Marine Pollution Bulletin 163 (2021) 111915

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Review

Kuwait's marine biodiversity: Qualitative assessment of indicator habitats and species

N.J. Edmonds [a,*], A.S. Al-Zaidan [b], A.A. Al-Sabah [b], W.J.F. Le Quesne [a], M.J. Devlin [a], P. I. Davison [a], B.P. Lyons [c,d]

[a] Centre for Environment, Fisheries, Aquaculture Science (Cefas), Pakefield Road, Lowestoft, Suffolk NR33 0HT, United Kingdom
[b] Kuwait Environment Public Authority (KEPA), P.O. Box: 24395, Safat 13104, Kuwait
[c] Cefas, Weymouth Laboratory, Barrack Road, Weymouth, Dorset DT4 8UB, UK
[d] British Embassy at the State of Kuwait, P.O. Box 2, Safat 13001, Kuwait

A B S T R A C T

The tropical waters of the Northern Arabian Gulf have a long history of maritime resource richness. High levels of biodiversity result from the complex matrix of coastal habitats, coral reefs and sea grass beds that characterise the region. Insight into the ongoing health of such habitats and the broader Kuwait maritime environment can be gauged by the status of indicator species found within these habitats. Here we review information on the occurrence, distribution and threats to key marine habitats and associated indicator species to provide an updated assessment of the state of the Kuwait's marine biodiversity. Critical evaluation of historic data highlights knowledge gaps needed inform the focus of future monitoring and conservation efforts. This assessment is designed to evaluate performance against environmental policy commitments, while providing a solid foundation for the design of comprehensive marine ecosystem management strategies.

1. Introduction

The Arabian Gulf (also known as the Persian Gulf and hereafter referred to as the Gulf) is bordered by Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and, at its southernmost extent, Oman. The Gulf is a shallow, semi-enclosed sea and naturally exposed to extreme conditions of temperature and salinity due to its location, limited freshwater input and restricted circulation (Sheppard et al., 2010; Vaughan et al., 2019). Yet despite these challenging and harsh environmental conditions the Gulf contains internationally important ecosystems comprising coral reefs, sea grass beds and mangroves forests (Sheppard et al., 2010; Erftemeijer and Shuail, 2012; Burt, 2014; Vaughan et al., 2019). These provide a home to species of global conservation significance, including sharks, rays, turtles and dugong (Moore et al., 2011, Pilcher et al., 2014a, 2014b, Marshall et al., 2018; Almojil et al., 2015). Along with their environmental significance the waters of the Gulf are of immense societal and economic importance to countries surrounding it, providing food and drinking water (via desalination) as well as supporting developing tourism and recreational sectors (Van Lavieren and Klaus, 2013; ROPME, 2013; Vaughan et al., 2019).

The Gulf states have seen rapid economic and societal development in recent decades, mainly driven by exploitation of the region's vast oil and gas reserves. This has led to steep rise in urbanisation, particularly along its coastal margins. The human population of Gulf countries has grown from 46.5 million in the early 1970s to nearly 150 million in the present day, and is estimated to reach 200 million by 2030 (ROPME, 2013). While economically and socially valuable, this growth has come with an associated environmental cost (Burt, 2014; Sheppard, 2016). The region is now facing increasing and accumulative degradation of its natural resources, which when combined with the overlying impacts of climate change is leading to a marked decline in the health status of its marine ecosystems (Sale et al., 2011; Van Lavieren and Klaus, 2013; Sheppard, 2016; Wabnitz et al., 2018; Vaughan et al., 2019).

Developing a coordinated assessment which enables the health of marine waters within the Gulf to be assessed can be challenging, as both detailed data sets and clearly specified management objectives for many aspects of the marine environment are sparsely available (Sale et al., 2010; Van Lavieren and Klaus, 2013; Devlin et al., 2019a, 2019b). However, there are now examples of best practice across the Gulf, where co-ordinated activity is leading to the establishment of Marine Protected Areas (MPAs), which along with ecosystem-based approaches to management are helping to rehabilitate key habitats and reverse the recorded declines in marine biodiversity (Van Lavieren and Klaus, 2013; Burt et al., 2017; Lamine et al., 2020).

Kuwait's marine environment comprises a range of biodiverse

* Corresponding author.
E-mail address: nathan.edmonds@cefas.co.uk (N.J. Edmonds).

https://doi.org/10.1016/j.marpolbul.2020.111915
Received 7 August 2020; Received in revised form 27 November 2020; Accepted 3 December 2020
Available online 24 December 2020

habitats, including some of the most northerly coral reef systems in the world, expansive intertidal mudflat habitats and marine turtle nesting beaches. These are ecologically important for both commercial fish/shellfish species as well as for migratory bird populations (particularly Kuwait Bay) (Al-Abdulghani et al., 2013; Al-Husaini et al., 2015; Al-Yamani et al., 2017).

Kuwait is situated at the north-western tip of the Gulf (Fig. 1). Despite its location at the mouth of the Shatt al-Arab river (confluence of the Euphrates and the Tigris rivers), the waters surrounding Kuwait are highly saline (average salinity 41 ppt). They are characterised by wide ranging sea water temperatures that fluctuate between 14 °C, in the winter, to over 30 °C in the summer (Al-Rifaie et al., 2007; Al-Yamani et al., 2017). With such variable natural conditions many marine species and habitats in Kuwait, and across the Gulf, are functioning close to their natural limits of physiological tolerance. As a consequence many may be sensitive to additional anthropogenic pressures, such as chemical pollution, effluent discharges (including thermal stress from desalination plants), habitat destruction, marine litter and invasive species introduction (Sheppard et al., 2010; Naser, 2013; ROPME, 2013; Al-Sarawi et al., 2015; Devlin et al., 2019a; Sheppard, 2016; Clarke et al., 2019; Khatir et al., 2020; Lyons et al., 2020).

In addition to supporting both regionally and globally important biodiversity, Kuwait's marine environment supports productive fisheries for human consumption, which is economically the second most important natural resource after oil (Al-Zaidan et al., 2013; Al-Husaini et al., 2015). The coastline and offshore areas have extensive recreational and amenity value (Al-Rifaie et al., 2007). Waters surrounding Kuwait and the Gulf also provide key ecosystem services, serving as a source of water for desalination plants and the receiving environment for industrial and domestic waste water (Al-Dousari, 2009; Al-Sarawi et al., 2015; Devlin et al., 2015b; Lyons et al., 2015; Nicolaus et al., 2017).

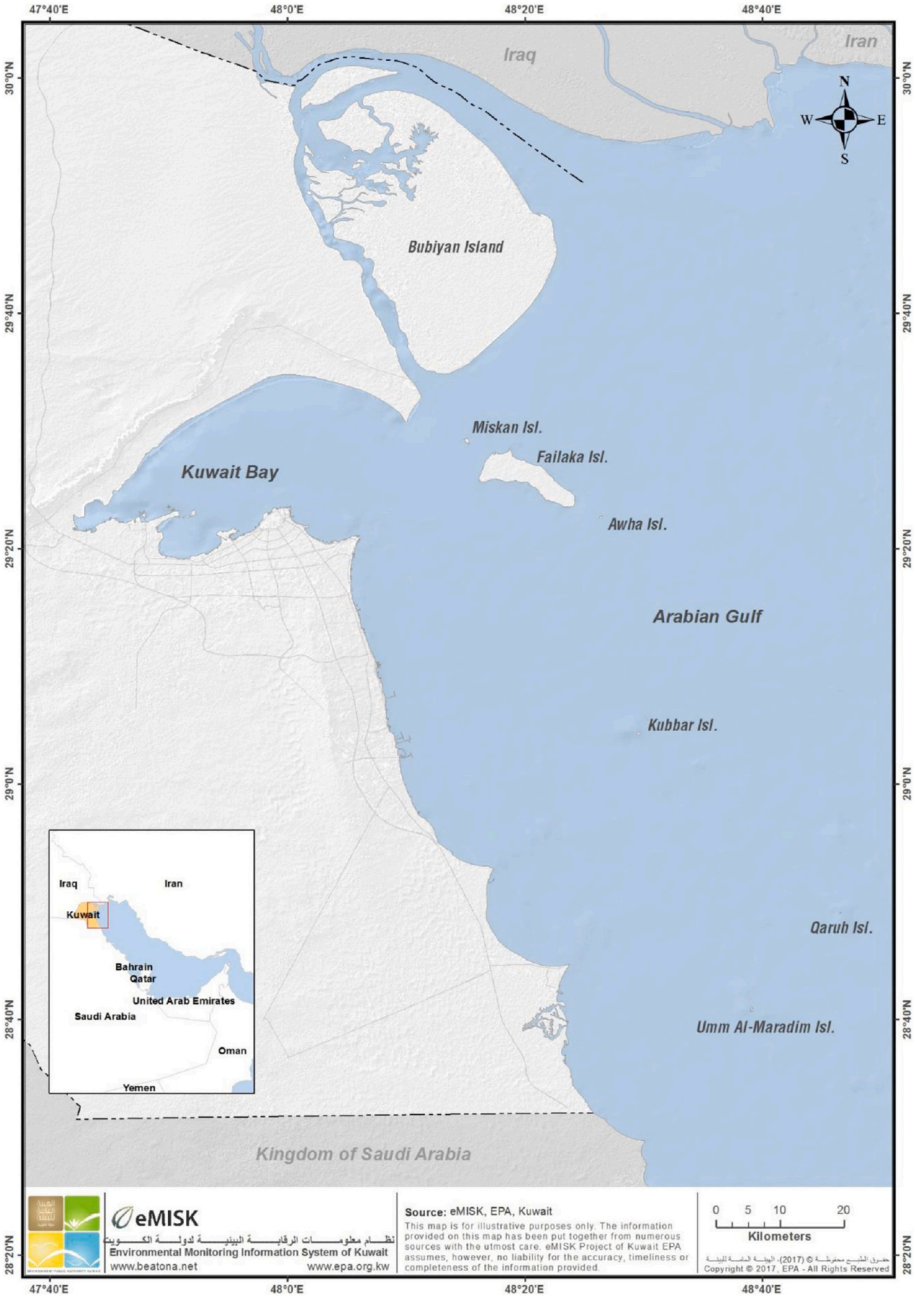

Fig. 1. Chart of Kuwait's marine environment (with permission from KEPA).

