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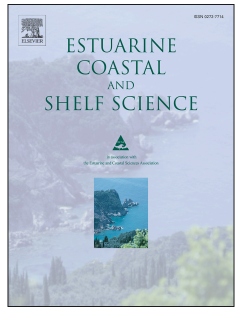

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Principles to enable comprehensive national marine ecosystem status assessments from disparate data: The State of the Marine Environment in Kuwait.

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Abstract

This paper presents an approach for preparing a comprehensive national marine ecosystem assessment and its application to the marine and coastal areas of the State of Kuwait. The approach is based on a set of principles to enable diverse data sources, of differing data quality and salience, to be combined into a single coordinated national assessment of marine ecosystem status to support the implementation of ecosystem-based management. The approach enables state assessments for multiple components of the marine ecosystem to be undertaken in a coordinated manner, using differing methods varying from quantitative to qualitative assessments depending on data and indicator availability. The marine ecosystem assessment is structured according to 6 major themes: i) Biodiversity, ii) Commercial Fisheries, iii) Food and Water Quality for Human Health, iv) Environmental Pollution, v) Eutrophication and Harmful Algal Blooms, and vi) Coastal Process and Oceanography. Comprehensive ecosystem assessments are an essential part of implementing the ecosystem approach, however detailed data directly related to clear, specified numerical management targets covering all aspects of a marine ecosystem are rarely available. The development of a State of the Marine Environment Report (SOMER) for Kuwait demonstrate that a coordinated comprehensive ecosystem assessment can be conducted using disparate data, and in relation to partially specified regulatory management objectives. The Kuwait SOMER highlighted the issues of coastal pollution, particularly sewage for human health and the environment. It shows that the rapid urbanization of Kuwait has led to significant changes in the ecology, with clear impacts on coral reef health, the availability of nesting locations for turtles and habitats for migratory birds. Long-term changes in nutrient input, via waste water and modified freshwater inputs is resulting in demonstrable impacts on a range of marine species and habitats within Kuwait marine waters. It also supports the move towards a regional approach required due to transboundary properties of many of the ecosystem components, drivers and pressures.

Keywords

State of Marine Environment Report, ecosystem approach, biodiversity, eutrophication, human health, ecological assessment.

Introduction

There has been an increasing global public and political attention focused on the health of coastal and marine environments since the 1972 Stockholm Declaration on the Human Environment (United_Nations, 1972). It is now widely accepted that the ecosystem approach, as enshrined in international environmental policy through the Convention on Biological Diversity (CBD), is the primary framework for implementing action to manage and protect marine ecosystems (Borja et al., 2016; Farmer et al., 2012; UNEP, 2015). The ecosystem approach explicitly recognises multiple objectives for the marine environment, the multiple impacts of human activities and internal interactions within ecosystems (Borja et al., 2016; Borja et al., 2014).

Developing a coordinated ecosystem assessment, which enables state and impacts to be compared across a diverse range of different ecosystem components can be challenging as both detailed data sets and clearly specified management objectives for all aspects of marine ecosystems are rarely available. A review of the scientific literature provides many examples of approaches to environmental assessment and health reporting in both data rich and data poor regions (Borja et al., 2014; Feary et al., 2014; Rombouts et al., 2013; Singh et al., 2012; Tett et al., 2013). However, despite a long history of active research and development there are no widely agreed global approaches for the integrated system-level assessment and reporting of environmental quality in large scale marine ecosystems. This is due to both a lack of clear, salient and reliable data within individual systems, and a lack of clearly defined management objectives for the assessment of the full range of ecosystem components. Therefore, there is often a need to develop bespoke regionally or nationally focused methods to enable rapid coordinated ecosystem assessments so that initial ecosystem situation analysis and prioritisation can occur (Borja et al., 2016; de Jonge et al., 2012; Kershner et al., 2011; Samhouri et al., 2012).

The State of Kuwait and the wider Gulf region faces many challenges related to multiple human impacts on the marine environment and there is a pressing need for assessment and sustainable management (Burt, 2014; Devlin et al., 2015a; Sheppard et al., 2010). The marine environment of Kuwait comprises a diverse range of habitats from some of the most northerly coral reef systems in the world, to extensive intertidal habitats that are important feeding grounds on the African-Eurasian migratory flyway (Al-Abdulghani et al., 2013). The Gulf comprises a relatively shallow, semi-enclosed sea with very high evaporation rates and poor flushing characteristics (Sheppard, 1993). The climate is sub–tropical, even though it is located within the large, arid, East Asian landmass, with fierce tropical summers, and temperate winters, in comparison to most seas of equivalent latitude (ROPME, 2013). The waters surrounding Kuwait are characterised by mean winter temperatures of 14^{o}C, mean summer values of 30^{o}C and an average salinities that exceed 40‰ (Al-Rifaie et al., 2007). One of the main features of its marine environment is Kuwait Bay, situated at the north-western tip of the Gulf (Figure 1). Kuwait’s marine and coastal environment provides multiple social and economic goods and services. In addition to supporting the conservation of regionally and globally important biodiversity, Kuwait’s marine environment supports productive fin-fish and shell-fish fisheries for human consumption and the culturally important pearl oyster, *Pinctada radiate* (Al-Husaini et al., 2015; Al-Zaidan et al., 2013). The coastline and offshore areas have extensive recreational and amenity value (Al-Rifaie et al., 2007). Furthermore, the waters of the Gulf are both a source of water for desalination plants – the main source of drinking water in Kuwait – and the receiving environment for terrestrial run off, sewage and industrial pollutants (Al-Dousari, 2009; Al-Sarawi et al., 2015; Devlin et al., 2015a; Devlin et al., 2015b; Lyons et al., 2015a; Lyons et al., 2015b; Nicolaus et al., 2017; Saeed et al., 2015).

The rapid development that has taken place in Kuwait over the last 50 years has led to a large increase in the intensity of human activities impacting its marine environment (Al-Rifaie et al., 2007; Devlin et al., 2015b). This includes coastal development that has changed the physical structure of the marine environment (Al-Abdulghani et al., 2013) and industrial and petrochemical discharges that changed the chemical nature of the marine environment (Al-Sarawi et al., 2015). Fishing has led to declines in species abundance and a number of commercially important fish stocks have significantly reduced (Al-Husaini et al., 2015; Al-Zaidan et al., 2013). Unregulated sewage inputs have led recreational beaches in Kuwait to regularly fail international water quality standards (Lyons et al., 2015b; Saeed et al., 2015) and the associated uncontrolled inputs of nutrients have been implicated in a number fish kill events (Devlin et al., 2015b; Gilbert et al., 2002; Heil et al., 2001). The rapid, and ongoing, increase of sea water desalination in Kuwait and around the Gulf (AGEDI, 2016) is leading to a variety of impacts including increasing salinity, thermal and chemical discharges, and impingement and entrainment of marine organisms (Lattemann and Höpner, 2008; Petersen et al., 2018). The waters of the Northern Gulf are also becoming more saline as freshwater flows from the Shat Al Arab have diminished in recent years due to water diversion and damming, leading to impacts on circulation, residence times and turnover rates (Alosairi and Pokavanich, 2017; Lachkar et al., 2018; Xue and Eltahir, 2015) and causing ecosystem change and stress (Al-Said et al., 2017; Al-Yamani et al., 2007; Al-Yamani et al., 2017; Ben-Hasan et al., 2018; Mahdi and Fawzi, 2014; Rao et al., 1999a).

