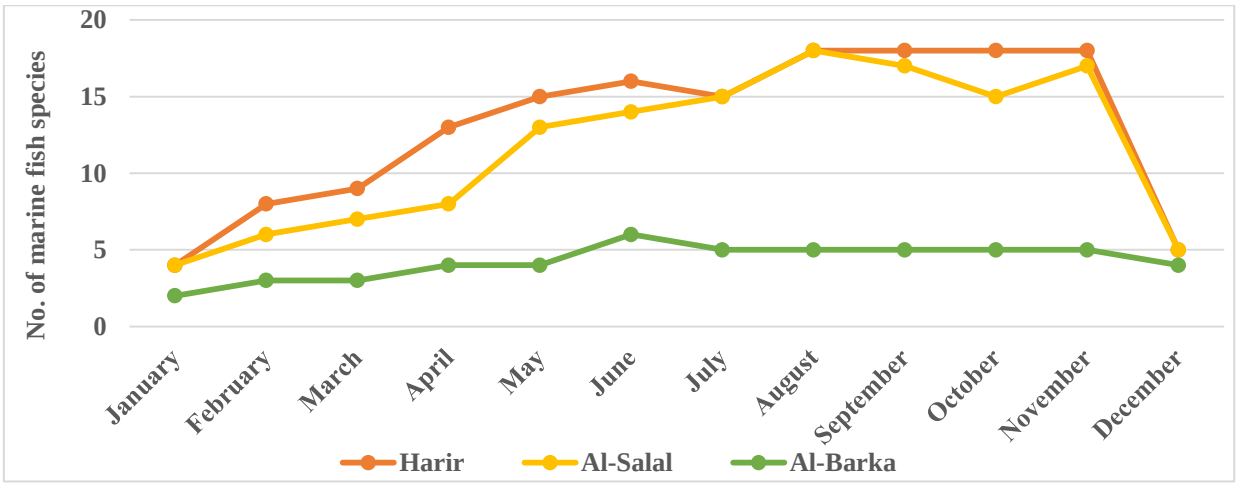

Figure (5): Number of marine fish species at all study stations of East Al-Hammar marsh

The fifth unit: The percentage of the native fish species

The first period had the greatest proportion of native species' individuals, especially in January (34.3%) in the first station, March in the second station (20%) and February (23.7%) in the third station, while no presence was recorded for these individuals, whereas, no presence individuals of This group was recorded in the second period, except for November in the first and second stations, which amounted to (0.07%) and (2.7%), respectively, and (5.5%) in December in the third station as shown in Figure (6).

Fish from *A. mossulnsis* made up the highest proportion of the native species, accounting for (4.7, 3.3, and 4.0%) of the total fish seized in the study stations, respectively.

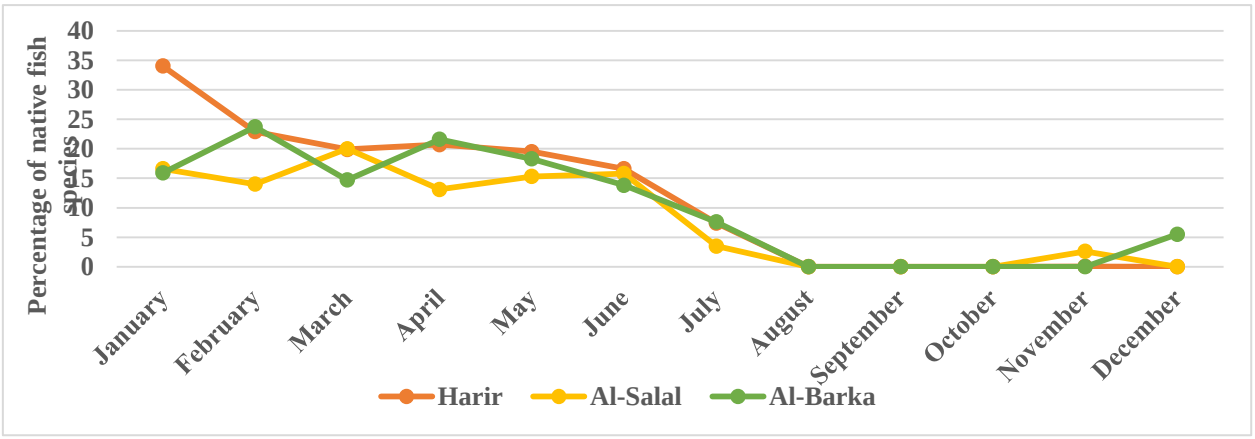

Figure (6): The percentage of native fish species at all study stations of East Al-Hammar marsh

The sixth unit: The percentage of the alien individual's species

The percentages of individuals in this group increased throughout the study period for the periods before and after the salinity intrusion, especially in December at the first and third stations, reaching (62.5%) and (92.4%) respectively, and in January (80.4%) in the second

station, while the period of the salinity intrusion was characterized by (August, September) with the disappearance of alien fish at all stations as shown in Figure (7). *O. niloticus* fish included 7.8% of the total fish taken at the station, which had the greatest percentage of alien species. In contrast, *C.zillii* fish formed the highest percentage in the second and third stations (11.82%) and (18.8) %) of the total number of fish caught in those two stations, respectively.

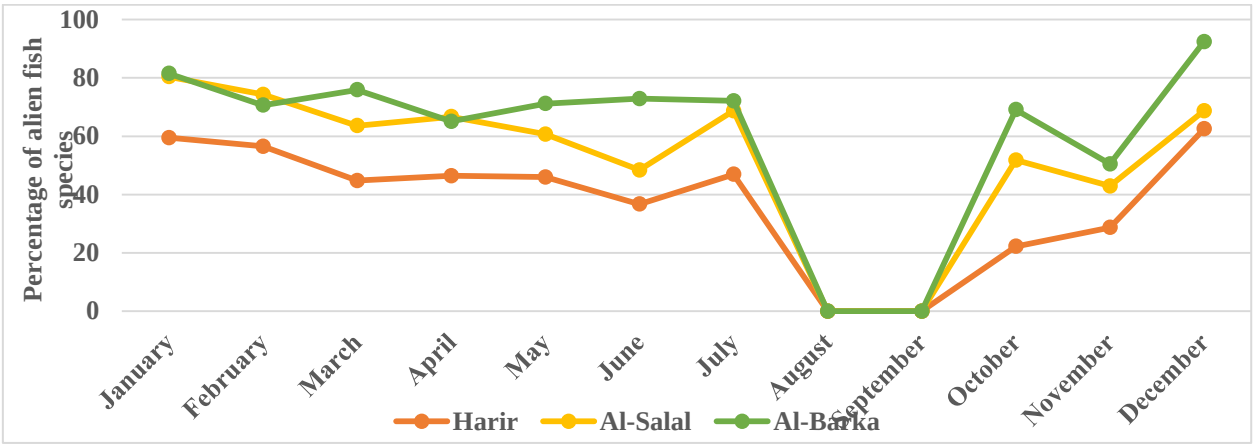

Figure (7): The percentage of alien fish species at all study stations of East Al-Hammar marsh

