



Fish zonation in the Tidal Mudflats of the Shatt Al-Arab Estuary in the Northwest Arabian Gulf

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Abstract

Ten thousand four hundred and thirty-five fish were collected from January 2021 to February 2022, belonging to 71 species distributed across 39 families and 20 orders in the intertidal zone of the Shatt al-Arab estuary in the northern Arabian Gulf. The results of the common or resident of fish species in the study area showed only 21.13%, while seasonal species recorded 25.35% and occasional or rare species 53.52%. The study focused on the zonation of the fish recorded in the three regions, as they represented the High (HW), Mean (MW) and Low (LW) waters. In general, the result showed that the the MW is more species with 53 species, followed by HW and LW with 50 species.

Keywords: zonation, resident, seasonal, occasional, high water, mean water, low water

Received 30/11/ 2023

Accepted 11/12/2023

Published 1 / 9 /2025

Introduction:

The tidal flats of estuaries play a major role by supporting many fish species, as they are considered a feeding and nursery area and escape from predators (Kanou *et al.*, 2004). Since fish movements during the tidal period are closely tied to feeding activities and avoiding predation, knowledge regarding fish movements during this period is necessary to comprehend the role that these surfaces play (Hampel *et al.*, 2003). Shallow intertidal habitats are essential to larvae and juvenile fish (AL-Shamary & Younis, 2020). Intertidal fish are characterized by a variety of functional, morphological, and behavioral adaptations that enable them to live in this environment (White and Brown, 2013).

Accordingly, the way fish feed, how they evade predators, and the local environment

all have a significant role in identifying the species of fish that inhabit a certain location (Laegdsgaard and Johnson, 2001). In general, the relative importance of different environmental factors varies between different biogeographical regions (Blaber, 2002). Because many species are selectively drawn to these locations due to the instability of abiotic conditions and the risk of stranding, the utilization of these habitats by fish species can be evaluated in terms of cost and benefit. Nonetheless, the aforementioned benefits are available to species that can withstand such circumstances (Salgado *et al.*, 2004; Vinagre *et al.*, 2006; Kanou *et al.*, 2005). The dominance of a few species is a general feature in fish communities of mudflat intertidal zones (Kneib, 1997); (Jin *et al.*, 2007. Fishes occupying upper intertidal

zones have proven difficult to classify in terms of conclusively estimating their habitat use. While some species become permanent residents here as they grow larger, some only come here during high tides, and yet others migrate down into deeper waters as they mature. Fish typically use these environments on a seasonal basis. (Salgado *et al.*, 2004; Cattrijsse *et al.*, 1994 & Rountree and Able, 1992). Numerous studies have examined intertidal variations in fish populations. (Rountree and Able, 1993; Sogard *et al.*, 1989; Gray *et al.*, 1998; Griffiths, 2001; Methven *et al.*, 2001; Morrison *et al.*, 2002; Guest *et al.*, 2003). In addition, tidal cycles generate two types of distinct environmental scenarios for intertidal fish. During the intertidal zone, large predators and other non-resident fish visit the intertidal zone, increasing the risk of predation and competition with resident fish. Conversely, non-resident fish remaining in isolated tidal pools during receding water will face extreme environmental conditions of temperature and salinity. Many visiting fish species make short visits simultaneously with the tide to take advantage of the intertidal zone (Gibson, 2003). In the other hand, these simultaneous visits have been temporarily attributed to increased feeding potential (Wirjoatmodjo and Pitcher, 1984) and predator avoidance (Gibson, 1973; Ellis and Bell, 2004). Gibson (1973) and Griffiths *et al.* (2003) showed that predation and feeding pressure are spatially and temporally uneven in the intertidal zone, which could translate into seasonal differences in the distribution of fish in the intertidal zone. When the primary function of marine fish movements is feeding, zonation has been linked to predator-prey behavior, competition

