Marine Pollution Bulletin xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Review

A review of the status and development of Kuwait's fisheries

M. Al-Husaini *, J.M. Bishop, H.M. Al-Foudari, A.F. Al-Baz

Ecosystem-based Management of Marine Resources, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, PO Box 24885, 13109 Safat, Kuwait

A R T I C L E I N F O

Article history:
Received 28 January 2015
Revised 14 July 2015
Accepted 23 July 2015
Available online xxxx

Keywords:
Kuwait
Fish
Shrimp
Landings
Bycatch
Biomass density

A B S T R A C T

The status of Kuwait's fisheries landings and relative abundance for major species was reviewed using research data from Kuwait Institute for Scientific Research and landing data from the Kuwait's Central Statistical Bureau. Landing data showed significant decreases for major commercial species such as zobaidy (*Pampus argenteus*), suboor (*Tenualosa ilisha*), hamoor (*Epinephelus coioides*), newaiby (*Otolithes ruber*) and hamra (*Lutjanus malabaricus*) while abundance data for the shrimp *Penaeus semisulcatus* showed significant reduction in the recent years mainly because of overfishing. The catch-rate data showed continuous decline for major species such as zobaidy, newaiby and hamoor, which indicate that stock abundances of these species are low. The reduction in stock abundance in context with changes in habitat quality, particularly the effects of reduced discharge of the Shatt Al-Arab, is discussed.

Contents

1. Introduction

Coastal communities of the Arabian Gulf have a long history of fish consumption. Fish was the most important source of protein of prehistoric coastal populations in the Arabian Gulf region (Beech, 2002). At several archaeological sites along the western Gulf, dating back 7000 years before present (ybp), fish bones account for the majority (up to 91%) of excavated faunal remains. At an archaeological settlement on Dubaij Island just north of Kuwait Bay, also dating 7000 ybp, excavated fish remains accounted for 58% of the total faunal assemblages. These assemblages include over 10 groups of fishes, with sharks, rays, groupers, seabreams, and jacks, being among the represented species (Beech, 2002). Fishing has always been a way of life in Kuwait, as fish represent one of the few naturally occurring renewable resources and a source of high-quality, fresh protein.

Occupying the western edge of the Mesopotamian shallow shelf of the northern Arabian Gulf, Kuwait lies within latitudes of 28 and 30°N, and longitudes of 47 and 49°E with a north-south coastline of 195 km. Being influence by the discharge of the Shatt Al-Arab River (Fig. 1), Kuwait's northern waters are somewhat estuarine and progressively increase in salinity toward the south. The Shatt Al-Arab estuary includes a submerged estuarine flat covering a shallow

* Corresponding author.
E-mail address: mhusaini@kisr.edu.kw (M. Al-Husaini).

http://dx.doi.org/10.1016/j.marpolbul.2015.07.053
0025-326X/

Fig. 1. Kuwait's sea area.

area not exceeding 10 m in depth, while the shelf slope extends along the coast south of Kuwait Bay to 20 m depth. The maximum depth of Kuwait's waters is less than 35 m. Tides are semi-diurnal and vary as much 3 m in amplitude. The prevailing climate is arid, with extremely harsh temperatures and high salinities. The highest and lowest mean seawater temperatures are 30.5 °C in July–August and 12 °C in January–February. Salinity fluctuates between 37 and 50 ppt due to the inflow of fresh water from the Shatt Al-Arab River caused by heavy rainfall during the winter, and melting of snow in Turkey, Syria, Iraq and Iran during the spring. The high salinity is due to the intensive evaporation of seawater during the hot summer months from May to October. The discharge of the Shatt Al-Arab River and topographical features, including extensive intertidal mud-flats, mud and/or sand bottoms, and coral reefs

Please cite this article in press as: Al-Husaini, M., et al. A review of the status and development of Kuwait's fisheries. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.07.053

(Khalaf et al., 1984; Carpenter et al., 1997), provide habitat for a wide variety of fauna and flora in Kuwait's waters.

Kuwait's sub-tropical fisheries are multi species and multi gear. Numerous studies over the past 40 years have shown that Kuwait's marine habitat serves as primary nursery grounds for a number of species (Bishop and Khan, 1999; Bishop, 1994; Al-Husaini et al., 2007; Al-Baz et al., 2003). In particular, the extensive mudflats and proximity of the Shatt Al-Arab provide ideal nursery grounds for penaeid shrimps and numerous fishes including members of families Sparidae, Clupeidae, Mugilidae, Sciaenidae and Stromateidae. Twenty three commercial species, belonging to 17 families (Table 1), are considered important enough to record landings statistics.

The fishing industry is comprised of three distinct fleets employing a variety of gears. These fleets have been divided into artisanal and industrial, although almost all are commercial, i.e., they fish for profit. Artisanal fleets include speed-boats and dhow boats, and these vessels are licensed to use only one type of gear, which can be *gargoor* (hemispherical wire fish traps), drift nets, or fixed gill nets of various mesh sizes. At present there are 694 licensed fiberglass speedboats, of which 154 fish *gargoor* and 540 fish gill nets. Not all fishing vessels are necessarily active, and those that are may vary their operations seasonally. Registered dhow boats number 87: 19 are licensed to deploy *gargoor* traps and 68 are licensed for gillnets (CSB, 2011). Additionally, two shrimp companies own a combined total of 63 dhows and 8 steel-hull, double-rigged trawlers (Public Authority for Agriculture and Fisheries Resources, personal communication).

The target species for the artisanal fishery principally depend on the gear used. Trawls are specific for shrimp, but fish bycatch, usually demersal species, is an important component of landings. *Gargoor* capture demersal species, while gill nets catch mostly pelagic species. Demersal species include hamoor (*Epinephelus coioides*), shaem (*Acanthopagrus latus*)[1], hamra (*Lutjanus malabaricus*), and newaiby (*Otolithes ruber*), and targeted pelagics are zobaidy (*Pampus argenteus*), suboor (*Tenualosa ilisha*), nagroor (*Pomadasys kaakan*), and maid (*Liza klunzingeri*).

Table 1
Main commercial shrimp and fish species in Kuwait.

No.	Species and (Family)	English name	Local name
1	*Penaeus semisulcatus* (Penaeidae)	Green tiger prawn	Umm Niaarah
2	*Metapenaeus affinis* (Penaeidae)	Jinga shrimp	Shahameyah
3	*Acanthopagrus latus* (Sparidae)	Yellowfin seabream	Shaem
4	*Pampus argenteus* (Stromateidae)	Silver pomfret	Zobaidy
5	*Tenualosa ilisha* (Clupeidae)	Hilsa shad	Suboor
6	*Epinephelus coioides* (Serranidae)	Orange-spotted grouper	Hamoor
7	*Pomadasys kaakan* (Haemulidae)	Javelin grunter	Nagroor
8	*Otolithes ruber* (Sciaenidae)	Tigertooth croaker	Newaiby
9	*Liza klunzingeri* (Mugilidae)	Klunzinger's mullet	Maid
10	*Lutjanus malabaricus* (Lutjanidae)	Malabar blood snapper	Hamra
11	*Scomberomorus commerson* (Scombridae)	Kingfish	Chanaad
12	*Scomberomorus guttatus* (Scombridae)	Indo-Pacific king mackerel	Khobat
13	*Pseudorhombus arsius* (Paralichthyidae)	Largetooth flounder	Khofaah
14	*Platycephalus indicus* (Platycephalidae)	Bartail flathead	Wahar
15	*Nemipterus peronii* (Hemipteridae)	Notched threadfin bream	Bassi
16	*Mugil cephalus* (Mugilidae)	Flathead mullet	Beyah
17	*Lethrinus nebulosus* (Lethrinidae)	Spangled emperor	Sheiry
18	*Protonibea diacantha* (Sciaenidae)	Spotted croaker	Shmahy
19	*Cynoglossus arel* (Cynoglossidae)	Largescale tongue sole	Lessan
20	*Parastromateus niger* (Carangidae)	Black pomfret	Halwayah
21	*Argyrops spinifer* (Sparidae)	King soldier bream	Andag
22	*Eleutheronemaa tetradactylum* (Polynemidae)	Fourfinger threadfin	Sheim
23	*Plectorhinchus pictus* (Haemulidae)	Trout sweetlips	Fersh

A fourth fishing gear, the inter-tidal stake net, locally known as *hadrah*, contributed substantially more to past landings than at present. In 2003, hadrah numbered 522, but a decree by Kuwait's cabinet in September 2003 resulted in the removal of all hadrah in Kuwait Bay and Khor Al-Sabiyah (Fig. 1). Currently, there are about 30 hadrah on Failaka Island and the coastal area south of Kuwait Bay. The primary reason for this decree was because of the heavy mortality of juvenile species (Al-Baz et al., 2003), which use the intertidal area as nursery grounds. Kuwait Bay and Khor Al-Sabiyah are among Kuwait's most important nursery areas (Al-Attar, 1984a,b; Bishop, 1988; Wright, 1988).

