ECOSYSTEMS AND BIODIVERSITY OF THE ARABIAN GULF

SAUDI ARABIAN WATERS

Fifty Years of Scientific Research

A Publication by Saudi Aramco and King Fahd University of Petroleum & Minerals

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جامعة الملك فهد للبترول والمعادن
King Fahd University of Petroleum & Minerals

أرامكو السعودية
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Preface

For nearly five decades, the King Fahd University of Petroleum and Minerals (KFUPM) has partnered with Saudi Aramco to document and explore the wondrous ecosystem that exists in the Arabian Gulf. The book before you offers a comprehensive and up to date guide on the fruits of that work and its findings.

Through its pages, marine scientists, decision makers, students and indeed anyone with an interest in marine environmental protection, will have access to a wealth of scientific information.

The Arabian Gulf is environmentally challenged because of the natural stressors of salinity and temperature fluctuations. Rapid population growth and associated developmental activities along its coasts, particularly those related to the urban and industrial development, are adding additional stress on the Arabian Gulf's fragile environment.

The partnership between KFUPM and Saudi Aramco, has resulted in a greater understanding of the Arabian Gulf's natural ecosystems, ensuring greater protection of biodiversity and natural resources. The backbone of this partnership has been the Marine Environmental Sustaining Research Program, which has produced fundamental knowledge on the Arabian Gulf's marine environment. In addition, detailed and in-depth environmental impact assessments have been systematically conducted for proposed development projects as well as environmental monitoring during construction and commencement of operations, all contributing to our knowledge of the ecosystems. This information has contributed to the protection of the ecosystems and the development of a fisheries management framework in the Arabian Gulf.

We are grateful for the collaboration and efforts of the interdisciplinary teams of the Environmental Protection Department of Saudi Aramco and the Marine Studies Section of KFUPM in preparation of this book. A deep and sincere appreciation is extended to each and every person who, for nearly five decades, has played a part in this partnership in marine environment protection. This book is a testament to your hard work and our collective desire to preserve the beautiful ecosystem that flourishes in the Arabian Gulf.

Amin H. Nasser
Saudi Aramco President & CEO

Foreword

The Arabian Gulf has always been a special component of the Kingdom's economy and culture. Aside from its rich oil and gas resources, it is also an important source of food and water, and is a major transportation point. But not to be undermined or forgotten is the fact that it also supports vital and thriving ecosystems. In its waters are seagrass, coral reefs, salt marshes, and mangroves, as well as intertidal and subtidal sediments and deeper water areas. These interacting habitats provide the essential components for a vibrant and productive marine ecosystem. However impressive this may sound, the Arabian Gulf is also facing natural and human-induced stress, such as elevated seawater temperature and salinity; coupled with coastal urbanization and rapid industrialization. These stresses, if not managed, can impact the long-term ecosystem services currently provided by the Arabian Gulf.

Scientific research on its marine environment is the result of collaboration between industry and academia. It was in 1982 that the Environmental Protection Department of Saudi Aramco and the Marine Studies Section of the King Fahd University of Petroleum and Minerals began joint research into the Arabian Gulf's ecosystem. This partnership involved the development of research programs to study the Arabian Gulf's ecosystem values, interactions, and reduce the impact of stress. Currently, the sixth phase of this sustaining research program is focusing on the biodiversity status across the Arabian Gulf's ecosystems. This book gathers the results and the major scientific findings of this long-term collaborative program and provides a detailed, updated review on the state of the marine ecosystems and biodiversity of the Western Arabian Gulf. For anyone who has an interest in the topic, it serves as the current definitive work, and is a reminder of the importance of marine ecosystems.

Prof. Sahel N. Abduljauwad
Rector of King Fahd University
of Petroleum & Minerals

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Marine Invertebrates

Lotfi Rabaoui[1], Ebrahim A. A. Abdulqader[1], Rommel H. Maneja[1], and Thadickal V. Joydas[1]

Introduction

Compared to other biota, marine invertebrates of the western Arabian Gulf have received scant attention from marine scientists and taxonomists leading to a very poor to moderately known invertebrate fauna. This chapter reviews the current status of knowledge of marine invertebrates of the western Arabian Gulf. The taxonomy/diversity, ecology (distribution, habitats and seasonality) and biology (reproduction, growth, mortality) as well as the ecological and economic benefits of eight major invertebrate groups are described for the western Arabian Gulf. These groups include the phyla of Porifera (or sponges), Cnidaria, Annelida, Arthropoda (mainly represented by the class of crustaceans), and Mollusca, Echinodermata, Bryozoa and Tunicata (mainly represented by ascidians). While the taxonomy, diversity and ecology of some groups (e.g., polychaetes, molluscs, crustaceans and echinoderms) are moderately known, the knowledge on other groups are still very scarce and even nonexistent. The latter groups include sponges, cnidarians (except for scleractinian corals), bryozoans and tunicates.

Methods

For each invertebrate phylum, a bibliographic review was conducted by consulting scientific documents, including King Fahd University of Petroleum and Minerals/Research Institute (KFUPM/RI) reports and published literature (research and review papers) done concerning the area of the western Arabian Gulf, including Saudi Arabia, Kuwait, Bahrain, Qatar and the UAE. Within this context, it is worth noting that the Research Institute of King Fahd University of Petroleum and Minerals has conducted extensive surveys on the marine habitats of the Saudi Arabian Gulf (KFUPM/RI, 1987, 1990 and 2003), in addition to several environmental impact assessment studies (KFUPM/RI, 2006a, 2006b and 2014). These research activities have resulted in identification and an expanded knowledge of a large number of biota. In addition, the published studies were categorized by invertebrate groups (Porifera, Cnidaria, Annelida, Arthropoda, Mollusca, Echinodermata, Bryozoa and Tunicata) and type of study (taxonomy/diversity, biology, ecology and ecological/economic benefits), depending on the availability of the literature for each phylum. For each invertebrate group, the bibliographic synthesis was structured with respect to the different study types.

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Phylum Porifera

Sponges represent an important component of benthic habitats in many parts of the world. These colonial invertebrates are mainly abundant in tropical oceans, but some species also occur in temperate regions and even in freshwaters (Campbell and Dawes, 2005). Consequently, in spite of the ubiquitous ecological role and the important benefits of sponges, little is known about the taxonomy and eco-biology of these colonial organisms in the western Arabian Gulf (Figure 4.29). KFUPM/RI (1987) recorded at least 26 taxa (identified only to genus level) belonging mainly to class demospongiae (Appendix II). Recently, Njinkoué, et al. (2006) reported the occurrence of six species of sponges while studying the composition of phospholipid fatty acids in sponges. The species belong mainly to the genera of *Gelliodes*, *Callyspongia* and *Niphates* (Appendix II). Their study enabled identification of more than 100 saturated and unsaturated fatty acids from the recorded species.

Phylum Cnidaria

Globally, cnidarians represent a very large group of over 10,000 species (Zhang, 2011). It is mainly classified into four classes: Hydrozoa (hydras), Scyphozoa (jellyfish), Cubozoa (sea wasps) and Anthozoa (sea anemones, seafans, sea pens and corals). Among the various groups of cnidarians, only corals (scleractinian and stony corals) have been studied in detail, compared to the remaining cnidarians, which have not received needed attention. So far, no Cubozoa species have been recorded from the western Arabian Gulf and only one Scyphozoa species was reported to occur in the area (Appendix II). Because of the limited number of studies on this group, collective information on diversity, biogeography, biology and ecology of these animals are still unknown.

Information on Hydrozoa is mainly from the benthic hydroids studied on only a few occasions. KFUPM/RI (1987) and Al-Yamani, et al. (2011, 2012) reported 23 species of hydroids from the seagrass beds of the northwestern Arabian Gulf (Appendix II). The density of hydroid colonies recorded from the sand/silt habitats ranged from nil to 30 colonies per 1 m^2 in this region (KFUPM/RI, 2003).

The taxonomic records of class Scyphozoa is unknown in the western Arabian Gulf. Some observations of jellyfish blooms have been observed, and they seemed to be related to the blockage of water intakes of the coastal desalinization plans. Jellyfish are being commercially exploited from Bahrain for exporting to other Asian markets. According to an estimate, about 100 tons of dried (10% of wet weight) jellyfishes were exported in 2005, and those were exploited from six locations in Bahrain (Abdulqader, 2006). Only one Scyphozoa species has been recorded in Kuwait by Al-Yamani, et al. (2011) (Appendix II).