Kuwait therefore faces the challenge of balancing the demands of a rapidly changing country with objectives to maintain, and restore, marine biodiversity and ecosystem status for the benefit of current and future generations. The limited systematic data available provides a strong indication that human activities are having adverse impacts on environmental status in Kuwait, and studies have raised concern over the extent of anthropogenic stressors affecting Kuwait's marine ecosystem (Al-Abdulghani et al., 2013; Al-Ghadban et al., 2002; Devlin et al., 2015a; Khan, 2008; Sheppard et al., 2010).

Therefore, there is an urgent need to identify priority issues for management action and research. To address this, and in accordance with requirements of Kuwait's Environment Protection Law (State of Kuwait, Law 42 of 2014), the Kuwait Environment Public Authority (EPA) is developing a National Plan for Marine Environmental Management (State of Kuwait, Law 42 of 2014, Art 65). The National Plan for Marine Environmental Management is based upon the iterative process of identifying objectives, assessing the status of the environment in relation to objectives, and then implementing management and research for priority areas identified in the assessment (Le Quesne et al., 2016). Identifying priority areas for management activity and research requires striking a balance between the desire for robust systematic information on environmental status, with the reality of limited data availability and few clearly specified management objectives.

This paper presents the first attempt to develop a comprehensive State of the Marine Environment Report (SOMER) for Kuwait, conducted as part of the implementation of the Kuwait National Plan for Marine Environmental Management. Due to the lack of systematic data and clearly specified environmental objectives available to form the basis of the assessment we established a set of principles to guide and enable a comprehensive assessment to be undertaken in a consistent and coordinated manner. These principles for rapid, coordinated ecosystem assessments enable quantitative and qualitative data to be integrated into a single consistent assessment and provide a pragmatic tool to support the implementation of ecosystem-based management that is applicable across other national and regional settings.

Methods

Environmental objectives and standards

The Environment Protection Law of Kuwait establishes the legislative basis for managing the marine environment of Kuwait and establishes the high-level objective for protecting and conserving environmental status in Kuwait (State of Kuwait, Law 42 of 2014). However, this directive offers limited information on environmental standards and regulatory guidance to conduct marine ecosystem status assessments, with the exception of ambient water quality standards for a limited set of organic and inorganic contaminants (State of Kuwait, Bylaw 210 of 2001). Beyond these nationally specified standards, the only formal policy guidance on objectives for the environment are objectives specified in Kuwait's regional and international policy commitments (Unger et al., 2017). A detailed set of strategic goals, management objectives, indicators and environmental standards are being developed as part of the implementation of the National Plan for Marine Environmental Management (Le Quesne et al., 2016). However, at this stage only a draft set of high-level narrative strategic goals are available to guide the SOMER assessment (Table 1). These strategic goals were based around six core themes addressing 1) Biodiversity; 2) Commercial Fisheries; 3) Food and Water Quality for Human Health; 4) Environmental Pollution; 5) Eutrophication and Water Quality; and 6) Coastal Processes and Oceanography. These themes were selected following a comprehensive review, with stakeholders, of Kuwait's national (including The Environment Protection Law of Kuwait, Law 42 of 2014), regional and international policy commitments to sustainable development, conservation of biodiversity and the associated requirements to monitor and assess the status of the marine environment. Technical definition of the more detailed management objectives and associated indicators and environmental standards will be developed on a prioritised basis following the identification of priority areas by the SOMER.

In the absence of national quantitative environmental standards, alternative approaches had to be defined to provide the basis for comparison for a range of ecosystem components in the assessment. The first set of principles developed defined the standards for comparison in the assessment when a nationally adopted standard was not available. The alternative approaches were defined as surrogate values or narrative standards (Table 2). For the SOMER the order of preference for selecting a standard for the assessment of a given ecosystem component was (1) national quantitative standards, (2) surrogate values, (3) narrative standards. Where a surrogate value or narrative standard had to be defined, the strategic environmental goals were used to guide the specification of an appropriate surrogate value or narrative standard.

Data sources

The preferred data source for environmental assessments is systematically collected long-term data from monitoring programmes, specifically designed to gather information on the status (and trend) of the ecosystem component being evaluated (such as that collated by the EPA and housed on their Environmental Monitoring Information System of Kuwait (eMISK) database (http://www.emisk.org/emisk/). A long-term water quality monitoring programme (including metals, hydrocarbons, nutrients and microbial data) has been in operation in Kuwait since the late 1980s (Lyons et al., 2015b; Nicolaus et al., 2017). However, the existing systematic national monitoring programme only covers a small number of ecosystem components under consideration in the SOMER. The lack of systematic monitoring data does not inhibit the ability to draw conclusions about the status of other components of the ecosystem.

A second set of principles was defined to guide the identification and use of data to draw inferences about the status of the ecosystem components for which systematic monitoring data was not available (Table 3). These principles identified a broad series of data types and information of relevance to the ecosystems, species and processes within Kuwait, from local research studies to understanding of global trends. These different data types are associated with varying degrees of confidence and relevance regarding their ability to inform state of specific strategic goals or ecosystem components in Kuwait. The different data sources used within the SOMER were assigned to one of the four different data categories and the confidence associated with the assessment of each strategic environmental objective or component clearly presented taking account of confidence in the data sources. The order of preference for using data within the SOMER is (1) systematic monitoring, (2) local research studies, (3) regional studies, (4) global trends.

Assessment evaluation criteria and reporting framework

The draft strategic environmental goals proposed for the Kuwait National Plan (Table 1) were used to provide the overall reporting framework for the SOMER. Within each of these strategic environmental goals separate assessments were conducted for different ecosystem components. Despite the variable extent to which environmental objectives and standards have been defined for ecosystem components, and the variable quality of data available, there is a clear management need to conduct a comprehensive and coordinated assessment of the state of the environment to identify priority areas for management and research activity.

To enable this the final step was to specify a third set of principles. These principles defined the different approaches for assessment to be applied based on the different data types and approaches to defining environmental standards (Table 4). This enabled quantitative and qualitative assessments of ecosystem status to be integrated into a single consistent assessment. For the SOMER the order of preference for applying the difference assessment tiers proceeded from applying a Tier 1 quantitative assessment in relation to a quantified adopted national standard, through to a Tier 4 narrative assessment based on ad hoc data in relation to a narrative standard.

The three sets of 'principles' identified environmental standards to be defined for the full range of ecosystem components considered in the assessment (Table 2), and enabled data to be drawn into the assessment from a wide variety of data sources (Table 3), and finally established a consistent approach to be applied in combining these data and standards in the assessment (Table 4). It is acknowledged that whilst this approach provides the flexibility to allow very different data sets to be drawn into a single assessment, there is a trade-off in the substantive difference in the quality and confidence of the assessments conducted for the different ecosystem components. In recognition of this, and to ensure clear presentation of the varying quality of the assessments a score for assessment "confidence" was defined, and presented, for each component of the SOMER (Figure 2, Tables 5 and 6). The assessments considered both current "status" and predicted "future trajectory".

Results - *Outcome of SOMER for the Sate of Kuwait*

The outcomes of the SOMER for the State of Kuwait is presented against a list of indicators for each strategic goal, along with the assessment approach applied, available data sources and confidence (Table 5). Further integration providing an overall summary against each strategic goal, with examples of remedial action if required and a theme assessment are also presented (Table 6). The principles developed above enabled a comprehensive marine ecosystem assessment to be conducted for the State of Kuwait in a coordinated and consistent manner.