Hadrah are not the only fishing gear that causes high mortalities of juveniles. Shrimp trawls are non-selective in their fishing, and juveniles can account for a major portion of the bycatch (Pender et al., 1993; Brewer et al., 1998; Ye et al., 2000). Some of the bycatch is landed and is an important component of revenue from shrimp fishing. The fish bycatch is significantly higher than the shrimp catch (Al-Ayoub et al., 2005). Because of the impact of this fish bycatch, trials have been completed on bycatch reduction devices (BRDs) for possible introduction into the shrimp fishery in order to reduce mortalities of commercially important juveniles and to maintain biodiversity.

Kuwait presently lacks a comprehensive fisheries statistical and biological monitoring system that enables managers and scientists to assess the *status quo* of the fishery stocks. Presently the only data recorded on Kuwait's shrimp and fin-fish landings are by the Kuwait's Central Statistical Bureau (CSB). The tabulated data are for Kuwait's most important commercial species (Table 1), with the remaining species categorized as "others". These statistics consist of daily landings volume (kg) by species from the wholesale auctions in the main fish market, and do not include information on fishing effort or fish sold outside the fish markets. The CSB data are used to evaluate the status and trends of Kuwait's primary fish stocks, and are considered as a primary proxy for stock abundance, assuming that fishing effort has been relatively constant over the last 10 years. Illegal fishing and non-reported catches are one of Kuwait's fisheries shortcomings, particularly after 1990/91 Gulf War when the country had other priorities in rebuilding its infrastructure.

All biological information used in this review was collected by KISR personnel from 1977 onward for shrimp and from 1980 for fish. Shrimp data include landings, fishing effort as well as biological observations. The collection of these data for stock assessment and catch per unit effort continued until 1990. Following 1990, fisheries data collection depended on specific projects such as those for the *gargoor* fishery (Al-Baz et al., 2007), the hadrah fishery (Al-Baz et al., 2003), bycatch reduction devices (Al-Ayoub et al., 2005), zobaidy (Al-Husaini et al., 2007), shrimp stocks (Bishop et al., 2001; Al-Foudari et al., in press), and demersal species (Al-Husaini et al., 2012) among others.

Recreational fishing is a popular pastime in Kuwait, and the number of recreational boats exceeds 30,000. There has been no study addressing the magnitude of sports fishing in Kuwait, so the number of recreational fishermen would be a rough estimate at best. This leaves the financial impact of sport fishing, the amount and size of fish landed, and the most common species captured

[1] This "species" is now known to represent three species: *A. randalli*, *A. sheim*, and *A. arabicus* (Iwatsuki and Carpenter, 2009; Iwatsuki, 2013).

open to question. Rao and Behbahani (1999) mentioned the impact of sport fishing, but provided no quantitative information. They did report the main impact of marine recreation was anchor damage to reefs surrounding Kuwait's coral islands.

Kuwait's demand for fresh fish and shrimp in the last 20 years had changed considerably. Local landings have decreased while demand has increased, with imports making up the difference. Per capita consumption has increased from 5.1 kg in 1983 to 6.3 kg in 1987 (KISR, 1989) and significantly to an average of 16.8 kg for the years 2007–2009 (NOAA, 2011). In the mid 1980s, no single fin-fish species accounted for more than 15% of the total landings. In 1995, however, zobaidy, suboor, and newaiby accounted for 55% of the total finfish landings, but by 2005, their combined contribution had decreased to 33% with most of the reduction resulting from declines in catches of zobaidy and suboor (CSB, 1985, 1995, 2005).

2. Shrimp fishery

Shrimp support the most important fishery in Kuwait as it accounts for more than 35% of the total landings volume and value annually. Commercial shrimping in the Arabian Gulf started over 50 years ago when, in 1959, seven industrial trawlers, 23 m in length, were transferred from the Gulf of Mexico to Kuwait (Kristjonsson, 1968). Initially, industrial boats dominated the new fishery employing the otter trawl, but wooden dhow boats were quick to adopt this gear and join the bonanza. Historically, dhows had employed a scoop net, the *qoofa*, to capture shrimp in waters less than 2 m deep (van Zalinge, 1981). In the 1960s, the focus of the industry was exploitation only, with little or no concern for regulation and conservation. During this seminal period of the fishery, catch rates in the Arabian Gulf were among the highest in the world (Kristjonsson, 1968), and this led to over exploitation. Landings dropped sharply after 1976 (van Zalinge et al., 1984), and encouraged Gulf countries, including Kuwait, to consider management policies. Since then, a number of studies have been completed on biology and management of Kuwait's shrimps (see reviews by van Zalinge et al., 1984; Abdul-Ghaffar and Al-Ghunaim, 1994; Mohammed et al., 1998; Ye et al., 1999a).

Although 14 species of shrimps have been identified in Kuwait's catches, only three are important commercially. In descending order of importance, they are the green tiger prawn (*Penaeus semisulcatus*), the kiddi shrimp (*Metapenaeus affinis*), and the jinga shrimp (*Parapenaeopsis stylifera*). Their percent contribution to shrimp landings varies from year to year, but generally *P. semisulcatus*, *M. affinis*, and *P. stylifera* account for about 60%, 30%, and 10% of the landings, respectively. During years of exceptionally good landings, *P. semisulcatus* accounts for 98% of the landings (Siddeek et al., 1994). Distribution of *P. semisulcatus* in the Gulf is not uniform, but this species is far more widespread than either *M. affinis* or *P. stylifera*. Both the latter species occur only in the extreme northern Gulf (Farmer and Ukawa, 1986), and contribute essentially nothing to shrimp landings in either Bahrain or Saudi's east coast fisheries. Kuwait's stock of *P. semisulcatus* appears to be discrete from that just south of the border with Saudi Arabia (Bishop et al., 2001).

Juvenile distributions of *P. semisulcatus* occur during spring in shallow waters of sandy or reefal bottoms, with attached vegetation such as *Sargassum*, whereas juveniles of *M. affinis* occupy shallow muddy bottoms during summer (Bishop, 1988, 1989, 1994). Kuwait Bay and its adjacent areas as well as coastal areas south of Kuwait Bay have been found to be the major nursery areas for *P. semisulcatus* (Mohamed et al., 1981; Jones and Al-Attar, 1982; Al-Attar, 1984a).

Management of Kuwait's shrimp stocks is based on the biology of *P. semisulcatus*. Juveniles recruit to the fishing grounds as early as June, but July and August are the strongest recruitment months (Bishop et al., 2001). Catch rates in July or July and August, prior to season opening, were used to develop a recruitment index to forecast seasonal landings with 95% confidence (Ye et al., 1999b). High catchability at the beginning of shrimping season was attributed to possible schooling, and Ye and Mohammed (1999) suggested that increased catchability in midwinter may be due to an inshore spawning migration. Two separate analyses have determined that the best bioeconomic yield is realized with a season opening date of 1 September or 1 October (Gulland, 1989; Ye, 1998). Season closure has been based on catch rates of spawning stock biomass, which should not be fished below a certain threshold to allow sufficient recruits for the following season (Morgan, 1989). Migration movement of *P. semisulcatus* between Kuwait Bay and deeper areas was observed as a result of two tagging studied in 1979 and 1982 (Mathews, 1986).

Estimated growth and mortality rates varied among several studies, possibly due to different methods and years (Jones and van Zalinge, 1981; Siddeek and Abdiul-Ghaffar, 1989; Xu et al., 1995; Mohammed et al., 1996; Xu and Mohammed, 1996; Bishop et al., 2001; Ye et al., 2003). Maximum carapace lengths (L_∞) ranged from 34.6 to 41.1 mm for males and from 48 to 58 mm for females. Growth rates (K) also differed between males and females with females averaging higher rates (1.64 yr^{-1}) than males (1.50 yr^{-1}). Estimates of natural mortality varied from 1.7 to 2.8 yr^{-1} for males and 1.8 to 5.3 yr^{-1} for females (Ye et al., 1999a). Spawning occurs throughout the year to some degree, but most spawning is restricted from December to April, peaking in March and April (Al-Attar and Ikenoue, 1974; Ye et al., 1999a).