The most studied group of Anthozoa in the western Arabian Gulf is the corals (Figure 4.30). In this region, corals form sparse to massive coral reefs and these reefs are of particular interest because of their occurrence in very harsh conditions of extremely high salinity and temperature (Kinsman, 1964; Sheppard, et al., 1992). These factors were reported to play a crucial role in the distribution of the coral reefs in the western Arabian Gulf; the number of coral reefs decreased gradually from Abu Ali south to Ras Tanura and declined dramatically toward Bahrain and Qatar (Basson, et al., 1977). Detailed descriptions of the coral reefs are provided in Chapters 3.10 and 3.11. Within the Arabian Gulf, about 60 coral species have been recorded (Sheppard and Borowitzka, 2012)

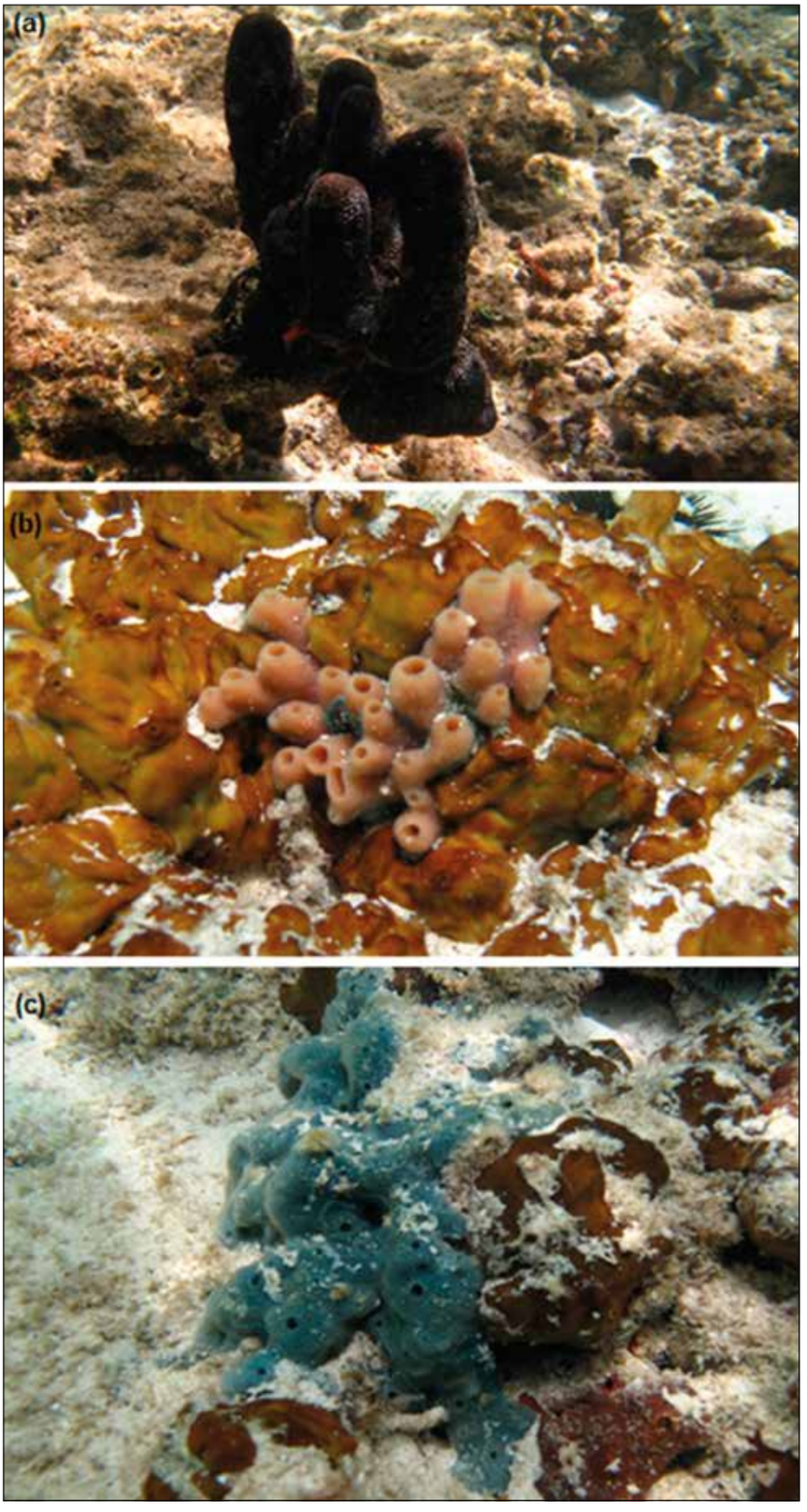

FIGURE 4.29. *Photographs of some sponge species living in the western Arabian Gulf. Unfortunately, none of the species appearing in the figure has been identified.*

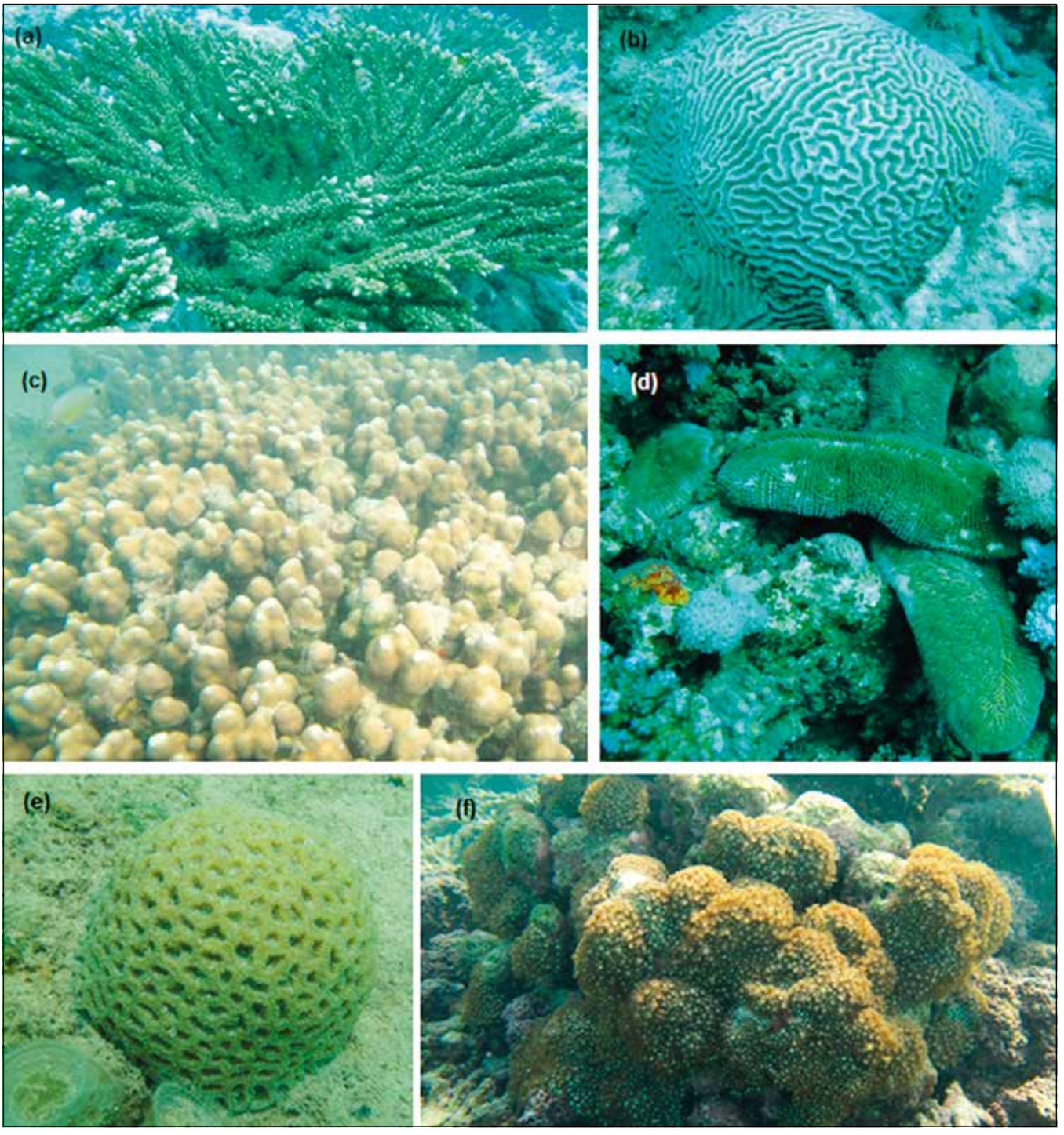

FIGURE 4.30. *Photographs of some coral species living in the Western Arabian Gulf: (a)* Acropora *sp., (b)* Platygyra *sp., (c)* Porites *sp., (d)* Ctenactis *sp., (e)* Favia *sp., (f)* Goniopora *sp.*

(Appendix II). Some of these species are endemic to the Arabian Gulf (Sheppard, et al., 2010; Claereboudt, 2006). Currently, the main reef building group is *Porites*; nevertheless, there is a chance that the increasing large colonies of *Favia* and *Platygyra* may become dominant in the future (Sheppard and Borowitzka, 2012).

Coral reefs in the Arabian Gulf have undergone huge declines in recent years due to environmental and anthropogenic reasons (Sheppard, et al., 2010). The extreme water temperatures in 1996, 1998 and 2000 caused mass coral mortality. Coastal developments have altered over 40% of the coast of most Gulf States resulting in significant loss of biodiversity and productivity (Al-Ghadban and Price, 2002).