The outcomes of this preliminary assessment of the state and trajectory of the marine environment identified concerns around Food and Water Quality for Human Health, Eutrophication, Biodiversity, Commercial Fisheries, Coastal Processes and Oceanography.

Under status quo management the future status is predicted to decline for all themes other than Environmental pollution. High uncertainty in the data or standards applied to many ecosystem components resulted in low confidence being associated with the assessment for many of the components considered. The following sections provide a summary of the some of the key data sources used to generate the assessments presented in Tables 5 and 6.

Biodiversity

The overall assessment of the Biodiversity theme was considered to be moderate status (Table 6), although clear assessments of biodiversity status was hindered by the lack of systematic marine biodiversity monitoring (Table 5). The moderate state for biodiversity reflects concern in relation to declines in turtles, rare and vulnerable fish, seabirds, coral reefs and coastal habitats (Meakins and Al Mohanna, 2004; Sheppard et al., 2010; Al-Mohanna et al., 2014; Baby et al., 2014; Moore et al., 2015; Sheppard, 2016). There is significant uncertainty over many of the aspects of biodiversity in the marine environment of Kuwait, but the limited data on much of the criteria show decline or deterioration (Table 5). Unfortunately, the confidence around the biodiversity assessment is low given the lack of monitoring data and limited knowledge of population thresholds. Kuwait plays a role in supporting biodiversity including species with regional and global conservation significance (Devlin et al., 2015a; Evans et al., 1993; Moore et al., 2015). The assessment presented here demonstrates the need to identify the current state and future trajectories of the biota that reside in Kuwait marine waters and the health of the habitats that support their continued existence.

Kuwait's varied coastal habitats support large populations of migratory birds and turtles, both of which face a challenging future as urban and coastal development reduce the extent of important coastal habitats (Al-Mohanna et al., 2014; Meakins and Al Mohanna, 2004; Rees et al., 2013; Sheppard et al., 2010). The destruction and modification of the coastal habitats has also impacted Kuwait's coral islands that support these important coastal ecosystems (Baby et al., 2014). The main impacts on biodiversity in Kuwait are coastal developments and coastal activity removing or damaging coastal and nearshore habitats, sewage inputs impacting water quality and fishing affecting vulnerable species and habitats (Devlin et al., 2015b). Future trajectories of coral reefs, seagrass beds, coastal habitats, turtles, seabirds and fish are likely to show a continued decline in status (Al-Mohanna et al., 2014; Buchanan et al., 2019; Rees et al., 2013; Sheppard et al., 2012; Sheppard, 1995; Wabnitz et al., 2018). Confidence in the assessment and prediction of trajectories for sharks, rays, whales, dolphins and impacts from alien species is low, reflecting a lack of knowledge on both the current state and the impacts of future pressures (Table 5). What is well established is a declining trajectory for turtles, particularly the endangered green turtle (Al-Mohanna et al., 2014) due to destruction of nesting beaches through coastal development, evacuation and dredging activities. Seabirds are also facing local habitat destruction, habitat impacted by climate change and international pressures that are affecting large numbers of migratory birds (Evans et al., 2012; Omar Asem and Roy, 2010).

The coral reefs of Kuwait, being in the most northern part of the Gulf, have thrived despite exposure to extremes of temperatures and salinity. They now face multiple pressures operating at a range of spatial scales, from the global pressures of climate change to local pressures from boat anchor damage (Burt et al., 2016; Burt et al., 2013; Gholoum et al., 2019; Sheppard, 2016; Sheppard et al., 2012) with particular concern over the capacity for recovery given ongoing bleaching events in the Gulf (Ben-Hasan and Christensen, 2019; Burt et al., 2019; Paparella et al., 2019). Recent research using remote sensing aligned with ground truthing has indicated a significant reduction (34% between 2006-2017) of coral reef cover around Kuwaiti's offshore islands (Gholoum et al., 2019). The occurrence of alien species is increasing and many alien species, which have caused adverse impacts in other areas, have been identified in Kuwaiti waters, though no measurable impact has yet been identified (Table 5). The assessment highlights that Kuwait is home to many iconic species which are ecologically, commercially and socially important and require significant conservation measures. The limited nature of the biodiversity data shows there is an urgent need for improved monitoring programmes to increase knowledge of the state and obtain better estimates of the trajectory of biodiversity indicators. The development of management objectives with associated environmental standards would provide regulatory guidance for management actions.

Commercial Fisheries

The overall assessment of the Commercial Fishing theme is moderate (Table 6) and the predicted trajectory for the state of commercial fisheries is for further decline without the introduction of additional management measures (Table 5 and Table 6). Limited fisheries data collection over long term means that the assessment is only assigned moderate confidence. Assessments were based on declining catches reported in landings data over the last 20 years

(Al-Zaidan et al., 2013; Al-Husaini et al., 2015). Officially reported landings peaked at 10,788t in 1988, but dropped to 5,503t in 2016, and official landings have been consistently between 4,000 – 6,000t since 2011 (FAO 2018). In comparison to the officially reported landings a reconstruction of total catch estimated a peak catch of 64,600t in 1988 declining to 33,200t by 2010 (Abdulrazzak & Pauly 2013). Declines in catches may be due to the combined impact of excess fishing pressure and environmental changes such as habitat loss and the reduction in river flow in the Shatt-al-Arab (Sheppard et al 2010, Al-Yamani et al 2017; Ben-Hasan et al., 2018). The overall decline in landings of fin fish of over 50% may mask greater declines in landings for sensitive species or species with specific habitat or environmental dependencies. The decline in the flow of the Shat-al-Arab, the main river draining Mesopotamia which enters the northern Gulf, has affected seasonal oceanography in the northern Gulf, lead to an increase in salinity and reduced migration potential for anadromous species (Al-Yamani et al 2017; Ben-Hasan et al., 2018). Landings of the anadromous *Tenualosa ilisha* and the estuarine dependent *Pampus argenteus* declined by >90% in the period 1995 to 2007, with their overall contribution to landings declining from 32% to 6% over this period (Sheppard et al 2010). The proportion of marine bony fishes which are regionally threatened is 8.2%, twice the proportion of other regions where similar assessments have occurred (Buchanan et al., 2019). This number increases in nearshore areas with the decline exacerbated by coastal development and loss of habitat (Buchanan et al., 2019). Coral dependent fishes face even greater impact with all species listed at elevated risk of extinction due to degraded and fragmented nature of coral assemblages in Gulf (Buchanan et al., 2016). Many of the fisheries in Kuwait waters share these issues with neighbouring countries and coordinated cross-boundary management is required to fully assess and manage transboundary fish communities.

Shrimp fisheries are an important component of Kuwaiti fisheries. The three species dominate the catch, in declining order of importance they are *Penaeus semisulcatus*, *Metapenaeus affinis* and *Parapenaeopsis stylifera*. The official landings show that following the development of the fishery in the 1960s and 1970s there was a period of very high catches in the late 1980s and early 1990s, attributed to a period of favourable environmental conditions (Al-Husaini et al 2015), but for the last 25 years catches have fluctuated between 1 500t – 2 500t (FAO 2018). During the period of reasonably consistent catches over the last 25 years an increase in effort may mask a decline in abundance. Al-Husaini et al (2015) reported a marked increase in effort for the last 4 years of data they reported, and a comparison of catch per unit effort (CPUE) for *P semisulcatus* showed a greater than 50% increase between the shrimp season of 1999-2000 and the shrimp season 2013-2014 (Al-Husaini et al 2015). In addition to direct impacts from fishing, shrimp stock status in Kuwait has declined due to the decline in river flow in the Shatt-al-Arb (Bishop et al 2011). Discarding by shrimp fisheries can have adverse impacts on commercial fin fish fisheries and wider environmental status as high levels of bycatch and discarding, up 98% of the total catch, have been observed (Ye et al., 2001; Chen et al., 2012). Cuttlefish, squid and octopus are targeted, and opportunistically harvested within Kuwait waters. Cuttlefish are the primary commercial cephalopod species however, insufficient information on the taxonomy, abundance and distribution of cephalopods species prohibits an accurate assessment of the fishery.