Over the long-term, Kuwait's shrimp landings have averaged about 2000/yr. Total landings have fluctuated between 1012 and 5125 tons from the 1960s to 2013 (Fig. 2). The highest landings recorded in 1988/89 and 1989/90 seasons were attributed to effort limitation imposed by the government in late 1980s, good enforcement, and favorable environmental conditions (Siddeek et al., 1994). Following the 1991 Gulf War, total landings varied between 1416 and 2727 tons due to significant reductions in recruitment as a result of high fishing effort (>10,000 boat-days) and probably less favorable environmental conditions. Using historical data, Siddeek et al. (1988) estimated the maximum sustained yield (MSY) for Kuwait's shrimp fishery to be from 1794 to 1872 tons/yr at 6061 to 7032 boat-days effort. Mathews and Samuel (1989) estimated a MSY of 2460 tons at 6500 fishing boat-days using research vessel catch rates for the same time period. Since 1993, the fishery has

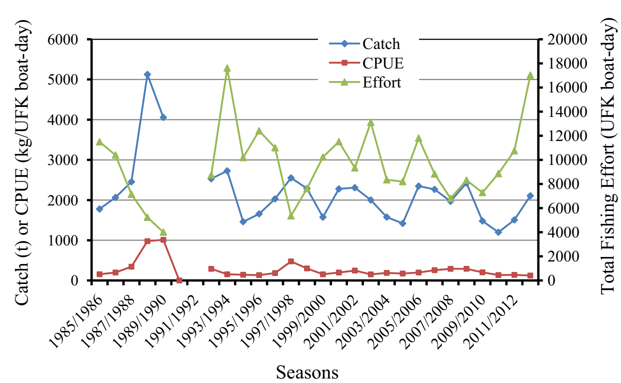

Fig. 2. Total catch, effort, and catch-per-unit-effort for Kuwait's shrimp fishery; 1985/1986 – 2012/2013 (Excluded the two seasons 1990/1991 and 1991/1992 with zero or low shrimp catch due to the Gulf War; UFK = United Fisheries of Kuwait).

Please cite this article in press as: Al-Husaini, M., et al. A review of the status and development of Kuwait's fisheries. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.07.053

been characterized by low catch rates, high fishing effort and illegal fishing during banned seasons. Kuwait's shrimp stocks appear to be overexploited by overfishing. It is doubtful that environmental conditions will ever be as good as those for the two record seasons (1988/89 and 1989/90) because of the reduced discharge of the Shatt-Al-Arab (Bishop et al., 2011).

Concern with overfishing resulted in the initial season closure in 1980 (Abdul-Ghaffar and Al-Ghunaim, 1994). In 1988, the Kuwait Government reduced the excessive trawling effort by purchasing fishing vessels, reducing the number of industrial boats by 50% and the number of dhow boats by 75% (Anonymous, 1988, 1989a,b). This resulted in only 35 industrial trawlers and 28 wooden dhow boats being licensed to trawl for shrimp, and set in motion the record seasons of 1988/89 and 1989/90. This action resulted in fishing effort decreasing from 10,400 boat-days in the 1986/87 season to just over 4000 boat-days in 1989/90 (Abdul-Ghaffar and Al-Ghunaim, 1994).

Following the 1991 Gulf War, annual fishing effort gradually increased with additional licenses being issued to dhow boats. Additionally, unlicensed dhow boats were often allowed to trawl, and the total fishing effort approached or exceeded the pre-war levels. Industrial boats numbered 35 in 2009, but high maintenance and low catch rates made the two shrimp fishing companies (United Fishing Company (UFK) and National Fishing Company (NFC) consider alternatives. The industrial shrimping fleet was restructured by exchanging one steel-hull trawler for 1.4 fiberglass dhow boats. Twenty-seven double rigged industrial trawlers were exchanged for 38 fiberglass dhow boats, which tow a single net. At present, UFK operates 8 industrial trawlers (Al-Foudari et al, in press).

The shrimp landings are able to meet 73% of the local demand and the remaining is imported as fresh shrimp from Iran, Saudi Arabia and India (CSB, 2011).

During its 50-yr history, shrimp landings in Kuwait have exceeded 3000 tons only during four seasons: 1966/67, 1983/84, 1988/89, and 1989/90 (Fig. 2). Although annual landings fluctuate, there has been an overall tendency downward. Landings decreased from 2309 t in 2001/2002 to 1420 t in 2004/2005, and increased the following season to 2348 t (Fig. 2). For the last 5 seasons, the total shrimp catch fluctuated between a low of 1200 t to high of 2424 t, and averaged 1743 ± 504 t. Catch rates (kg/industrial boat-day) have declined from 247 kg/day in 2001/2002 season to 140 kg/day in 2011/2012 season, while the effort has reached the highest level in recent years to 10454 ± 1738 standardized industrial boat-days (Fig. 2).

Shrimping seasons in Kuwait have essentially two opening dates: 1 August for waters outside Kuwait's jurisdiction, and 1 September for territorial waters. Consequently, all landings in August are from international waters, and there is no restriction for unlicensed boats. Unlicensed vessels contribute substantially to the catch and effort statistics. In the 2011/12 season, the shrimp landed by unlicensed dhow boats amounted to 580 t (69%) of the total dhow-boat shrimp landings. The total shrimp landing from international waters was 641 t (43%) of the total shrimp landings during the 2011/12 season (Al-Foudari et al., 2013).

As a measure of abundance, catch rates were compared over a 13-year period. Standardized mean catch rates in kg/net-h at 3.3 knots of a survey in 1999–2000 (Bishop et al., 2001) and another in 2013–2014 (Al-Foudari et al., 2013) were compared. The mean catch rate for *P. semisulcatus* and for all shrimp was 2.1 and 4.0 kg/net-h at 3.3 knots, respectively, for years 1999 and 2000. For 2013 and 2014, respective catch rates were 0.8 and 1.9 kg/net-h at 3.3 knots. Assuming these catch rates reflect shrimp density between the two periods, then stocks have declined about 53%.

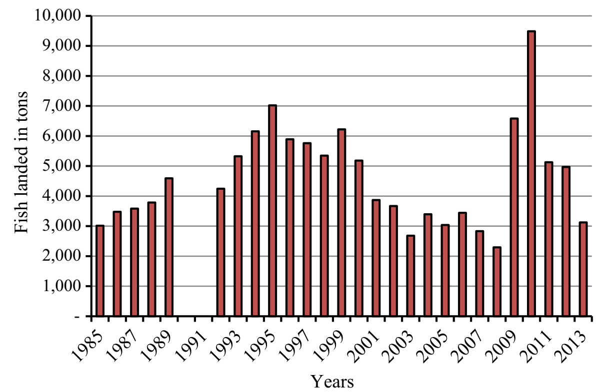

Fig. 3. Total fish landings by the artisanal and industrial fleets; data source CSB 1985–2013, data from 1990 to 1991 not included.

Table 2
Landings (t) of five important species of commercial fishes for 1995, 2005 and 2013.

Species	1995	2005	2013
Suboor	1197	154	137
Zobaidy	1085	168	247
Newaiby	1583	674	430
Hamoor	333	152	203
Hamra	137	15	29

3. Fin-fish fishery

Kuwait's main commercial fish species belong to 14 families. Some families are represented by a single species such Stromateidae (*P. argenteus*), while others, such as Sparidae) are represented by several species (Table 1). Fish stocks are often shared with neighboring countries, including Iraq, Iran, and Saudi Arabia, while others are considered to be local stocks such as *A. latus*, *O. ruber*, *L. klunzingeri*, and shrimp species. Shared stocks include *P. argenteus*, *Tenulosa ilisha*, *E. coioides*, *P. kaakan* that migrate seasonally to Kuwait waters for feeding or spawning (Al-Husaini, 2003).

P. argenteus' primary spawning grounds are Khor Musa in Iran and Kuwait Bay, while the main nursery areas include the extensive estuarine mudflats in Iran and Iraq and Khor Abdulla east of Bubyian Island (Fig. 1) in Kuwait (Al-Husaini et al., 2007). *T. ilisha* is an anadromous species and migrates up the tributaries of the Shatt Al-Arab and associated marshes for spawning and juvenile development. Juveniles, about 15 cm total length, migrate downstream to the Gulf for feeding and maturation.

It is believed that stocks of *E. coioides* (hamoor) and *L. malabaricus* (hamra) are thought to be of a single unit throughout the northern or possibly the entire Arabian Gulf, but there are few data to support or refute this assumption.

Kuwait's average landings of finfish from 1985 through 2013 is 4104 t. The maximum annual fish landings recorded since the first Gulf War was 7023 tons in 1995 (Fig. 3). Since then, landings decline gradually from 5894 tons in 1996 to 5183 t in 2000 and then dropped significantly to 4737 t in 2002. Landings continued to decrease and reached their lowest volume (2076 t) in 2008. Since then, landings have varied between 2428 in 2009 to 4199 t in 2010 (Fig. 3). The artisanal sector accounts for most of Kuwait's landings of finfish. On average the artisanal fleet accounts for 90% (3717 t) of Kuwait's finfish, but the percentage may range from 70% to 98% depending on year (Fig. 3).

