**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834

**ANNALS OF FOREST RESEARCH**
https://www.e-afr.org/

# EFFECT OF WATER DEPTH ON FISH DISTRIBUTION AND FEEDING HABITS IN EASTERN HAMMAR MARSH USING HEAT MAP PLOTTING TECHNIQUE

**Fadia KH Raadi*, Amjed K Resen & Salah M Najim**
Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Basrah Iraq
*Corresponding author: fodfod97@yahoo.com

## Abstract
Fish assemblage in the East Hammar marsh was described during November 2020 to October 2021. A total of 46,277 individuals comprises of 43 fish species belong to three origins were collected; 20 of marine fish, 12 native species and 11 of exotic species. Water and fish samples were collected from three stations which characterized as having different depths. Nile tilapia *Oreochromis niloticus* was the most abundant species which reached (18.47%) in Al- Sallal AL- while was the highest abundant species in AL-Mansory attaining (22.01%), Blue tilapia *Oreochromis aureus* was the most abundant species in AL-Burka which reached (18.43%). The heatmap showed a difference in fish densities according to the depths where fish diversity increased with depth as well as during flood tides. The subtidal zone characterized by variously feeding habit groups with dense herbivores and large –size piscivores unlike small fish that migrate to intertidal zone and shallow areas for feeding and protection from predators. Alien species were also found in all stations in East Hammar marsh but the highest abundance was in the shallow area. The study revealed the clear effect of water depth on fish abundance and diversity whereas exotic species have a significant negative correlation with the depth (r= -0.2) in contrast to the positive relation with native species (r=0.4), and also fish order according to their patterns of feeding habits.
Keywords: Basrah marsh, fish structure, feeding habits, heatmap, tidal effect.

## Introduction
Wetlands have multiple benefits to the ecosystem and life, the most important of which is that they are a repository of genetic diversity, and contain many types of organisms. It represents approximately 40% of the world's total species and supports almost all major living species. From microbes to mammals (1) in addition to its economic benefits as an important source of fish, rich in diverse products, fertile agricultural land, areas for recreation and tourism, part of humanity's cultural heritage, and an outstanding scientific laboratory.

Hammar marsh is one of the three main marshes in the southern region and extends between the provinces of Dhi Qar and Basrah, 56% of the total area of the marshes is located in Dhi Qar and 44% in Basrah. It was subjected to extensive drying in 1991 and after 2003 the eastern part, which was called East Hammer, was flooded again. It connects from the south to the Shatt al-Arab via Karmat-Ali river and from there southward to the Arabian Gulf. Thus, the southeastern part of the marshes is affected by the tidal phenomenon, which is the source of tidal energy coming from the Arabian Gulf (2).

This phenomenon helped the introduction of some marine fish species in addition to the existing freshwater fish species, and thus affected the increase in their biodiversity. Several studies have described the biodiversity and water quality of eastern Hammar marsh. Radee's study (3) was the first reference study that summarized the results of this research and indicated the diversity of the fish community for the presence of marine fish, and these studies and observations continued, Studies describing fish populations according to depth gradients have not been discussed widely. Studies on salinity gradients and longitudinal gradients of fish communities (4, 5, 6, 7) focused only on Hassan's study (8), who showed seasonal fish localization between intertidal zones. Moreover, the daily changes in water depth can affect animal migration between the areas that are affected by the tides and may extend to neighboring areas and systems, where many fish species were found also to feed during high tide (9, 10).

Despite the importance of tidal cycles on fish population structure and localization, there is limited research discussing it. However, some research works discussed the effect of lunar phases and their interaction with tides on estuaries habitat as well as the importance of daily water level fluctuations associated with the occurrence of tides and the effect of these changes on the distribution and density of different fish species (11).

The main goals of this study were to describe the distribution patterns of different species and their densities according to various depths, using heatmap plotting technique (12) at the intertidal (Al-Baraka station), the tidal (Al-Mansouri station) and the subtidal (Al- Sallal station) zones in the eastern Hammar Marsh.

## Materials and Methods

### Study area

East Hammar Marsh is located at the northern part of Basrah governorate (figure 1). It is bordered to the east and north-east by Shatt al-Arab, from the north by Euphrates River and Western Hammar Marsh to the west. Also, from the south and south-west, East Hammar Marsh is bordered by the plateau of Al-Zubair and the main drain channel.

East Hammar Marsh is connected to the south with Shatt Al-Arab through Garmat-Ali River. Its area varies according to the water discharges that resulted from the increase of the water levels in winter and during floods so as snowmelt in spring. However, it is considered now as a semi-closed and depends mainly on the water that comes from Shatt al-Arab and its branch, the Shafi River, and on the phenomenon of tides (2). The sediments of East Hammar Marsh consist of silt and clay. The prevailing climate in the region is desert climate, despite the wide wet areas of the southern marshes.

**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834


Three areas were selected for sample collection from East Hammar Marsh, according to the variation in water depth; ALSallal N: 300 360 470 E:470 400 15 0 which considered as tidal channel marsh; Al-Mansory N: 300 400 260 E:470 370570 and Al-Burka N: 470 330 20 E:300 410 440 which is described as tidal open shallow water body.

Table (1): the depth of stations

| Station No. | Station Name | depth |
|---|---|---|
| 1 | Al-Sallall station | (LLW) (9-7m) |
| 2 | Al-Mansory station | (MHW) (7-5m) |
| 3 | Al-Burka station | (HHW) (3-1m) |

## Sampling stations

The sites were selected according to the depths and the level of water immersion during the tides. When the tide level rises, it is called higher high water HHW and reaches to (Al-Burka) N: 470 330 20 E:300 410 440 which is described as tidal open shallow water and the low tide water level is called lower low water LLW (Al-Sallall) N:300 360 470 E:470 400 15 0 which considered as tidal channel marsh, and the mean tidal range MHW called (Al-Mansory) N: 300 400 260 E:470 370570 and according to the depths indicated in the table (1).


Figure (1): Map of study area

**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834



**Materials and Methodology**

From the three selected stations, water and fish samples were collected from November (2020) to October (2021) Samples were collected on a monthly basis. The environmental factors, including water temperature, salinity, DO, EC and TDS were measured by using multi-measure device (WTW Multi 350i).

Fish samples were collected by four method; (1) Trawl net (2) Gill nets (3) Cast nets , and (4) Electro fishing. Fish was classified according to (13, 14)

Environmental indicators of fish community included:

- The relative abundance of each species was calculated using [15]
- Occurrence

  Fish species were divided according to the period of their presence or their occurrence in the monthly samples based on (16)

  - Statistical analysis: SPSS statistical analysis package (version 20) was used.