The seventh unit: The percentage of marine fish species

Marine species showed complete dominance over the fish community in the second period, especially in August and September, where it reached (100%) at all stations. The lowest percentage was in January in the first and second stations, reaching (6.2%) and (3.0%) respectively, and (2.1%) in December in the third station as shown in Figure (8). *T. whiteheadi* fish In the first and second stations, marine fish individuals made up the largest proportion., as it reached (14.9% and 9.8%) respectively, *L. subviridis* made up the highest percentage in the third station, accounting for (11%) of the total number of fish taken there. Of the total number of fish caught.

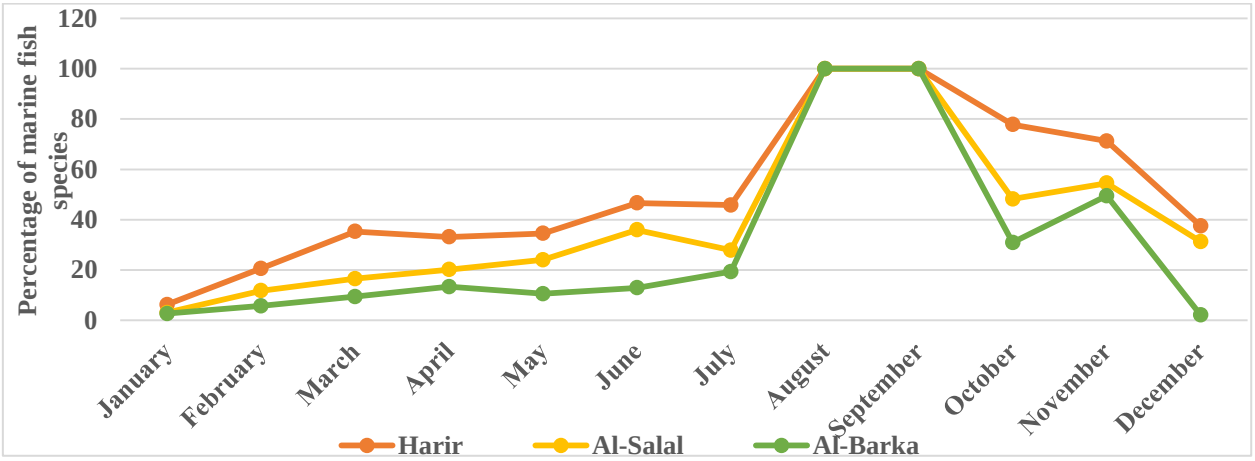

Figure (8): The percentage of the marine fish species at all study stations of East Al-Hammar marsh

The eighth unit: The Percentage of individuals in the tilapia family

Three species were represented in this group: *C. zillii*, *O. aureus, and O. nitoticus*. The first period

was characterized by the presence of all species of this group and their disappearance in the second period, especially August and September months, to reappear first in the period following these two months, the percentage of individuals of the tilapia family in the study stations reached (19.21%, 28.48%, and 35.23%) respectively as shown in Figure (9).

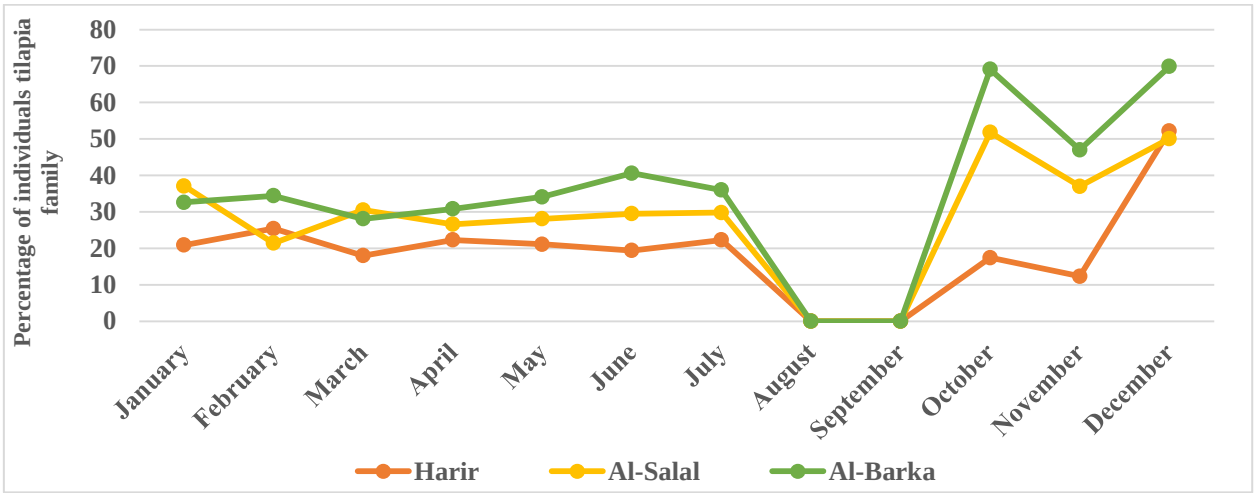

Figure (9): The percentage of individuals in the tilapia family at all study stations of East Al-Hammar marsh

The ninth unit: Percentage of individuals in the Engraulida*e* family

This unit included only two species, *T. hamiltonii and T. whiteheadi*. The percentage of individuals in this family reached (25.71%, 13.31%, and 7.1%) for the three stations, respectively. The members of this family were distinguished by their consistency in appearance at the three stations and over the course of the research months as shown in Figure (10).