As a nation, Kuwait is endeavouring to maintain economic diversification and development, without compromising the health of its environment (Kuwait National Development Plan, 2035). This is a common problem as many of the countries bordering the Gulf are facing a similar situation when attempting to balance the demands for coastal development, while protecting the ecosystems goods and services provided by their marine waters (Burt, 2014). At the intersection of these aims lies potential conflict between continued prosperity and the conservation of key species and habitats, some of which require integrated, cross-border, management approaches (Sale et al., 2010; Van Lavieren and Klaus, 2013. Kuwait has long recognised the importance of biodiversity and the key habitats found there. The country is signatory to numerous international, national, and regional policy commitments (see Table 1 and Unger et al., 2017). A need to protect and preserve the health of the marine ecosystem is highlighted as an essential component of the National Plan for Marine Environmental Management (Anon, 2019). Adoption of the 'Environment Protection Law of Kuwait' (2014) provides a legislative framework for such protection. This has significantly enhanced the legal, regulatory and enforcement options available to Government authorities responsible for managing the marine environment.

It is therefore imperative that robust baseline assessments of key marine habitats and indicator species are undertaken, both in Kuwait and across the Gulf (Al-Rifaie et al., 2007; Grizzle et al., 2016; Burt et al., 2017). These can then act as a benchmark against which to measure trends and guide future decisions relating to sustainable coastal development and use of marine resources. At a local level such efforts will help Kuwait deliver its obligations under international conventions; including the Convention on Biological Diversity (CBD), and reporting requirements for the United Nations Sustainable Develop Goals (UNDP, 2015; Kuwait Voluntary National Review, 2019).

Table 1
List of conventions and laws pertinent to protection of Kuwait's marine environment.

Scope of convention/law	Kuwait examples
International	United Nations Convention on the Law of the Sea (UN, 1986) Convention on Biological Diversity (CBD; Aichi Biodiversity Targets) (CBD, 2018) UNESCO Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (RAMSAR, 2015) UNESCO World Heritage Convention Concerning the Protection of the World Cultural and Natural Heritage (UNESCO, 2002) Marpol - International Convention for the Prevention of Pollution from Ships (under IMO) (Marpol, 1983) CITES - Convention on International Trade in Endangered Species (CITES, 2002)
Regional	Convention on the Conservation of Wildlife and their Natural Habitats in the Countries of the Gulf Corporation Council (GCC, 2001) Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution; Kuwait Action Plan Protocol concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substance in Cases of Emergency (UNEP, 1983) Kuwait Action Plan Protocol Concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf (ROPME, 1989) Kuwait Action Plan Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources (ROPME, 1985) Kuwait Action Plan Protocol on the Control of Marine Trans-Boundary Movements and Disposal of Hazardous Wastes and Other Wastes (ROPME, 1972) Agreement for the establishment of the Regional Commission for Fisheries (RECOFI) (FAO, 1999)
National	Kuwait Environment Protection Law - Law 42 of 2014 National Biodiversity Strategy for the State of Kuwait (NBSSK, 2011)

Assessments of the state of the marine environment can be undertaken in many ways. Methods vary from quantitative assessment (where numerical data is directly compared to a numerical standard), thorough to qualitative narrative assessments; (where trends in the data are discussed with no reference to specific numerical standards for the status of the environment) (Downey and Ireland, 1979; Al-Abdulghani et al., 2013; Borja et al., 2016; Devlin et al., 2019b). Numerical standards for environmental status have only been defined for a limited number of systemically monitored components within the Kuwait marine environment (e.g. microbial water quality) and are not yet developed for biodiversity elements (see Devlin et al., 2019b).

Data-limited biodiversity assessments are not perfect but can be of value in revealing insights and trends into population trajectories and habitat coverage. Here we focus on key habitats of ecological importance to Kuwait (coral reefs, sea grass beds and coastal habitats), along with the available data for species of conservation importance (sharks/rays, marine mammals, turtles and sea birds). There are no accessible, long-term quantitative data, or defined indicators for the biodiversity and key indicator habitats and species in Kuwait. As a result, the summaries presented here are based on a qualitative narrative, from the best available technical and scientific information (Devlin et al., 2019b). Data considered has been obtained from Kuwait's Environment Public Authority (KEPA), peer reviewed scientific papers, management reports, volunteer networks and relevant regional and international studies.

2. Indicator habitats of conservation importance

2.1. Coastal habitats

Kuwait has roughly 500 km of coastline comprising a diverse range of habitats including salt marshes, mudflats, sand plains, coarse habitats, and exposed bedrock critical to the survival of a wide variety of biodiversity (see Figs. 1 & 2). Soft sediment shores on the northern coast (Kuwait Bay) are graded from mud to muddy sand composing silt and clay deposited from the Shatt Al-Arab estuary (Fig. 2C & D). Generally, carbonate sediments predominate in the south, while land-derived clastics dominate in the north. Some of the most extensive intertidal mudflats occur around Kuwait Bay, particularly at Dawhat Kazima, at the west end of the Bay, and in Sulaibikhat Bay, on the south-west side (CBD, 2016).

Kuwait's intertidal sands and mudflats harbour an immense diversity of benthic organisms including 271 recorded species of Mollusca, many supported by vast microbial mats (Jones and Clayton, 1983; Al-Kandari et al., 2020). The high biomass found here, as well as within *Sargassum* beds, influences primary productivity and supports a productive commercial fishery within the marine ecosystem (Ali et al., 2018; Al-Kandari et al., 2020). Mud flats serve as a major feeding grounds for benthivores feeders including ciliates, shrimps and other crustaceans, molluscs and annelids (Al-Kandari et al., 2019; Al-Kandari et al., 2020), along with three species of mudskipper (Clayton and Vaughan, 1986). Many fish of commercial importance are reliant on the productivity and food webs associated with the mud flats found within Kuwait Bay (Al-Zaidan et al., 2006; Al-Mohanna et al., 2007). Sandy beaches provide important habitat for nesting turtles, while rocky regions provide habitat and refuge for algae and crustaceans. Rocky habitat has been shown to be degraded by bait harvesting (targeting *Leptodius exaratus*) (Al-Wazzan et al., 2020a). Though this activity varies significantly along the coastline it results in the widespread mortality of sessile fauna on turned rocks (tubeworms, rock oysters, barnacles, mussels, sponges, tunicates) as well as physical destruction of the rock habitats themselves. Subsequent effects on coastal biodiversity remain unquantified. To date, there is very little information on the patterns of spatial and temporal distribution of key intertidal organisms such as brachyuran crabs (Al-Wazzan et al., 2020b) available, and work is required to update the early descriptions of Kuwait's rocky shores provided by Jones (1986). Impacts

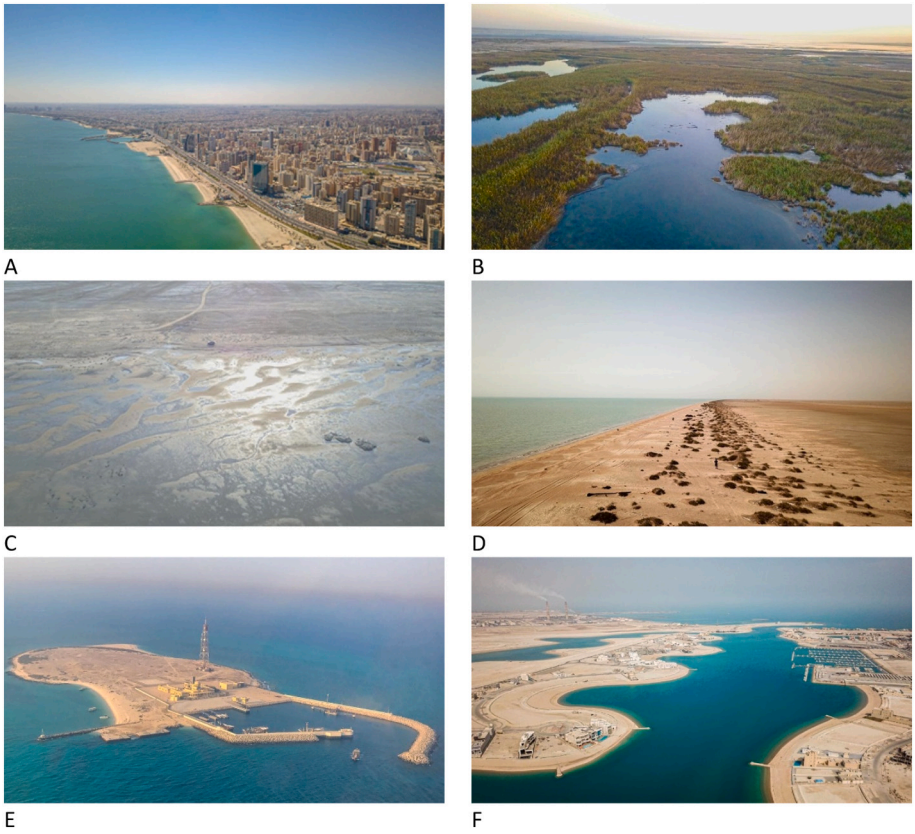

Fig. 2. Examples of coastal habitats found in Kuwait. A) Urbanised and reclaimed coast line of Kuwait City; B) Reed beds and salt marsh at the Jahra Pools nature reserve (Kuwait Bay); C & D) Coastal sabkha, sand plains, intertidal mudflats (North Kuwait Bay and southern section of Bubiyan Island); E) Umm Al Maradim Island; F) Sabah Al-Ahmad Sea City (all photo credits: Dr. Abdullah Al-Zaidan).