**Results and Discussion**

**Environmental parameters of East Hammar Marsh**

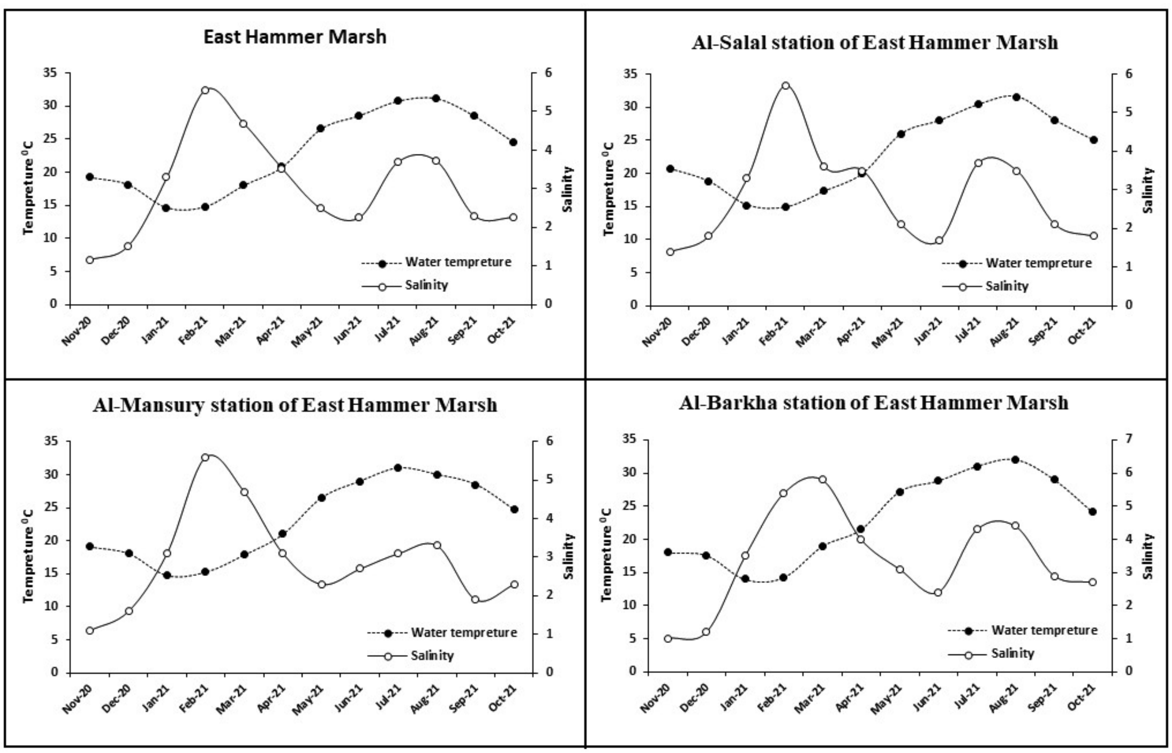


Figure (2): Monthly variations of water temperature and salinity at study area

**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834


The maximum temperature recorded was 33$^0$C during July 2021 and the minimum was 13.8 $^0$C during February 2021 at Burka stations, the temperature fluctuated from 32 $^0$C in July to 14.9 $^0$C in February at Al-Sallal, while maximum temperature in Al-Mansury station was 31$^0$C in July and the minimum was 14.8$^0$C in January m the water temperature values varied from 33$^0$C to 13.8$^0$C in East Hammer (fig.2).

A significant positive correlation (r=0.7, p-value=<0.05) was observed between water temperature and total fish catch and a significant positive correlation (r=0.8, p-value = <0.05) with the number of species. However, salinity showed a very week negative correlation (r= -0.2, p-value> 0.05) with total fish catch and a week negative correlation (r= -0.5, p-value> 0.05) with the number of species.

The salinity level in fig. (2) showed that the maximum concentration was 5.8 in March 2021 and the minimum was 1.0 in November at Al-Burka station, salinity was recorded between 4.7 in March and 1.1 during November at Al-Mansury station. Finally, at Al-Sallal station the salinity was between 3.6 in March and 1.4 in November.

Figure (3) showed that the maximum amount of TDS and EC was (7132 mg/l, 10050 µm/cm, respectively) in February and the minimum was (2000 mg/l, 2400 µm/cm) in November at Al-Mansury station. The amount of TDS and EC in Al-Sallal station varied from (7100 mg/l, 10000 µm/cm, respectively) in February to (2200 mg/l, 3000 µm/cm) in November. The maximum amount of TDS and EC was (7000 mg/l, 10050 µm/cm, respectively) in March and the minimum was (2100 mg/l, 3060 µm/cm) in November at Al-Baraka station.

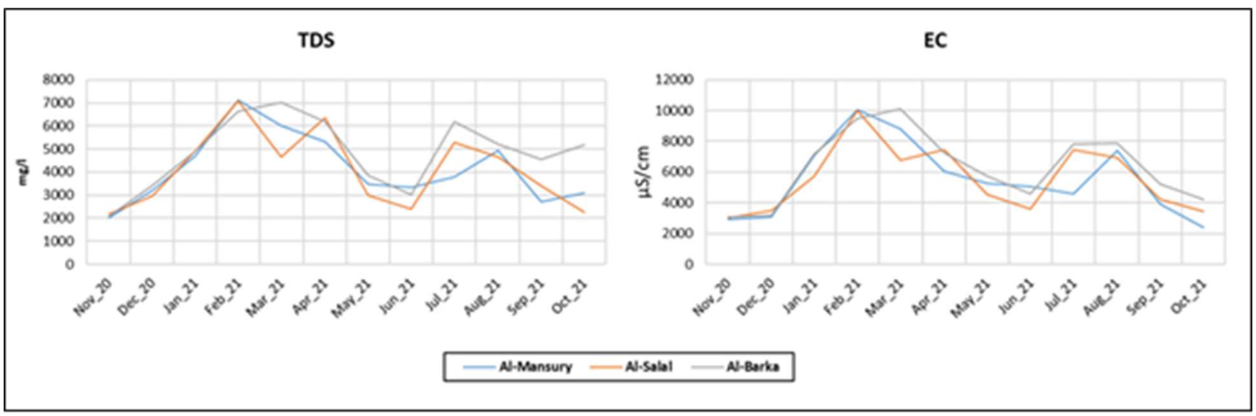


Figure (3): Variations of TDS and EC in East Hammar Marsh during the study period

Figure (4) showed dissolved oxygen DO levels where the maximum concentration was 10.1 mg/l in December and the minimum recorded 4.9 mg/l in August with an average of 7.5 mg/l. The low DO could be related to the high oxygen consumption by oxidizable organic matter [33]. On the other hand, DO content in East Hammar Marsh decreased in the summer season, which may due to the water temperature elevation that consequently decreased the solubility of dissolved oxygen (r= -0.7, p-value= <0.05) in the water as shown previously[17].

Ann. For. Res. 65(1): 944-967, 2022
DOI: 10.5281/zenodo.7262834


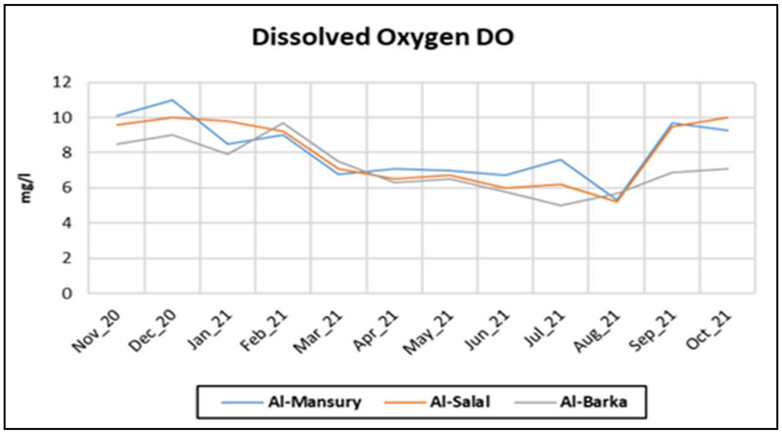


Figure (4): Figure presenting the variation of DO in East Hammar Marsh during the study period.

**Fish assemblages in East Hammar Marsh**

A total of 46277 fish from 43 species were collected from East Hammar Marsh where freshwater species contributed 23 species, including 12 endemic species (15.40%) and 11 exotic species (65.53%) and finally the largest number of marine species was 20 species (19.07%).(table2)

**Table 2.** Fish orders, families, origin and species collected from the study stations.

| Order | Family | Species | origin |
|---|---|---|---|
| Clupeiformes | Clupeidae | ***Nematalosa nasus*** | ***Marine*** |
| | | ***Tenualosa ilisha*** | ***Marine*** |
| | | ***Sardinella albella*** | ***Marine*** |
| | Engraulidae | ***Thryssa dussumieri*** | ***Marine*** |
| | | ***Thryssa vitrirostris*** | ***Marine*** |
| | | ***Thryssa whiteheadi*** | ***Marine*** |
| | Pristigasteridae | ***Ilisha compressa*** | ***Marine*** |
| | Cyprinidae | ***Carasobarbus luteus*** | ***Native*** |
| | | ***Carassius auratus*** | ***Native*** |
| | | ***Cyprinus carpio*** | ***Excotic*** |
| | | ***Luciobarbus xanthopterus*** | ***Native*** |
| | | ***Mesopotamichthys sharpeyi*** | ***Native*** |
| | Xenocyprididae | ***Ctenopharyngodon idella*** | ***Excotic*** |
| | | ***Hemiculter leucisculus*** | ***Excotic*** |
| | | ***Hypophthalmichthys molitrix*** | ***Excotic*** |

| | | | |
|---|---|---|---|
| | Leuciscidae | ***Acanthobrama marmid*** | ***Native*** |
| | | ***Alburnus sellal*** | ***Native*** |
| | | ***Leuciscus vorax*** | ***Native*** |
| Siluriformes | Bagridae | ***Mystus pelusius*** | ***Native*** |
| | Siluridae | ***Silurus triostegus*** | ***Native*** |
| | Heteropneustidae | ***Heteropneustes fossilis*** | ***Excotic*** |
| Gobiiformes | Gobiidae | ***Bathygobius fuscus*** | ***Marine*** |
| | | ***Boleophthalmus dussumieri*** | ***Marine*** |
| Synbranchiformes | Mastacembelidae | ***Mastacembelus mastacembelus*** | ***Native*** |
| | Soleidae | ***Brachirus orientalis*** | ***Marine*** |
| Cichliformes | Cichlidae | ***Oreochromis aureus*** | ***Excotic*** |
| | | ***Oreochromis niloticus*** | ***Excotic*** |
| | | ***Coptodon zillii*** | ***Excotic*** |
| Cyprinodontiformes | Poeciliidae | ***Gambusia holbrooki*** | ***Excotic*** |
| | | ***Poicilia latipinna*** | ***Excotic*** |
| | Aphaniidae | ***Aphanius dispar*** | ***Native*** |
| | | ***Paraphanius mento*** | ***Native*** |
| | Hemiramphidae | ***Hyporhamphus limbatus*** | ***Marine*** |
| Mugiliformes | Mugilidae | ***Planiliza carinatus*** | ***Marine*** |
| | | ***Planiliza abu*** | ***Native*** |
| | | ***Planiliza klunzingeri*** | ***Marine*** |
| | | ***Planiliza subviridis*** | ***Marine*** |
| Acanthuriformes | Leiognathidae | ***Photopectoralis bindus*** | ***Marine*** |
| | Scatophagidae | ***Scatophagus argus*** | ***Marine*** |
| | Sillaginidae | ***Sillago sihama*** | ***Marine*** |
| | Sparidae | ***Acanthopagrus arabicus*** | ***Marine*** |
| | | ***Sparidentex hasta*** | ***Marine*** |
| | Sciaenidae | ***Johnius belangerii*** | ***Marine*** |