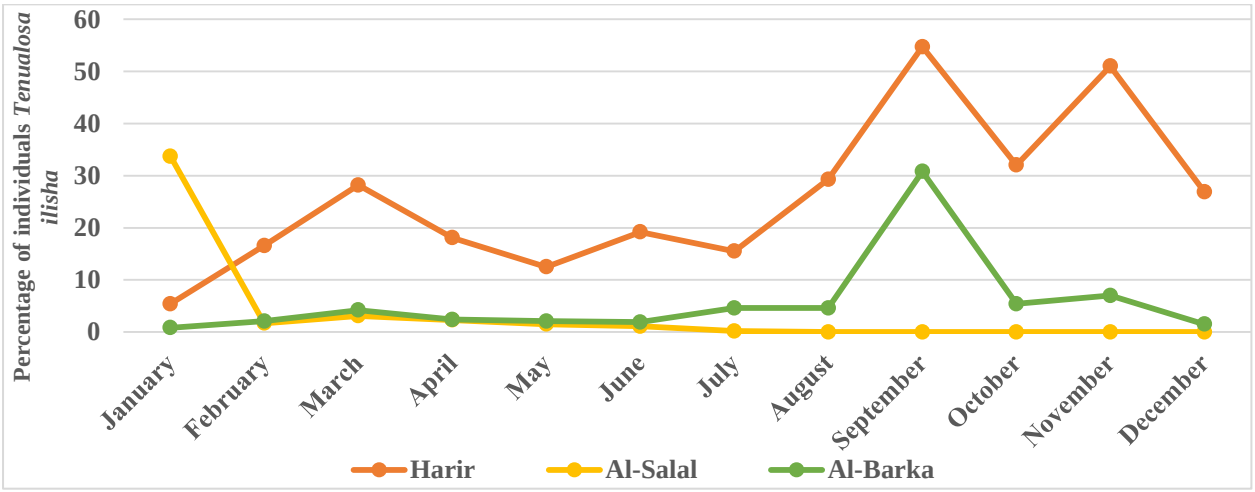

Figure (10): The Percentage of individuals of the Engraulida*e* family at all study stations of East Al-Hammar marsh

The ten-unit: the number of individuals of the *Planiliza abu* species

The percentage of *P. abu* individuals across the three locations was (1.6), (1.13), and 1.64, respectively.. Individuals of this species from the first periods might be identified by their regular monthly appearance.. reaching their highest value in February (5.7% and 6.1%) in the first and third stations, respectively, and January (3.7%) in the second station of the total number of fish caught, while the second period was characterized by the occurrence of individuals of this species in all stations as shown in Figure (11).

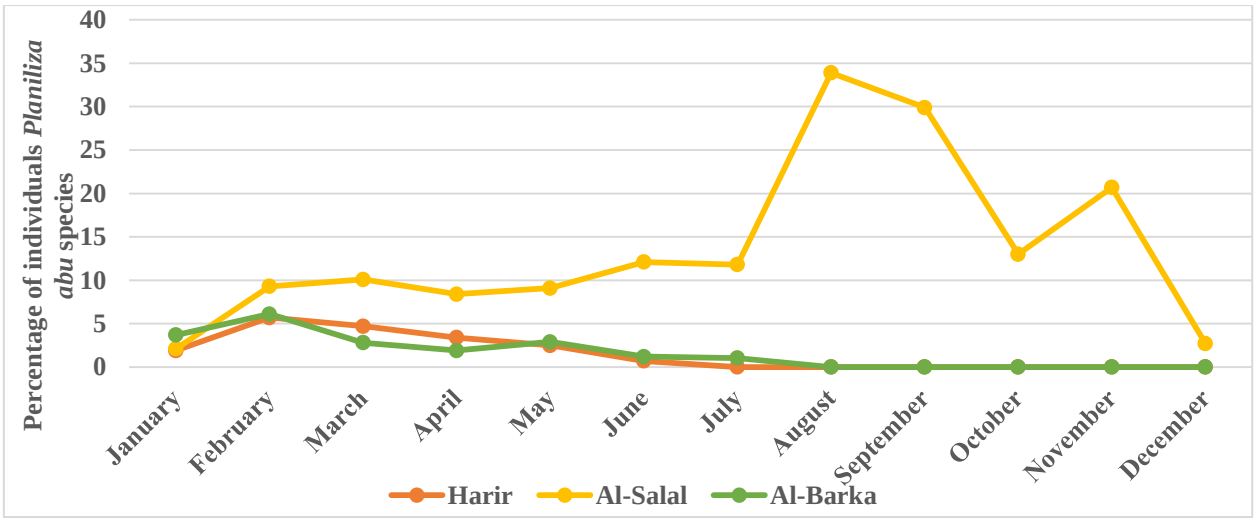

Figure (11): The Percentage of individuals of the *Planiliza abu* species at all study stations of East Al-Hammar marsh

The Eleventh unit: The number of resident fish species

This unit contained twelve different species (Tab.1), all of which could be found in the first station, nine species in the second station, and eight species in the third station, where the species *S. sihama*, *N.nasus*, and *H.limbatus* did not appear in the second and third stations, as well as the species *T. hamiltonii* at the third station as shown in Figure (12).