(natural and anthropogenic) cannot be well understood without further detailed information on species composition and habitat extent.

Saltmarshes, including the internationally important Jahra Pools Nature Reserve (Kuwait Bay) are biodiversity hotspots (Fig. 2B). Their associated pools, sabkhas and nabkas are dominated by salt tolerant halophytes e.g. *Nitraria retusa* (Al-Dousari et al., 2008), providing important habitats for bird, invertebrate, fish and mammal species (Omar and Roy, 2013; Edmonds and Davison, 2017; Edmonds et al., 2019). Many of these sites are poorly studied and new species for the country are still being discovered (see Edmonds et al., 2019). Hunting still occurs at Jahra Pools despite site fencing and warden patrols, and water quality appears to be declining (Edmonds and Davison, 2017; Edmonds et al., 2020).

There are nine natural islands in Kuwait (Failaka, Bubiyan, Miskan, Warbah, Auha, Umm Al-Maradim, Umm Al-Namil, Kubbar and Qaruh). Bubiyan is a nationally significant location for bird species which utilise the mud flats and salt marshes flanking its coastline, and as such was recently designated as a RAMSAR Convention Site (Ramsar, 2015). These coastal ecosystems sustain most of the island's biodiversity (Omar and Roy, 2013) and the northern intertidal areas of Bubiyan and Warbah island are of international importance for birds. The Shatt Al Arab meets the waters of the Northern Gulf close to Bubiyan and these are known to be highly productive and support nursey areas for many commercially important fish species (Ben-Hasan et al., 2018; Alsaffar and Chen, 2019).

Kuwait's islands and tidal flats are vulnerable to development schemes that modify the coastline. Much of the coast has now been subject to infill and seaward extension for housing, recreation, and industrial development. This has led to degradation of the highly productive intertidal and shallow subtidal marine ecosystems upon which fisheries depend (Jones et al., 2012; Al-Abdulghani et al., 2013). The continued productivity of tidal flats is threatened as formal protection is limited to Sabah Al Ahmad Natural Reserve and Jahra Pools (Kuwait Bay). Despite qualifying as an area of special scientific interest large parts of Bubiyan Island are earmarked for development, with the Sheikh Jaber Al-Ahmad Al-Sabah causeway across Kuwait Bay, paving the way for port development and increased urbanisation (Trade Arabia, 2017; Alsaffar and Chen, 2019).

Many coastal habitats in Kuwait have experienced marked reductions in size over recent decades with saltmarshes being especially adversely affected. Abd El-Wahab (2015) reports a 10% decrease in the saltmarsh plant *N. retusa* in Northern Kuwait between the 1970s–2000s and a 50% decrease in community coverage over the past decade. Abd El-Wahab (2016) also demonstrated a further decrease (up to 40%) in the annual species that are seasonally present within Kuwaiti saltmarshes. It is thought that this decrease is linked with increasingly arid conditions associated with removal of trees and shrubs for urban developments, further decreasing the chances of habitat recovery. On a broader scale Loughland et al. (2012) reports the loss of 90% of saltmarshes due to urban development in the wider Gulf region, providing context for the high ecological value of Kuwait's remaining saltmarsh habitat. Establishing ongoing coastal monitoring surveys and accompanying habitat management plans will be key to preserve existing saltmarsh.

Mangroves were once abundant on the coast of northern Kuwait, supported by the nutrient and silt-rich waters of the Shatt Al-Arab. A combination of overgrazing and utilisation for wood eventually led to their disappearance (Shuaib, 2006). Mangroves provide refuge, nurseries, and foraging habitat for a variety of species while also providing a natural coastal defence and trapping sediment and nutrients locally. Kuwait has no naturally surviving mangrove forests and a number of attempts have been made previously to re-establish mangroves along the Kuwaiti coast, but these have not thrived due to challenging conditions

not favouring the growth of pneumatophores (Almulla et al., 2013). Recently, replanting experiments have been undertaken on the man-made islands of Sabah-Al Ahmad Sea City (see Loughland et al., 2020) as well as by KEPA around the Jahra Pools reserve and Bubiyan Island. While initial results appear promising, longer-term monitoring is required to establish whether these have been successful. Across extensive parts of Kuwait's coastline poor urban planning and development continue to negatively affect the coastal environment and associated water quality (e.g. sewage pollution), disturbing the natural anoxic layer, salinity and textural composition which would allow mangroves to better thrive in the Kuwaiti coastal area.

Coastal and marine environments are where most of the major Kuwaiti housing, recreational, and economic developments have occurred in recent decades (Baby et al., 2013; Sheppard et al., 2010). Coastal development has led to the reduction (and destruction) of coastal habitats through dredging and land reclamation. At a regional level it is estimated that >40% of the coastline of the Gulf has been developed (Hamza and Munawar, 2009; Naser, 2014). It is estimated that land reclamation will accelerate in the future as the population continues to grow (Naser, 2014). Recent data for Sulaibikhat Bay indicates that the bay is being impacted by coastal urbanisation and industrialization, which is reducing the biodiversity of this nationally important ecosystem (CBD, 2016). Anthropogenic activities associated with land reclamation and sewage outlets, modifying the coastal fringes and reducing habitat integrity and water quality (Al-Abdulghani et al., 2013; Lyons et al., 2015; CBD, 2016; Devlin et al., 2019a).Such predictions highlight the precarious position of the remaining undeveloped coastal stretches. Coastal development is not always incompatible with retention of coastal habitats in Kuwait. Artificially created marine habitats such as Sabah Al-Ahmad Sea City (see Fig. 2F) have a species richness and abundance close to, or exceeding, that of similar open sea natural habitats. Here, saline desert has been excavated and flooded to create marine waterways, adding 180 km of additional shoreline to the coast of southern Kuwait (Jones et al., 2012; Nithyanandan et al., 2016).

Habitats of importance to Kuwait are those which provide key ecosystem services (e.g. nursery areas, foraging, nesting etc) supporting wider biodiversity. Conditional assessments from a dedicated coastal habitat monitoring programme are required to better assess these features. Data and evidence generated from conditional assessments can be used to underpin planning decision-making, which is the foundation for the sustainable use of the Kuwaiti aquatic ecosystem. Opportunities exist to combine such monitoring with citizen science and education programmes for the wider benefit of Kuwaiti society.

A dedicated baselining exercise is required to assess the current condition of coastal habitats. This should be used as the beginnings of a long-term monitoring strategy to assess changes in condition over time so that management action can be taken where required. The lack of data across all coastal habitats makes a quantitative assessment of Kuwait's coastal habitats difficult, however it is possible to infer the condition of habitats from the changes in anthropogenic coastal use over the last few decades. Recent work on the salt marsh habitats of Kuwait demonstrates the direct effects of human activities on vegetation of this developing region (Abd El-Wahab et al., 2014; Abd El-Wahab, 2016). Similarly, Almulla et al. (2013) discuss the possibilities of successfully re-introducing mangrove habitats to the Kuwaiti coastline, and the potential benefits of such an endeavour, but only where coastal management is appropriately monitored and observed. Studies such as Jones and Nithyanandanb (2013) show high levels of marine biota diversity and rates of colonisation on artificially created subtidal habitats. Evidence from Sabah Al-Ahmad Sea City shows artificial waterways provide spawning, nursery and feeding habitats for multiple commercial species and act as valuable conservation areas for Kuwait's fish stocks (Nithyanandan et al., 2016).

2.2. Coral reefs

Approximately 12 discrete reefs are found in Kuwait across both the nearshore and offshore environments. These range from small patch and fringing reefs inshore to platform reefs and coral cays (see Coles and Wilson, 2003; Papathanasopoulou and Zogaris, 2015). The offshore coral cays representing some of the best developed true coral reefs in the Gulf (Carpenter et al., 1997; Benzoni et al., 2006; Alhazeem et al., 2017).