Tables 3, 4 and 5 show the monthly variations in relative abundance and origin of fish species in three station for study area.

Table (3): Monthly variations in relative abundance (%) of fish species in Al-Sallal station LLW (November 2020 - October 2021).

| Species | No v_2 | Dec _20 | Jan _2 | Feb _21 | Mar _21 | Apr _21 | Ma y_2 | Jun _21 | Jul _2 | Au g_2 | Sep _21 | Oct _21 | A vg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | 1 | | | | 1 | | 1 | 1 | | | . |
| *Or_niloticus* | 20.2 | 20.3 | 30.9 | 30.1 | 24 | 18.4 | 14.6 | 14.9 | 9.5 | 13.5 | 15.6 | 18.2 | 18.47 |
| *O_aureus* | 15.9 | 15.2 | 26.3 | 36.1 | 15 | 19.4 | 10.5 | 15.8 | 14.8 | 20.3 | 17.9 | 22.3 | 18.3 |
| *C_auratus* | 17.4 | 18.3 | 11.2 | 11.1 | 12.7 | 14.4 | 21.3 | 15.3 | 7 | 7.6 | 5.5 | 6.3 | 12.33 |
| *Pl_abu* | 15.6 | 13 | 8.8 | 7.2 | 8.1 | 6.1 | 10.6 | 8.4 | 15.8 | 8.2 | 6.2 | 11.5 | 9.97 |
| *Te_ilisha* | 3 | 10.2 | 1.3 | 0 | 3.7 | 4.4 | 5.5 | 8.2 | 13.9 | 15 | 12.4 | 5.8 | 6.96 |
| *Po_latipinna* | 3.1 | 3 | 4.5 | 0 | 5.1 | 10.1 | 9.1 | 9.9 | 7.1 | 5.5 | 6.2 | 11 | 6.22 |
| *T_whiteheadi* | 6.3 | 3.1 | 2.8 | 1.2 | 13.3 | 6.5 | 8.9 | 5.7 | 8.5 | 4.4 | 6.2 | 5.8 | 6.06 |
| *Co_zillii* | 1.4 | 1 | 0.3 | 3.3 | 3.8 | 4 | 4.6 | 4.2 | 2.8 | 1.4 | 0.7 | 1.2 | 2.4 |
| *Pl_subviridis* | 2.7 | 0.9 | 1.7 | 1.2 | 1.2 | 2.4 | 2.7 | 1.8 | 3.5 | 3.2 | 4.4 | 2.9 | 2.38 |
| *Al_sellal* | 1.4 | 2.3 | 1.6 | 1.2 | 1.4 | 1.4 | 0.5 | 1.4 | 3.9 | 4.8 | 1.1 | 1.3 | 1.87 |
| *T_hamiltonii* | 1.5 | 1.1 | 1.2 | 0 | 0.8 | 1.4 | 0.2 | 0 | 0.9 | 2.7 | 5.5 | 4.5 | 1.66 |
| *Pl_klunzingeri* | 1.4 | 0 | 0 | 0 | 0.6 | 0.7 | 1 | 2.9 | 3.9 | 1.7 | 4.9 | 2.3 | 1.61 |
| *S_triostegus* | 1.3 | 2.5 | 4.5 | 6.6 | 1 | 0.1 | 0 | 0 | 0.2 | 0.2 | 0.2 | 0.4 | 1.42 |
| *T_vetrirostris* | 0.8 | 0 | 0 | 0 | 1.9 | 2.2 | 1.3 | 1.8 | 0 | 1.5 | 3.7 | 1.2 | 1.19 |
| *C_carpio* | 1.4 | 1.6 | 1.2 | 1.2 | 0.8 | 0.5 | 0.6 | 0.4 | 1.7 | 2.3 | 1.4 | 0.7 | 1.16 |
| *H_leuciscculus* | 0.5 | 1.5 | 1.2 | 0.2 | 1.9 | 0.9 | 0.8 | 0.2 | 0.7 | 1.2 | 1.2 | 0.7 | 0.93 |
| *Ac_arabicus* | 0.2 | 0 | 0 | 0 | 0.2 | 0.6 | 1.1 | 1.8 | 1.4 | 1.1 | 2.2 | 0.2 | 0.73 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *G_holbrooki* | 0.6 | 0.6 | 0 | 0 | 0 | 1.4 | 1.2 | 1.4 | 0.4 | 1.6 | 0.9 | 0.3 | 0.71 |
| *A_marmid* | 1.7 | 0.5 | 0 | 0 | 0.9 | 0.6 | 0.9 | 0.8 | 0.3 | 0.7 | 0.3 | 0.6 | 0.61 |
| *pa_mento* | 0 | 0 | 0 | 0 | 1.9 | 2.2 | 0.8 | 0.6 | 0.5 | 0.2 | 0.5 | 0 | 0.55 |
| *A_dispar* | 1 | 0.4 | 0 | 0 | 0.4 | 0.8 | 0.5 | 1.6 | 1 | 0 | 0 | 0.5 | 0.52 |
| *Ca_luteus* | 1.1 | 1 | 0.7 | 0 | 0.1 | 0.3 | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 | 0.1 | 0.39 |
| *Le_vorax* | 1.1 | 1.1 | 1.3 | 0.5 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.36 |
| *B_fuscus* | 0.1 | 0 | 0 | 0 | 0.8 | 0.4 | 0.6 | 0.8 | 0.3 | 0.5 | 0.4 | 0.1 | 0.33 |
| *Hy_limbatus* | 0 | 0 | 0 | 0 | 0.3 | 0.6 | 0.6 | 0.4 | 0.2 | 0.1 | 0.4 | 0.3 | 0.24 |
| *Ne_nasus* | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.5 | 0.2 | 0.4 | 0.5 | 0.3 | 0.1 | 0.18 |
| *Sp_hasta* | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.1 | 0.13 |
| *Ph_bindus* | 0 | 0.3 | 0 | 0 | 0 | 0 | 0.3 | 0.2 | 0.2 | 0.1 | 0 | 0.5 | 0.12 |
| *Me_sharpeyi* | 0.2 | 0.5 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0.11 |
| *Bo_dussumieri* | 0.2 | 0.5 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.3 | 0 | 0 | 0.2 | 0.11 |
| *Il_compressa* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.2 | 0 | 0.4 | 0.1 | 0.09 |
| *Si_sihama* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.3 | 0.2 | 0.1 | 0.2 | 0.1 | 0.08 |
| *Sc_argus* | 0 | 0.3 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0.3 | 0.2 | 0 | 0.07 |
| *Jo_belangeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0.2 | 0.2 | 0.1 | 0.06 |
| *Pl_carinata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.5 | 0.05 |
| *Hy_moli* | 0 | 0.2 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *trix* | | | | | | | | | | | | | 03 |
| *br_orientalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0.1 | 0.2 | 0 | 0.03 |
| *Ct_idella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.1 | 0 | 0.02 |
| *Lu_xanthopterus* | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| *My_pelusius* | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| *Sa_albella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0.01 |

Table (4): Monthly variations in relative abundance (%) of fish species in Al-Mansury station MHW (November 2020 - October 2021).