Three species have been largely responsible for the decline in the landings since 1995 (Table 2). Suboor (*T. ilisha*) landings

Please cite this article in press as: Al-Husaini, M., et al. A review of the status and development of Kuwait's fisheries. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.07.053

Table 3
Percentages of selected commercial fish species in the landings for the years 1995, 2000, 2005, 2012 and 2013, and differences in percentages (±%) between 1995 and 2012 & 2013 (Data Source CSO).

Species (local name)	1995	2000	2005	2012	2013	±% – 2012	±% – 2013
P. argenteus (Zobaidy)	15.45	2.32	5.52	3.78	7.92	−75.5	−48.7
T. ilisha (Suboor)	17.05	12.40	5.08	1.48	4.39	−91.3	−74.3
P. kaakan (Nagroor)	2.79	2.14	1.96	2.01	2.96	−27.9	+6.2
E. coioides (Hamoor)	4.75	5.07	5.00	2.41	6.50	−49.2	+36.9
Liza .(Maid)	8.27	14.38	7.26	1.57	18.28	−81.0	+121.0
O. ruber (Newaiby)	22.54	20.60	22.20	10.76	14.23	−52.3	−36.9
S. commerson (Chanaed)	0.97	4.20	2.97	1.33	2.77	+38.2	+186.5
L. malabaricus (Hamra)	1.95	0.91	0.49	0.40	0.91	−79.6	−53.2
P. niger (Halwayah)	4.13	2.93	2.64	0.85	1.23	−79.5	−70.2
A. latus (Shaem)	3.79	5.14	8.24	9.80	11.60	+158.3	+206.0
P. pictus (Fersh)	0.67	1.22	0.91	0.43	1.04	−36.5	+470.7
L. nebulosus (Sheiry)	0.24	1.33	5.75	2.43	0.70	+912.0	+3.6
P. diacantha (Shmahy)	0.21	0.59	1.05	1.34	2.34	+535.3	+1010.3
S. guttatus (Khobat)	2.24	4.46	3.19	0.79	1.80	−64.7	−19.6
N. peronii (Bassi)	1.18	0.57	1.31	0.60	0.79	−49.6	−33.3
Argyrops spinifer (Andag)	0.33	0.86	1.60	6.00	0.82	+1732.0	−45.0
Others	9.03	13.80	17.14	49.91	10.93	+452.7	+149.6
Total	95.59	92.92	92.31	95.89	89.21		

decreased 87% in the 10 year period from 1995 (1197 t) to 2005 (154 t), and the latest landings data show no recovery. The situation for zobaidy (*P. argenteus*) is similar with an 85% drop from over 1000 t in 1995 to 168 t in 2005. The latest landings data for this species does show some improvement, however, but hardly a recovery. Landings of newaiby (*O. ruber*) declined from 1583 t in 1995 to 674 t in 2005, representing a 57% drop. Newaiby landings in 2013 were 430 t. Hamoor (*E. coioides*) ranks with zobaidy as Kuwait's no. 1 fish in popularity. Landings of this grouper totaled 333 t in 1995, and had decreased by over half in 2005. The 203 t landed in 2013 may be an indication of some recovery. The most "endangered" commercial species is hamra (*L. malabaricus*). The landings of this species have shown a 90% decline from 1995 (173 t) to 2005 (15 t). Landings in 2013 are about double those in 2005, but the species remains in trouble.

There appears to be two major reasons for the decline of these species: the decreased discharge of the Shatt Al-Arab and overfishing. Damming the Tigris and Euphrates Rivers in Turkey and the Karoon River in Iran have directly affected nursery and spawning areas of the anadromous suboor. Zobaidy populations are associated with estuaries, and the reduced outflow has impacted their reproduction. Additionally, zobaidy are overfished. Newaiby are also tied to estuarine conditions as they are essentially unknown in fish markets south of Kuwait. Hamoor and hamra are also overfished, but hamra has been impacted the most because of its life cycle. This species longevity is about 46 years and age-at-first maturity is 5–6 years, which makes it highly vulnerable to recruitment overfishing.

The hamoor, *E. coioides*, like other serranids, is a protogynous hermaphrodite (Abu-Hakima, 1987; Shapiro, 1987; Koenig et al., 1996; Crabtree and Bullock, 1998). The majority of juveniles mature as females, and eventually become males. Average age-at-first maturity of females is 4-5 years (35 cm standard length) and that for transitional males, between 5 and 8 years, while that for fully mature males is >8.5 years (Abu-Hakima, 1987). The general consensus among fisheries scientists in the Gulf is that this species is overexploited and removal of large size males has impacted the spawning capacity of the population(s) (Al-Husaini et al., in preparation).

The percent composition of commercial landings by species for the years 1995, 2000, 2005, 2012 and 2013 are provided in Table 3. The percent decrease or increase for comparisons between 1995 and the two most recent years is also provided. The percent contribution to total landings of most prime species has decreased significantly such as those for *P. argenteus*, *T. ilisha*, *O. ruber*, *P. kaakan*, *L. malabaricus*, *S. guttatus*, *P. niger* and *N. peronii*, while the percentages of other species have increased. Percent increases were found for *S. commerson*, *A. latus*, *P. pictus*, *L. nebulosus*, *P. diacantha*, and *A. spinifer*. Few fish species, *Lethrinus* sp. and *Parupeneus* sp., have recently expanded their traditional range into Kuwait Bay and areas north of their traditional range in Kuwait. This expanded range is believed to be a result of increased salinities from the reduced discharge of the Shatt Al-Arab.

Table 4
The average catch per unit effort (kg/trap pull) for important fish species for Kuwait's gargoor fishery.

Local Name	Species	1982–1987[a]	1992[b]	1997–1999[c]	2003–2005[d]
Hamoor	*Epinephelus coioides*	4.813	0.962	0.373	0.494
Nagroor	*Pomadasys kaakan*	0.051	0.168	0.095	0.286
Newaiby	*Otolithes ruber*	0.631	0.094	2.347	0.073
Shaem	*Acanthopagrus latus*	0.074		0.183	0.158
Hamrah	*Lutjanus malabaricus*	3.338	0.515	0.531	0.079
Shiery	*Lethrinus* spp.	0.126		0.110	0.740
Fersh	*Plectorhinchus pictus*	0.808	0.193	0.346	0.403
Chanaaed	*Scomberomorus commerson*	0.210			
Others		2.352	0.324	0.440	1.438
Total		12.403	2.256	4.425	3.671

[a] KISR (1988).
[b] Al-Hossaini (1994).
[c] Al-Husaini et al. (2000).
[d] Al-Baz et al. (2007).

Since 1980, fishery operations have been limited to Kuwait's territorial waters due to restricted access by other Gulf countries. The fishery management regulations imposed in the 1980s include a closed season for zobaidy, protected areas (Kuwait Bay and three nautical mile coastal zone), mesh size restrictions, effort limitation, and hadrah removal from Kuwait Bay and Khor Sabiyah to reduce unnecessary mortality and optimize productivity.

Al-Husaini et al. (2007) found that Khor Abdulla, directly affected by the Shatt Al-Arab discharge, was the main nursery area for zobaidy in Kuwaiti waters. Systematic sampling around Bubyan Island (Bishop et al., 2005) found that the island's estuarine waters also to be prime nursery habitat for nagroor (*P. kaakan*) and the jinga prawn (*M. affinis*).

The most recent survey to estimate demersal fish abundance (biomass density, kg/km^2) was conducted from 2008 to 2011. Quarterly sampling of 18 stations using the swept area method

Table 5
Average catch per unit effort (kg/1000 m of net) for important fish species for Kuwait's gillnet fishery.

Local Name	Species	1982–1987[a]	1992–1993[b]	1994–1996[c]	1997–1999[d]	2003–2005[e]
Zobaidy	*Pampus argenteus*	43.695	5.752	9.161	13.190	3.510
Suboor	*Tenualosa ilisha*	72.198	12.249	65.980	25.300	
Maid	*Liza spp.*	485.342	227.823	397.791	289.000	
Newaiby	*Otolithes ruber*	16.830	3.775	52.279	1.467	
Shaem	*Acanthopagrus latus*	236.632	2.933	7.689	10.422	
Nagroor	*Pomadasys kaakan*	46.212	2.217	11.747	24.960	

[a] KISR (1988).
[b] Al-Hossaini (1994).
[c] Fisheries Research Activity (unpublished data).
[d] Al-Husaini et al. (2000).
[e] Al-Husaini et al. (2007).

Table 6
Standardized catch per unit effort (kg/fishing hour) for important fish species for Kuwait's trawl fishery.