avoidance, as well as heterogeneous distribution of prey species (Gibson, 1973; Miltner *et al.*, 1995). Many studies have reported that the movement and presence of fish in the intertidal zone during the tidal period depends on the size of these fish and the depth of the water, in addition to the quality of food and the method of feeding, as the size of the fish increases with the depth of the water. They explained that the density of large fish predators of other fish is less in the upper areas. For the intertidal zone although predation is important in shallow water (Baker and Sheaves, 2005). As a result of these studies, it was found that juvenile fish migrate to higher parts of the intertidal zone during high tide to avoid predation (Blaber and Blaber, 1980). Furthermore, physical factors such as temperature vary with water depth and may affect the distribution of fish in the intertidal zone, where growth is primarily regulated by ambient temperature (Gibson *et al.*, 2002). Most studies of estuarine tidal flats have focused on vegetated flats because of their major role in productivity, nutrient cycling, and providing different trophic levels, which is an important attracting factor for different fish communities, especially juveniles (Weinstein and Brooks, 1983; Heck *et al.* 1989; Sogard and Able, 1991). However, it was later recognized that vegetation-poor estuarine habitats, especially tidal mudflats, serve as refuge and foraging areas for juveniles of many fish species (Paterson and Whitfield, 2000). The study area is characterized by being a tidal area that is submerged during high tide and exposed during low tide, up to 15 km during the lowest tide near the Shatt Al-Arab estuary (Almahmood, 2023).

Material and methods:

The study was carried out in the tidal zone northwest of the Arabian Gulf between December 2021 and February 2022, a duration of 13 months, extending east

(N:29°53'49", E:48°38'16") to (N:29°53' 21", E:48°30'17") west, then (N: 29°50'25", E: 48°37'2") south. Three sites were chosen based on the highest and lowest tides on each trip, and the distance between one point to

another ranged from 1000 to 1250 meters, depending on the state of the tides (Figure, 1)

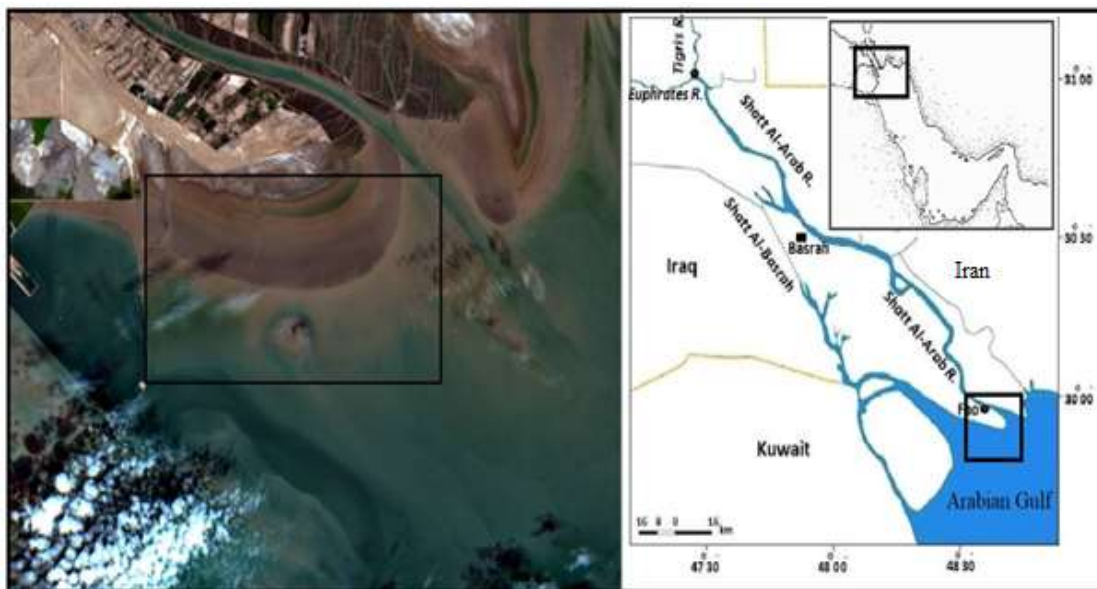


Fig. (1): Study area (modified map from google).