Food and Water Quality for Human Health

The overall assessment of the Food and Water Quality for Human Health theme is poor, with the trajectory predicted to decline (Table 6). The assessment is made with high confidence due to the availability of long-term monitoring data from the EPA national monitoring programme (www.emisk.org) as well as supporting information from research studies (Al-Muzaini et al., 1991; Saeed et al., 2012; Devlin et al., 2015a; Lyons et al., 2015b; Saeed et al., 2015) (Table 5). The assignment of a poor assessment status is due to chronic sewage pollution inputs along most of the marine coastline over the last few decades and coastal sewage recognized as one of the foremost environmental issues impacting Kuwaiti marine waters (Devlin et al., 2015a; Devlin et al., 2015b; Lyons et al., 2015b; Saeed et al., 2015). The malfunctioning of Mishref sewage pump station, between 2009 and 2012, resulted in discharges of around 150,000 m^3 per day of untreated sewage directly into the sea (Saeed et al., 2012). Continued high levels of microbial contamination over multiple sites illustrates that raw and partially treated sewage discharges are an ongoing problem, particularly around Kuwait City, Doha Bay and Sulaibikhat Bay (Lyons et al., 2015b; Saeed et al., 2015). Microbial water quality at recreational beach locations around Kuwait regularly breach regional and internationally adopted recreational bathing water quality guidelines, indicating a heightened risk to human health (Lyons et al., 2015b). The high levels of sewage contamination of coastal waters are partly attributed to the failure of the sewage treatment network to keep pace with demands for capacity due to rapid population growth, and illegal and unregulated discharges of sewage directly into the sea and via the storm-water drainage network.

The continued chronic sewage contamination is also a cause for concern for the quality of seafood caught for human consumption in Kuwaiti waters. At present there is no regular systematic seafood safety (market based) monitoring for produce destined for human consumption. The limited data available for analysis was derived from local research studies that indicated that most of the commonly consumed fish and shellfish species contained concentrations of metals that do not pose a threat to humans. However, for the popular fish species Hamoor (*Epinephelus coioides*), there is some evidence suggesting that concentrations of metals, including methylmercury and arsenic, exceed EC or WHO maximum guidelines in members of the general public who have a high consumption rate of fish (Al-Majed and Preston, 2000; Husain et al., 2017b; Laird et al., 2017). This assessment is made with low confidence given the lack of a dedicated monitoring and the limited availability of seafood data for a wider range of chemical contaminants.

Environmental Pollution

The overall assessment of the Environmental Pollution theme (not including nutrient pollution or microbial contamination) was good status, with the trajectory predicted to be stable (Table 6). The levels of contamination detected indicate that, in general, Kuwait's marine environment is relatively unpolluted when compared with other industrialised regions of the world (for review see Al-Sarawi et al., 2015). Assessments were based on a series of research reports and data from the national EPA long-term monitoring programme, which included data on water, sediment and biota contamination (Table 5). Data from Kuwaiti waters demonstrated no ecologically significant change in water contamination, indicating that for metals and petroleum hydrocarbon contamination there is no ongoing deterioration over time (Al-Sarawi et al., 2015; Nicolaus et al., 2017). Throughout the period monitored, the concentration of metals and total petroleum hydrocarbons in coastal and offshore waters are generally below concentrations thought to pose a toxicological threat (Nicolaus et al., 2017; ROPME, 2013). However, there are isolated hotspots of contamination at levels thought to pose a toxicological risk around some of the wastewater outfalls and industrialized centres along the coastline (Smith et al., 2015). Sewage discharges (see Food and Water Quality for Human Health theme assessment) are known to contain a complex mixture of chemical contaminants that can be directly toxic to marine species. Evidence is emerging to suggest these effluent streams contain a range of biological and chemical contaminants with potential endocrine disrupting and antimicrobial resistance properties (Al-Jandal et al., 2018; Al-Sarawi et al., 2018; Saeed et al., 2017; Saeed et al., 2015; Smith et al., 2015). This has raised concern over the threat so called, 'emerging' contaminants may pose (Al-Sarawi et al., 2018; Saeed et al., 2017) including the potential impact of radionucleotides (Uddin et al., 2015). Marine litter (including microplastics) is also another area with a paucity of published data for Kuwait. However, there is now data emerging from across the Gulf to suggest widespread contamination of water, sediment and biota (Abayomi et al., 2017; Naji et al., 2018; Sarafraz et al., 2016). These aspects require further investigation and to evaluate the impact they have on future Environmental Pollution thematic assessments. The assessment of sediment contamination by metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and other persistent organic pollutants (POPs), such as brominated flame retardants indicated little toxicological risk to marine biota inhabiting the areas sampled (Al-Sarawi et al., 2015). Where detected, hot spots of PAH and PCB contamination were restricted to locations associated with industry, such as the Shuaiba Industrial Area, located south of the city (Gevao et al., 2006a; Gevao et al., 2006b; Gevao et al., 2014; Lyons et al., 2015a).

The analysis of chemical contamination in biota, along with the levels of contaminant associated disease in fish and biological effects related biomarker data, supports an assessment of good for the Environmental Pollution component with most indicators showing levels that are generally indicative of an unpolluted environment (Al-Zaidan et al., 2015; Beg et al., 2018; Stentiford et al., 2014). However, there are some concerns around higher food chain predators and their potential to bioaccumulate chemical contaminants (Husain et al., 2017a; Laird et al., 2017; Moore et al., 2015) and this requires further investigation to understand the overall impact on this theme.

Eutrophication and Harmful Algal Blooms (HABs)

The overall assessment of the Eutrophication and Harmful Algal Blooms (HABs) is moderate (Table 6), with high confidence and a declining trajectory reflecting the ongoing and chronic issues associated with the discharge of sewage into the coastal waters (Table 5 and Table 6).

Establishing a baseline for eutrophication is particularly timely as it has been selected as one of the regionally important indicators under UNDP Sustainable Development Goal (SDG) 14 Life Below Water. The statistical assessment of the main water quality indicators show nutrients and dissolved oxygen indicators are failing, however other indicators, such as phytoplankton biomass, are difficult to assess due to a lack of an agreed environmental standard relevant for Kuwaiti marine waters (Al-Mutairi et al., 2014a; Al-Mutairi et al., 2014b; Smith et al., 2015). The concerns for eutrophication issues are driven by significant, long term increase in nutrient inputs to Kuwait coastal waters. Recent studies propose that the increased enrichment may also have additional impacts on food webs and species distribution due to changes in plankton community composition (Al-Yamani et al., 2019; Al-Yamani et al., 2017; Devlin et al., 2019; Devlin et al., 2015b; Polikarpov et al., 2016). It is also acknowledged that water circulation, hydrodynamics and the reduction of freshwater flow via the Shat Al Arab all play a significant role in governing nutrient and phytoplankton distribution in Kuwaiti and surrounding waters of the Northern Gulf (Al-Said et al., 2018; Devlin et al., 2019). However, confidence attached to this assessment is moderate due to a lack of appropriate environmental standards for the several of the water quality indicators (Table 5). Examples of negative impacts caused by phytoplankton blooms in the Gulf include mass mortality of marine animals such as fish (Gilbert et al., 2002) and shellfish (Richlen et al., 2010), and alternation of marine habitat and community structure (Devlin et al., 2019; Sheppard, 2016; Sheppard et al., 2012; Sheppard et al., 2010). Whilst many of these impacts have been measured outside of Kuwait waters, the pressures that are driving these impacts are rising across the Gulf environment and would be part of a negative future trajectory for Kuwait.