Local Name	Species	1982–1987[a]	1991–1992[b]	1997–1999[c]	2012–2014[d]
Zobaidy	*Pampus argenteus*	1.655	0.089	0.148	0.182
Newaiby	*Otolithes ruber*	1.065	1.436	1.564	0.498
Shaem	*Acanthopagrus latus*	0.080	0.252	0.526	0.728
Nagroor	*Pomadasys kaakan*	0.112		0.083	0.056
Hamoor	*Epinephelus coioides*	0.080	0.043	0.140	0.095

[a] KISR (1988).
[b] Al-Hossaini (1994).
[c] Al-Husaini et al. (2000).
[d] Shrimp dhow boat trawlers.

by trawl (Al-Husaini et al., 2012) found the mean biomass density to range from 831 to 1420 kg/km^2 (mean 1124). However, the average composition of the prime species was low: *E. coioides* (0.78%), *L. malabaricus* (0%), *P. kaakan* (0.39%), *N. peronei* (0.57%) and *A. spinifer* (0.3%). Percentages for *A. latus* (5.08%) and *O. ruber* (3.20%) were considerably higher, but biomass was dominated by non-commercial species such as *Plicofollis tenuispinis* (Family Ariidae, 22–41%) and *Pomadasys stridens* (Family Haemulidae, 7–26%).

Comparisons of the results of the above survey with those from previous surveys conducted by KISR were not possible because of data deficiencies, but comparisons were made with historical surveys conducted in the northern Arabian Gulf, which includes Kuwait's waters. Differences, however, in fishing gears, gear size, mesh size, area fished, time of fishing, and/or date of sampling, make direct comparisons of the survey results problematical.

We compared the peak densities during spring/summer (May–September) for three surveys results in Kuwait's waters: the FAO survey 1975/79 (FAO, 1981), RV *Georges Petit* Survey, 2003/04 (CIC, 2005) and KISR's RV *Bahith 2* in 2010 (Al-Husaini et al., 2012). The relative reduction of total demersal fish density or abundance was approximately 40%. These results are consistent and evident in other regions of the western Arabian Gulf (Al-Husaini et al., 2012).

Catch per unit effort was assessed as relative abundance for Kuwait's main prime fish species. The average catch rates (CPUE) for Kuwait's main commercial species estimated from several KISR research projects for the *gargoor* fishery (Table 4) showed continuous decreases for hamoor, nagroor, shaem and fersh from 1982–1987 to 2003–2005. CPUE for Kuwait's gillnet fishery (Table 5) showed decreases in catch rates for zobaidy, newaiby and hamra, but there were significant increases for suboor, maid, nagroor and hamoor. This is consistent with the high landings during 1995–1998. The CPUE for trawl nets (Table 6) showed the highest values were recorded after 1987, except for zobaidy. From 1997 to 1999, landings were also reasonably high prior to the decline of zobaidy, newaiby, nagroor and hamoor. The most recent CPUE (2012–14) showed decreased catch rates for newaiby, nagroor and hamoor, but an increase for shaem (Table 6).

4. Bycatch and discards

Discards consist of a mixture of non-commercial species, sharks and rays as well as juveniles of commercial species. The annual quantities of bycatch landings and discards depend on the amount of trawling effort exerted.

Most bycatch fish landings result from the shrimp fishery. KISR (1989) reported shrimp trawl bycatch composition as follows: (1) prime commercial species landed by the industrial and artisanal fleet was estimated to be 200 t/year; (2) sharks and rays of various species landed in small quantities, but the estimated quantities were approximately 4000 t/year (1984 estimates); (3) catfish volume (Family Ariidae, four species; majority *P. tenuispinis* and *Netuma bilineata*) estimated at 1400 t/year and landed in small quantities; (4) mixed fish of all small species of lower commercial value and also juveniles of commercial species. The estimated catches of this category was 10,000 t/year and only small quantities were landed. The main bycatch species included *Leiognathus* spp., *P. stridens*, *Cynoglossus arel*, *Saurida* spp., *Johnius* spp., *Nemipterus* spp., and *Platycephalus indicus*. The composition of the bycatch species vary seasonally for some major species such as *P. stridens*, *Parupeneus* spp., *Caranx* species, and catfish species.

A detailed shrimp bycatch study for the 1987/88, 1988/89, and 1989/90 seasons showed that bycatch quantities ranged from 34,740 to 55,500 tons and more than 98% of these catches were discarded (Ye et al., 2000). They reported the bycatch:shrimp ratio for the three shrimp seasons ranged from 6.78 to 15.32. Ariidae accounted for about 30% of the discarded fish, while the cat shark (*Chilloscyllium griseum* = *C. arabicum*) and mixed guitar fishes accounted for 14% and 3%, respectively. Capture of *C. arabicum* is of concern as this species is listed as near threatened by the IUCN (http://www.iucnredlist.org/details/161426/0; accessed 28 December 2014). The landed prime species were newaiby (*O. ruber*), maid (*Liza* species), zobaidy (*P. argenteus*), hamoor (*E. coioides*), shaem (*Acanthopagrus* sp.) and sheiry (*L. nebulosus*).

The bycatch:shrimp ratio in 1999–2000 was 74:1 (Bishop et al., 2001), but this ratio includes trawl catches in Kuwait Bay as well as prior to shrimp season opening. Guitarfish (Rhinobatidae) and mixed fish, which are mostly small and low commercial value species, constituted an average of 57% of the discards in the Kuwait shrimp fishery.

The composition of bycatch varies temporally between Kuwait's northern, including Kuwait Bay, and southern fishing grounds (Al-Ayoub et al., 2005). The most abundant bycatch species in decreasing order by weight were *O. ruber*, *Arius* [*Plicofollis*] *tenuispinis*, *P. stridens*, *Polydactylus sextarius*, *Himantura gerrardi* (= *H. randalli*), *Johnius vogleri*, *P. argenteus*, *C. arel*, *Himantura imbricata*. The discards were dominated by Ariidae species (sea catfishes) (49%), *P. stridens* (36.8%), *Nematalosa nasus* (11.6%). Other species contributing <10% of the mixed-fish bycatch were *P. indicus* (8.5%), *Terapon jarbua* (7.2%), of *Selaroides leptolepis* (6.2%) and *Chelonodon patoca* (5.4%). The remainder of the mix fish accounted for 24.3% (Al-Ayoub et al., 2005).

The bycatch:shrimp ratio varied from 5.4 to 73.6 at the beginning and end, respectively, of the 2010/11 shrimp season (Chen et al., 2013). Retained quantities of bycatch were 11.6–15.9% and were comprised mostly of *Acanthopagrus* sp., *O. ruber*, *Nemipterus* species, *Saurida tumbil*, *C. arel*, *Sphyraena* species, and *N. nasus*. Chen et al. (2013) estimated the landed bycatch at 2,192 tons, while the volume of discards was 13,512 tons, of which 7% were juveniles of commercial species.

5. Environmental issues

The marine ecosystem of the northern Arabian Gulf is characterized by high productivity, both benthic and pelagic, and about 70% is derived from phytoplankton (Jones et al., 2002). The nutrients and fluvial inputs from the Shatt Al-Arab River are the main reasons for high primary productivity in Kuwait's waters.

The average phytoplankton primary production rate in Kuwait waters is 153 $\mu g\ C\ l^{-1}\ d^{-1}$ (range 11–610 $\mu g\ C\ l^{-1}\ d^{-1}$) (Al-Yamani et al., 1997). Average chlorophyll concentration varied between 2.0 and 9.0 $\mu g\ l^{-1}$ (Al-Yamani et al., 2004). The mean value of chlorophyll in Kuwait's northern waters was 5.0 $\mu g\ l^{-1}$, but there is a significant downward trend of 0.08 μg chlorophyll $l^{-1}\ yr^{-1}$ over the 10 year-period from 2004 to 2013 (Al-Yamani et al., 2014). The mean chlorophyll concentration in Kuwait's southern offshore waters over this time period was 1.13 $\mu g\ l^{-1}$ (Al-Yamani et al., 2014). The change in primary productivity will probably alter zooplankton diversity and productivity and consequently the trophic chain.

The hydrodynamic regime of the northern Kuwait waters has been altered by the reduction in freshwater input as a result of dam construction in the Tigris, Euphrates, and Karoon drainage basins. These dams have virtually eliminated seasonal flood events, which are extremely important for nutrient input, lowering salinities, and triggering certain biological events such as migration or spawning. Salinities have increased from $\sim$36 in 1981–1982 to an average of $\sim$ 44 in recent years (Al-Yamani et al., 2014). This salinity change will result in changes in plankton species composition, diversity and biomass, which will have knock-on effects for higher trophic levels. Moreover, annually averaged sea temperature data for June–August over the years 2005–2012 have shown increasing tendencies (Al-Yamani et al., 2014).