| Month | Nov_20 | Dec_20 | Jan_21 | Feb_21 | Mar_21 | Apr_21 | May_21 | Jun_21 | Jul_21 | Aug_21 | Sep_21 | Oct_21 | avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Or_niloticus* | 21.8 | 32 | 37.4 | 42.6 | 23.6 | 18 | 9.6 | 17.4 | 17.8 | 22.8 | 17.6 | 19 | 22.01 |
| *Or_aureus* | 16.5 | 14.4 | 18.7 | 21.1 | 18.5 | 22.3 | 27.7 | 12.9 | 15.8 | 16.6 | 11 | 16.5 | 17.67 |
| *C_auratus* | 24 | 18.5 | 11 | 11 | 11.3 | 12.9 | 17.9 | 13.6 | 6.3 | 5.1 | 11 | 10.9 | 12.79 |
| *Pl_abu* | 16.8 | 12.6 | 10.6 | 10.3 | 7 | 6.7 | 7.4 | 12.4 | 15.8 | 11.5 | 7.9 | 7.7 | 10.56 |
| *Po_latipinna* | 1.6 | 2.8 | 2.6 | 5.9 | 9.3 | 11.9 | 8.3 | 11.6 | 10.6 | 7.4 | 16.6 | 15.2 | 8.65 |
| *T_whiteheadi* | 5.7 | 0.7 | 1 | 0 | 18.5 | 11.9 | 7.4 | 8.9 | 10.3 | 10 | 6.3 | 9.1 | 7.48 |
| *T_ilisha* | 1.5 | 3.7 | 1.4 | 0 | 1.9 | 2.5 | 3 | 5 | 3.7 | 5.2 | 7.9 | 3.4 | 3.27 |
| *T_hamiltonii* | 1.7 | 1.7 | 0 | 0 | 1.4 | 1.6 | 0 | 0 | 4.3 | 2.4 | 6.2 | 7.6 | 2.24 |
| *Co_zillii* | 2.1 | 0.3 | 0 | 2.3 | 3.3 | 1.5 | 3.2 | 3.7 | 1.7 | 3.2 | 2.2 | 1.3 | 2.07 |
| *Al_sellal* | 1.8 | 3.3 | 2.5 | 0.6 | 0.1 | 1.2 | 0.9 | 0.7 | 1.8 | 0.6 | 1.1 | 2.4 | 1.42 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *S_triostegus* | 1.6 | 3.5 | 6.2 | 4.1 | 0.6 | 0 | 0.1 | 0 | 0 | 0.1 | 0.2 | 0.3 | 1.39 |
| *pa_mento* | 0 | 0.4 | 0.9 | 0 | 3.1 | 3 | 1.9 | 1.2 | 0.3 | 0.8 | 1.1 | 0.3 | 1.08 |
| *G_holbrooki* | 0 | 0 | 0 | 0 | 0 | 2.2 | 1.7 | 0.6 | 2 | 2.2 | 2.9 | 1.1 | 1.06 |
| *A_dispar* | 0 | 1.3 | 1.2 | 0 | 0 | 0.6 | 1.8 | 2.7 | 1.8 | 1.5 | 0 | 0.8 | 0.98 |
| *Pl_subviridis* | 0.4 | 1.1 | 2 | 1.3 | 0 | 1.2 | 1.3 | 1.7 | 0.2 | 0.5 | 1.5 | 0 | 0.93 |
| *T_vetrirostris* | 0.4 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1.4 | 2.9 | 1.7 | 0.78 |
| *Pl_klunzingeri* | 0.6 | 0 | 0 | 0 | 0 | 0 | 0.1 | 1 | 2 | 3 | 0 | 0.5 | 0.6 |
| *C_carpio* | 1 | 0.9 | 0.5 | 0 | 0.3 | 0.2 | 0.3 | 0.2 | 2.3 | 0.8 | 0.3 | 0.3 | 0.59 |
| *H_leucisculus* | 0 | 0.9 | 0 | 0 | 0.9 | 0.8 | 2.4 | 0 | 0 | 0.3 | 0.7 | 0.4 | 0.53 |
| *A_marmid* | 1.5 | 0 | 0.9 | 0 | 0 | 0.1 | 1.5 | 1.2 | 0.5 | 0.1 | 0 | 0.5 | 0.53 |
| *B_fuscus* | 0 | 0.3 | 0.5 | 0 | 0.2 | 0.4 | 0.5 | 1 | 0.5 | 1 | 0.9 | 0 | 0.44 |
| *Ac_arabicus* | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.4 | 0.7 | 1.7 | 2 | 0 | 0.1 | 0.43 |
| *Le_vorax* | 1 | 0.9 | 1.9 | 0.9 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.41 |
| *Hy_limbatus* | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.4 | 0.2 | 0.2 | 0.1 | 0.4 | 0 | 0.13 |
| *Il_compressa* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.4 | 0 | 0.4 | 0.4 | 0.1 | 0.12 |
| *Ph_bindus* | 0.2 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0 | 0.3 | 0 | 0.2 | 0.11 |
| *Ca_luteus* | 0 | 0.2 | 0.4 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0.2 | 0 | 0.2 | 0.1 |
| *Bo_dussumieri* | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.3 | 0.2 | 0 | 0 | 0.1 | 0 | 0.08 |
| *Me_sharpeyi* | 0.1 | 0.2 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 |

**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834

**ANNALS OF FOREST RESEARCH**
https://www.e-afr.org/

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ne_nasus* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.3 | 0.1 | 0.1 | 0.2 | 0 | 0.07 |
| *Sp_hasta* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0.1 | 0.3 | 0 | 0.05 |
| *Si_sihama* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0.1 | 0.2 | 0.03 |
| *Jo_belangeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0 | 0.2 | 0 | 0.03 |
| *br_orientalis_* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0.02 |
| *Hy_molitrix* | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| *Ct_idella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.01 |
| *He_fossilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.01 |
| *Ma_mastacembelus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.01 |
| *Pl_carinata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.01 |
| *Sa_albella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0.01 |
| *Sc_argus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0.01 |

Table (5): Monthly variations in relative abundance (%) of fish species in Al-Burkha station HHW (November 2020 - October 2021).

| Month | Nov_20 | Dec_20 | Jan_21 | Feb_21 | Mar_21 | Apr_21 | May_21 | Jun_21 | Jul_21 | Aug_21 | Sep_21 | Oct_21 | avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Or_aureus* | 14.9 | 12.6 | 12 | 25.2 | 22 | 17.8 | 15.8 | 23.5 | 19.9 | 18 | 18.5 | 18.5 | 18.43 |
| *Or_niloticus* | 17.3 | 11.6 | 10 | 21.2 | 17 | 14.8 | 19.2 | 11.7 | 18.3 | 22.8 | 12 | 13.2 | 15.76 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Po_latipinna* | 6.7 | 3.5 | 17 | 17.6 | 11 | 14.1 | 11.8 | 14.7 | 13.3 | 11.6 | 16.5 | 13.4 | 12.6 |
| *Co_zillii* | 10 | 24.7 | 29.9 | 19.6 | 5.6 | 9.4 | 6.8 | 10.5 | 2.2 | 1.9 | 3.6 | 3.7 | 10.66 |
| *C_auratus* | 15 | 14 | 6.9 | 7.4 | 12.3 | 12.6 | 12 | 7.8 | 5.1 | 6.2 | 8.6 | 10.3 | 9.85 |
| *Pl_abu* | 14.9 | 13.8 | 10.3 | 4.7 | 4.7 | 6.2 | 9.3 | 6.3 | 7 | 11.1 | 9 | 9.8 | 8.93 |
| *Th_whiteheadi* | 3.8 | 4.9 | 3.1 | 0 | 14.9 | 10.5 | 6.9 | 4.2 | 2.9 | 1.2 | 3 | 7.7 | 5.26 |
| *Pl_subviridis* | 4.1 | 0.2 | 2.2 | 0 | 0 | 0.2 | 1.2 | 1.7 | 4.4 | 5.7 | 3.5 | 3.5 | 2.23 |
| *Al_sellal* | 2.5 | 4.4 | 3 | 0 | 1.8 | 2.8 | 1.3 | 1 | 4.1 | 0.2 | 1.7 | 1 | 1.98 |
| *Te_ilisha* | 0.6 | 0 | 0.9 | 0 | 0.7 | 1 | 1.9 | 2.3 | 0.7 | 4 | 6.6 | 3.6 | 1.86 |
| *Pl_klunzingeri* | 3.1 | 0 | 0 | 0 | 0 | 0.2 | 0.6 | 1 | 5.1 | 5.4 | 3 | 3.6 | 1.83 |
| *G_holbrooki* | 1 | 0.8 | 0.3 | 0 | 0 | 1.8 | 2.6 | 1.6 | 5.8 | 1.1 | 3.3 | 2.1 | 1.7 |
| *pa_mento* | 0.4 | 0 | 1.2 | 1.4 | 3.1 | 2.8 | 1.6 | 4.2 | 0.8 | 2 | 1.1 | 0.3 | 1.58 |
| *A_dispar* | 0.3 | 0.6 | 0.7 | 1.3 | 0 | 0.6 | 3.5 | 0.9 | 3.3 | 2.7 | 0.4 | 0.8 | 1.26 |
| *H_leucisculus* | 0.5 | 1.8 | 0.3 | 0.8 | 1.6 | 0.9 | 0 | 1 | 1.1 | 0 | 1.7 | 1.7 | 0.95 |
| *T_vetrirostris* | 0 | 0 | 0 | 0 | 3 | 1.5 | 1.3 | 0.9 | 0 | 0.3 | 1.3 | 1.8 | 0.84 |
| *B_fuscus* | 0.4 | 0.4 | 0.5 | 0.2 | 0.8 | 0.9 | 1.5 | 1.7 | 1.2 | 1.2 | 0.8 | 0.4 | 0.83 |
| *Ac_arabicus* | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.9 | 2.3 | 2.4 | 3.3 | 0.2 | 0.8 |
| *T_hamiltonii* | 1 | 1 | 0.5 | 0 | 1.3 | 1.5 | 0 | 0.2 | 0.3 | 0.5 | 0 | 2.6 | 0.74 |
| *A_marmid* | 0.5 | 2.2 | 0 | 0 | 0 | 0 | 1.8 | 1.7 | 0 | 0 | 0.1 | 0.2 | 0.54 |