HABS have been responsible for significant fish kills in Kuwait waters, and whilst the frequency of HABS in Kuwait waters have not increased over recent years, there are increasing incidences of outbreaks throughout the Gulf (Glibert et al., 2002; Heil et al., 2001; Richlen et al., 2010; Riegl et al., 2012; ROPME, 2013; Zhao et al., 2016). Factors that lead to new invasions of HAB species are still prevalent in Kuwait waters. The increases in anthropogenic discharges, ballast water discharges from regional shipping operations into warm waters with elevated nutrients and the increase in dust storms (Rao et al., 1999b; ROPME, 2013)combined with projected, episodic warming events (Sale et al., 2011; Sheppard et al., 2012) may continue to create suitable conditions leading to the expansion of HAB events in Kuwait and Gulf marine waters. However, the mechanisms underlying the increasing prevalence of HAB events requires further investigation with additional concerns around the cumulative impacts of nutrient enrichment of coastal waters, natural meteorological and oceanographic forcing, increases in maritime traffic and the introduction of HAB species through ballast water discharge (Anderson, 2009; Glibert and Bouwman, 2012; Glibert et al., 2002; ROPME, 2013).

Coastal Processes and Oceanography

The overall assessment of the Coastal Development and Oceanography theme is moderate, with the trajectory predicted to decline (Table 6). This thematic assessment included reporting the significant reduction in flow of freshwater from the Shatt al-Arab, which has had significant implications for Kuwaiti’s marine environment over the past decade (Table 5). The reduction of flow has seen an increase in salinity in the Northern Gulf, with values in Kuwaiti marine waters now >40 ppt (Al Said et al., 2017; Al-Yamani et al., 2017) and impacting on suspension and the sedimentation pattern in the northern Gulf (Al-Ghadban et al., 2000). Changes in the Shatt Al Arab river flow and resultant trend for increasing salinity of the norther Gulf waters is a major issue and data is suggesting impacts across food webs, fish recruitment and survival (Abdullah, 2017; Abdullah et al., 2015; Ben-Hasan et al., 2018; Bishop et al., 2011; Devlin et al., 2019; Al-Yamani et al., 2019) and is one of the more severe environmental issues facing Kuwait and the Northern Gulf. These drivers and pressures will be difficult to resolve for Kuwait as many of the drivers and pressures have transboundary properties and will require mitigation and management across the Gulf states (Devlin et al., 2015a; ROPME, 2013; Sheppard et al., 2010).

While coastal development has changed the shape of the Kuwait coastline, coastal stability is still functioning well. However, there are concerns for many of the future coastal development plans which could significantly impact on coastal processes and sedimentology. Increasing freshwater demand continues to drive the ongoing rapid growth of seawater desalination capacity and desalination processes do and will continue to impact on the hydrodynamic processes of the Gulf (AGEDI, 2016; Lee and Kaihatu, 2018; Purnama et al., 2005). The ability of the natural system to maintain an equilibrium and a stable coastal morphological system is most reliant upon sensitive and careful planning. The coastal landscape plays an important part in the protection of many iconic Kuwait species and habitats and needs to be fully protected for long term sustainability. Given that the stability in coastal processes is high and reported issues with coastal erosion are low. Kuwait coastal stability is still resilient, with only localised impacts of measured stress despite rapid coastal development over the past 30 years. The future coastal development trajectories are predicted to decline from current levels, given the continued modifications of the coastal zone. This is particularly exacerbated by the expansion of the northern residential area, construction of the Sheikh Jaber Al-Ahmad Al-Sabah causeway across Kuwait Bay, increasing desalination and expected development of Boubyian Island. However, there is a lack coordinated monitoring so confidence in these assessments remains low (Table 5).

Discussion

A framework for environmental reporting is essential to achieve ecosystem-based management and to inform policy on priority actions. The development of the SOMER for Kuwait demonstrated an approach to achieve this by integrating a wide variety of data sources including national, regional and international data sources into a single coordinated assessment.

Assessment of the strategic goals (SGs) in Table 6 show the assessment of the individual SG's (Table 1) and identify examples of actions required to continue to move towards achieving these goals. The outcomes of the SOMER, whilst a useful process to identify the major issues facing the Kuwait Marine environment, also provides guidance on the priorities for research and management. Lack of data around key biodiversity indicators including turtles, cetaceans, seabirds, coral reefs and seagrass beds makes it difficult to quantify the rate of change in these vulnerable habitats and species and could be underestimating the scale and urgency of the problem. Increased understanding around the state of the biodiversity indicators and further elucidation of the cumulative impacts of coastal pollution, fragmented river flows and a changing climate should be prioritised in future monitoring programs.

The principles for developing the assessment (Tables 2, 3 and 4) enabled quantitative assessment against nationally adopted quantified standards to be blended with qualitative narrative assessment against narrative standards in a coordinated and consistent manner. The use of quantitative data only against nationally adopted quantitative standards would have only provided an assessment of status for two of the twelve strategic goals. Instead the SOMER provided an assessment status in relation to ten of the twelve strategic goals. As noted above, an important corollary to the integration of diverse data sources is variable confidence in the outcomes of the assessment for different ecosystem components, which makes clear presentation of confidence. Clarity over the use of variable data sources within the assessment is enhanced by the use of clear principles to guide the development of the assessment in the absence of local data or national standards.

Developing frameworks to enable comprehensive environmental assessments, using multiple data sources with varying degrees of uncertainty, is consistent with the precautionary approach to environmental management. The precautionary approach was incorporated into international commitments for environmental management by Article 15 of the Rio Declaration on Environment and Development (UNCED, 1992), which stated that "lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". The precautionary approach has subsequently been incorporated into multilateral environmental commitments including the CBD.

The development of the data-limited marine ecosystem assessment framework presented in this paper reflects the usefulness of rapid, data-limited assessment methods that acknowledge the precautionary approach and acknowledge the need to avoid serious or irreversible damage to the environment in the absence of full quantitative assessments. The development of data-limited methods for marine ecosystem assessments in this and other papers (Borja et al., 2016; Feary et al., 2014) is consistent with the international development and implementation of data-limited assessment methods in fisheries management that have occurred over the last decade (Le Quesne et al., 2013; Newman et al., 2015; Zhou and Griffiths, 2008).