At least 36 coral species are found on Kuwaiti reefs, which are dominated by poritid and faviid assemblages (Downing, 1985; Pilcher et al., 2000; Maghsoudlou et al., 2008; Papathanasopoulou and Zogaris, 2015). Reef diversity is low in the context of the region but still provides habitat for 124 recorded fish species including those which are commercially exploited (Sheppard, 1987; Sheppard and Sheppard, 1991; Papathanasopoulou and Zogaris, 2015). Sea urchins (*Echinometra mathaei* and *Diadema setosum*) in particular, are abundant on the reefs and reported to occur in dense populations of 20–80 per m^2 (Papathanasopoulou and Zogaris, 2015) Kuwait coral assemblages vary markedly, even between reefs in neighbouring sites, highlighting variable conditions and the need for discrete, localised reef management (Downing, 1985; Pilcher et al., 2000).

Kuwait's largest coral reefs are concentrated around the southern islands, notably Umm Al-Maradim, Kubbar and Qaruh (Figs. 1 and 2E). The Umm Al-Maradim reef is 1.4 × 1.1 km and principally composed of stony porite corals (*Acropora* and *Stylophora*), the oceans primary reef builders (Papathanasopoulou, 2010). The reef margins at Umm Al-Maradim also contain populations of flowerpot corals (*Goniopora columna),* which although widespread in the wider Indo-Pacific is assessed as 'near threatened' by the International Union for Conservation of Nature (IUCN, 2020) and is protected as an Appendix II species in the Convention on International Trade in Endangered Species (CITES) (Papathanasopoulou and Zogaris, 2015; CITES, 2020). The Qaruh Island reef is ~1.3 × 0.6 km and reported to be the most ecologically diverse coral reef in Kuwait. Here, Porites coral heads (*Porites lutea*) dominate the reef close to the beach leading into expanses of branching Acropora table corals as the reef slopes further offshore (Papathanasopoulou, 2010; Papathanasopoulou and Zogaris, 2015). Closer to shore reef patches occur between Qulai'ah/Bnaider to Raz Al Zour, where dominant corals include Porites Finger Coral (*Porites compressa*) (Papathanasopoulou and Zogaris, 2015).

Coral communities in Kuwait occur in one of the most environmentally extreme coral habitats in the world. They are unique as they are marginal for reef development (situated at high latitudes 28° North, 48° East). Seawater temperature extremes range from 14 to 30 °C between summer and winter. Combined with high levels of salinity (>40 ppt) this constitutes a naturally environmentally stressed ecosystem (Harrison et al., 1997; Gischler et al., 2005; Alhazeem et al., 2017;). Sediment and water turbidity are additional factors regulating coral development. Inputs of sediment via the Mesopotamian delta restricts the northern development of significant reef structures, however the extent to which these natural forces affect the reefs in Kuwait are not well understood (Downing, 1985). Extreme temperatures are believed to be the single most important cause of coral reef decline in the region despite some resilience to this factor within the wider Gulf reef ecosystems. Early surveys of Kuwait's reefs indicate historical exposure to periods of acute stress. Bleaching and coral mortality occurred in 1982–83 (Downing, 1985), and 1984–85 (Downing, 1989), and in the winter of 1991–92 (Downing, 1992; Downing and Roberts, 1993). Sea water temperature in Kuwait Bay has been recorded to increase at a rate three times higher than global estimates (0.6 ± 0.3 °C/decade) (Al-Rashidi et al., 2009). This is primarily driven by global climate change, El-Nino, thermal plumes from power and desalinisation plants and urban storm drains (LNRCC, 2016).

The reefs of Kuwait are subjected to multiple anthropogenic impacts; particularly at Kubbar Island, which is closest to the main population centres and easily accessible by boat (Price, 1993; Papathanasopoulou

and Zogaris, 2015). The main reefs at Kubbar and Qaruh are often frequented by several hundred recreation boats during weekends (see Alhazeem et al., 2017) which impacts the reefs through litter and anchor damage. Resultant anchor damage has had chronic impacts here since the 1980s, with fragile branching corals particularly affected (Alhazeem et al., 2017). Associated recreational activity also disturbs the bird populations and marine turtles that nest on these small islands. Overfishing via spearfishing and recreational boat angling are also thought to have affected the health of the reefs in many areas. Due to the southern location of the reefs in Kuwait the major flood plumes from the Shatt Al-Arab do not appear to significantly affect the reefs around these islands. However, it is likely that the smaller patches of reef close to shore are impacted by uncontrolled sewage discharge, industrial activity, and coastal construction. Additional studies are required to confirm this.

The state of Kuwait's coral reefs was previously considered stable. The living percentage of recorded coral cover varied between 28 and 44.5% in 1989 (Downing, 1989) and 15–48% in 2003, with no significant difference between 1989 and 2005 (the high degree of variation in the living coral percentage cover, represents localised effects at each of the coral sites). More recently, surveys conducted by volunteer groups, such as the Kuwait Dive Team, reported bleaching to have affected over 90% of the Kuwaiti coral reefs examined (Naui, 2010). The latest information produced using satellite imagery has estimated that the coral reefs around Kubbar Island have reduced in size by 34% between 2006 (232,565 m^2) and 2017 (152,896 m^2) (Gholoum et al., 2019). While coral community structure appears to have remained stable, a 2017 survey of Kubber recorded 13 coral genera, compared with 12 in 1984 and 13 in 2003 (Alhazeem et al., 2017). Work by Nithyanandan et al. (2018) has shown that anchor-damaged staghorn coral (*Acropora downingi* colonies) can be successfully translocated and raised on artificial reefs south of Kuwait City. Such findings highlight the potential for coral reef restoration through the 'coral gardening concept' (Rinkevich, 2008) despite the extreme environmental conditions of the northern Gulf.

The coral reefs of Kuwait are under significant threat and their decline is regionally mirrored across the Gulf. It has been estimated that ~70% of original Gulf coral reef cover may be considered lost, with a further 27% threatened or at critical stages of degradation (Wilkinson, 2008; Sheppard, 2016). To understand and mitigate the causes of such declines it is crucial that a dedicated, scientifically robust, ongoing coral reef monitoring survey protocol is implemented. Widespread restrictions on data sharing limit opportunities to address the problem. Making output publicly available will be key for raising awareness and serving as a justification for grant-based aid and remedial management activity.

2.3. Sea grass

Two species of native seagrass are known to occur in the waters around Kuwait; *Halophila ovalis* and *Halodule uninervis* (Erftemeijer and Shuail, 2012; Phillips, 2003). Seagrass meadows are usually confined to sandy and muddy substrates in nearshore waters shallower than 10 m (Erftemeijer and Shuail, 2012). They are important habitats for commercially important shrimp (*Penaeus semisulcatus*) and the pearl oyster (*Pinctada imbricata radiata*), as well as for many fish species, including those which use seagrass habitat as nurseries (Carpenter et al., 1997). Seagrass beds also sustain the green turtle, *Chelonia mydas*, and, within the wider Gulf, the world's second largest population of the IUCN 'vulnerable' listed dugong (*Dugong dugong*) which are found between the UAE and Bahrain (Marsh et al., 2002; Preen, 2004).

Though widely distributed along the shores of the Gulf, seagrass habitat has been reported as limited within Kuwait's marine environment (see Erftemeijer and Shuail, 2012). The total Kuwaiti seagrass habitat spans 50 km^2 in total (Jones et al., 2002) with significant seagrass meadows of 2–3 km^2 at Dbaiyah and Nuwaiseeb (Shuail, 2008a, 2008b) and a 1 km^2 patch at Az Zour (Delf Hydraulics, 2004).

>530 species of plants and animals have been recorded among seagrasses across the Gulf (Price et al., 1993). To date, no specific, comparable figures exist for Kuwait. Seagrass habitat is economically important to the region. Estimates from Saudi Arabia's Tarut Bay (410 km^2) suggest regional seagrass beds support production of 2 million kilograms of fish annually at a 1987 value of US $10 million, or the same quantity of shrimp worth US $12 million (Price et al., 1993). No monitoring and mapping efforts have been conducted to delimit the extent of the seagrass beds in Kuwait thus far. This prohibits assessment of their biological and fiscal productivity. Large-scale land-reclamation projects, and rapid industrial developments (including power- and desalination plants) continue to pose a major threat to seagrass habitats in this region.

3. Indicator species of conservation importance

3.1. Sharks and rays (Chondrichthyes)

The Chondrichthyes are (typically) large, slow-growing, late-maturing low-fecundity fish species (Camhi et al., 1998). These characteristics make the Chondrichthyes ideal indicators of wider ecosystem health. This is due to their apical position within the marine food web as well as their susceptibility to overexploitation, by-catch and regional extinction (Henderson et al., 2007; Almojil, 2016). A previous species list of sharks and rays within Kuwaiti waters documented the presence of 37 previously recorded, and two unidentified, Chondrichthian species (Table 2; after Bishop, 2003). As such, Kuwait has historically provided habitat for at least two thirds of the shark and ray species found within the Gulf region (see Almojil et al., 2015).

Kuwait's waters of the northwestern Gulf and the Oman/Yemen coast of the Arabian Sea are the only locations where the endangered smoothtooth blacktip shark (*Carcharhinus leiodon*) is confirmed as occurring. This species, known to science from a single specimen for over 100 years, was rediscovered in Kuwait in 2008 (Moore et al., 2011;

Table 2
Kuwait shark and ray species and their conservation status (Data from Bishop, 2003; Moore et al., 2015; Moore et al., 2011; Almojil et al., 2015).