**Ann. For. Res. 65(1): 944-967, 2022**
DOI: 10.5281/zenodo.7262834



| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C_carpio* | 0.5 | 0.5 | 0.2 | 0 | 0.2 | 0 | 0.1 | 0 | 0.3 | 0 | 0.5 | 0.6 | 0.24 |
| *Bo_dussumieri* | 0.2 | 1 | 0 | 0 | 0.1 | 0.1 | 0 | 0.2 | 0.5 | 0 | 0.4 | 0.3 | 0.23 |
| *Le_vorax* | 1.1 | 0.6 | 0.5 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.21 |
| *S_triostegus* | 0.4 | 0.5 | 0.3 | 0.3 | 0 | 0 | 0.1 | 0 | 0.1 | 0 | 0.2 | 0.2 | 0.18 |
| *Ph_bindus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0.7 | 0.9 | 0 | 0 | 0.18 |
| *Ca_luteus* | 0.6 | 0.4 | 0.3 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.2 | 0.1 | 0.14 |
| *Hy_limbatus* | 0 | 0 | 0 | 0 | 0 | 0.2 | 0 | 0.5 | 0.4 | 0.3 | 0.1 | 0.2 | 0.14 |
| *Il_compressa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.1 | 0.1 | 0.3 | 0.2 | 0.09 |
| *Eu_orientalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 | 0.2 | 0.1 | 0 | 0.04 |
| *Jo_belangeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.04 |
| *Lu_xanthopterus* | 0 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 |
| *Me_sharpeyi* | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| *My_pelusius* | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| *Sa_albella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.1 | 0.02 |
| *Ne_nasus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0 | 0 | 0.02 |
| *Si_sihama* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.1 | 0 | 0.02 |
| *He_fossilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 0.01 |
| *Ma_mastacembelus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.01 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pl_carinata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.01 |

Figure (5) show, highest relative abundance of exotic species in all the three studied stations at East Hammar Marsh. The maximum relative abundance was observed during January and February 2021 in all stations except the Al-Mansury station which was at February 2021only.

Marine species have high relative abundance from July to September 2021 in Al-Sallal and Al-Mansury was during August and September 2021, while in Al-Burka station it extended from August to October 2021 (fig. 5). The abundance of native fish species was not affected by the variation in depth that appeared in all stations inside the marshes. The exotic species in the graph showed that it had the highest abundance in the shallow areas of Barkha Station.

The heatmap dipicted in (figure 6) illucidate the highest relative abundance fish species in the three stations within East Hammar Marsh which represented in the dark red. There was 10 marine species characterized in the Al-Sallal station (*T. ilisha, T.vetrirostris, S. argus, S. sihama, J. belangeri, P. carinata, B. orientalis, H. limbatus, N. nasus,* and *S. hasta*), The species of *T.whiteheadi* was in the Al-Mansury station, and Al-Burka station characterized by 4 species (*B. orientalis, B.fuscus, B. dussumieri, and P. bindus*). Al-Sallal station characterized by the high relative abundance of 3 native species (*M. sharpeyi*, *C. luteus*, and *A. marmid*) and 3 species in Al-Burka station (*P. mento, A. dispar*, and *C. luteus*). On the other hand, three exotic species (*C. Idella, H. molitrix*, and *C. carpio*) were characterized Al-Sallal station, in Al-Mansury station the species of *O. niloticus* was characterized, and four species in Al-Burka station (*G. holbrooki, P. latipinna, C. zillii*, and *O. aureus.*

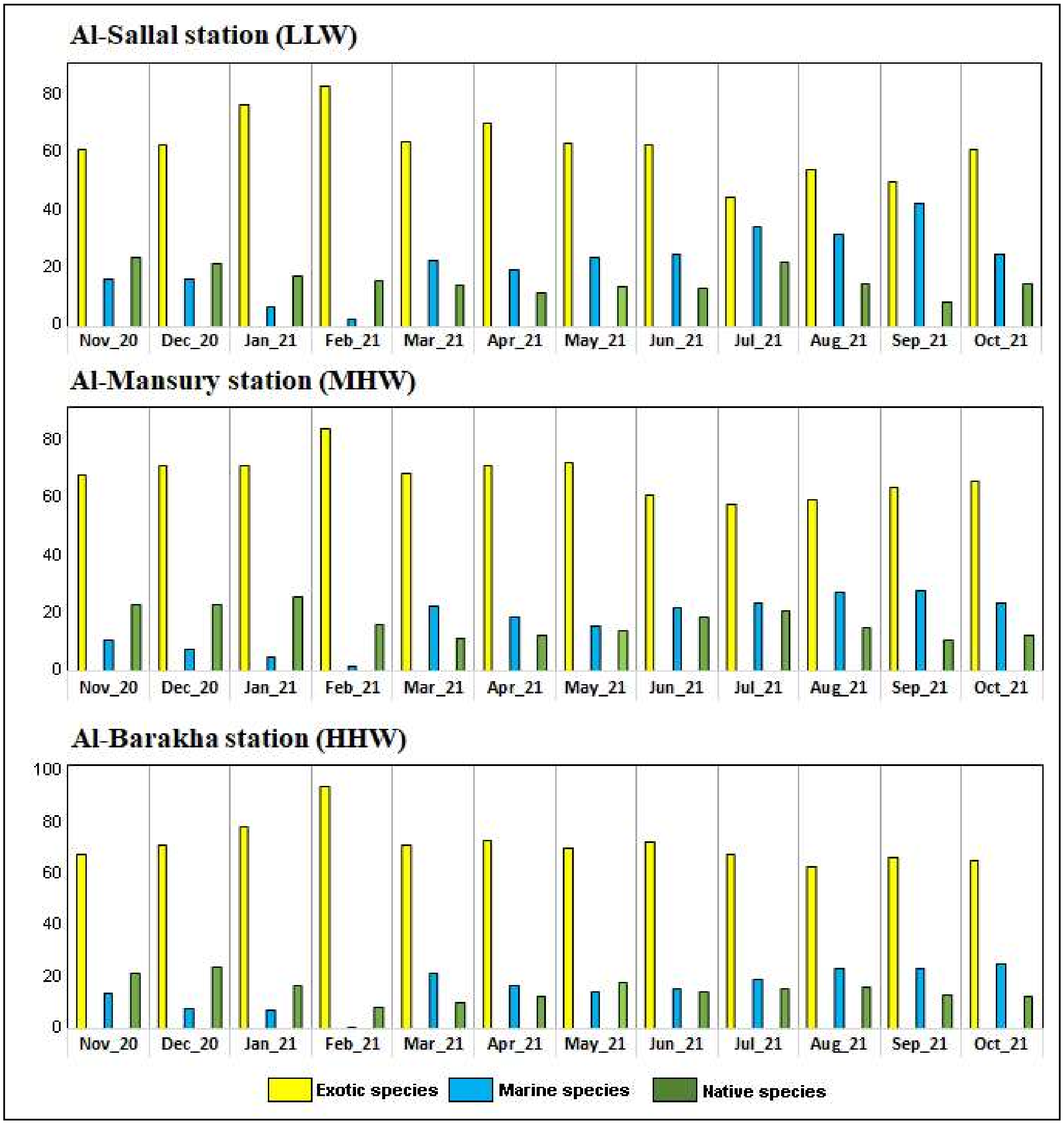


Figure (5): Figure showing the relative abundance variation of Exotic, Native, and Marine species