Implications for nutrient reduction are very likely to have a major impact on Kuwait's primary shrimp species, *P. semisulcatus*. Throughout its range, the juveniles of this species are associated with benthic vegetation. It is believed that one of the major causes of the maximum shrimp harvest in 1988/89 was good environmental conditions. A major flood occurred in the Shatt Al-Arab in 1988 (Al-Hassan, 1999) resulting in reducing salinities off Kuwait's coast to 38 and prolonging cool water temperatures. These conditions promote sargassum growth and delayed it from breaking free of its holdfast, thus providing post larvae and juveniles with prime nursery habitat over a prolonged period (Siddeek et al., 1994).

Contamination of coastal areas as a result of major discharge events of untreated sewage is also a concern. In August 2009, a breakdown of pumps resulted in the prolonged discharge of thousands of tons of sewage for more than a year (Saeed et al., 2012; Al-Yamani et al., 2011). Consequences of eutrophication with limited circulation and favorable sea temperatures lead to harmful algal blooms (HABs) (Heil et al., 2001; Subba Rao et al., 2003) or low dissolved oxygen that can result in fish kills (Gilbert et al., 2002). Brine released into the marine environment as a consequence of desalination is another stressor to the ecosystem. Power plant cooling water is returned to the sea at 5–6 °C higher than the ambient water temperature, and results in localized impacts with additional contaminants such as biocides.

Coastal developments and landfill along Kuwait shores in the past thirty years has destroyed or impacted negatively the nursery areas for shrimp and fish species. As of 1999, a total of over 13.4 km^2 had been reclaimed or dredged in Kuwait Bay, and another 6.6 km^2 reclaimed or dredged south of Kuwait Bay (Bishop, 1999). The intertidal zone is among the most productive and important as shrimp and many fish species depend on intertidal areas for nursery grounds.

Climate change and acidification will become increasingly important issues with time. Temperature rise of just one or two degrees will have profound effects on the timing and location of fish spawning, and decreasing pH will impact crustaceans, mollusks, corals, and other species ability to balance Ca/K ratios so important in osmoregulation. The mean annual air temperature in Kuwait over the last four decades has increased 1.7 °C (Al-Yamani et al., 2014). The temperature data series for Kuwait's waters is too short to show noticeable changes at present, but this will be a focus for long-term investigations.

In conclusion, fisheries management in Kuwait is confronting several environmental and anthropogenic challenges. The most demanding issue for fisheries management is a rigorous and robust monitoring system for the commercial and low-demanded fishery species. The system should monitor mainly catch, fishing effort by gear, discarded bycatch, and abundance including spawning biomass. Except for intermittent years, fishing effort estimates are lacking for most gear types, except for shrimp trawling. In addition, the impact of fishing gears, particularly shrimp trawling, on the fisheries ecosystem need to be lessened using bycatch reduction devises (BRD) and avoiding gear loss for gillnets and *gargoor* (Al-Ayoub et al., 2005; Al-Baz et al., 2007).

Ecosystem-based fisheries management (EBFM) concept would a suitable approach for Kuwait not only to manage single target species, but also to consider other ecosystem components such as critical habitats, fishing impacts on non-target and protected species, trophic interactions and socio-economic aspects.

Acknowledgements

Funding agencies for some of the projects on which this paper is based include the Kuwait Foundation for the Advancement of Science, the Gulf Cooperation Council, Islamic Development Bank, the Arab Fund for Economic and Social Development, the International Fund for Agricultural Development, Kuwait Public Authority for Agriculture Affairs and Fishery Resources, the Kuwait Environmental Protection Authority, and the Kuwait Ministry of Public Works. Their financial support is gratefully acknowledged. The Kuwait Institute for Scientific Research also provided financial support and served as the host institution for much of the research results cited in this review.

References

Abdul-Ghaffar, A.R., Al-Ghunaim, A.Y.Y., 1994. Review of Kuwait's shrimp fisheries, their development and present status. In: Proceedings, Technical Consultation on Shrimp Management in the Arabian Gulf. Al Khobar, 6–8 November 1994, Saudi Arabia.

Al-Attar, M.H., 1984a. Kuwait Bay: A nursery area for penaeid shrimp: I *Penaeus semisulcatus*. In: Mathews, C.P. (Ed.,) Proceedings, Third Shrimp and Fin