Actiniaria (sea anemones) is another group of anthozoans studied from this region, although in a limited way. KFUPM/RI (1987) recorded two species, of which one was identified to genus level (*Anemonactis* sp.) and the second was left unidentified (Appendix II). From the Kuwait waters, four definite species were recorded, yet, none was identified to genus or species level (Al-Yamani, et al., 2009).

Phylum Annelida

Annelida, commonly referred to as segmented worms (also called ringed worms), is a large phylum with an estimated number of 14,000 species (Rouse and Pleijel, 2006). Although the first annelid (earthworm *Lumbricus terrestris*) was named by Linnaeus in 1758, it was Lamarck in 1802 who first used the term "Annelida". Until the 20th century, Annelida was usually divided into four classes, including Archiannelida, Polychaeta, Oligochaeta and Hirudinea. The name Clitellata has also been used to denote the latter two classes as they were a clade. Later, as described in a review by Rouse and Pleijel (2007), other taxa such as Echiura, Myzostomida, Pogonophora and Sipuncula have also been considered to be annelids; however, some taxonomists still consider them as different phyla. Annelids are found throughout the world in terrestrial, freshwater and marine environments. But the majority of the annelid diversity lies among the marine representatives, which can be found in all types of marine habitats, from intertidal to deep-sea sediments in benthic form and in the water column in planktonic form (Rouse and Pleijel, 2007). In this section, the major annelids reported from the western Arabian Gulf are described with a special focus on Polychaetes, due to their abundance (compared to the other annelid groups) and the ecosystem services they provide in the Arabian Gulf marine environment.

Polychaetes

Polychaetes comprise the bulk of the diversity of Annelida with approximately 9,000 species (Rouse and Pleijel, 2001). They play an important role in the functioning of benthic communities (Hutchings, 1998) and are found in nearly every marine habitat, from intertidal algal mats to the deepest sediments. They have long been considered as the best proxy taxa to assess the biodiversity (Olsgard, et al., 2003) and the health of the benthic communities (Dean, 2008) due to their large number of species and numerical abundance. Any long-term changes in the well-being of benthos will be reflected in the polychaete community (Papageorgiou, et al., 2006). The sedentary nature and longevity of polychaetes, which provide long-term exposure to toxic substances, make them good candidates to act as indicator species (Pearson and Rosenberg, 1978; Guidetti, et al., 2000; Hampel, et al., 2009). The polychaetes contain both sensitive and tolerant species in a gradient from pristine to heavily disturbed habitats (Pocklington and Wells, 1992). The opportunistic properties of polychaetes (that are able to proliferate after an increase in organic matter) have made them one of the most useful tools of environmental impact assessment in oil pollution studies (Pearson and Rosenberg, 1978; Guidetti, et al., 2000; Giangranade, et al., 2005; Hampel, et al., 2009).

In the subtidal habitats of the western Arabian Gulf, polychaetes accounted for 40% to 90% of the total macrobenthic abundance (based on various KFUPM/RI studies). A checklist of polychaetes of the Arabian Peninsula shows the occurrence of 231 species, in the whole Arabian Gulf, of which about 29 species (13% of the total number of polychaete species) are considered to be endemic (Wehe and Fiege, 2002). From the western Arabian Gulf, KFUPM/RI (1987) reported the occurrence of 309 polychaetes (Figure 4.31). Subsequently, more recent studies carried out in the same area recorded a lower number of species. For instance, 216 polychaete species were found to occur along the Saudi waters of the Arabian Gulf from Al Khafji to Ras Tanura (KFUPM/RI, 2003); whereas in the northwestern Arabian Gulf (off Al Khafji), 218 species were recorded (KFUPM/RI, 2006a). Based on available published data on polychaetes of the Arabian Gulf, at least 405 species occur in the area (Appendix II). The most dominant and widely occurring, as well as the depth-wise and habitat-wise polychaetes are mainly represented by the families of Spionidae, Syllidae, Nephtyidae, Eunicidae, Lumbrineridae, Capitellidae, Terebellidae and Sabellidae (KFUPM/RI, 2003; Joydas, et al., 2011; Joydas, et al., 2012). Genera such as *Prionopio*, *Syllis*, *Exogone*, *Nephtys*, *Eunice*, *Lumbrineris*, *Heteromastus*, *Pista* and *Jasmineira*, which belong to the abovementioned families have been recorded from shallower to deeper regions, and from sandy, muddy and seagrass habitats.

Joydas, et al. (2012) described an increasing gradient of polychaete richness and diversity with depth (Figure 4.32). The latter authors reported that the high polychaete richness and diversity recorded in deeper areas is probably due to the affinity of these animals to finer sediment particles. In fact, owing to the water circulation in the shallow area of the western Gulf and to the increasing protection from wave action in the center of the basin, a gradual decrease in grain size is evident (Wagner and van der Togt, 1973). Therefore, silt/clay sediment type is found in the depth below 10 m. Joydas, et al. (2012) noticed that the increase in species diversity with depth was proportional to the increase in the number of locally rare species.

Polychaetes were found to occur in different habitats in the western Arabian Gulf; however, it is worth noting that the richest and most diversified polychaete communities were recorded in seagrass meadows. In fact, the number of species, density of individuals and biomass of polychaetes recorded in seagrass habitats were found to be higher than those noted in the adjacent sand/silt habitats (Coles and McCain, 1990). A description of the seagrass associated fauna, including polychaetes, is provided in Chapter 3.7.

It is well-known that the western Arabian Gulf has numerous coastal bays, where very extreme conditions related to high salinity (over 60‰) and high seasonal temperature variations occur (from 17 °C to 40 °C) (Coles and McCain, 1990; Qurban, et al., 2011). Bays like Manifa-Tanajib Bay System (MTBS) have more sheltered inner bays, where harsh environmental conditions prevail. Based on a study conducted in MTBS, inner bays were found to host a lower number of species and diversity of polychaetes (54 species) compared to the outer bay (105 species). Consequently, the species diversity (*H'*) was also found lower in the inner bay (2.26) compared to the outer bay (3.28) (Joydas, et al., 2011). Similar naturally stressed conditions also exist in the Gulf of Salwa, which is situated in the southern part of Saudi waters of the Arabian Gulf. In the Gulf of Salwa, a recent study reported a southward decrease in the diversity and number of polychaete species corresponding to the southward increase in salinity (KFUPM/RI, 2014). In the southern region of this latter Gulf, a considerable decrease in the number of species and diversity, as well as the disappearance of certain polychaete species, were observed in the summer when salinity and temperature exceeded 60 °C and 35 °C, respectively. The taxa, which disappeared at these conditions, include spionids and cirratulids. In contrast,