This national SOMER highlights the connectivity and interactions between Kuwait national territorial waters and the Gulf basin with many of the pressures, drivers and impacts being measured as a regional level (ROPME, 2013; UNEP, 2001). The recent report by Regional Organization for the Protection of the Marine Environment (ROPME) discusses the need for regional reporting where national and Gulf-wide SOMERs can complement one another if indicators and monitoring protocols are judiciously chosen to generate the assessment data designed to complement at scale, but also to co-leverage monitoring resources and expertise. This SOMER could serve as a template for other Gulf State SOMERs with the expectation that Gulf countries could transition towards a common set of quantitative metrics, indicators and status assessments. A collaborative approach remains the best hope for shared environmental concerns across the Gulf (Nadim et al., 2008; ROPME, 2013; UNEP, 1999, 2001; Van Lavieren and Klaus, 2013)

This current SOMER for Kuwait falls short of providing a fully quantified assessment, however by developing a framework and set of principles for conducting a national SOMER report, the current SOMER provides a clear baseline and structure for further development as part of the iterative implementation of ecosystem based approaches to management (UNEP, 2013.). The development of the SOMER for Kuwait should also be seen in the context of the implementation of the National Plan for Marine Environmental Management. The National Plan sets out a process for the cyclical development monitoring, assessment and management action, with this SOMER delivered at the start of the process, rather than as an end point. The preparation of future SOMERs for Kuwait will be further supported by the integration of additional datasets from national stakeholders and by the evolving long-term monitoring programmes supported by the national environment agency (EPA) (http://www.emisk.org/emisk/).

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Table 1: Description of the twelve Strategic Goals required for the Kuwait marine environment presented against major environmental theme.

Number	Environmental Strategic Goals (SGs)
	Biodiversity
B-SG1	• To prevent extinction of threatened and vulnerable species, and where possible, maintain abundant populations of all species.
B-SG2	• To prevent introduction and establishment of invasive species.
B-SG3	• To maintain the condition and extent of threatened and vulnerable habitats, and critical habitats that support threatened or vulnerable species; and to maintain all habitats in a condition to support key ecosystem functions that are dependent on them.
B-SG4	• To maintain community structure and food webs to ensure long-term abundance of species and productivity at all levels.
	Commercial Fisheries
F-SG1	• To ensure all stocks of commercially exploited species are at levels that enable high long-term sustainable yield consistent with the concept of maximum sustainable yield.
	Food and Water Quality for Human Health
FW-SG1	• To maintain the quality of seawater to protect human health
FW-SG2	• To ensure contaminants in fish and other seafood for human consumption do not lead to unacceptable risk to human health.
	Environmental Pollution
P-SG1	• To ensure that marine ecosystems are not adversely impacted by contaminants.
	Eutrophication and Harmful Algal Blooms
EH-SG1	• To minimise human-induced eutrophication, and its adverse or undesirable effects.
EH-SG2	• To reduce the frequency of human-induced Harmful Algal Blooms, and, where possible, minimise the adverse consequences of HABs.
	Coastal Processes and Oceanography
CO-SG1	• To minimise changes in sediment transport by coastal and offshore structures and developments that may lead to increased flood risk and undesirable erosion or changes in the shoreline.
CO-SG2	• Alterations to the hydrodynamic conditions do not adversely affect coastal and marine ecosystems.

Table 2: Description of environmental standards applied across the different components of the SOMER assessment

Environmental Standard Type	Description	Examples used in this assessment
National Quantitative Standard	A nationally adopted quantitative standard.	Kuwait coastal microbial standards based on a national and international standard related to human impact with an acceptable number of faecal coliforms under an environmental standard.
Surrogate Value	An applicable quantitative surrogate value, such as quantitative standards used in other national assessment or international guidelines. Or a quantitative value based on a baseline period.	Food safety limits such as those applied by the European Union or the World Health Organization, such as Maximum limits in fishery products set under EC 1881/2006 for dioxins and dioxin-like PCBs.
Narrative Standard	A narrative description of the objective to be achieved.	Turtles – recognition of the importance of nesting habitats and identification of the destruction of that nesting habitat provides a strong narrative of potential impacts on Kuwait turtle population.

Data Type	Description	Examples used in this assessment
Systematic monitoring	Long-term local systematic monitoring data collected for the purpose of quantitative monitoring of status and trends in the reported ecosystem components included in the SOMER.	EPA water quality and contaminant monitoring programme used to evaluate dissolved inorganic nutrients, microbial contamination, phytoplankton species composition and metals in water and sediments (Devlin 2015b, Lyons et al., 2015b and Nicolaus et al., 2017)
Local research studies	Ad hoc research studies conducted in Kuwait that provide quantitative information on reported ecosystem components included in the SOMER.	Research studies conducted in Kuwait that were used to provide quantitative data includes seafood safety, fisheries and turtles (Al-Mohanna, Al-Zaidan & George 2014; Moore *et al.* 2015; Laird et al., 2017)
Regional studies	Monitoring or research studies conducted in other areas across the Gulf region that have identified consistent regional trends that can be used for qualitative evaluation of ecosystem components included in the SOMER.	Studies identifying consistent regional trends in status were used as qualitative sources of information for HABS, (Zhao *et al.* 2016) and status of coral reefs (Sheppard et al., 2016)
Global trends	Monitoring or research studies conducted internationally that have identified consistent international or global trends that can be used for broad qualitative evaluation of ecosystem components included in the SOMER.	Studies identifying consistent international or global trends in status were used as qualitative sources of information compare with examples of components evaluated using local research studies and references (Burt et al., 2019)

Table 3: Description and examples of the four categories of data sources used in the SOMER assessment. Selection of data sources was based on the availability and accessibility of quantitative and qualitative data.

Approach	Description	Data source	Standards	Example indicators as applied in SOMER
Tier I	Quantitative assessment based on locally derived quantitative data assessed in relation to a nationally adopted quantitative standard.	Locally derived, current, quantitative from systematic monitoring or research studies.	National Quantitative Standard	Microbial counts – Faecal coliforms (cells/L) based on national and international thresholds for protecting human health. Water quality (metals) based national and international thresholds
Tier II	Quantitative assessment with long term locally quantitative data, but without appropriate a nationally adopted standard. Supported by analysis of changes in time/space.	Locally derived quantitative timeseries data from systematic monitoring or research studies. Maybe supplemented by regional timeseries data.	Surrogate value	Emerging pollutants where accepted thresholds are not available Long term trends in water quality (nutrients) where regional thresholds have not been developed
Tier III	Qualitative assessment with no systematic local quantitative data, instead based on sporadic research information, modelling, and regional or global studies of predominant trends assessed in relation to a narrative standard.	Regional studies, global trends	Narrative standard	Change in coral cover, and seagrass and seabirds based international (narrative) commitments for sustainable populations
Tier IV	Assessment which has very little to no data, and little to no information and based on global understanding of pressures and impacts. Lacking clear guidance on the standard for assessment.	Global trends	No clear guidance on environmental standard to be achieved.	Number and emergence of alien species Food web status

Table 4: Tiers of assessment applied depending on the available data type (Table 3) and environmental standard type (Table 2), and examples of the use of the different approaches. The level of assessment Tier was based on lower level of the data type or environmental standard type available for the ecosystem component under consideration.

Table 5: Outcomes of SOMER for each component under the six themes. The assessment is presented as a measure of status (high, good, moderate, poor, bad). The Tier refers to the type of assessment (Described in Table 2), and data sources (Table 3) identified as systematic monitoring (SM), local research studies (LRS), regional studies (RS)and/or global trends (GT). Data could be sources from more than one of these areas.