IUCN biodiversity category	Kuwait shark and ray species
Critically Endangered	Great hammerhead (*Sphyrna mokarran*), Green sawfish (*Pristis zijsron*), Bowmouth guitarfish (*Rhina ancyclostoma*), Giant guitarfish (Whitespotted wedgefish) (*Rhynchobatus djiddensis*), Sharpnose guitarfish (*Glaucostegus granulatus*)
Endangered	Whale shark (*Rhincodon typus*), Zebra shark (*Stegostoma fasciatum*), Whitecheek shark (*Carcharhinus dussumieri*), Smoothtooth blacktip shark (*Carcharhinus leiodon*),
Vulnerable	Tawny nurse shark (*Nebrius ferrugineus*), Sand tiger shark (*Carcharias taurus*), Hooktooth shark (*Chaenogaleus macrostoma*), Silvertip shark (*Carcharhinus albimarginatus*), Sandbar shark (*Carcharhinus plumbeus*), Reticulate whipray (*Himantura uarnak*), Blotched fantail ray (*Taeniurops meyeni*), Banded eagle ray (*Aetomylaeus nichofii*),
Near Threatened	Arabian carpet shark (*Chiloscyllium arabicum*), Grey bamboo shark (*Chiloscyllium griseum*), Arabian smoothhound (*Mustelus mosis*), Slender weasel shark (*Paragaleus randalli*), Spinner shark (*Carcharhinus brevipinna*), Bull shark (*Carcharhinus leucas*), Common blacktip shark (*Carcharhinus limbatus*), Blacktip reef shark (*Carcharhinus melanopterus*), Spot-tail shark (*Carcharhinus sorrah*), Tiger shark (*Galeocerdo cuvier*), Spadenose shark (*Scoliodon laticaudus*), Cowtail stingray (*Pastinachus sephen*), Arabian butterfly ray (*Gymnura poecilura*)
Least Concern	Milk shark (*Rhizoprionodon acutus*), Grey sharpnose shark (*Rhizoprionodon oligolinx*)
Data Deficient	Panther electric ray (*Torpedo panthera*), Marbled electric ray (*Torpedo sinuspersici*), Scaly whipray (*Himantura imbricata*)
Not Evaluated	Bleeker's whipray (*Pateobatis bleekeri*)
Uncategorised	Whipray sp. Unknown (*Himantura sp.*), Eagle ray sp. Unknown (*Aetomylaeus sp.*)

Moore et al., 2015). The records of five critically endangered species (green sawfish (*Pristis zijsron*), great hammerhead (*Sphyrna mokarran*) and three guitarfishes) and four endangered species (*C. leiodon*, zebra shark (*Stegostoma fasciatum*), whale shark (*Rhincodon typus*) and white-cheek shark (*C. dussumieri*)) suggest that Kuwait waters may be especially valuable for dwindling populations of these species. Of those species for which data are available to make a categorisation, most species are given threatened or near-threatened status, with only the milk shark (*Rhizoprionodon acutus*) and grey sharpnose shark (*Rhizoprionodon oligolinx*) listed as of least concern (IUCN, 2020).

It is likely, though unproven, that fisheries by-catch is the primary driver for such declines, as has been found in other locations (Lewison et al., 2004). There has been a significant increase in Kuwaiti fishing pressure over the past 40 years and trawls, gillnets, hadrah nets, longlines and gargoor traps are all used (Al-Baz et al., 2018). Chondrichthyes are not typically targeted but low-resolution catch/discard data means it is unclear whether they compose the majority of captured species by weight [listed under the 'other' (i.e. non-target species) record category] (see Al-Baz et al., 2018). Recreational fisheries in Kuwait do not appear to be directly influencing Chondrichthyes abundance as none were revealed to be targeted through a recent angling questionnaire survey (Al-Wazzan et al., 2020a).

Accessible fine-scale information concerning the distribution of Chondrichthyes, and fish in general, is lacking for Kuwait. Recent findings by Alsaffar and Chen (2019) suggest that the coastal waters around Bubiyan Island harbour a particularly biodiverse range of fish, also serving as an important nursery area. Evidence of temporal fluctuations in diversity are apparent here, with spring/summer records of species richness being over double winter levels (see Alsaffar and Chen, 2019). More widely, Al-Baz et al. (2018) note that the popularity of discrete fishing gear types being similarly influenced by season and suggested that this should be considered when developing future stock management plans.

3.2. Cetacea

Many marine megafauna populations around the world have declined due to unsustainable direct exploitation or incidental mortality (de Smet, 1981; Anderson et al., 2011; McClellan et al., 2014). However, very little information exists on the abundance and diversity of cetaceans found within Kuwait. Existing, publicly available data is based on ad-hoc observations (Bishop et al., 2008; Nithyanandan, 2010; Bohadi, 2019). Delphinid populations of the Gulf are believed to have declined by 71% between 1986 and 1999 (Preen, 2004). Drivers for this decline have not been clearly determined, but pollution events, reductions in riverine input from the Shatt Al-Arab river, by-catch and a reduction in food source have been implicated (Al-Yamani et al., 2007). Dead or stranded dolphins are periodically washed up on Kuwait beaches, some of which are entangled in fishing gear, though no regular recording of occurrence or post-mortems have been collated to ascertain direct causes of death (Bohadi, 2015; Bohadi, 2019). Where information is available boat strikes (propeller injury) and parasites are implicated in the few recorded autopsies (Bohadi, 2019).

The Indian Ocean humpback dolphin (*Sousa plumbea*), considered globally endangered (IUCN, 2020; Braulik et al., 2015), is one of the most sighted dolphin species in Kuwaiti waters (Baldwin et al., 2004; Bishop et al., 2008; Nithyanandan, 2010). A resident population is located around the waters of Bubiyan Island, with greatest numbers reported during spring (Bishop et al., 2008). Opportunistic sightings have also been recorded in Southern Kuwait (see Nithyanandan, 2010) though it is unclear if this is a separate population. The exact abundance, spatio-temporal distribution, and reproductive status of Kuwaiti *S. plumbea* population(s) is undetermined at present. However, behaviour commensurate with mating has been observed within Kuwait waters between April–May at a time when the species is known to conduct this activity around South Africa (Nithyanandan, 2010). It is therefore likely that Kuwait waters serve as breeding habitat for the species. The feeding habits and behaviour of *S. plumbea* are largely unknown from Kuwait waters although daytime feeding on shoals of Gulf Herring (*Herklotsichthys lossei*) has been reported near Al Khiran (south Kuwait) in the past (Nithyanandan, 2010). Such reports have implications for in-country fisheries management and by-catch reduction schemes. Though records of dead, stranded individuals exist for Kuwait in both 2013 and 2015 it is unclear whether fishing activities were implicated (Bohadi, 2019).

Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (IUCN 'data deficient') are the most common cetaceans in the Gulf comprising over 70% of groups and individuals sighted (Preen, 2004). Population sizes of ~1200 are reported for the region although it is unclear what percentage use, or are resident within, Kuwait waters, as sightings are limited to opportunistic records (Nithyanandan, 2010). A dead individual, with evidence of parasites was washed up on Anjafa beach in 2015 (see Bohadi, 2019).

Finless porpoise (*Neophocaena phocaenoides*) (IUCN 'vulnerable') are estimated to represent 2% of the delphinid population of the Gulf and are reported to inhabit both shallow and offshore waters of Kuwait (Clayton, 1983; Aspinall and Baldwin, 1999; Preen, 2004; Collins et al., 2005). The most recent, documented, sightings provide an estimate of 12 individuals (min) for the Kuwait Bay population (see Collins et al., 2005). Bohadi (2019) documents ten incidences of deceased *N. phocaenoides* stranding on Kuwait beaches between 2013 and 2018, suggesting a continued presence of individuals within Kuwait waters. Boating/propeller injuries were commonly determined as the cause of death (where this could be established).

A broad range of large cetacean species have been infrequently reported, dead and alive, within Kuwait waters including: blue whale (*Balaenoptera musculus*), Bryde's whale (*Balaenoptera brydei*), false killer whale (*Pseudorca crassidens*), and killer whale (*Orcinus orca*) (see Burahmah, 2013; Bohadi, 2015; Bohadi, 2019; Al-Robaae, Unknown; Baldwin et al., unknown). Records are anecdotal however and the abundance, temporal/spatial distribution, health, and breeding status of all whale species within Kuwait waters has yet to be ascertained.

3.3. Marine reptiles

Five species of marine turtles have been recorded within the Gulf: green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*) and occasionally leatherback turtle (*Dermochelys coriacea*) (Meakins and Al Mohanna, 2000; Al-Yamani et al., 2004; Meakins and Al Mohanna, 2004; Rees et al., 2013). Sightings of L. *olivacea* and *D. coriacea* are believed to be vagrants not typically resident within the region. All turtle species are considered globally threatened, with *E. imbricata* currently assessed as critically endangered, *C. mydas* as endangered, and the remaining three species as vulnerable. Sub-populations of some of these species have been separately assessed; the North-west Indian Ocean subpopulation of *C. caretta* has been assessed as critically endangered (IUCN, 2020).