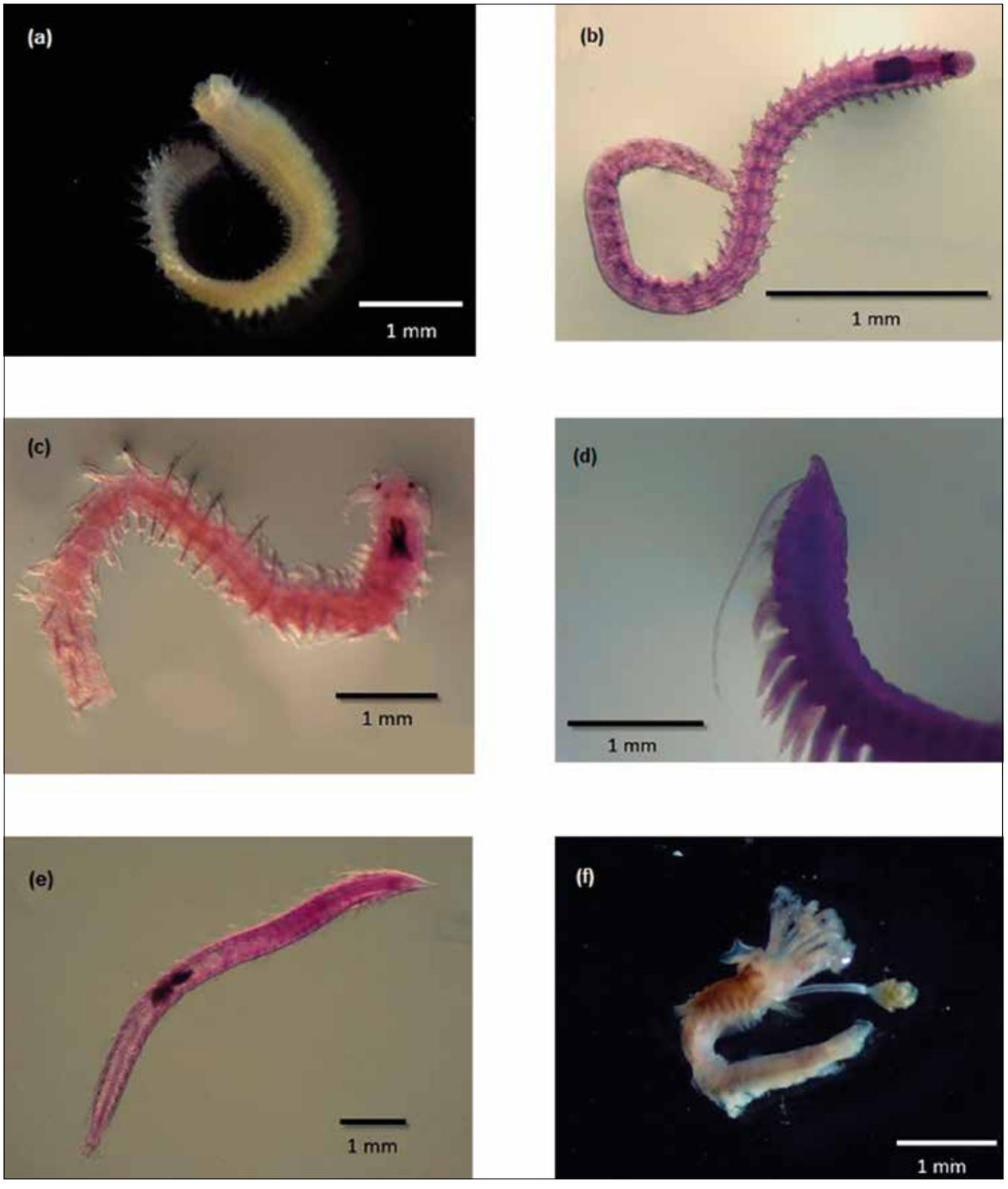

FIGURE 4.31. *Photographs of some benthic polychaete species recorded from the western Arabian Gulf. (a)* Ancystrosyllis parva*, (b)* Exogone clavator*, (c)* Dorvillea rudolphi*, (d)* Aricidea longobranchiata*, (e)* Armandia intermedia*, (f)* Serpula vermicularis.

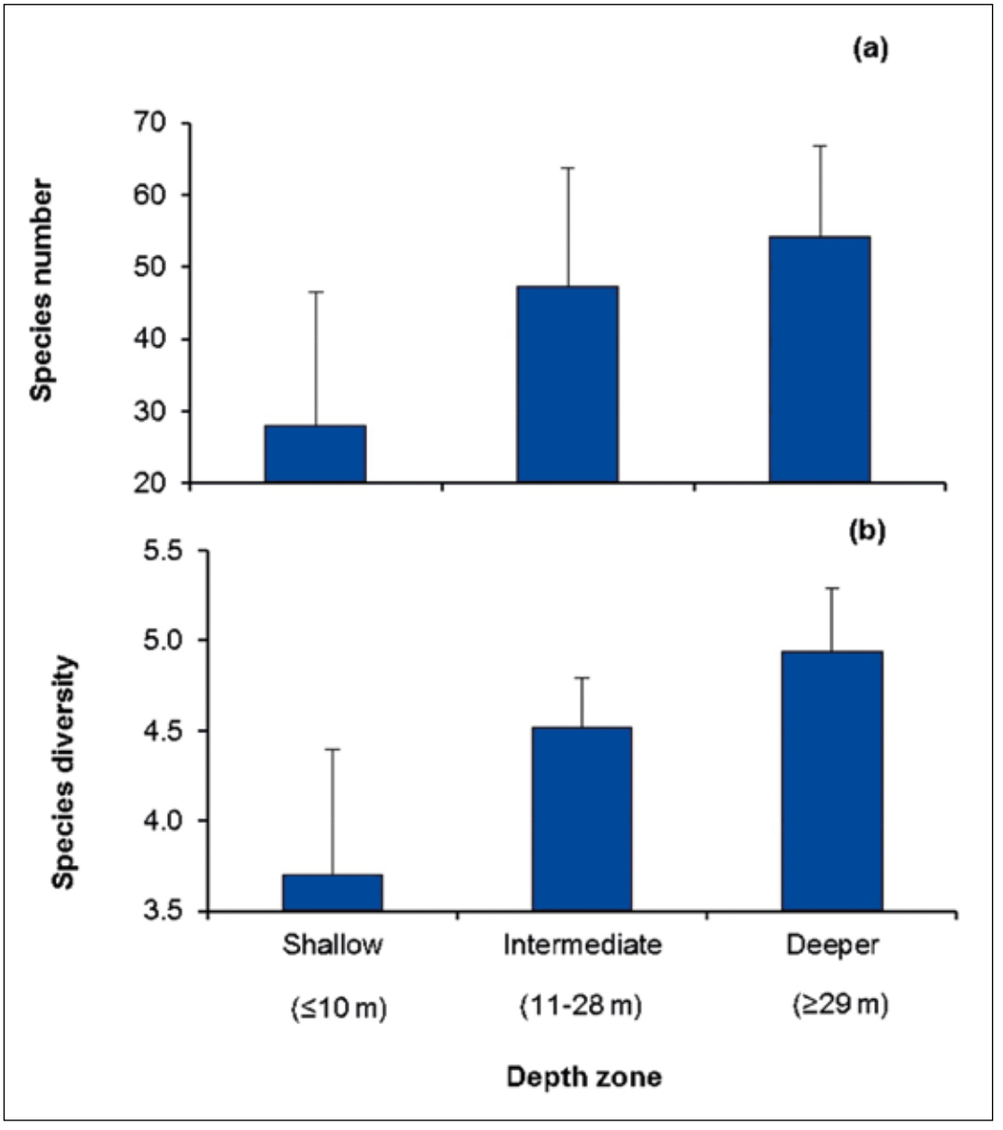

FIGURE 4.32. *Depth variations in (a) species number, and (b) Shannon-Wiener diversity* (H') *of polychaetes in the northwestern Arabian Gulf (Modified from Joydas, et al., 2012).*

these harsh conditions were found to enhance the appearance of some opportunistic species such as *Fabricia bansei*, *Heteromastus filiformis*, *Platynereis isolita* and *Nereis* sp. (KFUPM/RI, 2014).

While benthic polychaetes of the western Arabian Gulf received great attention from scientists and are then well-known, information on pelagic polychaetes are rather limited. Mohammad (1972) reported three species of planktonic polychaetes from the Arabian Gulf. These were *Plotohelmis capitata* (Family Alciopidae), *Tomopteris* sp. (Family Tomopteridae) and *Autolytus cf. A. longistaff* (Family Syllidae), which were collected from the near surface. The record of pelagic polychaetes from the Saudi waters of the Arabian Gulf is restricted to the report of larval forms. Of the zooplankton collected during November to December 2002, using a net having a mesh size of 250 µm, polychaete larvae constituted 5.3% (abundance 69.2 ind. m^{-3}) (KFUPM/RI, 2003).

Other Annelids

Oligochaeta: Like the other annelid groups, these worms also have a segmented body, but with few setae (or chaetae) compared to polychaetes. Although not a dominant taxa, they are also typical inhabitants of bottom sediment in the western Arabian Gulf. They have also been used to assess the health status of benthic ecosystems (Chapman, 2001; Verdonschot, 2006). Oligochaetes have been recorded in sandy as well as silt/clay substrata. KFUPM/RI (1987) recorded 18 oligochaete species (only 16 are presented in Appendix II) belonging to nine genera from the Saudi waters of the Arabian Gulf (Appendix II). Although oligochaetes have been recorded in various areas of the Gulf, the taxa collected were not unfortunately identified to the species or even to the genus level. The density of oligochaetes was found to vary between nil to 380 ind. m^{-2} (KFUPM/RI, 2003, 2006a and 2006b).

Sipuncula: These unsegmented marine worms without bristles (chaetae) are commonly known as "Peanut worms." They live either in burrows or in discarded shells like hermit crabs. These animals have been recorded in sandy as well as muddy bottoms. KFUPM/RI (1987) recorded 13 Sipunculid species (only eight are presented in Appendix II) belonging to five genera from the Saudi waters of the Arabian Gulf (Appendix II). Recently, Al-Yamani, et al. (2012) reported that along the Kuwaiti waters, the occurrence of six species belonging to only two genera, *Phascolion* (five species) and *Apionsoma* (one species). In the Saudi Arabian Gulf, the density of Sipunculids was found to range from nil to 170 ind. m^{-2} (KFUPM/RI, 2003, 2006a and 2006b).

Echiura: These animals are commonly called "spoon worms" because they have a worm-like body with large proboscis projecting forward from the head. Echiurans live in burrows they make in sandy and/or muddy areas; certain species live in rock and coral crevices. Three species representing Echiuridae (two species) and Ikedidae (one species) families have been recorded in Kuwaiti waters (Al-Yamani, et al., 2012) (Appendix II). The density of Echiurans, in the Saudi Arabian Gulf, was reported to vary between 0 ind. m^{-2} to 100 ind. m^{-2} (KFUPM/RI, 2003, 2006a and 2006b).