Results:

A total of 10,406 individuals were gathered, and after being further divided into 42 families and 22 orders, 71 species were identified. (Table ,1).

Table (1) The recorded fish species with orders and families Rearrange according to Frike *et al.* (2023).

Class: Elasmobranchii		
Order	Family	Scientific name
Orectolobiformes	Hemiscylliidae	<i>Chiloscyllium arabicum</i>
Carcharhiniformes	Carcharhinidae	<i>Rhizoprionodon oligolinx</i>
Rhinopristiformes	Glaucostegidae	<i>Glaucostegus granulatus</i>
Myliobatiformes	Dasyatidae	<i>Brevitrygon imbricata</i>
		<i>Brevitrygon walga</i>
		<i>Himantura uarnak</i>
		<i>Maculabatis randalli</i>
	Aetobatidae	<i>Aetobatus flagellum</i>
Class: Actinopteri		
Anguilliformes	Muraenesocidae	<i>Muraenesox cinereus</i>
Clupeiformes	Engraulidae	<i>Thryssa hamiltonii</i>
		<i>Thryssa whiteheadi</i>
	Dorosomatidae	<i>Anodontostoma chacunda</i>
		<i>Nematalosa nasus</i>

		<i>Sardinella albella</i>
		<i>Tenualosa ilisha</i>
	Chirocentridae	<i>Chirocentrus dorab</i>
		<i>Chirocentrus nudus</i>
	Dussumieriidae	<i>Dussumieria acuta</i>
	Pristigasteridae	<i>Ilisha compressa</i>
		<i>Ilisha melastoma</i>
Siluriformes	Plotosidae	<i>Plotosus lineatus</i>
	Ariidae	<i>Netuma thalassina</i>
		<i>Plicofollis layardi</i>
Aulopiformes	Synodontidae	<i>Saurida tumbil</i>
Batrachoidiformes	Batrachoididae	<i>Colletteichthys dussumieri</i>
Scombriformes	Scombridae	<i>Scomberomorus commerson</i>
		<i>Scomberomorus guttatus</i>
	Trichiuridae	<i>Eupleurogrammus muticus</i>
Syngnathiforme	Mullidae	<i>Upeneus doriae</i>
		<i>Upeneus tragula</i>
	Callionymidae	<i>Callionymus erythraeus</i>
Gobiiformes	Gobiidae	<i>Acentrogobius dayi</i>
		<i>Boleophthalmus dussumieri</i>
		<i>Trypauchen vagina</i>
Carangiformes	Polynemidae	<i>Eleutheronema tetradactylum</i>
	Soleidae	<i>Brachirus orientalis</i>
		<i>Solea elongata</i>
	Cynoglossidae	<i>Cynoglossus arel</i>
		<i>Cynoglossus bilineatus</i>
	Carangidae	<i>Alepes djedaba</i>
		<i>Alepes kleinii</i>
		<i>Alepes melanoptera</i>
		<i>Carangoides bajad</i>
		<i>Scomberoides commersonianus</i>
<i>Scomberoides tol</i>		
Rachycentridae	<i>Rachycentron canadum</i>	
Cichliformes	Cichlidae	<i>Oreochromis niloticus</i>
Beloniformes	Belonidae	<i>Strongylura leiura</i>
		<i>Strongylura strongylura</i>
Mugiliformes	Mugilidae	<i>Planiliza klunzingeri</i>

		<i>Planiliza subviridis</i>
		<i>Osteomugil speigleri</i>
Perciformes	Platycephalidae	<i>Platycephalus indicus</i>
	Synanceiidae	<i>Pseudosynanceia melanostigma</i>
Centrarchiformes	Terapontidae	<i>Terapon puta</i>
		<i>Terapon theraps</i>
Acanthuriformes	Sillaginidae	<i>Sillago arabica</i>
		<i>Sillago sihama</i>
	Haemulidae	<i>Pomadasys maculatus</i>
		<i>Pomadasys stridens</i>
	Sparidae	<i>Crenidens crenidens</i>
		<i>Sparidentex hasta</i>
		<i>Acanthopagrus arabicus</i>
	Sciaenidae	<i>Johnius belangerii</i>
		<i>Johnius borneensis</i>
		<i>Otolithes ruber</i>
Leiognathidae	<i>Photopectoralis bindus</i>	
Scatophagidae	<i>Scatophagus argus</i>	
Tetraodontiformes	Triacanthidae	<i>Triacanthus biaculeatus</i>
	Tetraodontidae	<i>Lagocephalus lunaris</i>