Population sizes for marine turtles are unknown for Kuwait. The green turtle (*C. mydas*) is the most sighted species; typically, in shallow waters where it feeds on seagrasses (Al-Sarawi et al., 1985; Rees et al., 2013; Al-Mohanna et al., 2014). Home ranges of tracked green turtles in Kuwait overlap with shallow coastal conditions suitable for the growth of sea grass and algae, which comprise the main food source of adults (Bjorndal, 1997; Rees et al., 2013). Small-scale tracking studies have shown *C. mydas* to reside (presumably feeding) for extended periods along the north coast of Failaka Island with individuals from this locality found to undertake periodic migration to waters off Saudi Arabia (Rees et al., 2013; Rees et al., 2018). This may indicate interconnection with Saudi Arabian populations where thousands of turtles nest each year on shallow sea islands though genetic links are unproven (Pilcher, 2000).

Hawksbill turtles (*Eretmochelys imbricata*) favour shallow coral reef

habitat and estuarine mangroves where they forage on marine invertebrates, especially sponges (Rincon-Diaz et al., 2011). This fact highlights the importance of remaining coral reef habitat around Umm Al-Maradim and Qaruh Island where *E. imbricata* remain at undefined levels (see Rees et al., 2019). A tracking study by Rees et al. (2019) revealed short migrations of female hawksbills (<150 km) into Saudi Arabian waters suggesting populations could be interconnected. Hawksbill turtles from the south of the Gulf have been shown to undertake 'summer migration loops' (SMLs) to avoid the most extreme sea temperatures (Pilcher et al., 2014b). However, satellite-tracked turtles from Kuwait showed no evidence of SMLs despite experiencing water temperatures >33 °C (Rees et al., 2019). No overlap was observed between the foraging areas utilised by tracked individuals. This is in keeping with irregular distribution of hawksbills in the region, likely based on the widespread occurrence of small patches of reef (Pilcher et al., 2014a; Rees et al., 2019).

Only *C. mydas* and *E. imbricata* have previously been recorded nesting on Kuwaiti beaches (Meakins and Al Mohanna, 2000; Al-Yamani et al., 2004; Meakins and Al Mohanna, 2004; Rees et al., 2013;). Existing turtle rookeries appear confined to offshore islands (including Umm Al Maradim and Qaruh) and inaccessible beaches around the Chevron Oil Complex (Mina Alzour area South Kuwait) (see Al-Yamani et al., 2001; Rees et al., 2013; Papathanasopoulou, 2015b; Papathanasopoulou, 2015c; Rees et al., 2019). Historic nesting reports have been documented for Qaruh, Kubbar Island and Umm Al-Maradim Island though exact beach locations are unknown. It is possible, though unconfirmed, that turtles continue to nest in other remote and undisturbed localities which share the characteristics of these remaining nest sites. Possible other sites include: Miskan Island, Auhah Island and Failaka Island though detailed nest suitability surveys have not been undertaken (Rees et al., 2013; Al-Yamani et al., 2001; Papathanasopoulou, 2015b; Papathanasopoulou, 2015c).

The most recent scientific surveys by Rees et al. (2013) found that *C. mydas* no longer nests on Umm Al-Maradim Island though individuals were still found to be nesting on Qaruh Island. The number of nesting *C. mydas* females is low (five were observed in 2008, one in both 2009 and 2010, and three in 2011), and none of the turtles were observed nesting over multiple years. Twelve *C. mydas* nests were recorded during the 2012 nesting season, likely equating to only three breeding females. The breeding population of green turtles nesting in Kuwait is therefore critically low and Quarah Island represents nationally important breeding habitat for the species.

Along with Quarah Island, the Chevron Oil Complex (Mina Al Zour) is the only known active breeding site for *E. imbricata* and, likewise, is of national importance for their continued status as a breeding species in Kuwait. It is likely that breeding persists at these sites owing to remoteness from public disturbance and inaccessibility to depredating canids. The numbers of hawksbill turtles nesting in Kuwait are unknown but the recorded presence of only two nests in 2015 (see Papathanasopoulou, 2015b; Papathanasopoulou, 2015c) suggest numbers of reproductively active females are critically low.

Marine turtles were historically harvested directly for food within the Gulf while by-catch from gill nets and 'hadrah traps' still represent a serious continuing threat for remaining populations (see Yaghmour et al., 2018). In-water distribution and abundance of each turtle species is unknown for Kuwait, as are levels of mortality arising from by-catch. Nest mortality arising from synanthropic predators can be so strong as to cause an almost complete reproductive failure in a populations of *E. imbricata* in other Gulf rookeries (Ficetola, 2008).

No comprehensive long-term data sets detail the distribution and success of sea turtle rookeries in Kuwait. It is likely, though unproven, that degradation of nesting habitat (sand compaction, light pollution and other stressors), by-catch and nest depredation have drastically reduced the abundance of marine turtles in Kuwait (Al-Mohanna et al., 2014). Indirect anthropogenic effects can also occur through the alteration of natural vegetation along the coastline can increase the temperature of nests and thus bias the sex ratio of hatchlings (Kamel and Mrosovsky, 2006). Monitoring, detailing availability of foraging areas, suitable nesting habitat and nest success would provide a mechanism to identify, and thereafter, protect key sites and improve the suitability of others. Immediate and concerted conservation efforts are required to protect remaining turtle nest sites from further degradation and adults of reproductive age from by-catch. Without such efforts, it is likely that marine turtles will cease to exist as breeding species within Kuwait waters.

At least five species of sea snake are occasionally sighted in Kuwait (Meakins and Al-Mohanna, 2003). The annulated sea snake, *Hydrophis cyanocinctus*, along with the Persian Gulf sea snake, *H. lapemoides*, are the two most abundant sea snakes in the Gulf (Rezaie-Atagholipour et al., 2012). This is reflected by regular sightings of *Hydrophis spp* off Bubiyan Island by Bishop et al. (2008) throughout 2004/2005 though little is known of their current distribution and populations.

3.4. Seabirds

Kuwait supports a disproportionately rich diversity of bird species in relation to its size owing to its location at the south-eastern extremity of the Western Palearctic, close to the boundaries of the Afrotropic and Eastern Palearctic zoogeographic regions. Many species are migrants exploiting Kuwait's key location on the West Asia/Africa flyway (Boere and Stroud, 2006; KuwaitBirds, 2017c). This involves movements by both long-distance and regional migrants, some of which spend the winter in Kuwait. Ornithologists have long submitted lists of bird species observed within Kuwaiti to the Ornithological Society of the Middle East (OSME) and BirdLife International such that comprehensive understanding of bird diversity has been established for the nation, and the Kuwait Ornithological Rarities Committee (KORC) maintains a country checklist, adjudicates rarity submissions and produces annual reports. To this end, 415 bird species (considering only Cat A and Cat C) have been recorded within Kuwait of which ~31% are closely associated with aquatic habitats (see Table 3; Al-Sirhan, 2020). Kuwait regularly supports 12 aquatic bird species categorised by the IUCN as vulnerable or near-threatened (see Table 3) (Al-Sirhan, 2020; IUCN, 2020). Areas such as Bubiyan Island and Jahra Pools support a diverse waterfowl and raptor community (see Omar and Roy, 2013). Many seabirds are migratory species that require a variety of marine and terrestrial habitats during different seasons and life stages (Lascelles et al., 2014). Many are also long-lived and slow reproducing. These characteristics make them particularly vulnerable to a wide range of pressures, where even quite small increases in mortality can lead to significant population declines. In addition, many seabirds have highly specialised diets, being reliant on just a few prey species, the abundance and distribution of which can alter dramatically in response to abrupt environmental changes (Ajawin et al., 2016).

Seabirds are the most threatened bird group and their decline has accelerated over recent decades. Globally 28% are threatened (5% are in the highest category of 'critically endangered') and a further 10% are IUCN 'near threatened'. The occurrence patterns of pelagic seabirds in Kuwaiti waters are little-known, and only three petrel species have been recorded, all as vagrants: Persian shearwater (*Puffinus persicus*), sooty shearwater (*Ardenna grisea*) and Jouanin's petrel (*Bulweria fallax)*. The latter two species are assessed as 'Near-Threatened' under IUCN criteria (IUCN, 2020), and *P. persicus* (although categorised as 'Least Concern' by IUCN) is of interest as it is restricted to the Arabian Sea and western Indian Ocean.

The most significant seabird species occurring in Kuwait in summer months is the Socotra cormorant (*Phalacrocorax nigrogularis*), which as a breeding species is globally restricted to this region, and is globally assessed as 'Vulnerable' (IUCN, 2020). Breeding colonies are currently known from Gulf islands of Saudi Arabia, Bahrain, Qatar and the United Arab Emirates, and Arabian Sea islands off Oman and Yemen, with possible nesting colonies also off Iran and Eritrea (Orta et al., 2017).

Table 3
Kuwait aquatic bird species and their conservation status. [B] denotes species which have been recorded breeding in Kuwait.