Unfortunately, there is not enough available data about the other annelid groups (i.e., Archiannelida, Pogonophora and Myzostomida) of the western Arabian Gulf. Based on some scattered information, Archiannelids were recorded in various habitats of the Gulf and their density ranged between 0 ind. m^{-2} and 680 ind. m^{-2} (KFUPM/RI, 2003, 2006a and 2006b). While, Pogonophorans were rarely recorded, in the Saudi Arabian Gulf, with a density varying between 0 ind. m^{-2} and 3 ind. m^{-2} (KFUPM/RI, 2003), Myzostomids have not been recorded in the area.

Phylum Arthropoda

The phylum of Arthropoda represents one of the richest and most diversified zoological groups. It includes insects, crustaceans, spiders, scorpions, and centipedes. Among the latter groups, the class of crustaceans is primarily composed by aquatic species occurring mostly in marine habitats, but also in freshwater systems (Barnes, 1974). The global number of crustaceans species may exceed 50,000 spread between eight subclasses, including Cephalocardia, Branchiopoda, Ostracoda, Mystacocarida, Copepoda, Branchiura, Cirripedia (barnacles), and Malacostraca (crabs, shrimps and lobsters) (Waterman and Chace, 1960). While crustaceans have been extensively studied in other parts of the world, those of the western Arabian Gulf have received, unfortunately, very small attention from marine scientists and there is still a knowledge gap about the ecology and biology of the species

living in this area. The very few papers or reports published about crustaceans of the western Arabian Gulf focused mainly on some commercially important groups, including shrimps, crabs, and lobsters (Figure 4.33).

Among the eight crustacean subclasses mentioned above, there are no published records about species belonging to the subclasses of Cephalocarida, Mystacocarida and Brachiura in the western Arabian Gulf. The five other subclasses have, however, their representative in the area. Appendix II summarizes the list of species, belonging to each of these latter taxa, which were recorded in the Arabian Gulf.

Branchiopoda: To our knowledge, only two species belonging to the subclass Branchiopoda, *Branchinella spinosa* and *Branchipus schaefferi*, have been recorded in the Arabian *sabkhas* and vernal pools of Bahrain (Hogarth and Tigar, 2002; Al-Sayed and Zainal, 2005).

Ostracoda: The subclass Ostracoda is mainly represented in this area by 45 species (Al-Furaih, 1984; KFUPM/RI, 1987 and 2003; Razzaq, 1991) (Appendix II).

Copepoda: The subclass Copepoda is globally known to host small crustaceans (size between 1 mm to several millimeters) inhabiting either freshwater or marine habitats, with many parasite species. It is estimated that the Saudi Arabian Gulf hosts around 172 copepod species, but only 60 species were identified in KFUPM surveys (Appendix II) (KFUPM/RI, 1987 and 1990). Of these, 24 species have been recorded from the UAE waters (Sharaf and Al-Ghais, 1997).

Cirripedia: Cirripedia (barnacles) are represented by two species along the Saudi waters of the Gulf and by six species in the Northern Arabian Gulf (KFUPM, 1990; Al-Khayat and Al-Maslamani, 2001; Al-Yamani, et al., 2011 and 2012). These latter species are listed in Appendix II. Studies indicate that the barnacle species *Balanus amphitrite* is widely distributed along the rocky coasts and also in pearl oyster (*Pinctada radiata*) beds of the Qatari coasts (Al-Khayat and Al-Maslamani, 2001).

Malacostraca: The group Malacostraca is the most important crustacean group in terms of number of species (around 75% of all known crustaceans) and it includes crabs, lobsters, and shrimp (Barnes, 1974). Twelve orders are included in this subclass such as Leptostraca, Anaspidacea, Stygocaridacea, Bathynellacea, Stomatopoda, Mysidacea, Cumacea, Tanaidacea, Isopoda, Amphipoda, Euphausiacea, and Decapoda. Of these, orders Anaspidacea, Stygocaridacea, Bathynellacea and Euphausiacea were so far not recorded from the western Arabian Gulf. The order Leptostraca is represented by only two species recorded along the Saudi Arabian Gulf (KFUPM/RI, 1987) (Appendix II). For Stomatopoda, although a few authors reported that some species belonging to this group can be occasionally caught in shrimp bycatches, there is only limited information about the species occurring in this area. Worth mentioning is the record of two species, *Gonodactylus demanii* and *Manningia* sp., from the seagrass beds of the northwestern Arabian Gulf (KFUPM/RI, 1987; Chen, et al., 2013). Species belonging to Mysidacea order are generally small sized (1.5 cm to 3 cm) and are mostly marine (Barnes, 1974). Mysids play an important ecological role in coastal ecosystems as carnivores, planktivores, carrion feeders and detritivores (Mauchline, 1980). They are often key dietary for fishes and birds (Mauchline, 1980; Hoostens and Mees, 1999). In the Saudi waters of the Arabian Gulf, Murano (1998) and KFUPM/RI (2003) reported six species belonging to five genera (Appendix II), while 11 species belonging to seven genera (Appendix II) were reported from the Bahraini waters (Grabe, et al., 2004).

Cumaceans are mostly marine species inhabiting sandy and muddy bottoms (Barnes, 1974). Fifty-nine cumacean species were reported to occur in the northern Arabian Gulf (KFUPM/RI, 1987, 1990 and

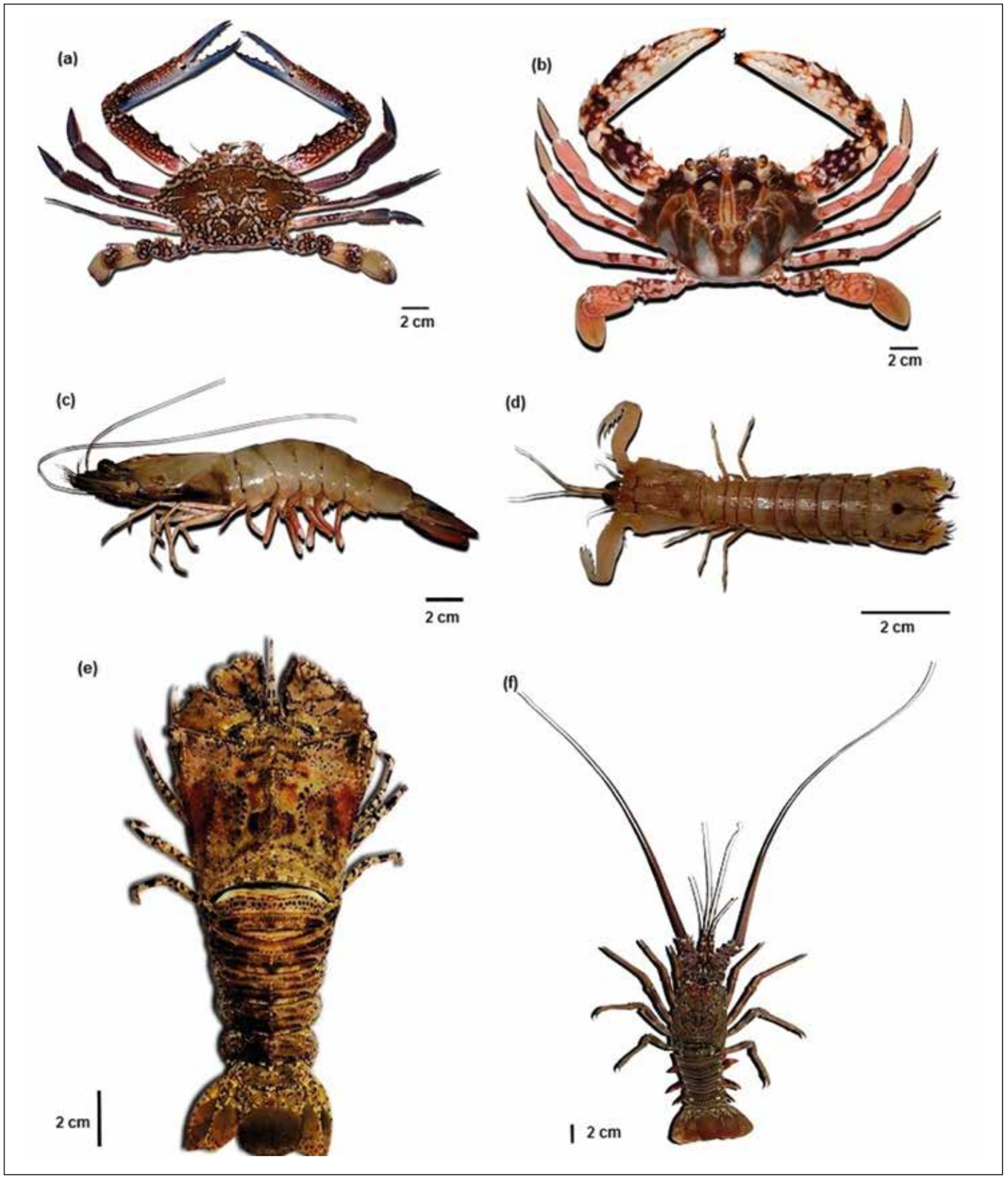

FIGURE 4.33. *Photographs of some crustacean species living in the western Arabian Gulf. (a) The blue swimming crab* Portunus segnis *(previously named* Portunus pelagicus*), (b) The crucifix crab* Charybdis feriatus*, (c) The green tiger prawn* Penaeus semisulcatus*, (d) The spot-tail mantis shrimp* Squilla mantis*, (e) The flathead locust lobster* Thenus orientalis*, (f) The painted spiny lobster* Panulirus versicolor.

