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WINNERS AND LOSERS: POST CONFLICT BIODIVERSITY IN THE STRESSED ECOSYSTEM OF KHOR AL-ZUBAIR, IRAQ

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ABSTRACT: A rapid assessment of biodiversity in the immediate wake of civil conflict and other disasters is critical to inform recovery efforts. We report on the first surveys of aquatic biodiversity in Khor Al-Zubair (KAZ) in southern Iraq, following the cessation of recent violence in the region. This site is in the midst of ongoing environmental changes due to climate change and reductions in water flow from the Tigris and Euphrates rivers, which have led to increases in salinity in the KAZ. Monthly surveys of biodiversity were conducted in 2017-2018 and compared to historical data from the site obtained from a literature survey. Results indicate a loss of 80% of species richness, suggesting a fundamental and potential catastrophic decline in species diversity resulting from largely anthropogenic drivers.

KEYWORDS: Biodiversity, Iraq, mud flat, warfare ecology

INTRODUCTION

Environmental change continues to accelerate globally, with severe consequences for ecosystems and the human societies that depend on them. Forecasting the location and severity of these impacts and understanding the underlying mechanisms driving these changes, remains a high priority. But, for many (if not most) regions of the world a major impediment continues to be a lack of basic information on biodiversity and the distribution of species in relation to environmental drivers (Mieszkowska *et al.*, 2014). These challenges are especially acute in politically volatile regions (Hanson 2018), especially in aquatic habitats (Francis, 2011). A 2009 review by Hanson *et al.* (2009), found that 90% of the major armed conflicts during the latter half of the 20th century occurred in countries with biodiversity hotspots, emphasizing the paradox that many of the places for which field data are most important are also those that are the least accessible. Hanson (2018) further defines three stages of "warfare ecology"- preparations, armed conflict, and postwar activities-pointing to the vital importance of post-conflict periods for incorporating biodiversity into recovery planning. This study provides the first post-conflict evaluation of invertebrate biodiversity in mudflats in Khor Al-Zubair (KAZ) region in southern Iraq and at the northern end of the Arabian (Persian) Gulf (Figs. 1 and 2), with the goal of informing biodiversity and water management planning efforts.