IUCN biodiversity category	Species name
Critically endangered	Sociable lapwing (*Vanellus gregarious*)
Endangered	N/A
Vulnerable	Common pochard (*Aythya farina*), Marbled duck (*Marmaronetta angustirostris*), Dalmatian pelican (*Pelecanus crispus*) [B], Socotra cormorant (*Phalacrocorax nigrogularis*) [B]
Near Threatened	Ferruginous duck (*Aythya nyroca*) [B], Eurasian oystercatcher (*Haematopus ostralegus*), Black-winged pratincole(*Glareola nordmanni*), Northern lapwing (*Vanellus vanellus*), Black-tailed godwit (*Limosa limosa*), Bar-tailed godwit (*Limosa lapponica*), Eurasian curlew (*Numenius arquata*), Great knot (*Calidris tenuirostris*), Curlew sandpiper (*Calidris ferruginea*), Armenian gull (*Larus armenicus*)
Least Concern	Greylag goose (*Anser anser*), Ruddy shelduck (*Tadorna ferruginea*), Common shelduck (*Tadorna tadorna*), Eurasian wigeon (*Anas penelope*), Gadwall (*Anas strepera*), Eurasian teal (*Anas crecca*), Mallard (*Anas platyrhynchos*) [B], Northern pintail (*Anas acuta*), Garganey (*Anas querquedula*), Northern shoveler (*Anas clypeata*), Tufted duck (*Aythya fuligula*), Little grebe (*Tachybaptus ruficollis*) [B], Great-crested grebe (*Podiceps cristatus*), Black-necked grebe (*Podiceps nigricollis*), Greater flamingo (*Phoenicopterus roseus*) [B], Black stork (*Ciconia nigra*), White stork (*Ciconia ciconia*), Glossy ibis (*Plegadis falcinellus*), Eurasian spoonbill (*Platalea leucorodia*) [B], Eurasian bittern (*Botaurus stellaris*), Little bittern (*Ixobrychus minutus*) [B], Black-crowned night heron (*Nycticorax nycticorax*) [B], Squacco heron (*Ardeola ralloides*) [B], Western cattle egret (*Bubulcus ibis*), Grey heron (*Ardea cinerea*) [B], Purple heron (*Ardea purpurea*), Great egret (*Ardea alba*), Little egret (*Egretta garzetta*), Western reef heron (*Egretta gularis*) [B], Great cormorant (*Phalacrocorax carbo*), Western osprey (*Pandion haliaetus*), Water rail (*Rallus aquaticus*) [B], Corn crake (*Crex crex*), Little crake (*Porzana parva*) [B], Baillon's crake (*Porzana pusilla*), Great white pelican (*Pelecanus onocrotalus*) [B], Spotted crake (*Porzana porzana*) [B], Grey-headed swamphen (*Porphyrio poliocephalus*) [B], Common moorhen (*Gallinula chloropus*) [B], Eurasian coot (*Fulica atra*) [B], Eurasian stone-curlew (*Burhinus oedicnemus*), Crab-plover (*Dromas ardeola*) [B], Black-winged stilt (*Himantopus himantopus*) [B], Pied avocet (*Recurvirostra avosetta),* Cream-coloured courser (*Cursorius cursor*) [B], Collared pratincole (*Glareola pratincole*), Spur-winged plover (*Vanellus spinosus*) [B], Red-wattled lapwing (*Vanellus indicus*) [B], White-tailed lapwing (*Vanellus leucurus*) [B], Pacific golden plover (*Pluvialis fulva*), Grey plover (*Pluvialis squatarola*), Common ringed plover (*Charadrius hiaticula*), Little ringed plover (*Charadrius dubius*) [B], Kentish plover (*Charadrius alexandrinus*) [B], Lesser sand plover (*Charadrius mongolus*), Greater sand plover (*Charadrius leschenaultia*) [B], Caspian plover (*Charadrius asiaticus*), Jack snipe (*Lymnocryptes minimus*), Common snipe (*Gallinago gallinago*), Eurasian whimbrel (*Numenius phaeopus*), Spotted redshank (*Tringa erythropus*), Common redshank (*Tringa tetanus*), Marsh sandpiper (*Tringa stagnatilis*), Common greenshank (*Tringa nebularia*), Green sandpiper (*Tringa ochropus*), Wood sandpiper (*Tringa glareola*), Terek sandpiper (*Xenus cinereus*), Common sandpiper (*Actitis hypoleucus*), Ruddy turnstone (*Arenaria interpres*), Red knot (*Calidris canutus*), Sanderling (*Calidris alba*), Little stint (*Calidris minuta*), Temminck's stint (*Calidris temminckii*), Dunlin (*Calidris alpine*), Broad-billed sandpiper (*Calidris falcinellus*), Ruff (*Calidris pugnax*), Red-necked phalarope (*Phalaropus lobatus*), Grey phalarope (*Phalaropus fulicarius*), Mew gull (*Larus canus*), Lesser black-backed gull (*Larus fuscus*), Caspian gull (*Larus cachinnans*), Pallas's gull (*Ichthyaetus ichthyaetus*), Black-headed gull (*Chroicocephalus ridibundus*), Slender-billed gull (*Chroicocephalus genei*) [B], Little gull (*Hydrocoloeus minutus*), Gull-billed tern *Gelochelidon nilotica* [B], Caspian tern (*Hydroprogne caspia*) [B], Lesser crested tern (*Thalasseus bengalensis*) [B], Sandwich tern (*Thalasseus sandvicensis*), Greater crested tern (*Thalasseus bergii*) [B], Common tern (*Sterna hirundo*), Arctic tern (*Sterna paradisaea*), White-cheeked tern (*Sterna repressa*) [B], Little tern (*Sternula albifrons*), Saunders's tern (*Sternula saundersi*), Bridled tern (*Onychoprion anaethetus*) [B], Whiskered tern (*Chlidonias hybrida*), White-winged tern (*Chlidonias leucopterus*) [B], Black tern (*Chlidonias niger*), Pomarine skua (*Stercorarius pomarinus*), Arctic skua (*Stercorarius parasiticus*), Long-tailed skua (*Stercorarius longicaudus*), White-breasted kingfisher (*Halcyon smyrnensis*) [B], Common kingfisher (*Alcedo atthis*), Pied kingfisher (*Ceryle rudis*)
Data Deficient	N/A
Not Evaluated	N/A
Uncategorised	N/A

Breeding has previously been recorded in Kuwait, on Umm Al Maradim and Qaruh islands (Jennings, 2017), but it is now considered to be an uncommon disperser in Kuwaiti waters in summer months from colonies elsewhere in the Gulf (Al-Sirhan, 2020).

In Kuwait, the numbers of shorebirds currently breeding are of international significance (Bom and Al-Nasrallah, 2015; KuwaitBirds, 2017b). This includes one of the world's highest concentrations of crab-plovers (*Dromas ardeola*). With a global population estimated at 60,000–80,000 birds, this species is categorised as 'least concern' by IUCN but is restricted as a breeding species to the NW Indian Ocean, the Gulf and Red Sea. A global review of known breeding sites found 56 breeding colonies at 19 sites, with two-thirds of all breeding crab-plovers within the Gulf. The colonies on Bubiyan Island, numbering up to 1750 nesting burrows, are among the five largest known colonies in the world and are estimated to comprise 3–5% of the global population (Bom and Al-Nasrallah, 2015). The population disperses to coastal mudflats after breeding, and three sites in Kuwait, Jahra Pools, Dawhat Kazima and Sulaibikhat Bay, are listed as Important Bird and Biodiversity Areas (IBAs) by Birdlife International for their importance to large numbers of this species on migration (WWT, 2017; Birdlife International, 2020).

Small islets such as Kubbar, Qaruh and Um Al-Maradim host some of the northern Gulf's largest seabird colonies. These are the most north-western coral cays in the Gulf and birds nesting here feed in the waters of the nearby Mesopotamian Delta plume. Kuwait's offshore islands are especially important for terns which use them for breeding purposes, and Kubbar Island is listed by Birdlife International as an Important Bird and Biodiversity Area because of its tern populations (Birdlife International, 2020). Five species of tern are known to nest on Kuwait's islands [Caspian (*Hydroprogne caspia*), bridled (*Onychoprion anaethetus*), lesser crested (*Thalasseus bengalensis*), greater crested (*T. bergii*) and white-cheeked (*Sterna repressa*)]. Their breeding residence in Kuwait is entirely dependent upon these locations; Kubbar and Qaruh Island in particular (Al-Yamani et al., 2001; Al-Yamani et al., 2004).

Anthropogenic pressures present ongoing issue at these locations as recreational boat users visiting the islands and causing disturbance by walking among the birds during crucial breeding periods, littering in their wake (Kuwait Birding, 2012). Bubiyan Island also hosts regionally important nesting colonies of grey heron (*Ardea cinerea*), Indian reef heron (*Egretta gularis schistacea*), Eurasian spoonbill (*Platalea leucorodia*), gull-billed tern (*Gelochelidon nilotica*) and slender-billed gull (*Chroicocephalus genei*), and has in the past held breeding colonies of great white pelican (*Pelecanus onocrotalus*), and greater flamingo (*Phoenicopterus roseus*) (Ramadan et al., 2004). Nesting of dalmatian pelicans (*Pelecanus crispus*) has recently been recorded on Bubiyan Island (Al-Sirhan, 2020).

With its position on the Asian- East Africa flyway, the coastal mudflats of Kuwait provide important feeding habitat for globally significant

numbers of waders. Few rigorous surveys have been conducted to assess the numbers of birds involved until recently, but in 2014 the Wildfowl and Wetland Trust began working with the Kuwaiti Public Authority for Agriculture and Fish Resources to assess the importance of Jahra Pools nature reserve and Sulaibikhat Bay for water birds. In January 2015, the first coordinated counts produced a total of 66,070 birds of 67 species. Under the Ramsar Convention on Wetlands (1994), any site supporting >1% of the flyway population of a species is recognised as a Wetland of International Importance. This criterion was met in January 2015 counts for nine species: great cormorant (*Phalacrocorax carbo sinensis*), Indian reef heron, greater flamingo, Kentish plover (*Charadrius alexandrinus*), Eurasian curlew (*Numenius arquata*), dunlin (*Calidris alpina*), little stint (*C. minuta*), slender-billed gull, and black-headed gull (*Chroicocephalus ridibundus*) (Wildfowl and Wetland Trust, 2017).