2003; Al-Yamani, et al., 2012) (Appendix II). Although the order Tanaidacea did not receive much attention in taxonomic studies in this region, KFUPM/RI (1987) recorded 10 species and Al-Yamani, et al. (2012) recorded three species of tanaids (Appendix II). Around 29 isopods were reported from the Saudi and Kuwaiti waters of the Arabian Gulf by KFUPM/RI (1987, 1990) and Al-Yamani, et al. (2012) (Appendix II). Amphipods are one of the most diverse crustaceans in this region, where KFUPM/RI (1987, 2003) reported the occurrence of around 145 species (including six caprellids) from the seagrass beds of the northwestern Arabian Gulf. Although the former study identified 100 different amphipods, at least 15% of them were not identified down to species level. About 22 amphipod species were recorded from the Kuwaiti waters also (Al-Yamani, et al., 2012). As for ostracods, around 43 species have been reported, by KFUPM/RI (1987) and Razzaq (1991), among which 10 species were found in Kuwait.

The order Decapoda is known globally by a very high diversity, reaching 14,335 extant species (De Grave, et al., 2009). It includes the largest and highly specialized crustaceans (e.g., shrimps, crayfish, lobsters, and crabs). The order Decapoda contains two suborders: Dendrobranchiata and Pleocyemata (De Grave, et al., 2009). While the former suborder is only represented by two superfamilies: Penaeoidea and Sergestoidea, the latter is further subdivided into 10 infraorders: Stenopodidea, Caridea, Astacidea, Glypheidea, Axiidea, Gebiidea, Achelata, Polychelida, Anomura, and Brachura. The decapod species encountered in the northern Arabian Gulf area are listed in Appendix II. Apart from this; a majority of the available data is on the commercially important groups (i.e., shrimps, lobsters and crabs). A summary of the knowledge on these latter groups is given below.

Shrimp: Several Penaeidae species belonging to six different genera (*Penaeus*, *Metapenaeus*, *Parapenaepsis*, *Metapenaeopsis*, *Trachypenaeus* and *Solenocera*) have been recorded in the western Arabian Gulf (Price and Jones, 1975; Hassan, 1978; Buqis and Abdulqader, 1993; Abdulqader, 1999). Among the shrimp species recorded, the Green Tiger Prawn *Penaeus semisulcatus* was reported to be the most abundant reaching 80% to 90% of shrimp catches (Price and Jones, 1975; Abdulqader and Naylor, 1995; Hosny, 2007). In the western Arabian Gulf, the commercial export-oriented exploitation of shrimp resources started in Kuwaiti waters in 1959 (Boerema, 1969), and within the next few years it extended to Saudi Arabia, Bahrain, and finally Qatar. During the recent GCC shrimp survey (1999–2001), three separated populations of *P. semisulcatus* have been defined in the western Arabian Gulf: Kuwait, Khafji-Manifa and Dareen-Bahrain-Qatar. Spawning of *P. semisulcatus* occurs in relatively deeper waters and along an extended period from October to April (Price and Jones, 1975). Recruitment occurs mainly between April and July (Abdulqader and Naylor, 1995). Coastal embayment systems along the Saudi waters in the Gulf were reported to be important nursery grounds for *P. semisulactus* (Rabaoui, et al., 2017). The latter authors showed also that the spawning of this species is continuous along the year with two main peaks in early summer and in December. While natural mortality was estimated at 2.391 yr^{-1}, fishing mortality corresponding to a target of 40% of virgin spawning biomass per recruit is 1.3 yr^{-1}. In all, the life history traits of *P. semisulcatus* described along the Saudi waters in the Gulf correspond to a short-lived stock whose abundance is driven by recent recruitment pulses (Rabaoui, et al., 2017).

Lobster: To our knowledge, only two lobster species have been recorded in the western Arabian Gulf: the Slipper Lobster *Thenus orientalis* and the Spiny Lobster *Panulirus versicolor* (Al-Yamani, et al., 2012). In Bahrain, *T. orientalis* supports the small directed otter trawl fishery, which extends from November to March (Abdulqader, 2006). Unfortunately, no studies are available on the biology and ecology of these lobster species in this region.

Crabs: Crabs represent the infra-order of Brachyurans, which hosts around 126 families (De Grave, et al., 2009). From the intertidal flats and mangrove along the UAE and Saudi Arabia, Apel and Türkay (1999)

identified six species of grapsid and 21 taxa (species and subspecies) of ocypodid crabs. More recently, Al-Yamani, et al. (2012) recorded 19 Brachyurans occurring along the Kuwaiti waters. In the western Arabian Gulf, the Blue Swimming Crab *Portunus segnis* (previously named *Portunus pelagicus*) is the only commercially important brachyuran species. It is traditionally caught in coastal waters, mainly by barrier fixed traps and also as bycatch from the shrimp otter trawls (Abdulqader, 2001; Chen, et al., 2013). Due to the increasing demand of *P. segnis* in Asian markets, a specialized trap fishery targeting this crab species has been developed in Bahrain and Saudi Arabia, leading to an evident increase of the landings for Bahrain, it passes from 518 mt in 1985 to 4,319 mt in 2012. Currently, *P. segnis* is the principal species based on data from the landings. Ovigerous females of *P. segnis* were observed in Bahrain between March and November with higher numbers in June to September. The main recruitment period was reported to occur between December and April (Al-Rumaidh, 2002).

Phylum Mollusca

The phylum Mollusca is comprised of invertebrate animals characterized by having a soft mantle with a large cavity and often with hard shells for protection. The group has around 85,000 species, which is considered one of the largest phyla of animals (Chapman, 2009). The phylum is divided into eight living classes with three considered as the major classes, namely gastropods (snails and slugs), bivalves (oysters and clams), and cephalopods (octopus and squids) (Raven and Johnson, 2002). In spite of the high biodiversity and ecological and economic value of molluscs, this group has not been extensively studied in the western Arabian Gulf and little is known about the species living in this area (Figure 4.34).

Based on the survey conducted along the Saudi Arabian Gulf by Hasan (1994), 61 species of gastropods (belonging to 46 genera and 33 families) and 68 species of bivalves (belonging to 52 genera and 26 families) were recorded in the intertidal area between Jubail and the Gulf of Salwa (Table 4.7). *Trochus erythraeus* and *Turbo radiata* were found to be the most widely distributed gastropod species (Hasan, 1994). As for bivalves, they were not as widely distributed as gastropods. It is worth noting that the highest number of species was recorded in the Jubail area with 44 species of gastropods and 55 species of bivalves. In contrast, the coastal areas of al-Khobar and Dammam were found to host the lowest number of species (only seven gastropods in al-Khobar and only six bivalves in Dammam) (Hasan, 1994). More recently, Al-Naser, et al. (2010) reported in the Khor Al-Zubair channel, which is a shallow arm in the northern part of the Arabian Gulf, the occurrence of only six gastropod species, including *Euchelus asper*, *Clypeomorus clypeomorus*, *Hexaplex kusterianus*, *Murex tribulus*, *Nassarius arcularius* and *Thais* sp. Moreover, within the adjacent Kuwait Bay and Failaka-Bubiyan Is. in Kuwait, located south of the Khor Al-Zubair channel, higher diversity was reported by Al-Yamani, et al. (2012). The latter authors recorded the occurrence of 131 species of gastropods, one species of Polyplacophora, 99 species of bivalves, and three species of Scaphopoda. Although the number of species is high in Kuwait Bay, only four species were found to be common in 25% to 50% of the total sampling stations. These include three gastropods, namely *Tornatina incospicua*, *Retusa* sp., and *Chrysallida* sp., and one tusk shell *Tesseracme quadrapicalis*.