The numbers of individuals of recorded species varied during the study period. The highest number of individuals recorded for

the *N. nasus* was 2462 individuals, while only one individual was recorded, belonging to 20 species, as shown in Table (2).

Table. (2): fish species with monthly occurrence for Tyler during the study period.

Scientific name	Jan. 21	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 22
<i>Chiloscyllium arabicum</i>	■									■			
<i>Rhizoprionodon oligolinx</i>								■					
<i>Glaucostegus granulatus</i>				■		■	■	■					
<i>Brevitrygon imbricata</i>			■			■							
<i>Maculabatis randalli</i>					■	■	■	■			■		
<i>Brevitrygon walga</i>				■						■	■		
<i>Himantura uarnak</i>							■						
<i>Aetobatus flagellum</i>							■						
<i>Muraenesox cinereus</i>													■
<i>Thryssa whiteheadi</i>						■							■

recorded to be more frequent in MW region which are *P. klunzingeri*, *O. speigleri*, *N. nasus*, *P. bindus* and *B. orientalis*. As for the LW region, the presence of only four species

was recorded which are *S. sihama*, *A. chacunda*, *T. ilisha* and *J. belangerii*. (Figure, 3).

	HW	MW	LW
<i>P. subviridis</i>	51	37	42
<i>P. klunzingeri</i>	84	161	135
<i>O. speigleri</i>	42	196	40
<i>S. arabica</i>	9	4	3
<i>N. nasus</i>	612	1028	920
<i>S. sihama</i>	60	45	77
<i>T. hamiltonii</i>	257	247	168
<i>T. ilisha</i>	503	437	588
<i>S. commersonianus</i>	101	80	25
<i>J. belangerii</i>	119	138	178
<i>P. melanostigma</i>	41	40	40
<i>P. bindus</i>	965	1076	108
<i>B. orientalis</i>	30	31	28
<i>S. elongata</i>	177	163	165
<i>A. chacunda</i>	5	11	12

Fig. (3): Resident fish zonation in study area.

Ternary plot analysis also showed that the numbers of individuals of resident species were centered in the common area between the three points, with some tendency towards HT and MT areas. This indicates that there

was no major extreme in the distribution, except for *S. arabica*, which was within HT area, *O. speigleri*, and *P. bindus* Within MW area (Figure, 4).

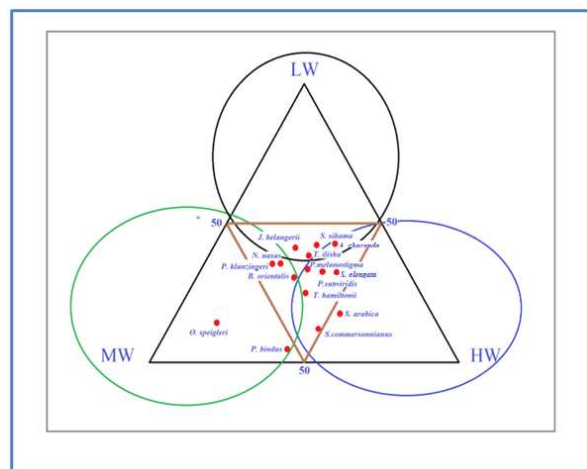


Fig. (4): Ternary plot analysis of resident fish species in study area

Seasonal fish zonation

Seasonal fish species recorded the highest presence in the central MW region compared to the other two regions, HW and LW. Out of a total of 18 seasonal species, 11 species were recorded in MW which are *I. compressa*, *T. biaculeatus*, *P. layardi*, *N. thalassina*, *A. kleinii*, *S. albella*, *T.theraps*, *D. acuta*, *A. arabicus*, *M. randalli* and *O. ruber*. all of which are non-commercial species, except for *A. arabicus* and *O. ruber*, which are found in non-commercial sizes and numbers. As for the lower LW region, four species were

recorded which are *A. chacunda*, *C. arel*, *S. elongata*, and *P. indicus*. As for the upper region HW, only three species were recorded which are *C. bilineatu*, *T. puta*, and *U. doriae*. (Fig., 5).