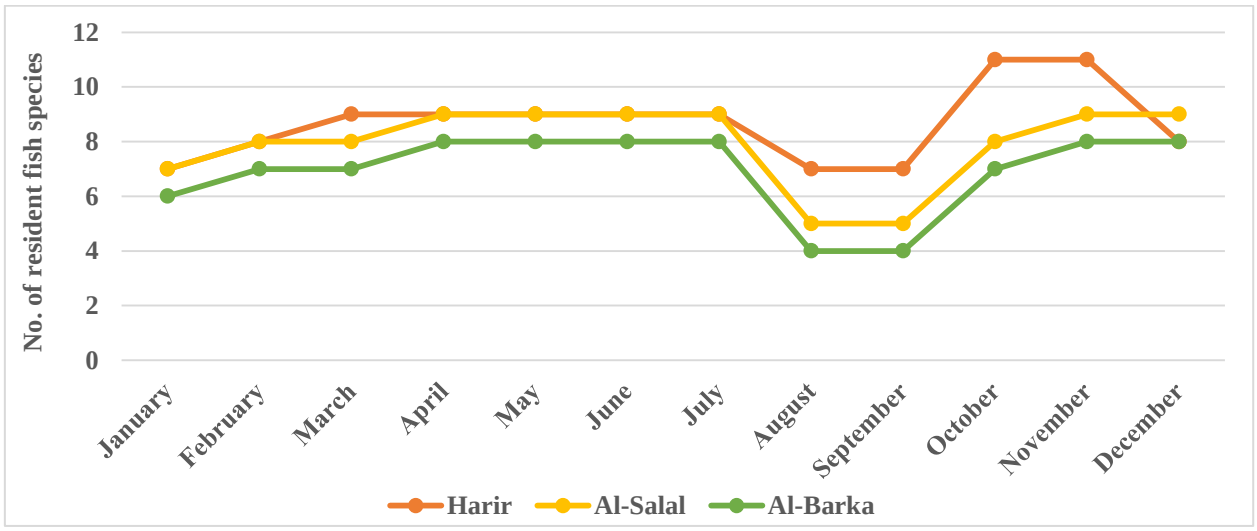

Figure (12): Number of individuals resident fish species at all study stations of East Al-Hammar marsh

The twelve-unit Diversity Index (H)

When compared to the values obtained in the second period, the diversity index (H) values in the first period were characterized by high values. Where the values of diversity (H) for the before salinity intrusion period were (2.53, 2.50, 2.31) for the three stations, respectively, compared to (1.26, 2.2, 1.56) for the second period as shown in Figure (13).

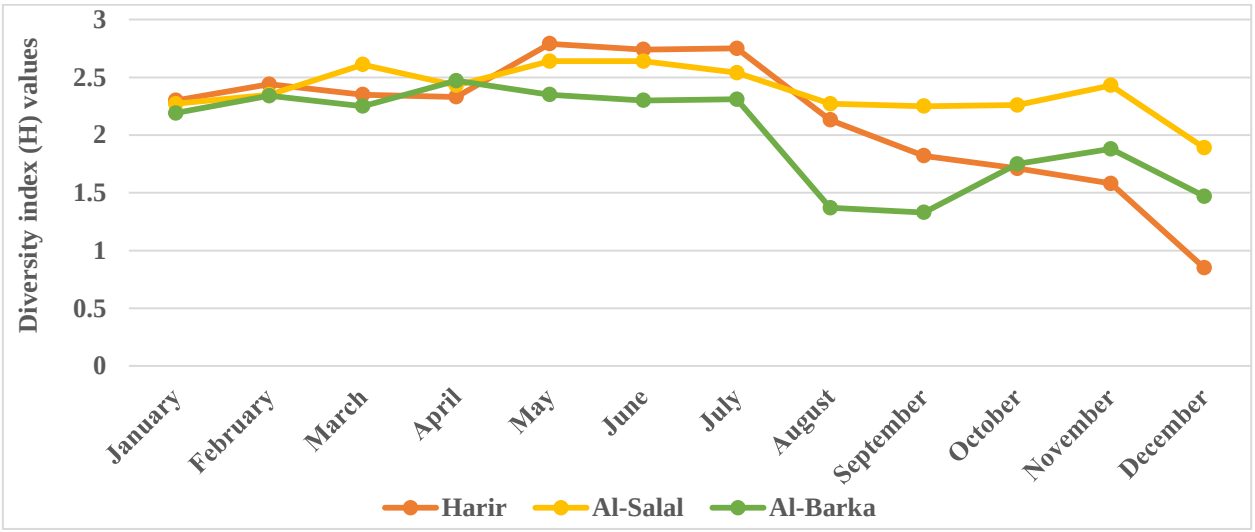

Figure (13): The diversity index (H) values at all study stations of East Al-Hammar marsh

The thirteen unit: – Richness index (D) value

The values of the richness index (D) were characterized by a rise in the first period (2.49, 2.38, 2.06) compared to their counterparts in the second period (2.37, 2.38, 1.0) for the three study stations, respectively as shown in Figure (14).

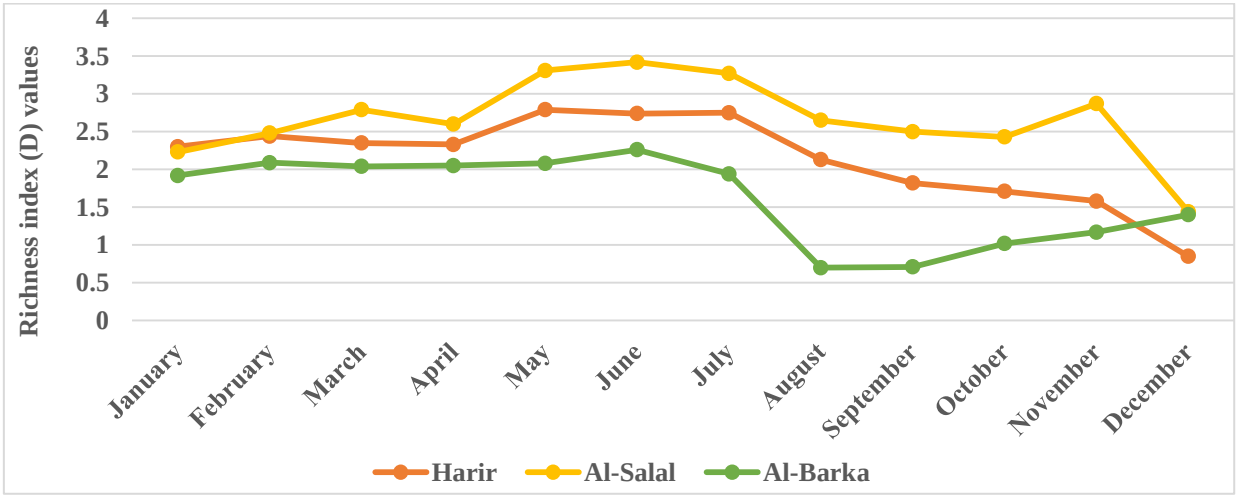

Figure (14): Richness index (D) value at all study stations within Al-Hmmar marsh

The fourteenth unit: The salinity values gm.L-1

The salinity values fluctuated between the first and second study periods. The lowest values were in February 3.43, 3.81, and 4.23 gm.L-1 and the highest values were 6.83, 6.16, and 5.64 gm.L-1 in July in the first period of the study stations, respectively as shown in Figure (15), while lowest values were during the second period in December (7.1, 9.1 and 15.2 gm.L-1) in the three stations, respectively, the highest was in August and

September (27 gm.L-1).