Recently, Nithyanandan (2012) reported 12 species of nudibranches from the Kuwaiti waters. The number of molluscan species (particularly gastropods and bivalves) in Kuwait Bay is considerably higher than that recorded in the Saudi Arabian waters because of lack of deeper water studies on the taxonomy and diversity of the Saudi Arabian malacofauna. For example, the only in-depth research, conducted by Hasan (1994), along the Eastern

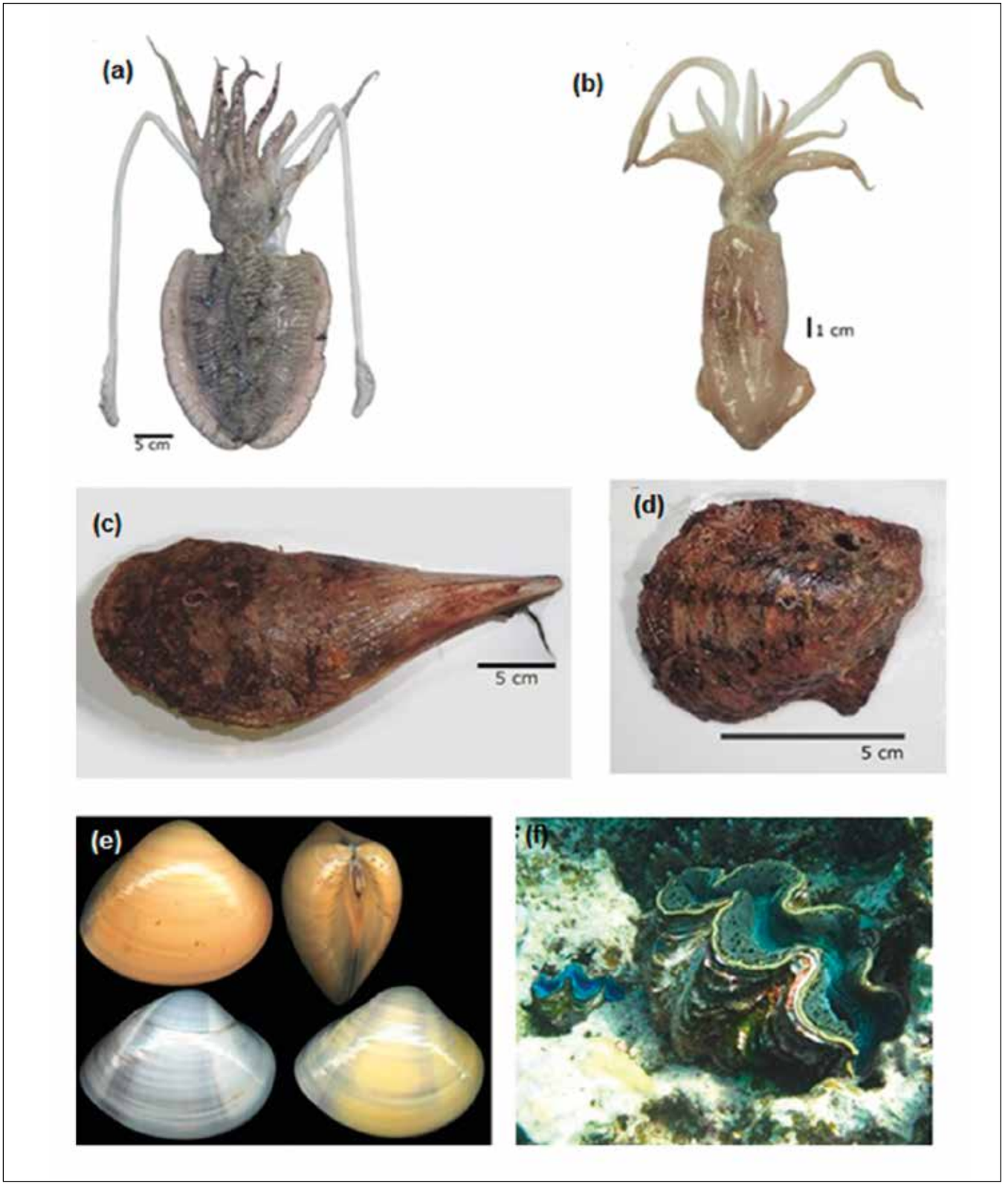

FIGURE 4.34. *Photographs of some molluscan species living in the western Arabian Gulf. (a) The Pharaoh cuttlefish* Sepia pharaonis*, (b) The Indian squid* Loligo duvauceli*, (c) The Prickly pen shell* Pinna muricata*, (d) The pearl oyster* Pinctada radiata*, (e) The Asiatic hard clam* Meretrix meretrix*, (f) The Maxima clam* Tridacna maxima.

TABLE 4.7. *Records of molluscan diversity along different regions in the Arabian Gulf.*

Area of Study	Classes	Families	Genera	Species	References
Saudi Arabian Gulf	*Gastropoda*	33	46	61	Hasan, 1994
	Bivalvia	26	52	68	
Khor Al-Zubair Channel, Iraq	*Gastropoda*	4	6	6	Al-Naser, et al., 2010
Kuwait Bay, Failaka-Bubiyan Is. Kuwait	*Gastropoda*	54	97	131	Al-Yamani, et al., 2012
	Bivalvia	30	64	99	
	Scaphopoda	2	3	3	
	Polyplacophora	1	1	1	
Kuwait	*Gastropoda (nudibranchs)*	6	9	12	Nithyanandan, 2012
Bahrain	*Gastropoda*	25	35	49	Smythe, 1972
	Bivalvia	16	26	34	
Eastern Qatar EEZ	*Gastropoda*	22	27	41	Al-Khayat and Al-Ansi, 2008
	Bivalvia	17	35	60	
	Scaphopoda	2	2	2	
	Amphineura	1	1	1	

Province coasts of Saudi Arabia only included sampling in the intertidal areas. In contrast, sampling in Kuwait Bay was done in the intertidal, nearshore and offshore zones up to a depth of 18 m (Al-Yamani, et al., 2012). In Bahrain, 49 species of gastropods and 34 species of bivalves were reported by Smythe (1972).

Along the Qatari coastal waters, bivalves and gastropods are also the main groups representing the mollusc assemblages, with a total number of species of 144 and 123, respectively (Al-Khayat, 2008). Among the bivalve species, the pearl oyster *Pinctada radiata* is considered of special commercial and ecological importance. In addition to the pearls it may produce, *P. radiata* occurs along the western side of the Arabian Gulf, from Kuwait to Oman, in developed beds that have many ecological benefits for other macroinvertebrates (Al-Khayat and Al-Ansi, 2008). The other taxa of molluscs are represented by fewer numbers of species, including Scaphopoda (five species), Polyplacophora (six species), Opisthobranchia (six species) and Cephalopoda (two species). The two latter cephalopod species are commercially important and they include the cuttlefish *Sepia pharaonis* and the octopus *Octopus cyaneus* (Al-Khayat, 2008). *S. pharaonis* is considered as one of the most important fisheries not only in the western Arabian Gulf, but also in the entire Arabian Gulf area, including Iran (Tehranifard and Dastan, 2011).

The six species of gastropods recorded in Khor Al-Zubair channel, north of the Arabian Gulf, were found in sandy and muddy substrata at depths ranging from 1 m to 15 m (Al-Naser, et al., 2010). Molluscs inside Kuwait Bay and Bubiyan-Failaka Islands were reported to live in mostly silty or silty clay substratum with mean salinities ranging between 35.3 psu and 41.4 psu, mean turbidity of 3.83 mg L^{-1} to 43.66 mg L^{-1}, and high concentration of hydrogen sulfide due to anthropogenic effluents (Al-Yamani, et al., 2012).

P. radiata beds recorded within the eastern Exclusive Economic Zone of Qatar were mostly found in sandy-rocky and coral block bottom at depths ranging from 2 m to 36 m with variations in the

abundance of the species influenced by the characteristics of bottom substrates (Al-Khayat and Al-Ansi, 2008). The pearl oyster beds in Qatar were also reported to host other marine biota, mainly represented by gastropods (41 species) and bivalves (60 species). Other associated groups include algae, sponges, cnidarians, polychaetes, echinoderms, ascidians, and crustaceans. Settlement patterns of *P. radiata* in Bahrain had been studied by Al-Sayed, et al. (1997). Settlement occurred from July to November with increased settling intensity in August. *P. radiata* larvae settle in depths of 0.5 m to 1.5 m in a wide range of substrates, but with more preference on the rough surfaces of empty oyster shells. Growth of the settled larvae was closely associated with water temperature, resulting in faster growth right after settlement.

The pharaoh cuttlefish *S. pharaonis* along the Bahrakan coasts in Iran were reported to spawn all year-round with maximum peaks in May and June (Ghazvineh, et al., 2012).

Molluscs have been continuously exploited by humans as sources of food and ornamentations such as pearls and house decorations (Beasley, et al., 2005; Tabugo, et al., 2013; Mannino and Thomas, 2002; Ruppert, 2004). Low-income families in many countries heavily depend on some species of molluscs as sources of income and food (Glaser, 2003; Tabugo, et al., 2013). In some early societies, gastropod shells such as the Cowry shells (*Cypraea* sp.) have been exchanged as a form of money (Hingston Quiggin, 1949; Wang, 1980; Saul, 2004). Recently, some research has focused on the potential of some gastropods, particularly cone shells (*Conus* sp.) for pharmaceutical applications such as therapeutic agents in medicine and biodegradable toxic agents in agroveterinary applications (Adams, et al., 1999; Livett, et al., 2004). Molluscs, particularly bivalves, have been recently used as biological monitors of pollution (Carvalho, et al., 2000); Fernandez-Tajes, et al., 2011; Zuykov, et al., 2013). In Qatar and Saudi Arabia, the cuttlefish *Sepia pharaonis* is the most common mollusc species exploited by the local fisheries (Al-Khayat, 2008). A few species of gastropods in Qatar are exploited for consumption (*Monodonta nebulosa* and *Turbo coronatus*) and for shell trade (*Conus textile*, *Murex scolopax* and *Cypraea carneola*) (Al-Khayat, 2008). Great pearling traditions were developed in and dominated some early settlements in the Arabian Gulf with coastal trading cities built on the pearl trade such as Al Zubarah in Qatar, and settlements in Dubai and Abu Dhabi (Parry, 2013). The list of mollusk species recorded by different studies carried in the Arabian Gulf is given in Appendix II.