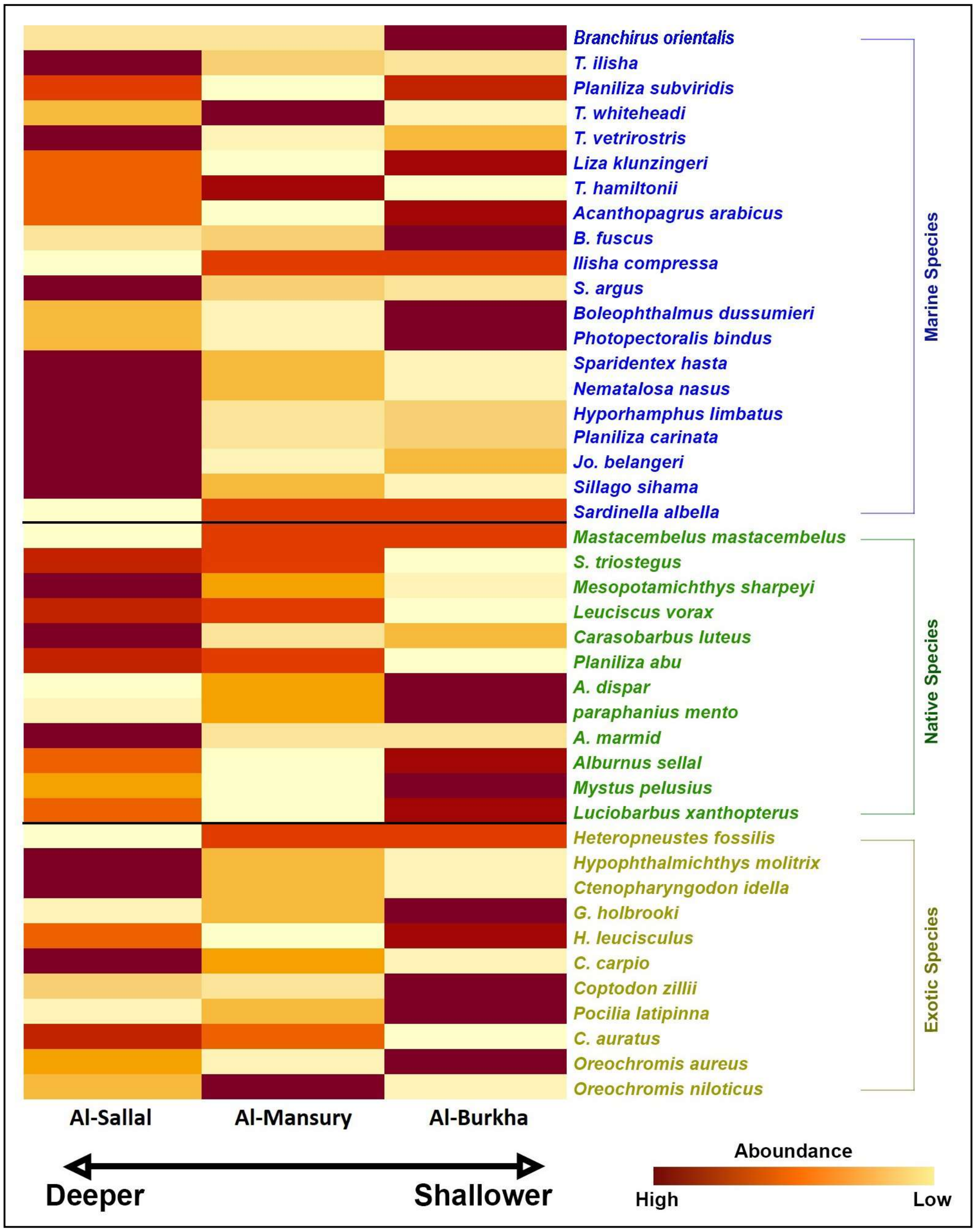


Figure (6): Heatmap patterns of the relative abundance for the fish species in the studied areas (Al-Sallal, Al-Mansoury, Al-Burkha). Darker red color indicates greater fish density. The blue color species are related to marine species, the green color species are related to native species, the golden color species are related to exotic species

The heatmap plotting in figure (6) illustrates the highest relative abundance fish species in the three stations within East Hammar Marsh which represented in the dark red. There was 10 marine species charactered in the Al-Sallal station (*T. ilisha, T.vetrirostris, S. argus, S.sihama, J. belangeri, P. carinata, B. orientalis, H. limbatus, N.nasus, and S. hasta),* The species of

*T.whiteheadi* was in the Al-Mansury station, and Al-Burka station characterized by 4 species (*B.orientalis, B.fuscus, B. dussumieri, and P. bindus*). Al-Sallal station characterized by the high relative abundance of 3 native species (*M. sharpeyi, C. luteus*, and *A. marmid*) and 3 species in Al-Burka station (*P. mento*, *A. dispar*, and *C. luteus*). While a 3 exotic species (*C. Idella, H. molitrix*, and *C. carpio*) characterized in Al-Sallal station, in Al-Mansury station the species of *O. niloticus* was characterized, and a 4 species (*G. holbrooki, P. latipinna, C.zillii,* and *O. aureus.*

In the heatmap plot (figure 7) at Al-Sallal station, the native species have highest relative abundance from November 2020 to January 2021. Whereas several species were characterized with the highest relative abundance, *C. luteus* and *A. marmid* characterized in November 2020, (*M. sharpeyi, L. xanthopterus,* and *M. pelusius*) at December 2020, *S. triostegus* was in February 2021, *P. mento* in April 2021, *A. dispar* in June 2021, and *A. sellal* in August 2021.

The marine species in the heatmap plot showed an increasing from May to October 2021. The species of *B. dussumieri* and *S.argus* were characterized in December 2020, *T. whiteheadi* in March 2021 and *S. albella* and *S. sihama* at June 2021. During September, 6 species (*T. hamiltonii, Planiliza klunzingeri, T. vetrirostris, I. compressa, B. orientalis,* and *J. belangeri*) were characterized in this station in addition to two species of *P. bindus* and *P. carinata* in October 2021.

As to the relative abundance of exotic species dipicted in the heatmap, there was an abundance almost at all months. However, *H. molitrix* was characterized during December 2020, *O. niloticus* wasin February 2021, and grass carp *C. idella* and common carp *C. carpio* were characterized at August 2021.

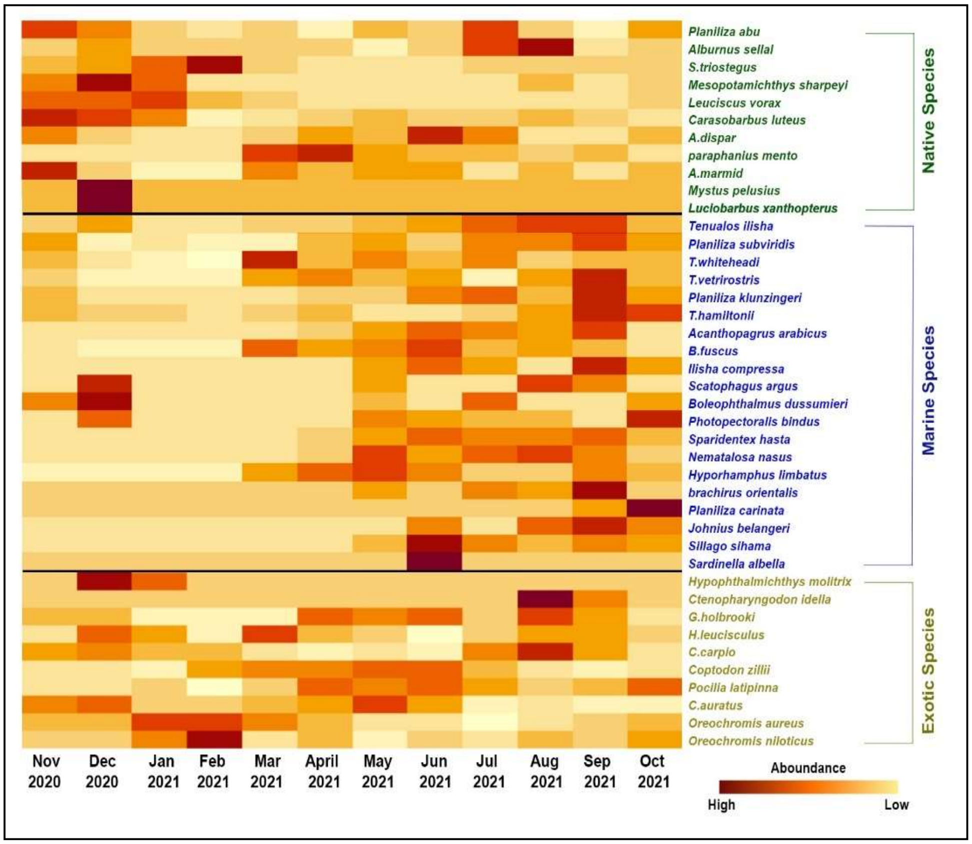


Figure (7): Heatmap patterns of the relative abundance for the fish species in the **Al-Sallall**.