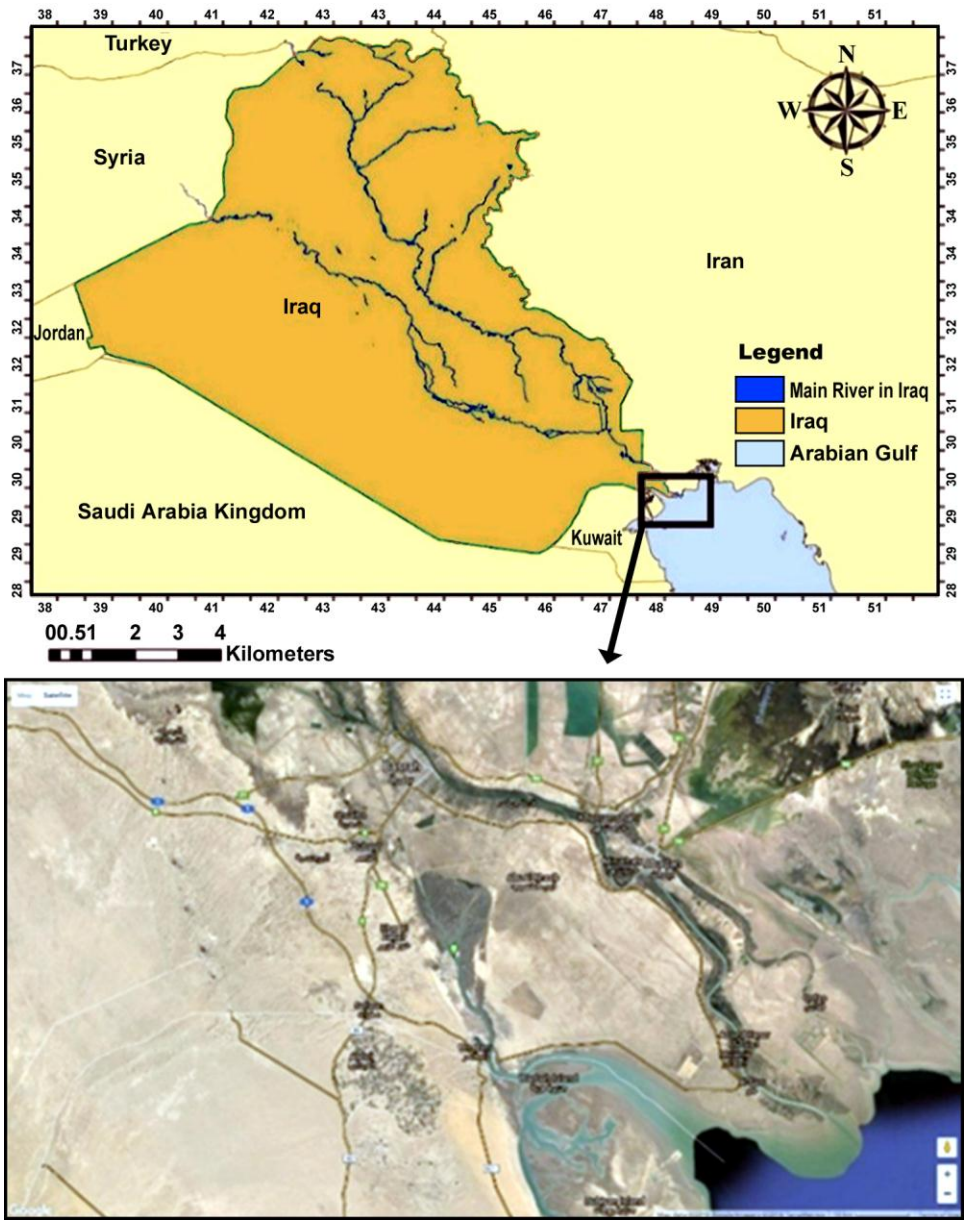

Fig. 1. Map of study site.

Southern Iraq has been exposed to many environmental challenges during the last forty years, many the direct result of human conflict, beginning with the Iraq-Iran war (1980–1988) followed by the first (1990-1991) and second (2003) Gulf Wars (Al-Mudaffar Fawzi & Mahdi, 2014). These conflicts caused direct ecological damage to the ecosystems in the entire region (Price, 1998). Sheppard *et al.* (2010), not only as a result

of warfare but also as the result of the release of several millions of barrels of oil that created a slick over 100 miles long: the Gulf War Oil spill, one of the largest spills in human history (Tawfiq & Olsen, 1993). During this period, from 1985-2000, the southern marsh ecosystem, located at the juncture of the Tigris and Euphrates rivers (Fig. 1) was drained via the construction of a series of canals by the Ba'ath regime under Saddam Hussein (Pearce 1993; Richardson *et al.*, 2005).