Indicator/Component	Assessment Tier	Data Sources	Status	Trend	Confidence
BIODIVERSITY					
Strategic Goal B-SG1: to prevent extinction of threatened and vulnerable species, and where possible, maintain abundant populations of all species.					
Rare and Vulnerable fish species	III	○●○○	● (orange)	↓ (red)	■
Cetaceans	III	○●○●	?	?	■
Marine Turtles	III	○●●●	● (red)	↓ (red)	■■
Seabirds	III	○●●●	?	↓ (red)	■
B-SG2: to prevent introduction and establishment of invasive species.					
Alien Species	III	○●●○	?	?	■
B-SG3: to maintain the condition and extent of threatened and vulnerable habitats, and critical habitats that support threatened or vulnerable species; and to maintain all habitats in a condition to support key ecosystem functions that are dependent on them.					
Coastal habitats	II	○●●●	● (orange)	↓ (red)	■■
Coral Reefs	III	○●●●	● (orange)	↓ (red)	■■
Seagrass	III	○●●●	?	↓ (red)	■
B-SG4: to maintain community structure and food webs to ensure long-term abundance of species and productivity at all levels.					
Food webs	IV	○○○●	?	?	■
COMMERCIAL FISHERIES					
F-SG1: to ensure all stocks of commercially exploited species are at levels that enable high long-term sustainable yield consistent with the concept of maximum sustainable yield.					
Commercial fish stocks	III	●●●○	● (orange)	↓ (red)	■■
Prawns	III	●●●○	● (orange)	?	■■
Cephalopods	III	○●●○	?	?	■
Crabs and lobsters	III	○●●○	?	?	■
Bivavles	III	○●●○	?	?	■
FOOD AND WATER QUALITY FOR HUMAN HEALTH					
FW-SG1: to maintain the quality of seawater to protect human health.					
Microbial WQ	I	●●○○	● (red)	↓ (red)	■■■
FW-SG2: to ensure contaminants in fish and other seafood for human consumption do not lead to unacceptable risk to human health.					
Food health	II	○●○○	● (orange)	?	■
ENVIRONMENTAL POLLUTION					
P-SG1: to ensure that marine ecosystems are not adversely impacted by contaminants.					
Water (TPH)	I	●●○○	● (green)	○ (no change)	■■■
Water (heavy metals)	I	●●○○	● (green)	○ (no change)	■■■
Ecotoxicology	III	○●○○	● (red)	?	■
Sediment (PAH)	III	○●○○	● (green)	?	■■
Sediment (PCB)	III	○●○○	● (green)	↑ (green)	■■
Sediment (metals)	III	○●○○	● (orange)	○ (no change)	■■
Sediment (PBDE)	III	○●○○	● (green)	?	■
Sediment (Faecal sterols)	III	○●○○	● (red)	↓ (red)	■■■
Biota (chemical contamination)	III	○●○○	● (green)	?	■
Biota (Fish health)	III	○●○○	● (green)	?	■
EUTROPHICATION AND HARMFUL ALGAL BLOOMS (HABs)					
EH-SG1: to minimise human-induced eutrophication, and its adverse or undesirable effects.					
Nutrients (DIN)	I	●●○○	● (red)	↓ (red)	■■■
Nutrients (DIP)	I	●●○○	● (red)	↓ (red)	■■■
Phytoplankton (Chlorophyll-a)	I	●●○○	● (orange)	↓ (red)	■■
Plankton community composition	II	●●○○	?	?	■
Dissolved Oxygen	II	●●○○	● (orange)	↓ (red)	■
Water Quality Index (integrated)	I, II	●●○○	● (orange)	↓ (red)	■■
EH-SG2: to reduce the frequency of human-induced HABs, and, where possible, minimise the adverse consequences of HABs.					
HABs	III	○●○○	● (orange)	?	■
COASTAL PROCESSES AND OCEANOGRAPHY					
CO-SG1: to minimise changes in sediment transport by coastal and offshore structures and developments that may lead to increased flood risk and undesirable erosion or changes in the shoreline.					
Coastal change	III	○●●○	● (green)	○ (no change)	■
Changes in sedimentology	III	○●●○	● (orange)	○ (no change)	■
CO-SG2: alterations to the hydrodynamic conditions do not adversely affect coastal and marine ecosystems.					
River Flow	II	○●●●	● (red)	↓ (red)	■■■

Table 6: Outcomes of SOMER presented at the theme level and against the strategic environmental goals (SGs) identified under each theme (Table 1). Theme is presented as a status and a trajectory, with strategic goals presented agaisnt a status assessment, trajectory and confidence. The assessment is presented as a meaure of four categories of state (high – blue, good – green, moderate – orange, red – poor). The future trajectory is reported over three categories (improving, stable or declining) and high, medium, low confidence. Actions required to move towards achieving the strategic environmental goals are suggested for each SG.

Theme	Theme Status	Theme Trajectory	Strategic Environmental Goal (SG)	SG Status	SG Trajectory	SG Confidence	Examples of actions required to meet SGs
Biodiversity	● (orange)	⬇ (red)	*B-SG1:* **Prevent** extinction of vulnerable species and maintain populations.	● (red)	⬇ (red)	■■	Increased protection for turtle nesting beaches (e.g. restrict access nesting sites at night and control of surrounding light pollution). Ongoing nest monitoring including success rates to better inform management regimes. Turtle satellite tracking programmes to inform tempero-spatial marine usage and identify key areas of vulnerability and implement by-catch reduction actions in these locations. Identification of key seabird nesting, foraging and migration areas and implementation of seasonal access restrictions to protect nesting seabird colonies.
			B-SG2: **Prevent** introdution of Invasive species.	? (grey)	? (grey)	■	Increase public awareness and actions to reduce spread of alien species. Manage shipping and ballast water to reduce pathways.
			B-SG3: **Maintain** threatened & vulnerable habitats for support of key ecosystem function.	● (orange)	⬇ (red)	■■	Ongoing marine and coastal surveys to identify and protect the most valuable habitats for implementation of management regimes where appropriate. Protection of coastal and marine habitats, anchoring free zone on coral reefs.
			B-SG4: **Maintain** community structure and food webs.	? (grey)	? (grey)	■	Increase data confidence around food web shifts
Commercial Fisheries	● (orange)	⬇ (red)	*F-SG1:* **Ensure** long term sustainable yield for commercial species.	● (orange)	⬇ (red)	■■	Improve fisheries data collection to provide estimates of total catch, fishing effort and fisheries independent stock surveys. Strengthened regulatory processes need to be established to control inputs and/or outputs by national and foreign vessels operating in Kuwaiti waters. Multilateral management plans should be established for shared stocks.
Food and Water Quality for Human Health	● (red)	⬇ (red)	*FW-SG1:* **Maintain** quality of seawater to protect human health.	● (red)	⬇ (red)	■■■	Improve infrastructure on sewage and industrial treatment works. Reduce or eliminate illegal discharges.
			FW-SG2: **Ensure** contaminants in seafood for human consumption do not lead to risk to human health.	● (orange)	? (grey)	■	Improve infrastructure on sewage and industrial treatment works. Reduce or eliminate illegal discharges.
Environmental Pollution	● (green)	➡ (grey)	*P-SG1:* **Ensure** that marine ecosystems are not adversely impacted by contaminants.	● (green)	➡ (grey)	■■	Reduce the contaminant flow by improved infrastructure around sewage and industrial disposal.
Eutrophication and Harmful Algal Blooms (HABs)	● (orange)	⬇ (red)	*EH-SG1:* **Minimise** human-induced eutrophication, and its adverse or undesirable effects.	● (orange)	⬇ (red)	■■	Improve infrastructure on sewage and industrial treatment works. Reduce or eliminate illegal discharges.
			EH-SG2: **Reduce** frequency and minimise adverse consequences of Harmful Algal Blooms.	● (orange)	? (grey)	■	Local remediation of nutrient enrichment. Regional collaboration on the Gulf wide issues of HABS.
Coastal Processes and Oceanography	● (orange)	⬇ (red)	*CO-SG1:* **Minimise** changes in sediment transport that may lead to coastal impacts.	● (green)	➡ (grey)	■	Close surveillance of existing areas of erosion (hotspots). Maintain a regional approach to monitoring coastal stability and morphology.
			CO-SG2: Alterations to the hydrodynamic conditions **do not adversely affect** coastal and marine ecosystems	● (red)	⬇ (red)	■■■	Cross regional and harmonised approach to restoring and maintaining river flows.