The marine species in the heatmap plot showed an increasing from April to October 2021 at the station of Al-Mansury (figure 8). The species of *Planiliza subviridis* and *T. whiteheadi* were characterized in January and March 2021, respectively, *Boleophthalmus dussumieri* and *Photopectoralis bindus* in May 2021, the species of (*Scatophagus argus*, *Sardinella albella*, and *Nematalosa nasus*) during June, at August 2021 there were *Sardinella albella* and *Planiliza klunzingeri*, in September 2021 *Brachirus orientalis* and *Sparidentex hasta*, and the species of *Sillago sihama* and *Planiliza carinata* were characterized in October 2021.

The station of Al-Mansury was also characterized by the high relative abundance of *Mesopotamichthys sharpeyi* and *Leuciscus vorax* in January 2021, and *Mastacembelus mastacembelus* at July.

The heatmap plot of the station showed increasing of some exotic species such as *C. auratus* and *Hypophthalmichthys molitrix* in November and December 2020, respectively. On the other hand, *Oreochromis niloticus*, *H. leucisculus*, *C. carpio*, *Heteropneustes fossilis*, and *Ctenopharyngodon idella* were characterized during February, May, July, September, and October 2021, respectively.

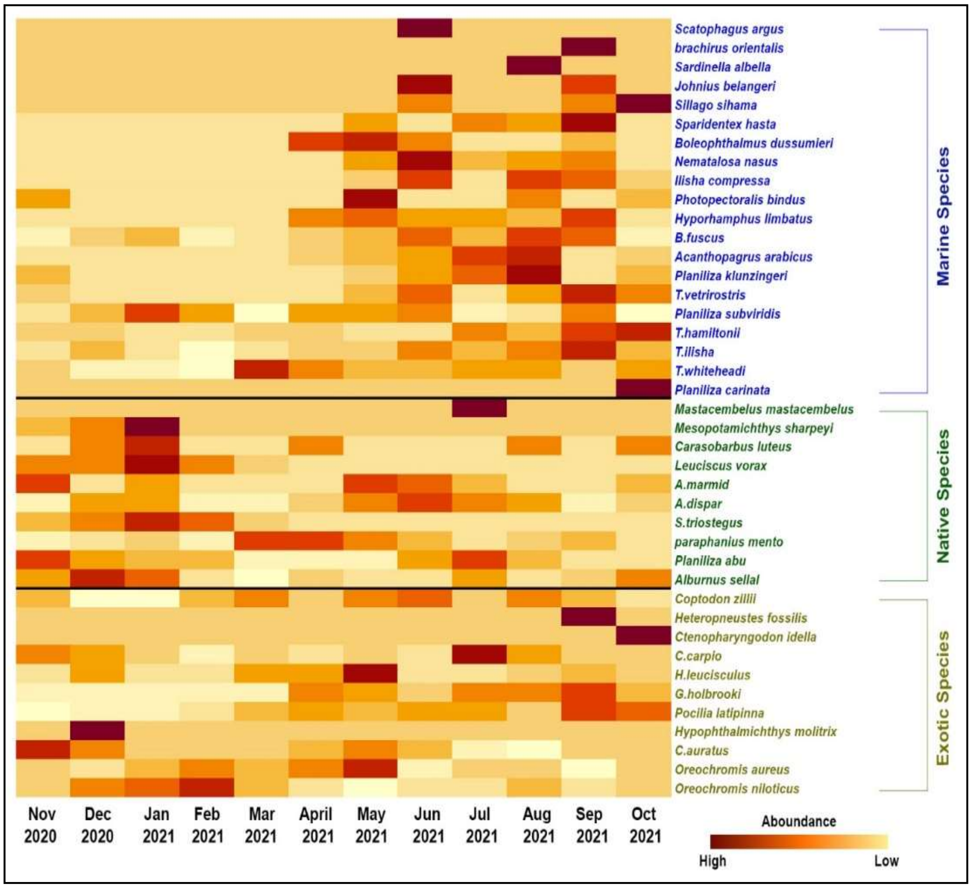


Figure (8): Heatmap patterns of the relative abundance for the fish species in the **Al-Mansoury**

Figure (9) is showing that the Marine species in the Al-Burkha station were represented by *B. dussumieri* in December 2020, (*T. vetrirostris* and *T. whiteheadi*) in March 2021, (*S.albella* and *N. nasus*) in June 2021. In August, there were (*B. orientalis* and *. belangeri*) and *T.ilisha* in September 2021 with (*P. carinata* and *T. hamiltonii*) in October 2021. The Al-Burkha station charactrised by the abundante of some native species, such as (*C. luteus, L. vorax,* and *M. sharpeyi*) in November 2020, (*L. xanthopterus and M. pelusius*) in December 2020, *Paraphanius mento* in June 2021, *M. mastacembelus* in September 2021. The Exotic species were represented by *C. zillii* in January 2021, and (*H. fossilis* and *G. holbrooki* ) during July 2021.

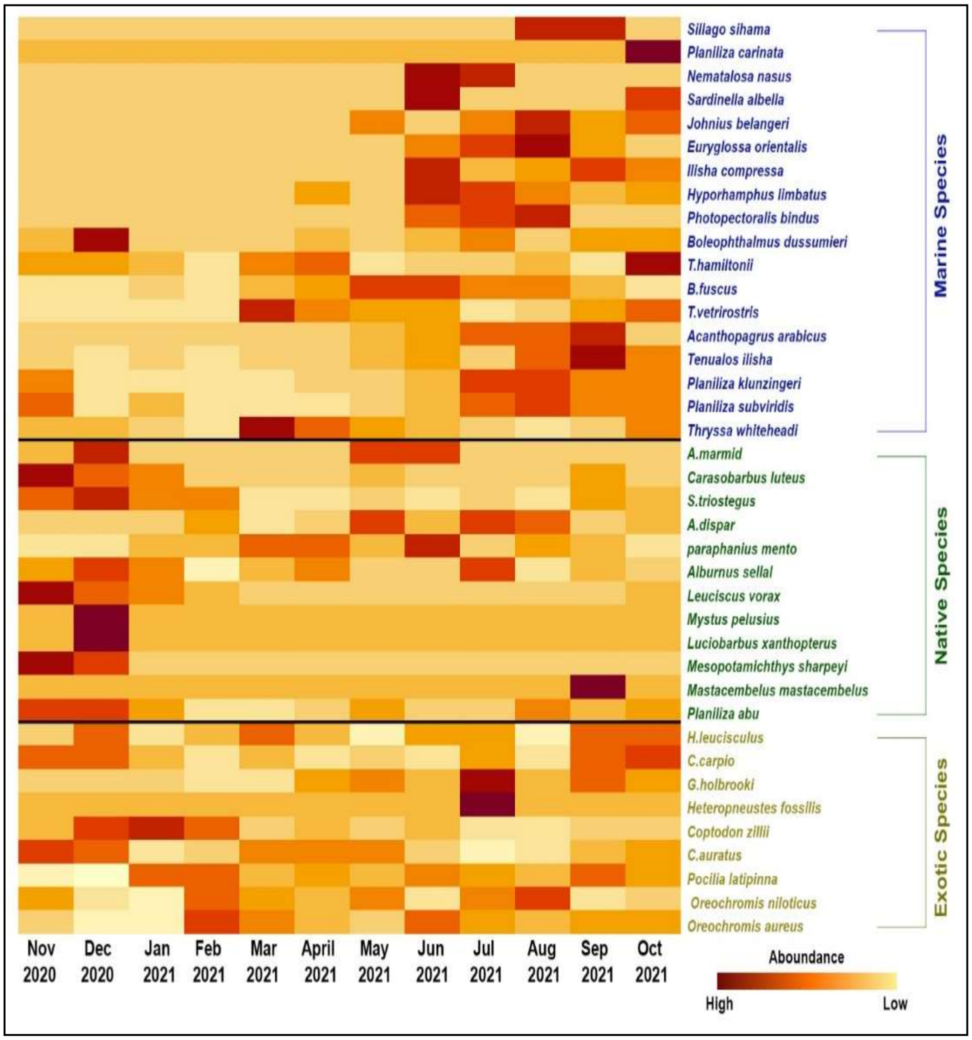


Figure (9): Heatmap patterns of the relative abundance for the fish species in the **Al-Baraka**.