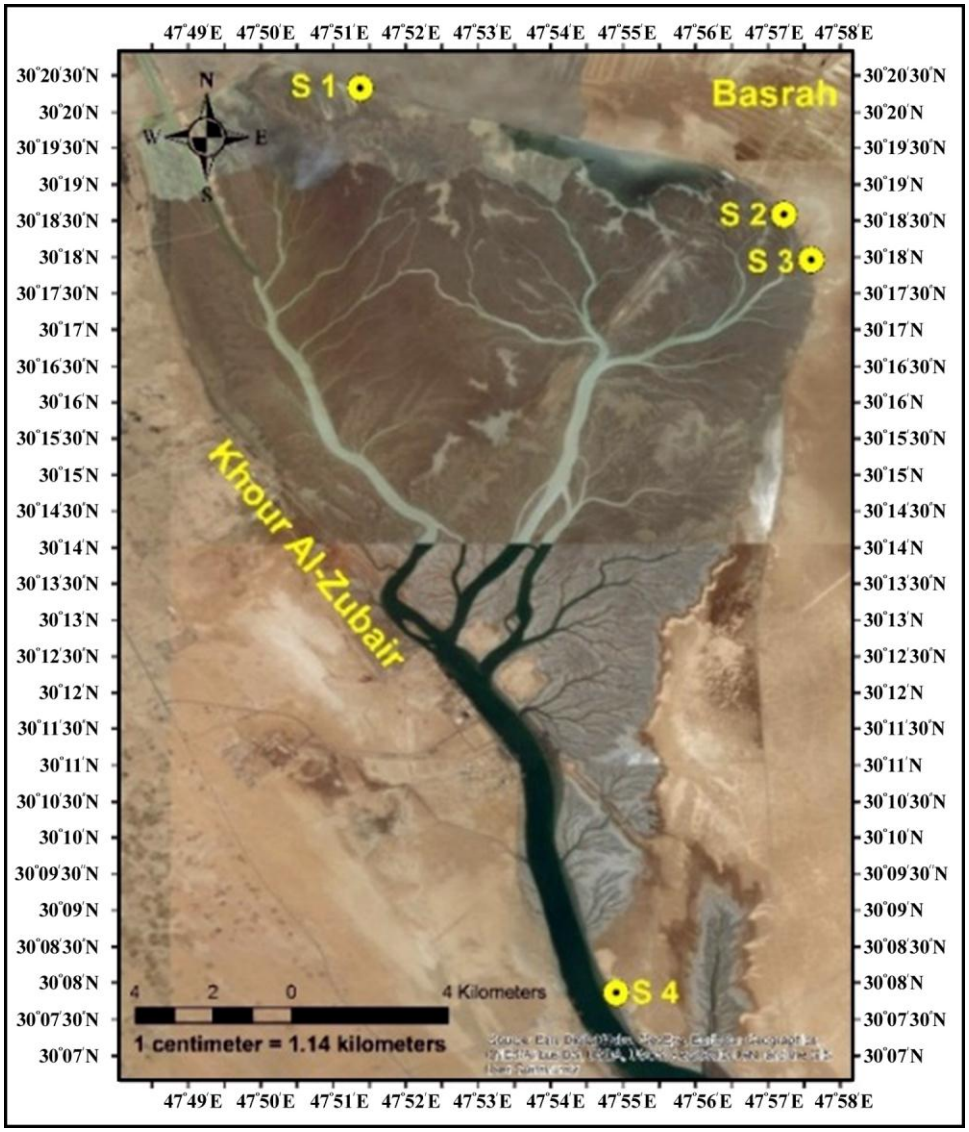

Fig. 2. Aerial photograph showing the KAZ multibranched tidal channels and the study area.

This action resulted in a loss of upwards of 90% of their aerial extent (Munro & Touron, 1997; Al-Handal & Hu, 2015). Once covering 15,000-20,000 km2 (Partow, 2001), these marshes, considered by many scholars to be the "cradle of civilization" were home to an indigenous population of marsh dwellers who, for at least 5000 years, relied on the ecosystem services provided by the marsh for their way of life (Thesiger, 1964). As part of this drainage, a series of canals were built to divert water from the marshes, including the Shatt Al-Basrah which delivered large amounts of water to the northern Gulf, including the KAZ (Fig. 2).

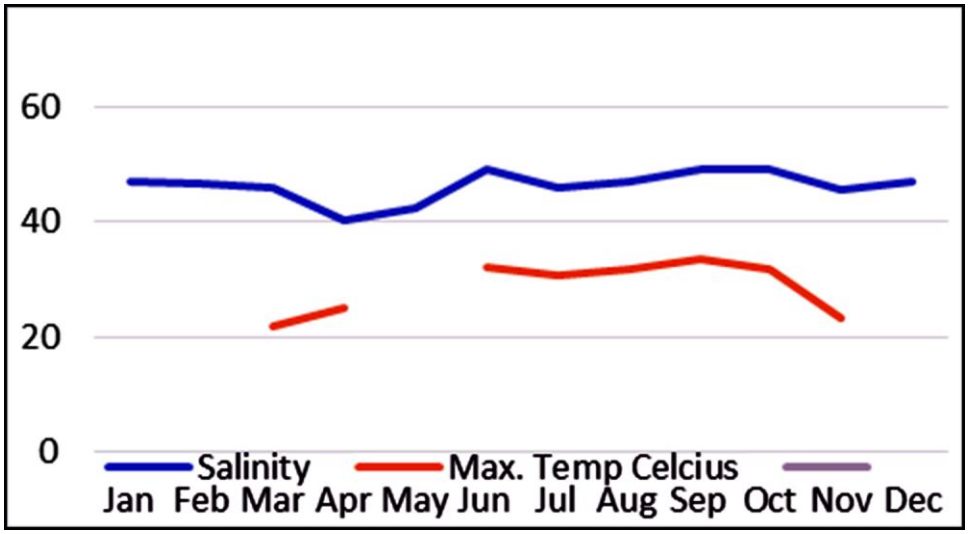

Fig. 3. Khor Al-Zubair water temperature and maximum salinity during 2018.

Since the end of the Second Gulf War 2003 the region was rocked with additional conflict, most recently as a result of violence initiated by the Islamic State (IS), (Bunzel, 2015). While open warfare has ceased in the region, ecosystems and the people who depend on them face additional challenges related to severe decreases in water flow in the Shatt Al-Arab River (SAR), which flows from the southern marshes to the Arabian Gulf (Abdullah *et al.*, 2016) (Fig.1). Decreased flow is related both to increases in temperature and decreases in precipitation associated with global climate change (Mahmood Agha & Sarlak, 2016; Albarakat *et al.*, 2018), and also to obstruction of natural water flow through the Tigris and Euphrates Rivers due to the construction of dams in Turkey (Becker, 2014). The consequence has been severe salt-water intrusion into the SAR (Abdullah *et al.*, 2016) as well as significant declines in water quality in both the SAR and the southern marshes (Al-Musawi *et al.*, 2018). All of these processes have had clear impacts on the environment of Southern Iraq in general, and especially on the coastal environment of the region's tidal flats (Shubbar *et al.*, 2016; Al-Timimi & Al-Khudhairy 2018) due to reduced freshwater input which has led to increased salinity (Fig. 3). Specifically, not only do increases in temperature and salinity create the potential for declines in ecologically key species, but they also potentially create opportunities for

invasive marine species to move from the Arabian Gulf into the SAR and, possibly, into the marshes. Yet quantitative information on current species richness is lacking (Birdlife International, 2019), especially in light of the severe environmental changes underway (Yaseen *et al.*, 2016). This study compares historical information on mudflat invertebrates, fish and plant biodiversity gleaned from both published and unpublished literature, against surveys conducted in 2017-2018.