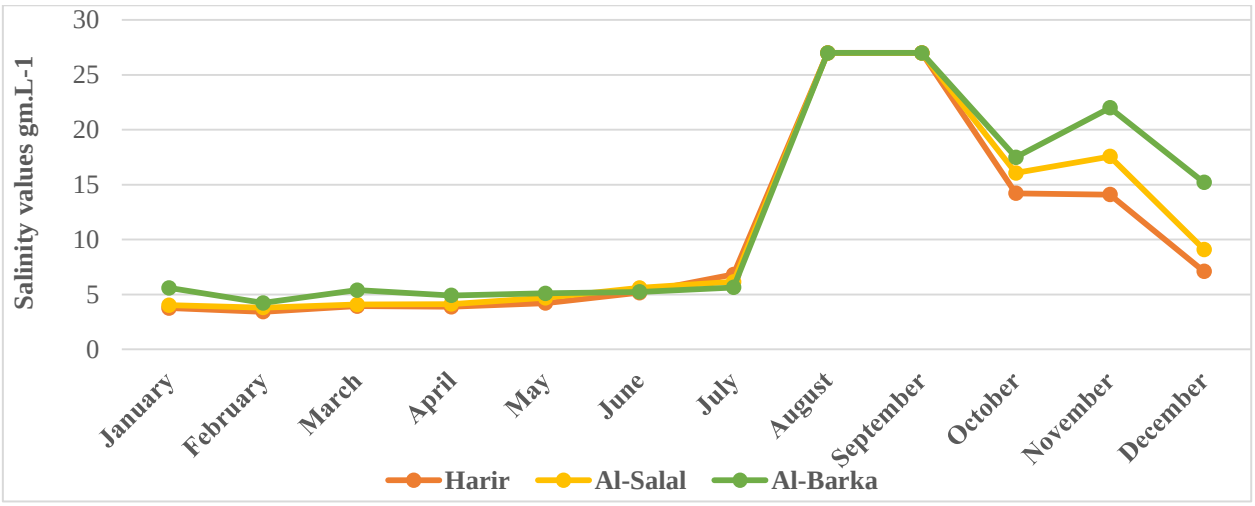

Figure (15): Salinity values mg.l^{-1} at all study stations within Al-Hmmar marsh

The fifteenth unit: The amount of chlorophyll (A) mg/L-3

The monthly changes in the study stations' chlorophyll (A) values for the two periods are shown in Figure (16). The highest values were recorded in the first period (3.1 mg.L-3 in June at the first station, (5.6 mg.L-3 in January at the second station, and (2.2 mg.L-3) in March at the third station), where no value of chlorophyll was reported during the second period (August and September).

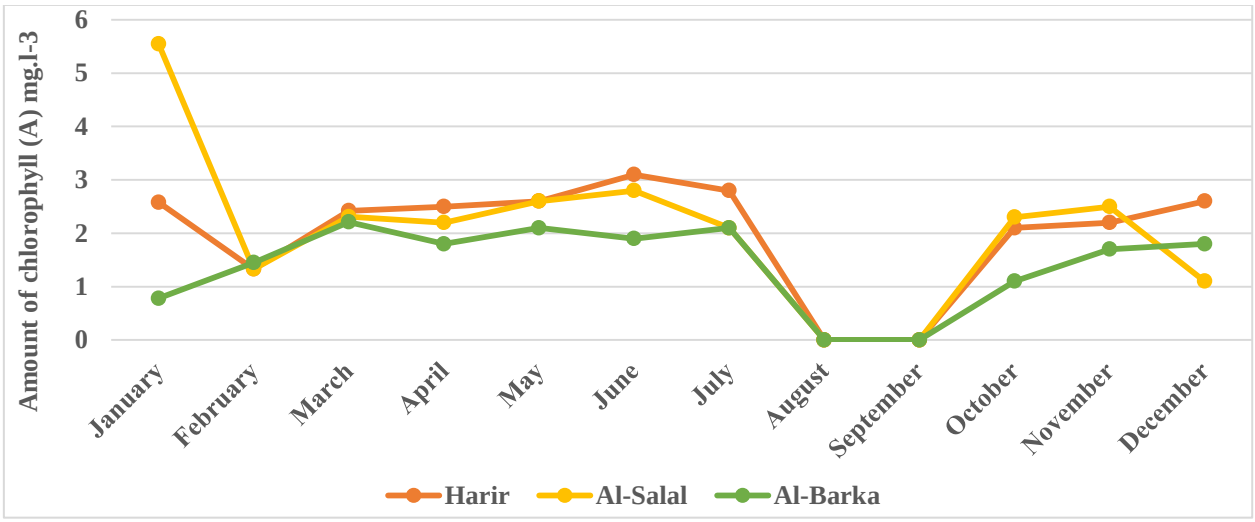

Figure (16): Amount of chlorophyll (A) mg.l^{-3} at all study stations within Al-Hmmar marsh

The sixteenth unit:- Biological Oxygen demand (BOD) mg.L-1

Figure (17) shows the monthly changes in the values of the Biological Oxygen demand mg.L-1 for the study stations in August at the second and third stations, and in September at the first station during the second period, no value for this component was observed... The highest values were obtained in the first period (8.4, 12.2, 14 mg L-1) in March for the three stations, respectively.