Fisheries Management Workshop, Fin Fisheries Session 4–5 December 1982, Final Report (MB-41), vol. 1. Kuwait Institute for Scientific Research Report No. 1156, pp. 85–112.
Al-Attar, M.H., 1984b. Kuwait Bay: A nursery area for penaeid shrimp: II. *Metapenaeus* sp. In: Mathews, C.P. (Ed.), Proceedings, Shrimp and Fin Fisheries Management Workshop, 9–11 October 1983, Final Report (MB-48), vol 1. Kuwait Institute for Scientific Research Report No. 1366, pp. 207–222.
Al-Attar, M.H., Ikenoue, H., 1974. Spawning Season of Shrimp Penaeus Semisulcatus in the Sea along the Coast of Kuwait. Kuwait Institute for Scientific Research, 16 p.
Abu-Hakima, R., 1987. Aspects of the reproductive biology of the grouper, *Epinephelus tauvina* (Forskal), in Kuwait waters. J. Fish Biol. 30, 213–222.
Al-Ayoub, S., Al-Husaini, M., Al-Baz, A., Chen, W., Alsaffar, A.H., Bishop, J.M., Dashti, T., Al-Jazzaf, S., TAqi, A., Al-Saad, F., Almatar, S., Eayrs, S., Bose, S., Day, G., Murad, H., 2005. Application of bycatch Reduction Devices to Kuwait's Shrimp Fishery (Final Report FM029). Kuwait Institute for Scientific Research Report No. KISR7762.
Al-Baz, A.F., Bishop, J.M., Chen, W., Al-Husaini, M., Al-Jazzaf, S., Dashti, T., Taqi, A., 2007. An Investigation to Improve Kuwait's Demersal Trap Fishery (Final Report FM022). Kuwait Institute for Scientific Research Report No. KISR8856.
Al-Baz, A.F., Al-Husaini, M.M., Bishop, J., Al-Ayoub, S.A., Chen, W., Al-Jazzaf, S., Dashti, T., Murad, H., 2003. An Assessment of the Hadrah Fishery and its Impact of commercial Fish Species. Kuwait Institute for Scientific Research, Report No. KISR 7032, (Final Report, FM031C), Safat, Kuwait.
Al-Foudari, H.M., Alsaffar, A.H., Bishop, J.M., Chen, W., Dashti, T., Al-Jazzaf, S.T., Al-Alawi, A., Taqi, A. 2013. A Comparative Management Strategy for the Long-Term Sustainability of Kuwait's Shrimp Stocks. Progress Report No. 4. Kuwait Institute for Scientific Research Report No. KISR11688, Kuwait.
Al-Foudari, H.M., Chen, W., Bishop, J.M., Alsaffar, A.H., Deshti, T., Al-Jazzaf, S.T., Al-Alawi, A., Taqi, A., in press. A Comprehensive Management Strategy for Long-term Sustainability of Kuwait's Shrimp Stocks. Final Report (FM047C). Kuwait Institute for Scientific Research, Kuwait.
Al-Hassan, L.A.J., 1999. Shad of the Shatt Al-Arab River in Iraq. Shad J. 4, 1–4.
Al-Husaini, M., Al-Baz, A., Rajab, S., Al-Alawi, A., Chen, W., Dashti, T., Al-Jazzaf, S., Husain, H., Almatar, S., Al-Ramadhan, A., Al-Radhi, A.K., Al-Binali, A.R., Al-Yafee, E., Al- Maamari, J., 2012. Survey of the Demersal Fish Stocks of the Arabian Gulf and Sea of Oman, Volume 1: Main Text. Kuwait Institute for Scientific Research, Report No. KISR 11170, (Final Report, FM045C), Safat, Kuwait.
Al-Husaini, M., Marammazi, J., Al-Baz, A., Al Ayoub, S., Chen, W., Eskandari, G., Safikhani, H., Ansari, H., Dehghani, S., Al-Jazzaf, S., Dashti, T., Al-Sabah, I., Taqi, A., Rezwani, S., Kashi, M.T., Valinasab, T., Maiiahi, Y., Murad, H., 2007. Stock Assessment of Zobaidy, Pampus argenteus, in the Northern Gulf (Final Report FM039). Kuwait Institute for Scientific Research Report No. KISR8695.
Al-Husaini, M., 2003. Fishery of shared stock of the silver pomfret, Pampus argenteus, in the Northern Gulf: A case study. In: FAO Papers Presented at the Norway-FAO Expert Consultation on the Management of Shared Fish Stocks Bergen, Norway, 7–10 October 2002, FAO Fisheries Report No. 695 Supplement, Rome: 44–56.
Al-Hossaini, M., 1994. Fin-fish and Shrimp Fisheries Management, Kuwait Institute for Scientific Research, Report No. 4367, (Final Report, Food-4), Safat, Kuwait.
Al-Husaini, M., Al-Baz, A., Ye, Y., Al-Ayoub, S., Dashti, J., Safar, S., Al-Wazan, Z., Al-Baghli, A.A., Al-Jazzaf, S., 2000. Stock Assessment of Finfish Resources (FM014C) – Final Report. Kuwait Institute for Scientific Research. Report No. KISR 5935, Kuwait.
Al-Husaini, M., Chen, W., Al-Baz, A., Rajab, S., Under preparation. Age, Growth, and Stock Assessment of Orange-Spotted Grouper, Epinephelus coioides, in Kuwait Waters.
Al-Yamani, F., Polikarpov, I., Al-Said, T., Skryabin, V., Al-Rifaie, Kh., Al-Ismail, W., Saburova, M., 2011. Sewage wastewater dumping into Kuwait's waters and its effect on plankton communities, A preliminary report of the Oceanography Group/MFD-KISR on the Results of the Surveys. Kuwait Institute for Scientific Research, Kuwait.
Al-Yamani, F., Durvasula, R., Ismail, W., Al-Rifaie, K., Al-Saeed, T., Al-Yaqout, A., Al-Omran, L., 1997. Dynamic oceanography of the northwestern waters of the Arabian Gulf: ecological significance of the marine food web. Kuwait Institute for Scientific Research Report No. KISR5173. Safat, Kuwait. 252 p.
Al-Yamani, F., Stokozov, N., Polikarpov, I., Al-Said, T., Al-Rifaie, K., Lennox, A., 2014. Oceanography Annual Report Card 2013–2014. Kuwait Institute for Scientific Research, Kuwait.
Anonymous, 1988. On the cancellation of some licenses for wooden shrimp trawlers (in Arabic). Ministerial Decree 727/88, 24 December.
Anonymous, 1989a. On the cancellation of some licenses for wooden shrimp trawlers which are outside the country [Kuwait] (in Arabic). Ministerial Decree 91/89, 6 February.
Anonymous, 1989b. On the cancellation of some licenses for steel shrimp trawlers (in Arabic). Ministerial Decree 92/89, 6 February.
Beech, M., 2002. Fishing in the 'Ubaid: a review of fish-bone assemblages from early prehistoric coastal settlements in the Arabian Gulf. J. Oman Studies 12, 25–40.
Bishop, J.M., Ye, Y., Alsaffar, A.H., Fetta, N., Abdulqader, E., Lui, Q., Al-Mohammadi, J., Al-Qasseer, J., Al-Mulla, A.A., Sudiqe, A.R., El Abdulhady, A.R.M., Al-Jazzaf, S.T., Al-Dhubaib, A.H., Al-Juwaied, K.H., Al-Foudari, H., Almatar, S., El-Ramadan, A.H.M., El-Salah, A.A., El-Rabeigh, A.A., El-Askary, S.A., Al-Ibrahim, E.H., 2001. Shrimp Stock Assessment in the Western Arabian Gulf by Countries of the Gulf Cooperation Council, Final Report (MB021C). Kuwait Institute for Scientific Research Report No. 6291, Kuwait.
Bishop, J.M., 1988. A survey of Kuwait shrimp nursery grounds and establishment of a shrimp recruitment index, final report. Kuwait Institute for Scientific Research, Report No. KISR2622, Kuwait.
Bishop, J.M., 1989. Review of shrimp nursery ground studies in Kuwait Bay, 1984–1986. Kuwait Bullet. Mar. Sci. 10, 37–50.
Bishop, J.M., 1994. Post-war survey and evaluation of Kuwait shrimp nursery grounds with emphasis on those south of Kuwait Bay, Phase II. Kuwait Institute for Scientific Research, Report No. KISR4357, Kuwait.
Bishop, J.M., 1999. Current and planned coastal urban development. In: Al-Yamani, F., Bishop, J., Al-Hossaini, M., Subba Rao, D.V., Al-Attar, M., Salman, M., AbdelJawad, M., Al-Tabtabaei, M., Behbahani, M., Morgan, G.R. (Eds.), Development Study for the Optimal Utilization of the Marine Environment. Current and Planned Utilization and Management of Kuwait's Marine Environment. Kuwait Institute for Scientific Research, Report No. KISR5511, Kuwait (FM004C; Final Report, Task 2), pp. 169–184.
Bishop, J.M., Khan, M.H., 1999. Use of intertidal and adjacent mudflats by juvenile penaeid shrimps during 24-h tidal cycles. J. Exp. Mar. Biol. Ecol. 232, 39–60.
Bishop, J.M., Chen, W., Alsaffar, A.H., Al-Foudari, H.M., 2011. Indirect effects of salinity and temperature on Kuwait's shrimp stocks. Estuaries Coasts 34, 1246–1254.
Brewer, D., Rawlinson, N., Eayrs, S., Burridge, C., 1998. An assessment of by catch reduction devices in a tropical Australian prawn trawl fishery. Fish. Res. 36, 195–215.
Carpenter, K.E., Harrison, P.L., Hodgson, G., ALsafar, A.H., Alhazeem, S.H., 1997. Corals and Coral Reef Fishes of Kuwait. Fahad Al-Marzouk Printing & Publishing, Kuwait.
Chen, W., Almatar, S., Alsaffar, A., Yousef, A.R., 2013. Retained and discarded bycatch from Kuwait's shrimp fishery. Aquatic Science and Technology 1, 2168–9148.
Consortium of International Consultants (CIC), 2005. Final Report to the Public Authority for the Assessment of Claims of Compensation for Damages Resulting from Iraqi Aggression (PAAC) on Assessment of Marine Environmental Damage, Report No. MD 5.12, Cluster 2, work program 2, Kuwait.
Crabtree, R.E., Bullock, L.H., 1998. Age, growth, and reproduction of black grouper, *Mycteroperca bonaci*, in Florida waters. Fish Bull. 96, 735–753.
CSB, 1985. Fisheries Statistics. Central Statistical Office, Ministry of Planning, Kuwait.
CSB, 1995. Fisheries Statistics. Central Statistical Office, Ministry of Planning, Kuwait.
CSB, 2005. Fisheries Statistics. Central Statistical Office, Ministry of Planning, Kuwait.
CSB, 2011. Fisheries Statistics. Central Statistical Office, Ministry of Planning, Kuwait.
FAO, 1981. Demersal resources of the Gulf and the Gulf of Oman, Food and Agriculture Organization. Regional Fishery Survey and Development Project DP/RAB/71/278/10, Rome, Italy.
Farmer, A.S.D., Ukawa, M., 1986. A provisional atlas for the commercially important penaeid shrimps of the Arabian Gulf. Kuwait Bull. Mar. Sci. 7, 23–44.
Gilbert, P.M., Landsberg, J.H., Evans, J.J., Al-Sarawi, M.A., Faraj, M., Al-Jarallah, M.A., Allison Haywood, A., Klesius, P., Powell, C., Shoemaker, C., 2002. A fish kill of massive proportion in Kuwait Bay, Arabian Gulf, 2001: the roles of bacterial disease, harmful algae, and eutrophication. Harmful Algae 1, 215–231.
Gulland, J.A., 1989. The optimum opening date in shrimp fishing; a sensitivity analysis. Kuwait Bull. Mar. Sci. 10, 71–79.
Heil, C.A., Gilbert, P.M., Al-Sarawi, A., Faraj, M.Behbehani., Husain, M., 2001. First record of fish-killing Gymnodinium sp. bloom in Kuwait Bay, Arabian Sea: chronology and potential causes. Mar. Ecol. Prog. Ser. 214, 15–23.
Iwatsuki, Y., 2013. Review of the *Acanthopagrus latus* complex (Perciformes: Sparidae) with descriptions of three new species from the Indo-West Pacific Ocean. J. Fish Biol. 83, 64–95.
Iwatsuki, Y., Carpenter, K.E., 2009. *Acanthopagrus randalli* (Perciformes: Sparidae), a new black seabream from the Persian Gulf. Zootaxa 2267, 43–54.
Jones, D., Al-Attar, M.H., 1982. Observation on the post-larval and juvenile habitats of Penaeus semisulcatus in Kuwait Bay and adjacent waters. In: Mathews, C.P. (Ed.), Revised Proceedings, Shrimp Fisheries Management Workshop, Final Report (MB-32). Kuwait Institute for Scientific Research Report No. KISR670, pp. 112–133.
Jones, D.A., Price, A.R.G., Al-Yamani, F., Al-Zaidan, A., 2002. Coastal and marine ecology. In: Khan, N.Y., Munawar, M., Price, A.R.G. (Eds.), The Gulf Ecosystem Health and Sustainability. Kuwait Institute for Scientific Research and Backhuys Publishers, Leiden, pp. 65–103.
Jones, R., van Zalinge, N.P., 1981. Estimates of mortality rate and population size for shrimp in Kuwait waters. In: Proceedings of the International Shrimp Releasing, Marking and Recruitment Workshop, 25–29 November 1978, Salmiya, State of Kuwait. Kuwait Bulletin of Marine Science 2:273–288.
Khalaf, F., Al-Bakri, D., Al-Ghadban, A., 1984. Sedimentological characteristics of the surficial sediments of the Kuwaiti marine environment, northern Arabian Gulf. Sedimentology 31, 531–545.
KISR, 1989. Strategic Framework and Master Plan for Fisheries Development in Kuwait. Technical Appendix 4: Evaluation of Fisheries Bycatch and Agricultural By-products for Fish Feed. Kuwait Institute for Scientific Research Report No. KISR2907, Kuwait. 59 p.
KISR, 1988. Strategic Framework and Master Plan for Fisheries Development in Kuwait. Technical Appendix 3: Monthly Catch and Fishing Effort Data for Kuwait's Shrimp and Fish Landings (1982–1987). Kuwait Institute for Scientific Research Report No. KISR2907, Kuwait. 206 p.