The ternary plot showed a shift in the seasonal species in and close to the MW region, and this indicates the presence of an extremity in the distribution in favor of this region, except for *C. arel* and *P. indicus*, which were largely extreme to the LW region (Fig., 6).

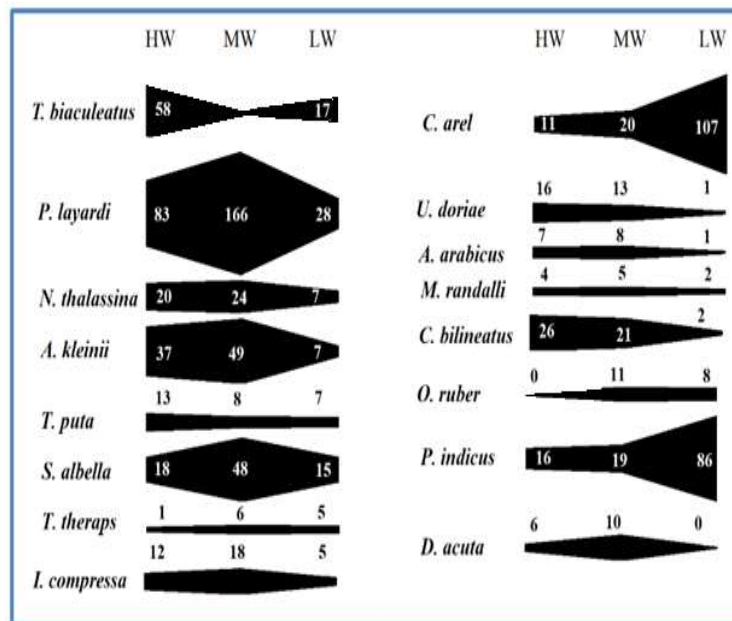


Fig. (5): Seasonal fish zonation in study area.

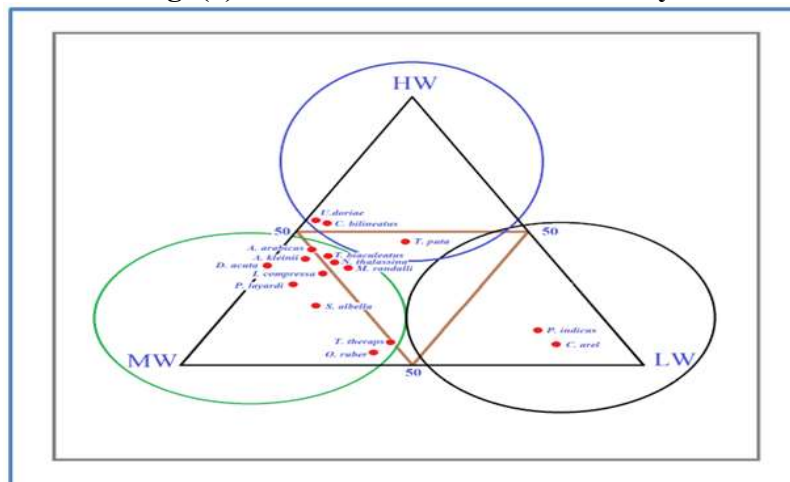


Fig. (6) Ternary plot analysis of seasonal fish species in study area.