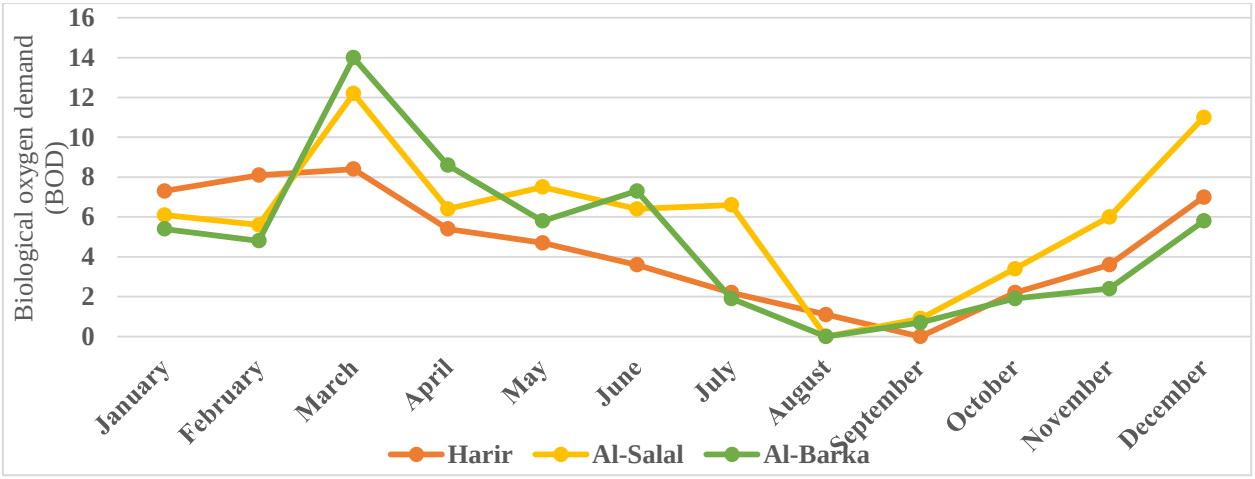

Figure (17): Biological oxygen demand (BOD) values mg.l^{-1} at all study stations within Al-Hmmar marsh

The seventeen unit: The percentage of the carnivore individuals, fish species

There were 20 species total in this unit, comprising 13 marine species and 7 freshwater species (Table 1). The second period's largest proportion of carnivores was recorded at the first station in November (62.3%) and the second and third stations in August (55.9%), respectively., whereas the lowest value in December reached 33.1 in the first station and 14.2% in October at the third station as shown in Figure (18). In the three sites, *T. whiteheadi* fish made up the highest proportion of carnivorous species (14.9, 9.76, and 7.05%, respectively) of the total fish catch.

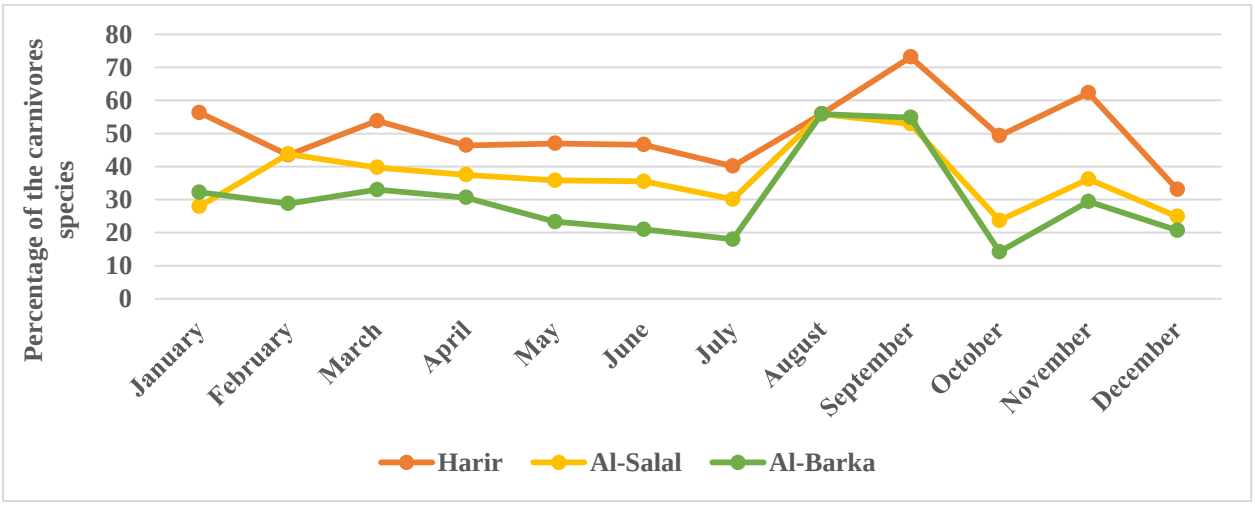

Figure (18): The percentage of the carnivore individuals fish species at all study stations of Al-Hmmar marsh

The eighteen unit: The percentage of the herbivore individuals of the fish species

Three species made up this group: *C. zilli*, *O. niloticus*, and *O. aureus*. December saw the highest proportion of herbivores, reaching (52.5, 50.1, and 69.9%) of the total fish collected in the three station, respectively, while no presence of individuals of this group was recorded in August and September in all stations as shown in Figure (19). *C. zilli* had the highest presence in the second and third stations, where it reached (11.82, and

18.0%), respectively, while *O. niloticus* had the highest presence in the first station and constituted (7.8%) of the total number of fish caught in this station.

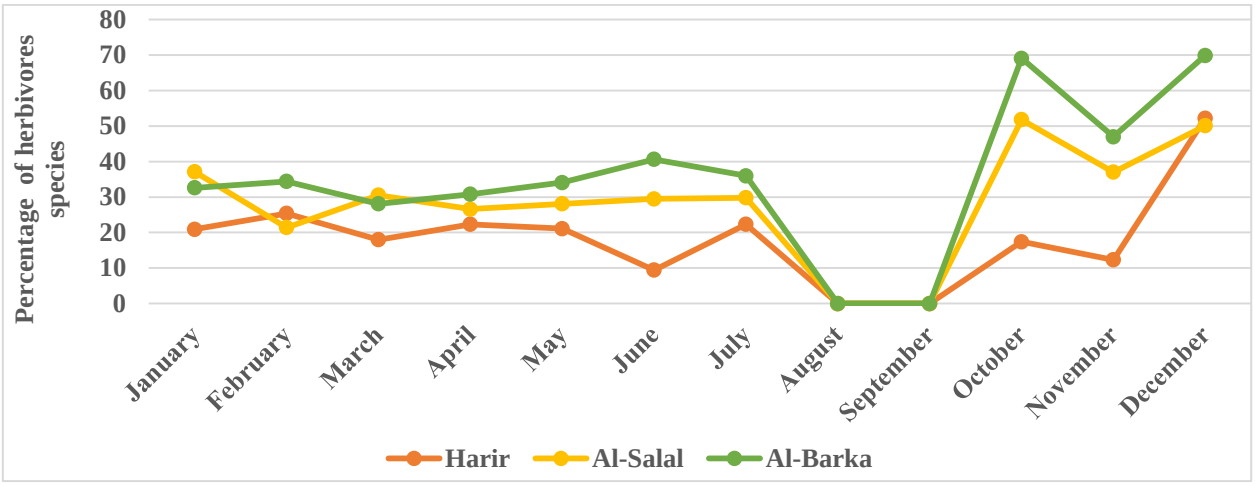

Figure (19): The percentage of the herbivorous fish species at all study stations of Al-Hmmar marsh