General declines in bird populations have been caused by ten primary pressures. At sea, these include incidental bycatch (in longline, gillnet and trawl fisheries); pollution (oil spills, marine debris); overfishing; energy production and mining. On land, invasive alien species, problematic native species (e.g. those that have become superabundant), human disturbance, infrastructural, commercial, and residential development, hunting and trapping have driven declines (BirdLife International, 2017). Climate change and severe weather affect seabirds on land and at sea (Ajawin et al., 2016). Apart from 'problematic native species' these pressures are currently experienced by Kuwait water birds. From a national perspective, pollution (oil spills), overfishing (average landings of finfish dropped 33% between 1995 and 2002), human disturbance (day boats around Umm Al-Maradim and Kubbar Island), uncontrolled coastal development (south Kuwait beach chalets) and especially hunting and trapping (raptors) represent overriding threats to populations (Glibert et al., 2001; Baby, 2011; Al-Abdulrazzak et al., 2015; Al-Husaini et al., 2015; Kuwaitbirds, 2017a).

Birds are often shot and killed for target practice, for trophies or as delicacies in Kuwait (Alshaheen, 2020). This is damaging to populations during both spring and autumn migration as they fly to and from their breeding grounds, at a critical time in their life cycle. Shooting also disturbs and displaces bird populations and disrupts staging and roosting sites. Indiscriminate shooting and poaching are currently a severe problem in Kuwait, even within protected areas, such as Jahra Pools reserve (KuwaitBirds, 2017a; Edmonds and Davison, 2017; Alshaheen, 2020), despite legislation being in place since June 2014 to prohibit these activities and prosecute offenders.

4. Conclusions

Kuwait and the wider Gulf region faces many challenges concerning human impacts on the marine environment (Van Lavieren and Klaus, 2013; Burt, 2014; Le Quesne et al., 2018; Devlin et al., 2019b). Kuwait's National Biodiversity Strategy (NBSSK, 2011) highlights that 'sustained inventory programmes are a prerequisite to monitor the health and productivity status of economically productive ecosystems to maintain the sustainability of harvest' (KEPA, 1998; Kuwait Nature Protection Laws Handbook, 2016). However, knowledge about the health of Kuwait's marine biodiversity is incomplete, outdated and often inferred from other Gulf States. There is a pressing need for a strong evidence base to support national assessments and sustainable management plans (Sheppard et al., 2010; Burt, 2014; Devlin et al., 2015a; Devlin et al., 2019b). These challenges are also faced in many of the countries bordering the Gulf and the general lack of co-ordinated transboundary monitoring is inhibiting the establishment of effective Gulf wide measures, such as the development of regionally co-ordinated MPAs to help act as sanctuaries for sensitive habitats and species (Van Lavieren and Klaus, 2013; Vaughan et al., 2019).

In Kuwait insufficient publicly available numerical data exists to inform a comprehensive biodiversity assessment at present. Despite the lack of systematic monitoring data, we can still draw conclusions about the status of discrete ecosystem components (Devlin et al., 2019b). Marine turtles, rare and vulnerable chondrichthian fish, coral reefs and coastal habitats are all are experiencing clear declines. This trend is not unique to Kuwait, but it places the country at odds with strategic objectives to protect biodiversity established through both regionally (GCC, 2001) and internationally (CBD, 2018) ratified commitments (Table 1).

There is uncertainty concerning the status of other habitats and biodiversity within Kuwait's marine environment. The extent, condition, and in many cases, location of coral reefs, seagrass meadows and the populations of marine mammals and birds associated with coastal habitats is unknown and/or not publicly accessible. Clearly the national cause would benefit from ensuring that all publicly funded monitoring data is made available. Efforts to address this are underway in Kuwait via initiatives such as the Environmental Monitoring Information System of Kuwait (eMISK) (KEPA, 2020).Uncertainties concerning coral reefs are particularly relevant for marine turtle and migratory bird populations that are reliant upon the continued existence and functionality of these biodiverse ecosystems.

Kuwait's national strategy sets out an ambition to protect Kuwait's biological diversity for the benefit of present and the future generations (NBSSK, 2011). However, information on the distribution and abundance of Kuwait's marine biodiversity is fundamentally required to achieve such aims. In keeping with Article 7 of the CBD (1992) the first requirement in any programme should be to characterise the status of the subject (see also Devlin et al., 2019b). Concerted monitoring programmes are therefore urgently required to assess the status of key indicator habitats and species to inform and direct effective conservation efforts. Under CBD Aichi Biodiversity Targets (CBD, 2018) Kuwait should also seek to '*improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity*'. In doing so, the development of management objectives to guide future management action with environmental standards is required in recognition of the importance of biodiversity. The establishment of a Marine Plan (under Kuwait Law 42, 2014) goes someway to initiating the framework for such processes.

The main impacts on Kuwait biodiversity are coastal developments, removing/damaging coastal and nearshore habitats, sewage inputs impacting water quality and fishing affecting vulnerable species and the sensitive ecosystems upon which they depend (e.g. coral reefs). By-catch of Chondrichthian fish, turtles and cetaceans is also believed to be a significant issue warranting urgent investigation (Devlin et al., 2019b). The frequency of these interactions of activities and pressures is dependent upon temporo-spatial overlap between critical habitat (for a given species) and fishing activities (Wallace et al., 2008; Wallace et al., 2010). Such parameters have yet to be established in Kuwait.

Kuwait hosts many iconic habitats and species which are ecologically, commercially, and socially important. Nonetheless the environment of Kuwait is changing rapidly, (see Devlin et al., 2015a) and targeted management and conservation measures will be required to maintain them. Taking these factors into consideration, our review of Kuwait's marine biodiversity suggests that:

- Marine turtles are at risk of becoming functionally extinct as breeding species in Kuwait due to destruction and degradation of historic nesting beaches. Exact breeding beaches and spatio-temporal distribution of adults is unknown. Routinely applied monitoring programmes would provide the evidence required for targeted management measure to project these iconic species. The conservation status of all marine turtles remains a global concern and opportunity exists for Kuwait to lead the way in protecting these species.
- Seabirds are facing local habitat destruction, disturbance and pressure from illegal hunting. This is coupled with international pressures that are affecting migratory numbers. Structured monitoring is restricted to Kuwait bay and should be geographically expanded.
- Coral reefs are facing regional and global crises (global warming, pollution, marine litter, anchor damage) that are severely impacting

their long-term viability. The condition, distribution and health of Kuwaiti coral reefs is undefined and regular and repeatable monitoring should be implemented across the major reef systems.

- Seagrass and coastal habitats are under threat from development, pollution, and land reclamation. The condition, distribution and health of these habitats is not defined or monitored. Mapping surveys are required to understand the health and extent of these important habitats.
- Kuwait has provided habitat for Chondrichthyes fish including many which are now rare and threatened. Knowledge about their populations, distributions and threats are limited. Monitoring is not formally conducted, and by-catch is not assessed. Monitoring programmes should be developed to address this important evidence gap to help inform the development of fisheries management plans.

Targeted and regular monitoring is key to determine whether habitats or populations are stable, decreasing (e.g. due to anthropogenic pressures) or increasing (e.g. responding positively to conservation measures). The most robust biodiversity/habitat assessments and effective managerial responses are underpinned by this information (Sutherland et al., 2004; Fox et al., 2017). A targeted programme of ongoing monitoring will allow establishment of meaningful indicators to be identified and monitored and habitat/species-specific targets to be set. These indicators turn can be used for robust status assessments and effective management of marine biodiversity in Kuwait. Regional examples, such as those in Qatar (Burt et al., 2017) and UAE (Lamine et al., 2020) now exist where decision making is evidence driven, and data on the distribution and abundance of key habitats and species is being collected to help inform management and policy development. The responsible authorities across the region need to build on these studies and develop institutional capacity to expand both the range of data being collected and their ability to use this evidence to implement effective marine management plans. The enclosed nature and relatively small size of the Gulf also means that regional co-ordination of these activities is essential. Therefore, efforts should also be directed toward ensuring the Regional Organisation for the Protection of the Marine Environment (ROPME), which covers the Gulf (along with the Gulf of Oman and the south-eastern coasts of Oman located in the Arabian Sea) is sufficiently supported to conducted these tasks. Calls to adopt a more holistic and integrated approach to ecosystem-based management of coastal and marine areas are not new (see Sheppard et al., 2010; Sale et al., 2011; Van Lavieren and Klaus, 2013; Vaughan et al., 2019), but it is clear that action must now be rapidly accelerated across the Gulf if we are to reverse the clear declines observed in the biodiversity at both a national and regional level.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was funded under the UK-Gulf Marine Environment Partnership (GMEP). The authors extend thanks to the anonymous reviewers of the manuscript, as well as to Hessa Al-Khalid, Omar Alshaheen and Jim Bishop for their valuable insights into the biodiversity of Kuwait. Thanks also go to Kuwait's Environment Public Authority for their dedicated engagement throughout this process.

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