Occasional fish zonation

This group was represented by species that recorded appearances at four months or less during a period of 12 months. This group included 38 Occasional species, 20 of which recorded only one individual of the species during the study period, that is, they appeared only at one site, of which four species were recorded in HW, which are *R. canadum*, *U. tragula*, *S. hasta* and *P. maculatus*, and seven species were recorded in MW, which are *C. bajad*, *T. mookalee*, *C. crenidens*, *S. guttatus*, *C. dussumieri*, *R. oligolinx* and *H. uarnak*, and nine species recorded in LW, which are *M. cinereus*, *P. lineatus*, *C. dorab*, *A. melanoptera*, *T. vagina*, *S. tol*, *P. stridens*, *L. lunaris* and *A. flagellum*. Many species were also recorded at only one site with many individuals, including *A. djedaba*, which recorded five individuals at HW, *C. arabicum* at LW where eight individuals were recorded, *J. borneensis*, which recorded five individuals at LW, *B. walga*, which recorded four individuals at MW And *C. erythraeus*, which recorded three individuals in HW.

Eight species of fish were recorded in only two stations which are *S. tumbil*, which appeared in MW and LW, *I. melastoma* in MW and LW, *O. niloticus* in HW and MW, *S. commerson* which appeared in HW and LW, *E. muticus* which appeared in MW and LW, *B. dayi* appeared in HW and MW, *S. leiura* which appeared in HW and MW, *B. dussumieri* which appeared in HW and MW. Only seven species appeared in the three stations which are *S. argus*, *C. nudus*, *E. tetradactylum*, *T. whiteheadi*, *G. granulatus*, *B. imbricata* and *S. strongylura*. In general, the appearance of this species was equal among the three points.

This group was represented by species that recorded their occurrence in four months or less during a period of 12 months. But in general, this group, especially the one that recorded only one individual, showed a tendency toward deeper places than shallow ones, meaning that what attracted them was the high tide in the area and not for feeding, even if the water was shallow (Fig., 7).

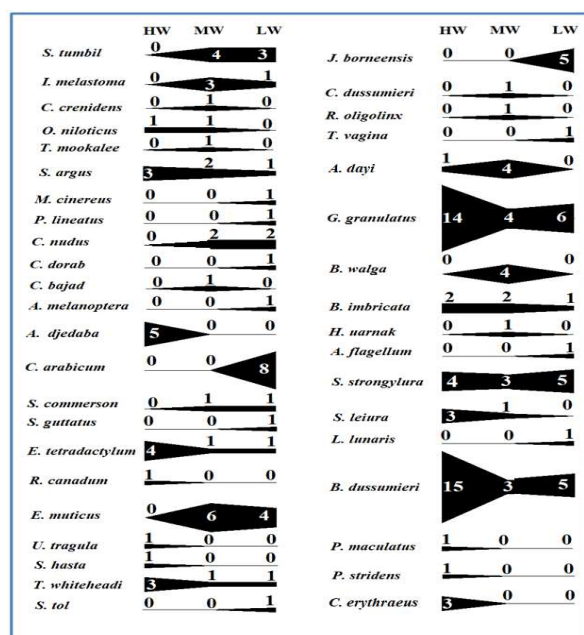


Fig. (7) Occasional zonation of fish in study area.

Ternary plot analysis showed the extremes of species that recorded only one individual or a number of individuals appearing at one station in the far corners of each area where the species was recorded. As for the species

that were recorded in only two stations, they appeared on the external line linking the two stations. The seven species recorded at the three stations generally appeared in or near an area (Fig., 8).