The nineteen units: The Percentage of detritivore individuals of the fish species

This group included five species, including four marine species and one freshwater species. This group's highest percentage of individuals was obtained in the second period (25.3%) during August at the first station and (34.4% and 37.1%) in September at the second and third stations, respectively, of the total number of fish caught. The highest percentage was obtained in January (2.5%) at the first station and (2.6%) at the second station in February, while in the third station, it was (0.2%) in December as shown in Figure (20). The species *L. klunzingerii* made up the biggest proportion of this group's species at the first station, *L. subvirdis* made up the biggest percentage of this group in the first station, where it reached (4.69%), and the second and third stations, where it reached (6.2 and 11.0%) of the total number of fish captured.

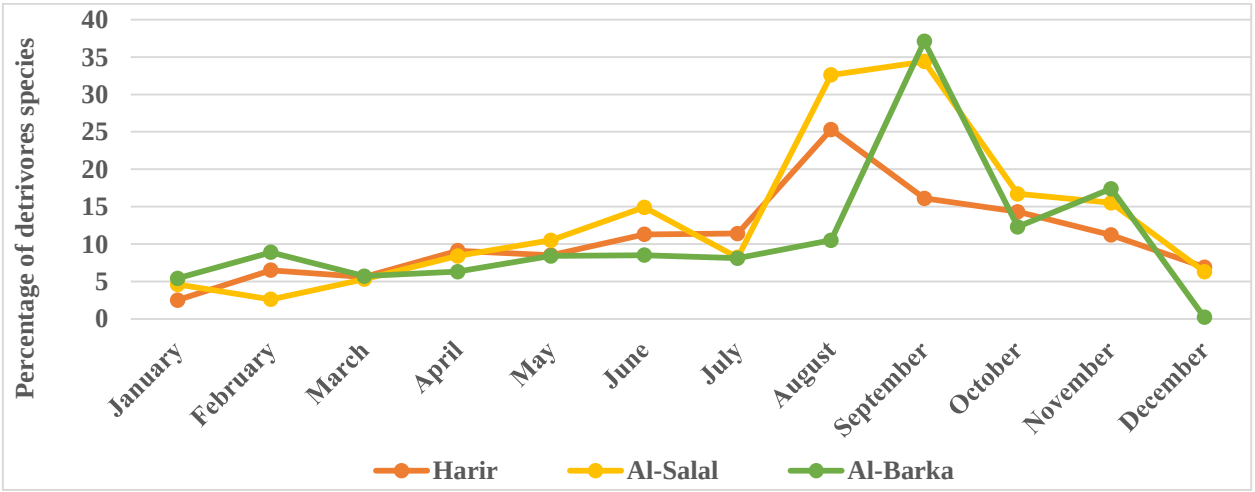

Figure (20): The percentage of detritivore fish species at all study stations of Al-Hmmar marsh

The twenty unit: The percentage of omnivore individuals, fish species

There were six species in this group, three of which were marine and one of which was freshwater (Table 1). The first period of July (26.2%) at the first station yielded the largest proportion of individuals in this group. And (30.4%) in January at the second station, and (37.9 %) in July at the third station. In contrast, the lowest percentage in the second period, done (7.8%) in December at the first station and (7.9 and 4.4%) in October at the second and third stations, respectively as shown in Figure (21) The species *P. latipinna* made up the highest percentage of this category, accounting for 6.52, 8.84, and 8.47, respectively, of the total fish caught in the three sites.

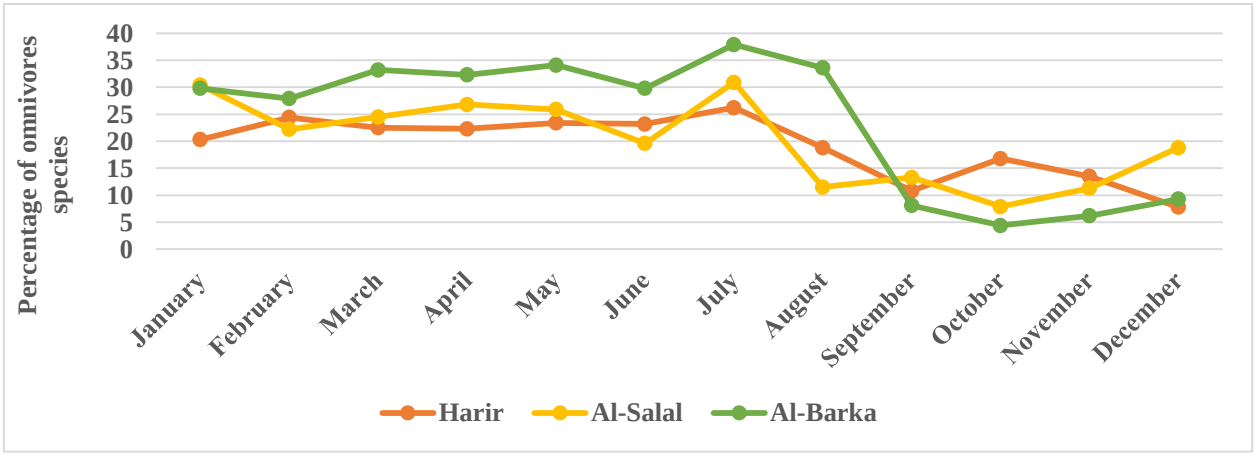

Figure (21): The percentage of the omnivores individuals fish species at all study stations of Al-Hmmar marsh

Integrated Biological Index (IBI)

The three stations' respective averages for the Integrated Biological Index (IBI) for the East Al-Hammar marsh were 56.8, 55.3, and 53.4, respectively, and it was included under poor evaluation (<60). The average IBI index in the first period (before the salinity intrusion) for the three stations, respectively, was 58.2, 55.9, and 56.9, and it was also included under a weak evaluation. The highest value of the IBI index in this period was obtained in June at 61.6 at the second station and was included under the marginally impaired assessment (60-80). The lowest value was 48.6 in January at the second station also, while the average of the Integrated Biological in the second period (salinity intrusion) for the three stations, respectively 54.8, 54.4, and 48.5, the highest index value in this period was 62.5 was obtained in November at the first station 44.1 in December at the first station as well as shown in Figure (22).