Koenig, C.C., Coleman, F.C., Collins, L.A., Sadovy, Y., Colin, P.L., 1996. Reproduction in gag (*Mycteroperca microlepis*) (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregation. In: Arreguín-Sánchez, F., Munro, J.L., Balgos, M.C., Pauly, D. (Eds.), Biology, Fisheries and Culture of Tropical Groupers and Snappers. ICLARM Conf. Proc. vol. 48, pp. 307–323.

Kristjonsson, H., 1968. Techniques of finding and catching shrimp in commercial fishing. Food and Agriculture Organization of the United Nations, Fisheries Report 57. vol 2, pp. 125–192.

Mathews, C.P., 1986. Shrimp Fisheries Management Project, Phase III, Final Report (MB-47). Kuwait Institute for Scientific Research Report No. KISR2180, Kuwait.

Mathews, C.P., Samuel, M., 1989. The relation between bycatch, shrimp catches and shrimp landings in Kuwait. Kuwait Bull. Mar. Sci. 10, 135–146.

Mohamed, K.H., El-Musa, M., Abdul-Ghaffar, A.-R., 1981. Observations on the biology of an exploited species of shrimp, *Penaeus. Semisulcatus* De Haan, in Kuwait. Kuwait Bull. Mar. Sci. 2, 33–52.

Mohammed, H.M.A., Bishop, J.M., Xu, X., 1996. Population characteristics of green tiger prawns, *Penaeus semisulcatus,* in Kuwait waters prior to the Gulf war. Hydrobilogia 337, 37–47.

Mohammed, H.M.A., Bishop, J.M., Ye, Y., 1998. Kuwait's post Gulf-War shrimp fishery and stock status from 1991/92 through 1995/96. Rev. Fish. Sci. 6, 253–280.

Morgan, G.R., 1989. Separating environmental and fisheries effects in the recruitment of Gulf shrimp. Kuwait Bull. Mar. Sci. 10, 51–59.

NOAA, 2011. <http://www.st.nmfs.noaa.gov/st1/fus/fus11/08_percapita2011.pdf>.

Pender, P, Willing, R., Ramm, D., 1993. Northern prawn fisheries bycatch study: distribution, abundance, size and use of by catch from mixed species fishery. Northern Territory Department of primary Industry and Fisheries, Darwin, N.T. (Australia), pp. 1–70.

Rao, D.V. Subba, Behbahani, M., 1999. Current and planned development of marine based recreation. In: Al-Yamani, F., Bishop, J., Al-Hossaini, M., Subba Rao, D.V., (Eds.), Development Study for the Optimal Utilization of the Marine Environment. Task 2. Current and Planned Utilization and Management of Kuwait's Maine Environment. Final Report (FM004C). Kuwait Institute for scientific Research Report No. KISR5511, pp. 98–123.

Saeed, T., Al-Bloushi, A., Abdullah, H.I., Al-Khabbaz, A., Jamal, Z., 2012. Preliminary assessment of sewage contamination in coastal sediments of Kuwait following a major pumping station failure using fecal sterol markers. Aquat. Ecosyst. Health Manage. 15, 25–32.

Siddeek, M.S.M., Abdul-Ghaffar, A.R., El-Musa, M., 1988. Shrimp Fisheries Management Project, Phase IV, Final Report (MB-62). Kuwait Institute for Scientific Research Report No. KISR2570, Kuwait.

Siddeek, M.S.M., Abdiul-Ghaffar, A.R., 1989. The effects of the one month delay in opening the shrimp fishing season of *Panaeus semisulcatus* in 1986 in Kuwait waters. Kuwait Bull. Mar. Sci. 10, 81–96.

Siddeek, M.S.M., Bishop, J.M., El-Musa, M., Abdul-Ghaffar, A.R., Abdulla, M.S., 1994. Possible reasons for increased landings of Kuwait's green tiger shrimp (*Penaeus semisulcatus*) in the 1ate 1980s. In: Chou, L.M., Munro, A.D., Lam, T.J., Chen, T.W., Cheong, L.K.K., Ding, J.K., Hooi, K.K., Khoo, H.W., Phang, V.P.E., Shim, K.F., Tan, C.H. (Eds.), Proceedings of the Third Asian Fisheries Forum, 26–30 October 1992, Singapore. The Asian Fisheries Society, Manila, pp. 224–227.

Shapiro, D.Y., 1987. Reproduction in groupers. In: Polovina, J.T., Ralston, S. (Eds.), Tropical Snappers and Groupers: Biology and Fisheries Management. West View Press, pp. 295–327.

Subba Rao, D.V., Al-Hassan, J.M., Al-Yamani, F., Nageswara Rao, C., Al-Hassan, M., 2003. Elusive red tides in Kuwait coastal waters. Harmful Algal News, IOC, UNESCO 24, 10–13.

van Zalinge, N.P., 1981. Kuwait's artisanal fisheries: A sampling program for shrimp landings (MB-29). KISR/FAO: NO5. Kuwait Institute for Scientific Research, Report No. KISR396, Kuwait.

van Zalinge, N.P., El-Musa, M., Abdul-Ghaffar, A.R., 1984. The development of the Kuwait's shrimp fishery and a preliminary analysis of its present status. Kuwait Bull. Mar. Sci. 2, 11–32.

Wright, J.M., 1988. Recruitment patterns and trophic relationships of fish in Sulaibikhat Bay, Kuwait. J. Fish Biol. 33, 671–687.

Xu, X., Mohammed, H.M.A., 1996. An alternative approach to estimating growth parameters from length-frequency data, with application to green tiger prawns. Fish. Bull. 94, 145–155.

Xu, X., Bishop, J.M., Mohammed, H.M.A., Alsaffari, A.H., 1995. Estimation of the natural mortality rate of green tiger prawns *Penaeus semisulcatus* (De Hann, 1844) in Kuwait waters using relative abundance data. J. Shellfish Res. 14, 179–184.

Ye, Y., 1998. Assessing effects of closed seasons in tropical and subtropical penaeid shrimp fisheries using a length-based yield-per-recruit model. ICES J. Mar. Sci. 55, 1112–1124.

Ye, Y., Mohammed, H.M.A., 1999. An analysis of variation in catchability of green tiger prawn, *Penaeus semisulcatus*, in waters off Kuwait. Fish. Bull. 97 (3), 702–712.

Ye, Y., Al-Foudari, H.M., Bishop, J.M., 1999a. Shrimp resources and fisheries in Kuwait waters. Technical Report of Kuwait Institute for Scientific Research. KISR 5473.

Ye, Y., Bishop, J.M., Mohammed, H.M.A., Alsaffar, A.H., 1999b. Development of a recruitment index for forecasting seasonal landings of the Kuwait shrimp fisheries. J. Shellfish Res. 18, 185–192.

Ye, Yimin, Alsaffar, A.H., Mohammed, H.M.A., 2000. Bycatch and discards of the Kuwait shrimp fishery. Fish. Res. 45, 9–19.

Ye, Y., Bishop, J.M., Fetta, N., Abdulqader, E., Al-Mohammadi, J., Alsaffar, A.H., Almatar, S., 2003. Spatial variation in growth of the green tiger prawn (*Penaeus semisulcatus*) along the coastal waters of Kuwait, eastern Saudi Arabia, Baharin, and Qatar. ICES J. Mar. Sci. 60, 806–817.

Please cite this article in press as: Al-Husaini, M., et al. A review of the status and development of Kuwait's fisheries. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.07.053