Study area: Tidal flats are among the world's most diverse and productive ecosystems and provide vital ecosystem services such as shoreline stabilization and the provision of nursery habitat for commercially important species of fish and shrimp. Yet a recent study (Murray *et al.*, 2018) found that 16% of the world's tidal flats have been lost primarily from coastal development, reduced sediment delivery from rivers and coastal erosion and sea-level rise.

Iraq has limited coastal and territorial waters in the northern Arabian Gulf, where the total area of Iraq's regional waters is about 900 km^2 with a coastline of only 58 km (Bird 2010). However, this ecosystem is considered among the most highly productive and biodiverse. These waters also serve as a passageway for migratory fish from the Gulf into the Iraqi inland waters through the Shatt Al-Arab and Khor Al-Zubair (KAZ) up to the Marshlands. KAZ is an estuarine lagoon, situated in the south-west of Basrah city, Iraq. The lower boundary of KAZ is located near Warba Island about 8 km south-east of Umm Qasr (Fig. 1). The total length of Khor Al-Zubair is about 40 km from the upper reaches to the lower boundary, and the width of the channel varies between 1 km and 2 km at high water on an average spring tide and an average depth of the waterway channel is 10-20 m (Al-Taei *et al.*, 2012). The KAZ has a mixed semi-diurnal tidal regime that follows that of the northern Arabian Gulf, and the mean tidal range is about 3.2 m. (Al-Mukhtar *et al.*, 1992).

The KAZ Channel is an important shipping route for commercial vessels traveling to the Um-Qaser port and is under ever-increasing pressure from anthropogenic activities associated with the rapid economic, social and industrial activities that contribute to the degradation of these stressed marine ecosystems. The KAZ water channel and its banks are also affected by intensive dredging and dumping activities to maintain the navigation channel, and by several sources of pollution, including industrial waste, ports activities, oil spills, and domestic sewage. (Al-Dabbas & Al-Jaberi, 2015). An assessment of 200 sediment samples collected along the coastal area and the KAZ channel by JICA (2012) showed generally low concentrations of a wide range of organochlorinated pesticides and several PCB including DDT and Aroclor 1254, also Dioxins and total furans were detected at several sampling points although still not considered to be significant. While oil pollution is the main threat to the coastal ecosystems of KAZ, the area has largely recovered from previous catastrophic spills during the war times (1980 to 2003). Metal concentration in sediment showed a spatial trend with respect to copper, nickel, lead, zinc, iron, and manganese for the same area. The marine waters did not display signs of pollution indicators like oil (petroleum hydrocarbons), nitrogen, phosphate, and BOD were generally low and did not indicate significantly polluted waters.

The waterway and northern section of the intertidal area of KAZ is designated as a Potentially Critical Habitat (KBA/IBA - IQ081 Khor Al-Zubair) by the Iraqi Government (Iraqi Ministry of Environment, 2015) and Birdlife International (2019). The KBA/IBA designation is related to the area containing birds of restricted range and significant

populations. In addition, the area may contain Red Listed (endangered) species and also potentially significant fish and benthos populations (Birdlife International, 2017). However, as documented in the most recent Birdlife International Status report (2019) and, to the best of our knowledge, virtually nothing is known of recent patterns of non-bird diversity at this site.

Until 1983 KAZ was considered as an estuarine lagoon or 'negative estuary' because the evaporation exceeds the freshwater inflow plus precipitation, where the salinity reached up to 47 ppt in summer months. In 1983 the northern end of KAZ was connected to the Euphrates River after emerging from Hour Al-Hammar through an artificial canal called the Shatt Al-Basrah (Al-Ramadhan, 1988) built as a mechanism to drain the Hammar marshes by the previous regime. This connection had a significant effect on the characteristics of the KAZ environment as well as on the hydrodynamic mixing. Since then the environment of KAZ completely changed to form a positively estuarine environment (estuarine lagoon), with a well-developed longitudinal salinity gradient, and a mean monthly freshwater discharge ranged between (0-109 m^3/sec). Surface salinity ranged from 28.5 to 33.5 ppt. Water temperature varied from 11.0 to 32.0 °C (Hussain & Ahmed, 1999). The current is characterized by one direction during the tidal cycle towards the Arabian Gulf. Once again, the environment of KAZ changed back to a negative estuary after the Euphrates was completely cut off discharging waters north of Basrah city in 2012.