Tidal currents affect the vertical and horizontal distributions of aquatic organisms so they can maintain or change their position accordingly within a body of water (18). Research studies have often discussed the tidal movement and its impact on the characteristics of the waters of the Shatt al-Arab and the marshes, where some variables were measured, such as salinity, total dissolved solids, conductivity, oxygen, nitrate and other physical and chemical variables of water during tidal movement and explaining the difference between them. (19, 20,21).

Previous studies also indicated the composition of fish according to the gradients of salinity and the distribution of fish according to the longitudinal patterns of the river and (22,3, 23) except for the study (8) which described the distribution of fish seasonally in areas that chose their location in relation to the tides using the Kite chart.

The depth had a prominent effect on the spatial pattern of fish individuals in the East Hammar tidal marsh during investigation period; this effect was represented by diurnal and nocturnal tidal level which changes movement and localization of fish between the studied stations. Fernandes

[24] indicated that the tropical wetland was highly affected by water depth which had a direct impact on the spatial patterns of fish individuals.

Through a heatmap plotting (figure 6) which revealed the gradient of fish density according to depths, and was used for the first time in local studies, the largest number of densities of marine species were discovered in Al-Salal station, which is one of the deepest and most contact area with marine environment, as well as exotic and large-sized native fish. Pogoreutz (25) found that large fish as well as mature fish remain in the subtidal zone, while young ones migrate to the intertidal and shallow areas. Higher depths provide a comfortable and stable space for large-sized fish, and this result is consistent with what was found by (26) where the depth affects the dynamics of the distribution and the different trophic groups of fish, as herbivores such as *M. sharpeyi* and *C.idella and* also higher predators such as *S. triostegus* and *L. vorax* increase at various depths.

This study provides a new insight and updated information on fish movements during different tidal cycles and depths. In this study, an interrelation could be recognized between the abundance of fish, origin and depth changes of East Hammar marsh, especially the exotic species which have a significant negative correlation with the depth (r= -0.2) in contrast to the positive correlation with native species (r=0.4). Within the same concept, several previous studies suggested that fish abundance can affected by changing the depth [27, 28]. It was concluded discreetly from the demonstrated data in this investigation that diverse water depths may be responsible for these complex spatial and temporal patterns which simultaneously observed with fish aggregation dynamics and various feeding habit groups.

## References

1- Dorney, J., Savage, R., Tiner, R.W. and Adamus, P. eds., 2018. Wetland and stream rapid assessments: Development, validation, and application. Academic Press.
2- Al-Tememi, M.K., Hussein, M.A., Khaleefa, U.Q., Ghalib, H.B., Al-Mayah, A.M. and Ruhmah, A.J., 2015. The Salts diffusion between East Hammar marsh area and Shatt Al-Arab River Northern Basrah City. Marsh Bull, 10(1), pp.36-45.
3- Radee, F.Kh. 2014. Environmental Assessment for the East Hammar marsh and the possibility of establishment as A nature reserve.Basrahh University 131p (Arabic).
4- Mohamed, A.R.M., Hussein, S.A. and Mutlak, F.M., 2016. Stock assessment of four fish species in the East Hammar Marsh, Iraq. Asian Journal of Applied Sciences, 4(3).
5- Mohamed, A.R.M. and Hussain, N.A., 2012. Evaluation of Fish assemblage environment in east Hammar using Integrated Biological Index. Basrahh journal of science, 30(2), pp.87-105.
6- Mohamed, A.R.M., Hussain, N.A., Al-Noor, S.S., Coad, B.W. and Mutlak, F.M., 2009. Status of diadromous fish species in the restored East Hammar Marsh in Southern Iraq. In American Fisheries Society Symposium (Vol. 69, pp. 577-588).

7- Hussain, N.A. and Saoud, H.A., 2008. Species composition and ecological indices of fishes in the restored marshes of southern Mesopotamia. Marsh Bulletin, 3(1).
8- Abdalhsan, H.T. 2019. Study of zonation and ecological indices for fish assemblage in East Hammar marsh, Southern Iraq. Basrahh University .129pp.
9- Krumme U. 2004. Pattern in the tidal migration of fish in a north Brazilian mangrove channel as revealed by a vertical split-beam echosounder. Fish Res 70:1–15
10- Krumme U. 2009. Diel and tidal movements by fish and decapods linking tropical coastal ecosystems. In: Nagelkerken I (ed) Ecological Connectivity among Tropical Coastal Ecosystems. Springer, Netherlands, pp 271–324
11- Giarrizzo T. and Krumme U. 2009. Temporal patterns in the occurrence of selected tropical fish to mangrove creeks: implication for the fish- eries management in north Brazil. Brazilian Archives of Biology and Technology 52, 679 – 688.
12- Wilkinson L, Friendly M (2009) the history of the cluster heat map. Am Stat 63:179–184
13- Carpenter, K.E.; Krupp, F. and Jones, D.A. (1997). Living marine resour-ces of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar and the United Arab Emirates. FAO of the United Nations Rome. 293p. https://books.google.iq/books?id=ljk_BYW8oHMC&printsec=frontcover&hl=ar
14- Coad BW. Freshwater fishes of Iraq. Freshwater fishes of Iraq checklist. From: www.briancoad.com. Downloaded 05 April (2019).
15- Krebs, C. J., & Myers, J. H. (1974). Population Cycles in Small Mammals. Advances in Ecological Research, 8, 267-339. http://dx.doi.org/10.1016/S0065-2504 (08)60280-9.
16- Tyler AV. Periodic and resident components in communities of Atlantic fishes. Can J Fish Aquat Sci. 1971 Jul 1; 28 (7): 935- 946
17- Sayed, B.A.D.R., Nadia, B. and Massoud, A., 2005. Dissolved Oxygen and Organic Matter in a Harbor and a Bay in Egypt receiving Organic Pollutants from different sources. CM2005, (13).
18- Bennett, William A., and Jon R. Burau. 2015. Riders on the storm: Selective tidal movements facilitate the spawning migration of threatened delta smelt in the San Francisco Estuary. Estuaries and Coasts 38: 826–835.
19- Al-Galibi MKN. Deterioration of water Characteristics in Shatt Al-Arab River and ways of treatments. MS [thesis], Coll. of Edu. For Human Sci., Univ. of Basrahh. 2020, 126 pp. (In Arabic).
20- Al-Aesawi, Q., Al-Nasrawi, A.K., Jones, B.G. and Yang, S.Q., 2021. Geomatic freshwater discharge estimations and their effect on saltwater intrusion in alluvial systems: a case study in Shatt Al-Arab estuary. Environmental Earth Sciences, 80(18), pp.1-15.
21- Lafta, A.A., 2022. Investigation of tidal asymmetry in the Shatt Al-Arab river estuary, Northwest of Arabian Gulf. Oceanologia, 64(2), pp.376-386.

22- Mohamed, A.R.M., Hussain, N.A., Al-Noor, S.S., Coad, B.W. and Mutlak, F.M., 2009. Status of diadromous fish species in the restored East Hammar Marsh in Southern Iraq. In American Fisheries Society Symposium (Vol. 69, pp. 577-588).
23- Ghassan, A., 2019. The influence of salinity increasing on the fish communities in the east of Al-Hammar marsh-southern Iraq. Iraqi Journal of Aquaculture, 16(2), pp.109-128.
24- Fernandes, I.M., Machado, F.A. and Penha, J., 2010. Spatial pattern of a fish assemblage in a seasonal tropical wetland: effects of habitat, herbaceous plant biomass, water depth, and distance from species sources. Neotropical Ichthyology, 8, pp.289-298.
25- Pogoreutz C, Kneer D, Litaay M, Asmus H, Ahnelt H (2012) The influence of canopy structure and tidal level on fish assemblages in tropical Southeast Asian seagrass meadows. Estuar Coast Shelf Sci 107:58–68
26- Lee, C.L., Huang, Y.H., Chung, C.Y. and Lin, H.J., 2014. Tidal variation in fish assemblages and trophic structures in tropical Indo-Pacific seagrass beds. Zoological Studies, 53(1), pp.1-13.
27- Stefanoudis, P.V., Gress, E., Pitt, J.M., Smith, S.R., Kincaid, T., Rivers, M., Andradi-Brown, D.A., Rowlands, G., Woodall, L.C. and Rogers, A.D., 2019. Depth-dependent structuring of reef fish assemblages from the shallows to the rariphotic zone. Frontiers in Marine Science, 6, p.307.
28- Bell, J.D., 1983. Effects of depth and marine reserve fishing restrictions on the structure of a rocky reef fish assemblage in the north-western Mediterranean Sea. Journal of applied Ecology, pp.357-369.