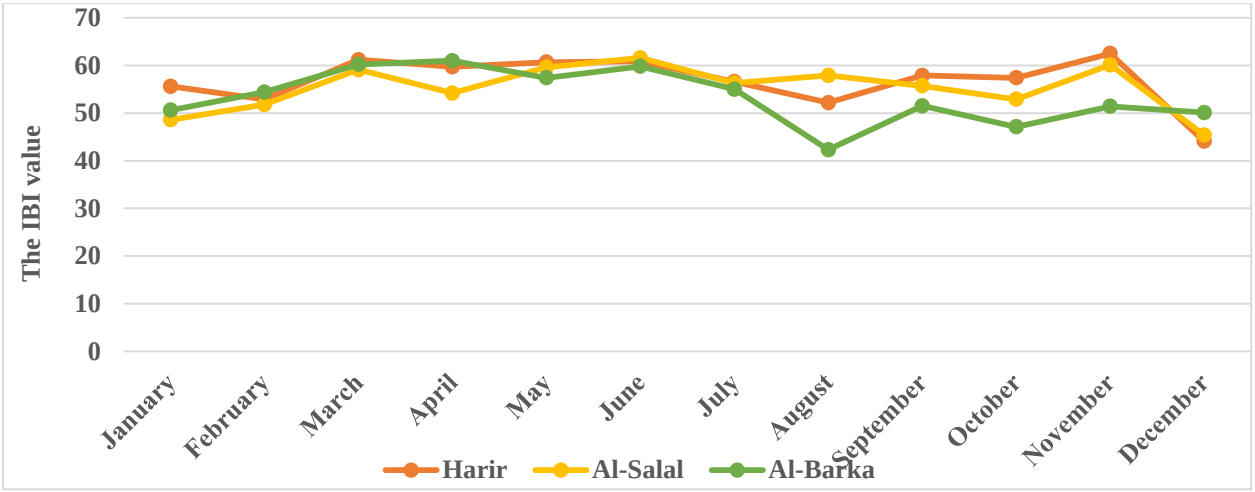

Figure (22): Value of the Integrated Biological Index (IBI) for East Al-Hammar marsh at all study stations

Discussion

[21]and [23]pointed out that seasonal changes in temperature, precipitation, and river flow have a direct impact on the nature of the fish community in many ecosystems; the Integrated Biological Index (IBI) depends on river flow, energy input, and water quality[24,25]. The phenomena of salt intrusion is when salty ocean water creeps up the riverbank. One issue with downstream settings around the globe endangers the maintenance of the ecosystem and optimal use of freshwater [26]. Almost yearly, the Shatt al-Arab River watercourse experiences salt intrusion occurrence. Every year, particularly in the months of June, July, and August, the lack of water, the degradation of its quality, and the approaching characteristics of seawater almost completely overrun it [27].

The amount of salinity intrusion penetration from the Arabian Gulf into the Shatt al-Arab varies according to the volume of freshwater flowing into the Shatt al-Arab from the Tigris River in the Northern part and the volume of temporary water released from the Karun River after diverting its course into Iranian territory since 2009[28]. Many studies have indicated a deterioration in the water quality of the Shatt al-Arab in recent years and an increase in the impact of saline water [29,30,31,32].

The Integrated Biological Index provides a precise indicator of how water bodies are assessed in accordance with predetermined standards. It is regarded as one of the crucial techniques for managing water resources and safeguarding them against environmental degradation. [33]

The results of the current study showed a decrease in the values of the Integrated Biological Index for fish in the East Al-Hammar region in general and three selected stations, respectively (56.8, 55.3, and 53.4), and their inclusion under a poor assessment (<60) and the decrease of the index significantly more significant than the period of the salt incursion, where the value of the salt incursion reached (54.8, 54.4 and 48.5) for the three stations, respectively.

As a result of the altered Shatt al-Arab drainage system and the salinity intrusion, the composition of the fish community has been significantly impacted by environmental changes, and this was confirmed. With [19]. Who noted that, in addition to recording Unprecedented exposure to various pollutants, the climatic changes taking place in the

region also include rising temperatures and the advancement of the salt front from the Gulf, which have caused a change in the composition of the fish community in the area.

The eastern Al-Hammar marsh experienced environmental disturbance, which led to a decline in native species and an increase in alien species. This is what was validated by the fall in the values of the Integrated Biological Index in the present study, with Confermed [24]. One of the disturbances brought on by human activities may be the prevalence of alien species, and their invasion constitutes a disruption of life that gets worse as the environment and water quality deteriorate. It was also demonstrated that native species numbers often decline as disturbance levels rise. [34,35,36,21].

The present study witnessed the disappearance of *Leuciobarbus xanthopterus, Barbus sharpeyi*, *Arabibarbus grypus,* and *Barbus kersin* fish after they made up a noticeable proportion of the fish population in previous studies [37].

The development of species belonging to the tilapia family, which contains the highest proportion of individuals of this group, and the high percentage of alien species in the East Al-Hammar marsh are two additional factors that contributed to the fall in the index's values by [36]. A decrease in the percentage of individuals of the carnivore and herbivore species and a high percentage of individuals of the ferocious and omnivore species were discovered when studying to evaluate the fish population of Al-Hawizeh marsh. This finding has been documented in numerous studies that have included the calculation of the Integrated Biological Index. [7,12,37].

Conclusions

We conclude from this study that the evaluation of the Al-Hammar Marsh environment was included under a poor evaluation, which led to the deterioration of the Al-Hammar Marsh water quality**.**

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