Most of the industrial activities along KAZ were impeded during the war times. Soon after the fall of the previous regime in 2003 the rehabilitation and development of the Um-Qasr and KAZ ports recommenced, including the rehabilitation of Um-Qasr port, and construction of LPG Terminal Facility Gas storage and shipping port facilities just opposite the study area (Fig. 1). Most of the port activities including dredging of the channel and the disposal of the dredged materials, shore development, increased maritime traffic, and vehicular traffic during the construction and operation stages likely released natural and anthropogenic contaminants to the surrounding environment. A monthly study of sediment and water of KAZ for the period May 2010 to Sep. 2011 estimated total hydrocarbon (THC) concentration in the water as 2.45- 14.88 μg/l, total HC concentration in the sediment as 2.86- 26.54 μg/g, and the average polycyclic aromatics PAHs were 0.79- 5.4 ng/L. A report published by the University of Basrah Marine Science Centre (2011), indicated that different species of fish and shrimp showed a variable range of HCs pollutants in their tissues. The waters of KAZ and Um-Qasr are also polluted with total and fecal coliform bacteria indicating a concern bacterial water pollution (Al-Taei *et al.*, 2012; Al-Taee & Hassan, 2011).

Sediments of the KAZ banks include accumulation characterized as mud flats, or erosion represented by tidal channels (Tidal creeks). The tidal flat is the coastal muddy shore of the head of the Arabian Gulf, occupying the intertidal zone between the high and low tides. In general, the sediments of the tidal flats comprise lacustrine soils (silts and clays) (Aqrawi, 1994; Al-Mussawy & Basi, 1993). Suspended and surficial sediment of KAZ are of fluviatile origin, transported by the Shatt Al-Arab River to the Gulf and then by wave action to the KAZ. Eolian fallout is also a source of clay, silt and fine sediments. On the other hand, sediment from the tidal flats can be transported back to the channel by tide and wave actions. The tidal flats, especially in the eastern part of the channel, are

composed mainly of clay (70-75%), silt and sand (Al-Mussawy & Basi, 1993) which are considered as washed sediment from the flood plains (Alainachi & Albadran, 2009).The most apparent character of the coastal zone along KAZ opposite the Basrah Gas Company (BGC) terminal is the development of multi-branched tidal channels with intertidal mudflats where the drainage system is extremely fine dendritic pattern (Fig. 2).

MATERIAL AND METHODS

Literature review: A literature review was conducted as part of this study, both of published and unpublished research, and suggested that most ecological work done in the KAZ, UQ and northern Arabian Gulf shores of Iraq was published in the early 1980s (e.g. in the Mesopotamian Journal of Marine Science Centre which was previously called Marina Mesopotamica). This lack of data is understandable given the history of conflict in the region, but points to the need for the current research.

Field surveys: The fieldwork was done by surveying, monitoring, observing, and scoping inventories (inventory measurement), sampling using telescopic zoom camera, normal camera, sampling bags, water containers, Ethanol, hand nets, hand lenses, thermometers, portable refracto meters, digital Lux meter, measuring tapes and ropes and GPS (Garmin 1300), using methods described below.

The species composition of macrobenthos at UQ/KAZ (KBA) mudflat was investigated from 2012 to 2018. Plants and animals collected during the fieldwork were kept alive in water from their surroundings, and some were preserved in ethanol. In the laboratory, the collected specimens were examined and identified using a dissecting microscope, hand lens aided by available local and regional guides/keys for classification (Ahmed, 1975; Jones and Clayton, 1983; ROPME, 1986). The intertidal and the subtidal zones of the KAZ channel were randomly sampled for macro-benthic fauna using the following techniques:

From June 20th to July 10th, 2012 and 2014, the dredging of the channel was carried out using the MSC research vessel AL-Bahith to examine subtidal macrobenthos. The dredger used was a 1.0X2.0 m metal frame with a mesh net and was pulled for 30 minutes along the channel. Collected sediment then washed through a 1 mm sieve using seawater from the same area. In the intertidal zone, direct observations and photography were used to document the presence and abundance of macrobenthos from five sites (Fig. 2).

Benthos inside the sediment as well as in the burrows of the intertidal zone were examined regularly on a nearly monthly basis during the period April 15th, 2017-August 12th 2018. Benthos were randomly collected using (1.0X1.0 m) quadrats (Fig. 4). The means of burrows and individual's density per m^2 of crabs and mudskippers were estimated from 32 quadrats covering four seasons. Sediments were dug to about 10 cm below surface and washed with sea water from the area through a 1mm mesh sieve to collect all the benthic organisms. The collected samples then were preserved in a 50/50 methanol/ water in polyethylene bottles and kept in a cooling box to be carried to the laboratories for further studies, identification and classification.