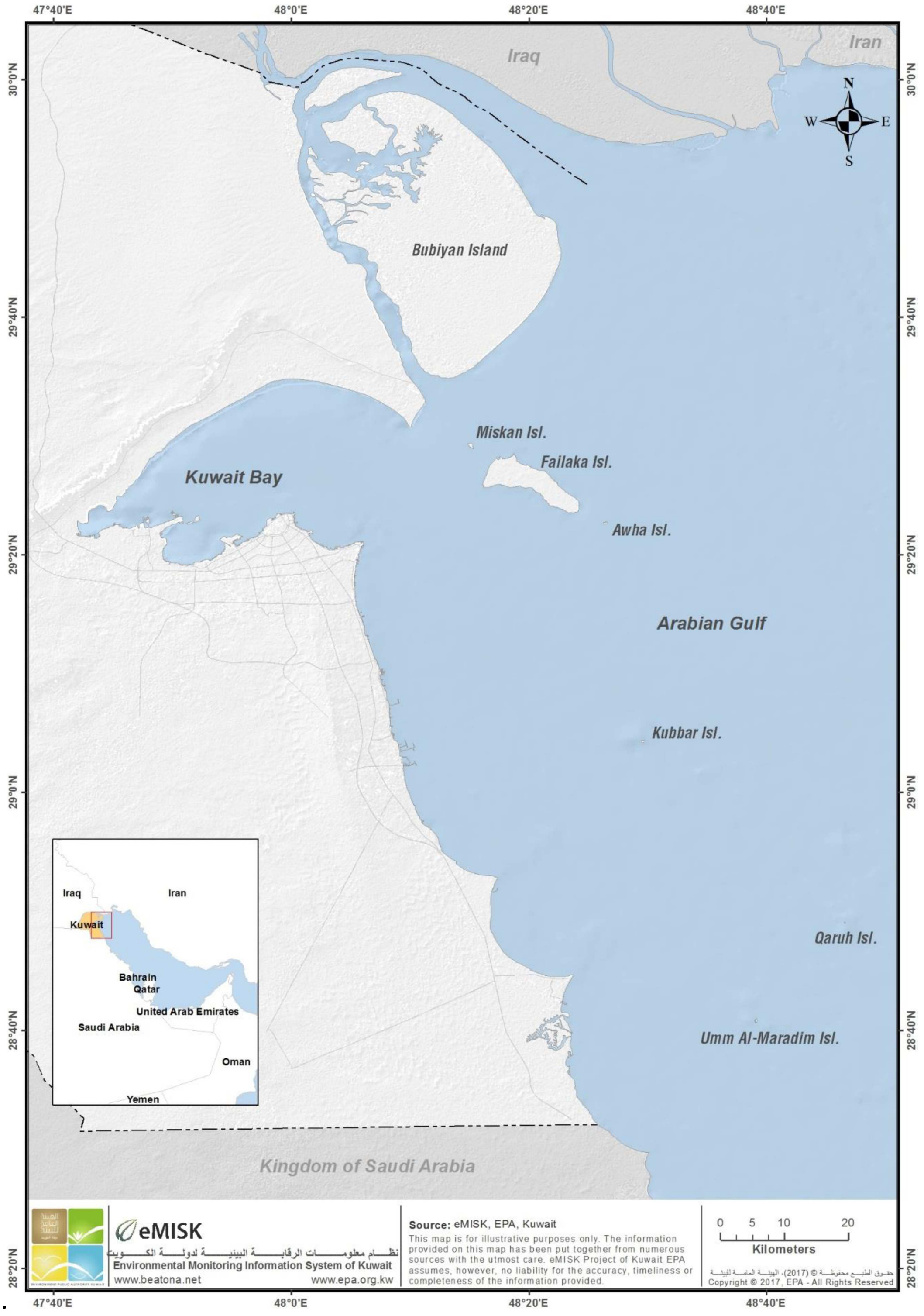

Figure 1: Location of Kuwait and Kuwait Bay in context of the Arabian Gulf

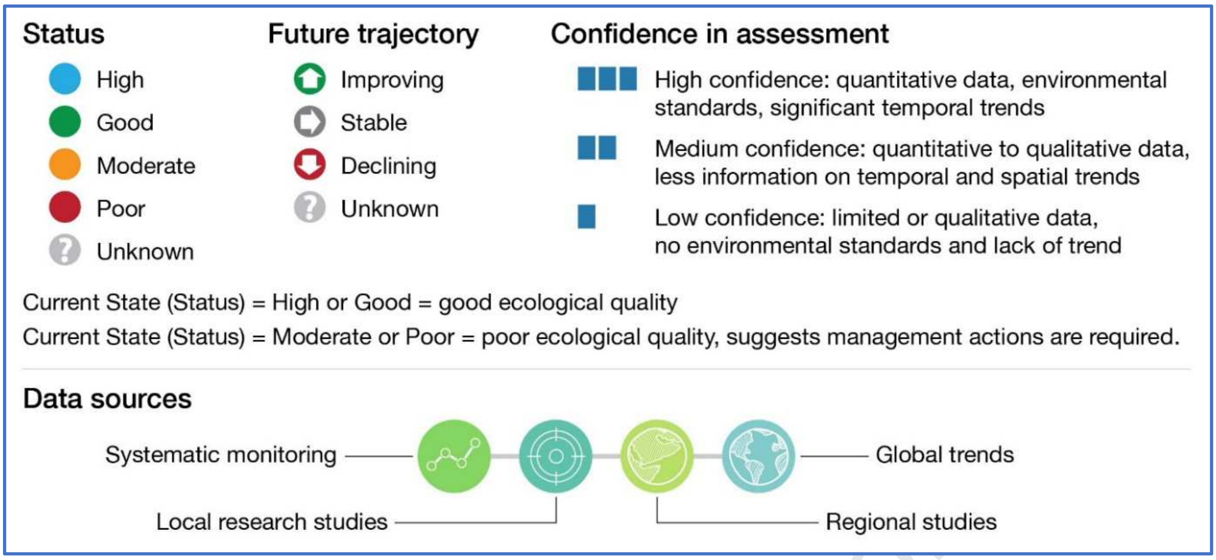

Figure 2: The different categories related to the assessment of Status, Future trajectory) and the confidence in the assessment of Status and Trajectory.

- An approach for preparing comprehensive national ecosystem assessment for Kuwait
- Based on principles to integrate diverse data into single coordinated assessment
- State assessments for co-ordination of multiple components of the marine ecosystem
- The development of a State of the Marine Environment Report (SOMER) for Kuwait
- The Kuwait SOMER highlighted the issues of coastal pollution