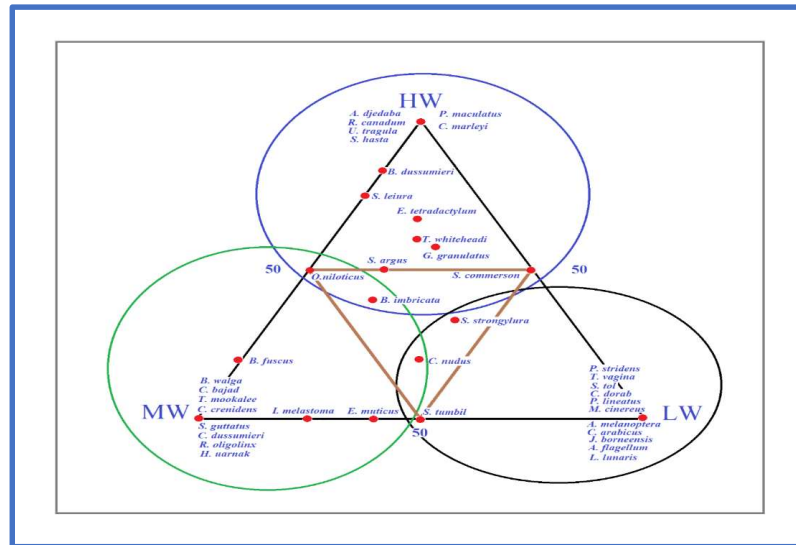


Fig. (8) Ternary plot analysis of Occasional fish species in study area.

Total fish zonation

A ternary plot analysis of the overall species distribution among the three regions showed that, in general, the MW is more species with 53 species, followed by HW and LW with 50 species. (Figure, 9).

Despite the irregular distribution of the totals of resident, seasonal, and Occasional species in the three regions, and there is a concentration in the middle of the distance for the ternary analysis, the result in general

showed a tendency toward the MW region, as it was more numerous in species and individuals, followed by HW, then LW, which indicates that MW region is more richness in commercial species and individuals, so it was seen that the effectiveness of commercial fishing is concentrated in this area to the extent that it is sometimes difficult to find a place that allows the installation of the middle site network during the study period.

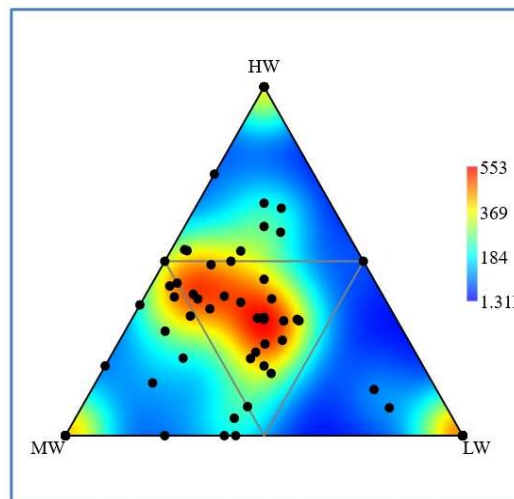


Fig. (8) Ternary plot analysis for species and total numbers in the study area**Conclusion**

The results showed that the widening of the intertidal zone at the Shatt al-Arab estuary plays a major role in clearly showing the phenomenon of fish zonation. The study showed that most of the resident fish were concentrated in the HW and then MW region, while the seasonal species were generally concentrated in MW, and the Occasional species were distributed closely across the regions. The study also showed that the number of individuals was concentrated between HW region and MW region, with a tendency toward the middle region.

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تمنطق الأسماك في المسطحات المدية الطينية لمصب شط العرب شمال غرب الخليج العربي

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الملخص

جمعت عشرة آلاف وأربعمائة وخمسة وثلاثون سمكة خلال الفترة من كانون الثاني 2021 إلى شباط 2022، تعود إلى 71 نوعاً موزعة على 39 عائلة و20 رتبة في المسطحات المدية الطينية لمصب شط العرب شمال الخليج العربي. أظهرت نتائج الدراسة أن نسبة الأنواع السمكية المقيمة في منطقة الدراسة بلغت 21.13% فقط، بينما بلغت نسبة الأنواع الموسمية 25.35%، والأنواع النادرة أو العرضية 53.52%. ركزت الدراسة على توزيع الأسماك المسجلة في المناطق الثلاث، التي تمثل المياه العالية (HW) والمتوسطة (MW) والمنخفضة (LW). وبشكل عام، أظهرت النتائج أن المياه المتوسطة (MW) تضم أكبر عدد من الأنواع (53 نوعاً)، تليها المياه العالية (HW) والمياه المنخفضة (LW) بـ 50 نوعاً لكل منهما.