Monthly water temperature and maximum salinity data from Khor Al-Zubair were obtained from public records for 2018 (sea temperature.org).

Fig. 4. Individuals density per square meter of crabs and mudskippers were estimated using quadrats.

RESULTS AND DISCUSSION

Macrobenthos of the study area: Table 1 lists the macro-invertebrates and intertidal fish recorded in the area during the periods: 1970-1971 (Ahmed, 1975) and 1982-1984 (ROPME, 1986).

Table 1. Macro-benthic invertebrates MBI and mudskipper species of KAZ and Um Qasr (UQ) intertidal mudflats. (*Data presented in the table are historic*).

species	Collection site			species	Collection site	
	UQ	KAZ	sampling date		UQ	KAZ
Class Bivalvae			**1970-1971**	**Class Gastropoda**	√	
Acra holoserica	√			*Diodora funiculata* *	√	
A. Foliata				*Gibbula kotschyi* *	√	

Continued……

A. Uropyogomelana				*Minolia caifasli* *	√
Brachyodontes variabillis				*Vmbonium vestiarium* *	√
Spondylus costatus				*Amaea acuminate* *	√
Laevicardium flavum				*Thais carinifera* *	√*
Dosinia laminata				*Gibberula granum* *	√
Abra cadabra				*Odostomia laevis* *	√
Mactra dissimilis (Reeve, 1958) Deshuyes				*Turbonilla umbrina* *	√
Aciculina sp.				*Relusa canaliculata* *	√
Angulus sp.				*Dentalium octangulatum**	√
Mactra sp.				*Turritella nivea* *	√
Crassostrea cucullata				Onondonata sp.*	√ *
Macrocallista umbonella				Crustacea	
Caryactis cer				Decapoda (crabs)	
Tellina sp.				*Macrophalmus depressus* *	
Placenta placuna		√ *		*Seasarma plioatum**	
Anodora antiquata		√ *		*Paguristes perspicax* *	
Solen vogina		√ *		*Eurycarcinus orientalis* *	
Class Scaphopoda				*Metapograpsus messor* *	
Dentalium oclangulatum	√			Amphipoda	
Polychaetes		√	1982-1984	*Elasmopus* sp.**	√
Nephtys hombergii		√		Isopoda	
Nereis sp.		√		*Sphaeroma annandalii* **	√
Scololepis squamata		√		Mudskippers	
			1994	*Periophthalmus waltoni* *Boleophthalmus boddarti* *** (Pallas)	√
				Boleophthalmus dissumieri ***	√

*Ahmed, 1975, **ROPME, 1986, ***Al-Noor, 1994

The list comprised a total of 33 species of Mollusca, 19 species of gastropods, three species of polychaetes and seven species of crustaceans, mostly crabs. A comparison of historical lists of macro-invertebrates and fish from KAZ with the results from our recent survey showed that more than 80% of what used to occupy the mud flats has disappeared. In addition to the macro-benthos two species of mudskippers were recorded. It is believed that the mudskipper species represents the original dominant mudflat community before the environment of the KAZ changed from a negative estuary to a positive one in 1983 (before linking to the Euphrates River through the artificial canal of the Shatt Al-Basra).

We recorded only two species of mudskippers and six species of crabs in the intertidal flats of KAZ and UQ; none of the bivalve, gastropods, or polychaetes from previous surveys were found. Both mudskippers and crabs were found year-round through the sampling period and in high abundance (Table 2). During low tide, the intertidal mud flat appeared crowded with a large number of mixed populations of crabs and mudskippers actively moving around and slipping into their burrows (Fig. 5) when they feel any disturbance. The two-mudskippers identified *Periophthalmus waltoni* and *Boleophthalmus dissumieri* (Shukla *et al.*, 2014), belong to the Gobiidae family.

Table 2. Currently observed species of macrobenthic fauna at KAZ/UQ intertidal mudflats area.

Species	
Mudskipper	Crustacea, crabs
Periophthalmus waltoni Koumans, 1941	*Uca sindensis*
Boleophthalmus dissumieri Valenciennes, 1837	*Macrophthalmus dentipes*
	*Leptochryseus kuwaitens*is
	Parasesarma plicatum
	Eurycarcinus orientalis
	Nasima dotiliformis

Table (3) summarizes the values of 32 replicates of (1.0 m^2) quadrat of crab's burrows and 32 replicates (1.0 m^2) quadrat of mudskipper's burrows, which were collected during the present study. It's clear that the density of the crab's burrows (mean=155/ m^2) were higher than the density of mudskipper's burrows (mean=39/ m^2); the estimated mean annual density of crabs was 109 (ind./ m^2) and that of the mudskipper was six (ind./ m^2).

Table 3. Density (ind. /m^2) and number of crabs and mudskippers estimated in the KAZ & UQ during the period May 2017 to May-2018 (this study).

	Burrows density (no./m^2)			Estimated animals' density (ind./m^2)
	M_1	R_2	N_3	M_1
Crabs	352	8-2050	25	282
Mudskippers	70	10-146	15	11.0

Although the area is inhabited by few species, it appears that the area shows high population density of the burrowing mudskippers and crabs causing effective bioturbation. On the other hand, these benthic populations provide a prey base to large number of marine species during high tide as well as for many local and migratory birds.

Fig. 5. Crabs and mudskipper actively moving around and slipping into their burrows during low tide.

Crabs (Brachyura): Currently, the macrobenthic invertebrates of the KAZ tidal flat, appeared limited to at least six species of burrowing crabs (Table 2). The fiddler crab *Uca sindensis* was identified for the first time by (Naser *et al.*, 2010), although this crab was commonly dominant and observed in the area of tidal flat since 1972 (authors personal

observations), yet these observations were not documented or published. This species inhabits a narrow zone, seaward and above the zone of the carnivorous mudskipper *P. waltoni*, presumably to avoid predation. *Leptochryseus kuwaitense* is also widely distributed in the mean high intertidal zone. This species has been described from the Kuwaiti mudflats by Jones and Clayton (1983), and from Iran (Ng *et al.*, 2009; Naderloo *et al.*, 2015; Trivedi *et al.*, 2017). It is easily distinguished by the yellow legs and chelae of the male. Another common species was found in the upper HHT area *Nasima dotiliformis*, that was mixed with the *L. kuwaitensis*.

Mudskippers (Gobiidae): The mudflats surrounding the KAZ are occupied by large populations of two species of mud skippers in the subfamily Oxudercine: *Priophthalmus waltoni* **(**Koumans, 1941), *Boleophthalmus dussumieri* (Valenciennes, 1837). These are completely amphibious fishes that can use their pectoral fins to scuttle around during aerial exposure at low tide. Both species were abundant in the KAZ region, usually in tidal mudflats, but also on sandy and rocky shores. *B. dissumieri*, had previously been misclassified as *B. boddarti* (Pallas) (Al-Noor, 1994), but an examination of morphological characters of specimens collected from KAZ mudflat confirmed its identity as *B. dissumieri* (G. Polgar, Xiamen University, pers. comm.)

Fig. 6. The polygonal territories surrounding the burrows building by adult mudskippers.

The distribution of mudskippers is generally related to the presence of a suitable muddy substratum and also on the species' ability to live out of water (Clayton, 1993). On the open mudflats *Periophthalmus waltoni* was found in a zone extending from above mean higher high water (MHHW) to below mean lower high water (MLHW). This zone

overlaps with that of *Boleophthalmus dussumieri* which extends from above MLHW to mean sea level (MSL). *B. dussumieri* has a microphytobenthic feeding habits, where the adults were usually seen, building polygonal territories surrounding their burrows of a size (0.5 -1.0 m^2) (Fig. 6) surrounded by dams for defending and providing food (benthic diatoms).

Rubec *et al.* (2009) and Salim *et al.* (2009), considered the Khor Al-Zubair area as a Key Biodiversity Area (KBA) with important plant, fish, reptile, birds and mammal species in and around the Khor channel itself. In their survey of 2004-2008 they concluded that the tidal inlet and intertidal mudflats of the KAZ region harbors many unique bird and fish species. The study area is part of the Key Biodiversity Area (KBA) and the intertidal zone is considered of regional importance (Iraqi Ministry of Environment and Nature Iraq, 2015). Significant changes in diversity over time are highlighted by the observed dramatic decline in the number of species; however, there is still evidence of very high productivity. It is still reasonable to treat this area as a site with KBA significance.

KAZ is considered a spawning and nursery ground for many marine fish of the northwest Arabian Gulf. Six fish species recorded including *Liza subviridis*, *Pompus argenteus*, *Otolithes ruber*, *Tenualosa ilisha*, *Siliago sihama*, and *Epinephelus diacanthus* (Hussain and Ahmed, 1999). Only one halophytic plant species was detected covering the intertidal mudflat being *Salicornia perennans* which is an annual herb, up to 30 cm in height. It grows in clay soil and salt marshes (Al-Mayah *et al.*, 2016).

Mean annual temperatures have increased in Iraq by approximately 0.7°C since 1950 (Hassan *et al.*, 2018), while an assessment of the observable changes in Iraq's mean monthly temperatures and precipitations of available historical climatological data for four major Iraqi cities including Basrah, covering a time span of about one century (1900-2013) estimated increase in mean temperatures in Iraq between the years 1900–2050 of about 2.2°C and about 25% decrease in precipitation. The authors suggest that these data are in agreement with the IPCC 2007 conclusions reported for the expected global warming (Azooz and Talal, 2015).

These extremely high temperatures will almost certainly impact the benthic fauna. Obviously, the rising temperature will be stressful for organisms that are exposed to the air during low tides directly or indirectly by increasing the water temperature inside their burrows. This is one of the main limiting factors affecting the occurrence and distribution of some of the intertidal zone species. Increased temperature is associated with the raise of the salinity, exerting more stress on the benthos population (Ali *et al.*, 2000). Parmesan (2006) stated that difference in physical environmental conditions plays an important role in regulating the distribution and abundance of natural populations. How species can adapt and respond to extreme events of climate change is becoming an area of increasing interest in terrestrial and marine ecosystems (Helmuth *et al.* 2006). Physical stresses, particularly extreme hot temperatures, are commonly invoked to explain the 'high-shore kills' in temperate areas (Harley, 2008). Mobile species also suffer such events and hundreds of individuals can be killed during calm, hot, low tide days (Williams, 1994; Firth and Williams, 2009). Studies have shown that changes in the environmental conditions affect the physiology and biochemistry of the organisms like variations in body temperature or heart rates and production of heat shock proteins (Ali *et al.*, 2020; Williams *et al.*, 2005; Helmuth and Hofmann, 2001).

The challenges facing ecosystems of Iraq, particularly southern Iraq region are exacerbated by the rapid impacts of environmental changes associated with the reduced inflow in the main rivers systems which is occurring at a fast pace as well as increased pressure on ecosystems due to anthropogenic effects resulting in loss of biodiversity, habitat and ecosystem functioning.

These changes are hypothetically anticipated, however there are still significant gaps in biodiversity-related information, the distribution of species and the physiological effects of environmental changes on organisms and ecosystem functions. This arises because the region is undergoing constant changes including climatic, hydrological, social and political changes affecting ecosystems. KAZ is a good example where the environment has changed twice in less than half a century as discussed earlier. The region witnessed wars and social unrest that led to rapid social changes and the inability of researchers to access the various regions to conduct regular monitoring studies due to lack of security, technical and financial resources.

The absence of biodiversity concerns in the national policies is still regarded as the main issue identified with regards to poverty reduction and economic planning. Still, environmental issues are not addressed as an important factor in the wider context of national importance which raises deep concerns about the necessity of the mainstreaming process. The first National Environmental Strategy and Action Plan of Iraq (2013-2017) (NESAP) was issued in June 2013 by the Iraqi Ministry of Environment with the support of UNEP and UNDP. The document addresses environmental issues and concerns in Iraq and provides for actions and objectives within a set time frame. Many issues raised in the NESAP are crosscutting and addressing biodiversity concerns and issues that will be covered and developed also in the National Biodiversity Strategies and Action Plans 2015-2020 (NBSAP) of Iraq (Ministry of Environment, 2015). However, social and political unrest hampers the implementation of the Action Plan while we are concerned that environmental degradation has reached critical and dangerous points.

A review of available environmental data suggests that increases in salinity and temperature have likely had strong negative impacts on the macrobenthos of KAZ ecosystem and ultimately the loss of many species of molluscs and polychaetes (Table 1). Further stress likely occurred from droughts, drying of the marshes, desertification, serious reduction of water inflow in the Tigris and Euphrates Rivers, increased oil and gas production and exporting (current production 3.0 – 3.2 million barrels a day, Basrah oil company (2016)) and with burning of billions of cubic feet of associated natural gas leading to emissions of about 38 million tons of CO2 and other greenhouse gases (BGC 2018).

The examples given in this paper are from only one site, and comparable losses of biodiversity and ecosystem services are expected to have occurred throughout southern Iraq. However, given logistical difficulties due to recent violence, most of these remain undocumented. Whilst increasing impacts within these areas are anticipated, accurate predictions of future effects are difficult due to a lack of adequate baseline data on environmental conditions, species distribution patterns and physiological vulnerabilities (Williams *et al.*, 2016).

CONCLUSIONS

- Mudflat is an important biodiversity system, despite the environmental changes that have occurred over the past five decades, particularly changes in temperature and salinity.
- It seems that the benthic fauna of the intertidal zone of (KAZ) have been subjected to extreme harsh environmental conditions, where many species, especially molluscs and polychaetes could be not continue living and disappeared.

Although there are only few microbenthic species (low biodiversity) in the KAZ intertidal mudflats; they are clearly well adapted to this habitat as they have high density and wide distribution, and are thus a very productive community.

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