Phylum Echinodermata

Globally, the phylum of Echinodermata (or echinoderms) includes approximately 7,000 living species and 13,000 fossil species, and is subdivided into five extant classes: Asteroidea (sea stars, starfish), Ophiuroidea (brittle stars, serpent stars, basket stars), Echinoidea (sea urchins, sand dollars, heart urchins), Holothuroidea (sea cucumbers, beche de mer), and Crinoidea (sea lilies, feather stars) (Pawson, 2007). In the western Arabian Gulf, studies on this zoological group (Figure 4.35) are very few (Clarke and Le Baron Bowen, 1949; Basson, et al., 1977; Price, 1981, 1982a and 1982b). Among these latter studies, only the study of Price (1981) provided a checklist of the echinoderm species living in the western Arabian Gulf, which is approximately 58 species. In addition, Price (1981) added 13 newly recorded species, described the habitats of this fauna, and the localities for each species. KFUPM/RI (1987) reported later the occurrence of other species in the area, increasing the total number of species to 92 (Appendix II).

This species richness (58 species) is very low compared to other areas around the world. Price (1982a) and Sheppard, et al. (1992) reported that this low diversity is mainly the result of the stressful environment

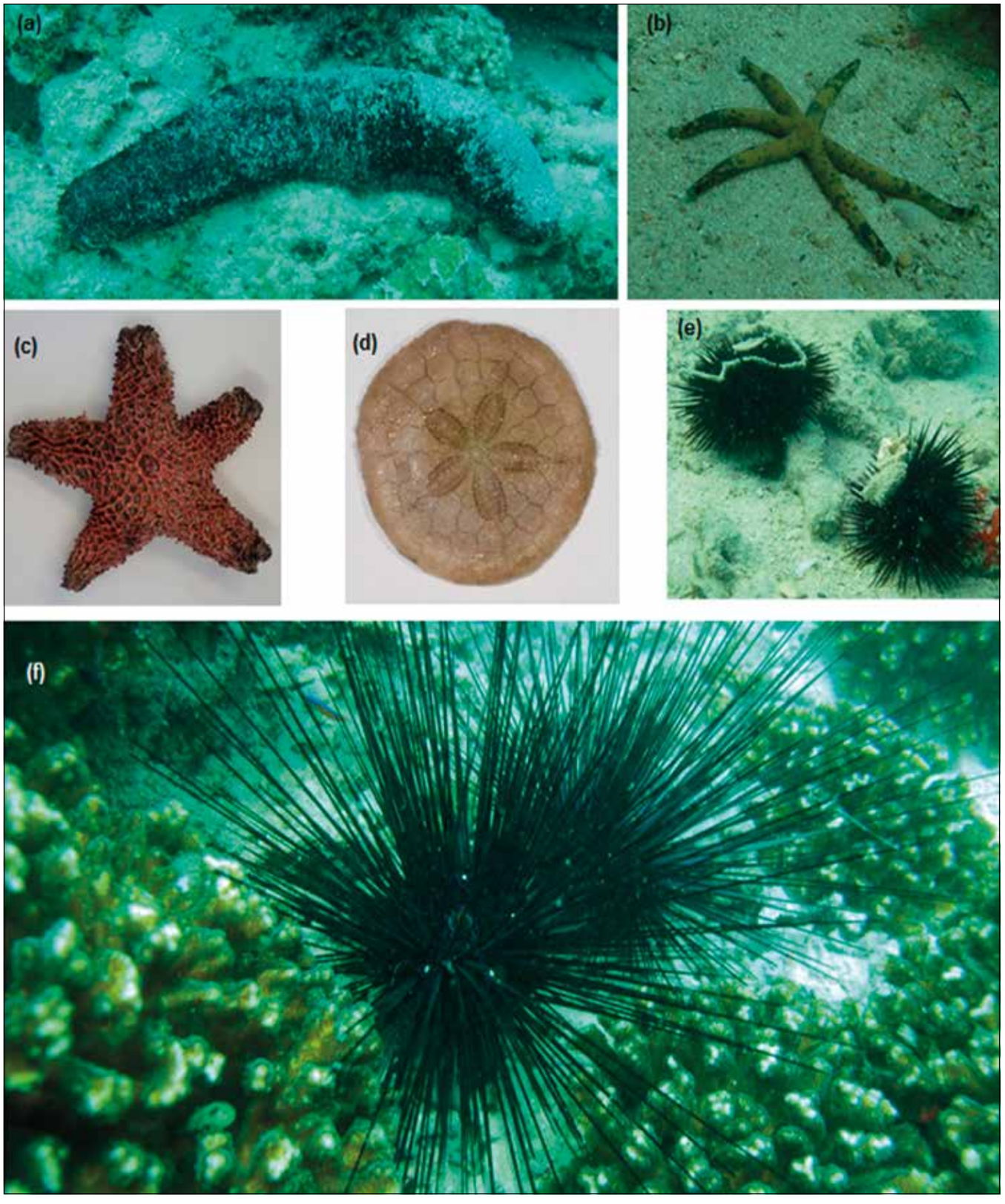

FIGURE 4.35. *Photographs of some echinoderm species living in the western Arabian Gulf: Sea cucumber species (a) nonidentified, Sea Star species (b and c) non-identified, Sand Dollar species (d) non-identified, Sea Urchin species (e)* Echinometra mathaei, *(f)* Diadema setosum.

of the Arabian Gulf, in particular the extreme sea temperatures (<12 °C to 30 °C) and high salinities (40 psu to 60 psu) (Sheppard, et al., 1992), coupled with devastating post-Pleistocene sea level fluctuations (Price, 1982a). One particularity of the echinoderm community of the Arabian Gulf is the high endemism that displays with a rate of 15% (Price, 1982b).

Various habitats of echinoderms have been recorded and described by Price (1981). These habitats vary with respect to species and/or group. The habitats include subtidal sand, which hosts a diversified assemblage of organisms, including species of heart urchins and sand dollars, and muddy bottom areas, which also support a diverse biota. Another habitat for echinoderms is the grass beds, which represents one of the most extensive habitats along the western Arabian Gulf, commonly occurring in shallow coastal areas. This habitat is extremely productive, supporting a diverse fauna, including many species of echinoderms. Coral reefs of the Arabian Gulf were also reported to host many echinoderms. In fact, more than 500 species have been recorded among Gulf coral reefs, including species from the five classes/subclasses of echinoderms. Aggregations of the sea urchins *Diadema setosum* and *Echinometra mathaei* are often a conspicuous feature around coral reefs, although these species also occur in other habitats. Finally, artificial structures, such as oil platforms, provide a substrate for many forms of marine life, acting as an "artificial reef." More than 170 species, including echinoderms, have been recorded from such habitats in the Gulf (Price, 1981).

Comparing his findings with those of previous studies (Clarke and Le Baron Bowe, 1949; Basson, et al., 1977), Price (1981) found considerable difference in the distribution and abundance of some echinoderm species and concluded that the variability in echinoderm distribution and abundance is probably a consequence of the changes in substrate and water quality over the years or also by long-term population changes in the echinoderm fauna of the western Arabian Gulf. The distribution and abundance of echinoderms in the Arabian Gulf were also reported to be influenced by physico-chemical parameters, in particular, salinity, which is considered to have a limiting effect not only on echinoderm fauna but also on other biota (Price, 1982b).

While echinoderms have been extensively studied in other areas of the world, echinoderms of the Arabian Gulf are still poorly studied and only limited data have been published on the biology and ecology of some echinoderm species. For example, among the 58 species living in the western Arabian Gulf (Price, 1981), only one study on the reproduction biology of two echinoids, *Diadema setosum* and *Echinometra mathei*, was carried out in Kuwait (Alsaffar and Lone, 2000). *D. setosum* and *E. mathei* were reported to be associated to coral reefs with densities varying between three to 15 individuals m^{-2} for the former species and exceeding 100 individuals m^{-2} for the latter (Downing and El-Zahr, 1987; Downing, 1992; Downing and Roberts, 1993; Carpenter, et al., 1997; Harrison, et al., 1997). Alsaffar and Lone (2000) found that the spawning activity of these echinoids is related to seawater temperature and day-length and that spawning peaks for both species were recorded in the summer season (Figure 4.36).

Because echinoderms are sensitive to changing water quality, they are often used for environmental monitoring for both ecological and practical reasons (Nelson Smith, 1972; Price, 1982b). In fact, it was reported that the abundance of certain species can increase in association with degraded environments sometimes leading to population outbreaks (Ormond, et al., 1990; Johnson and Babcock, 1994).

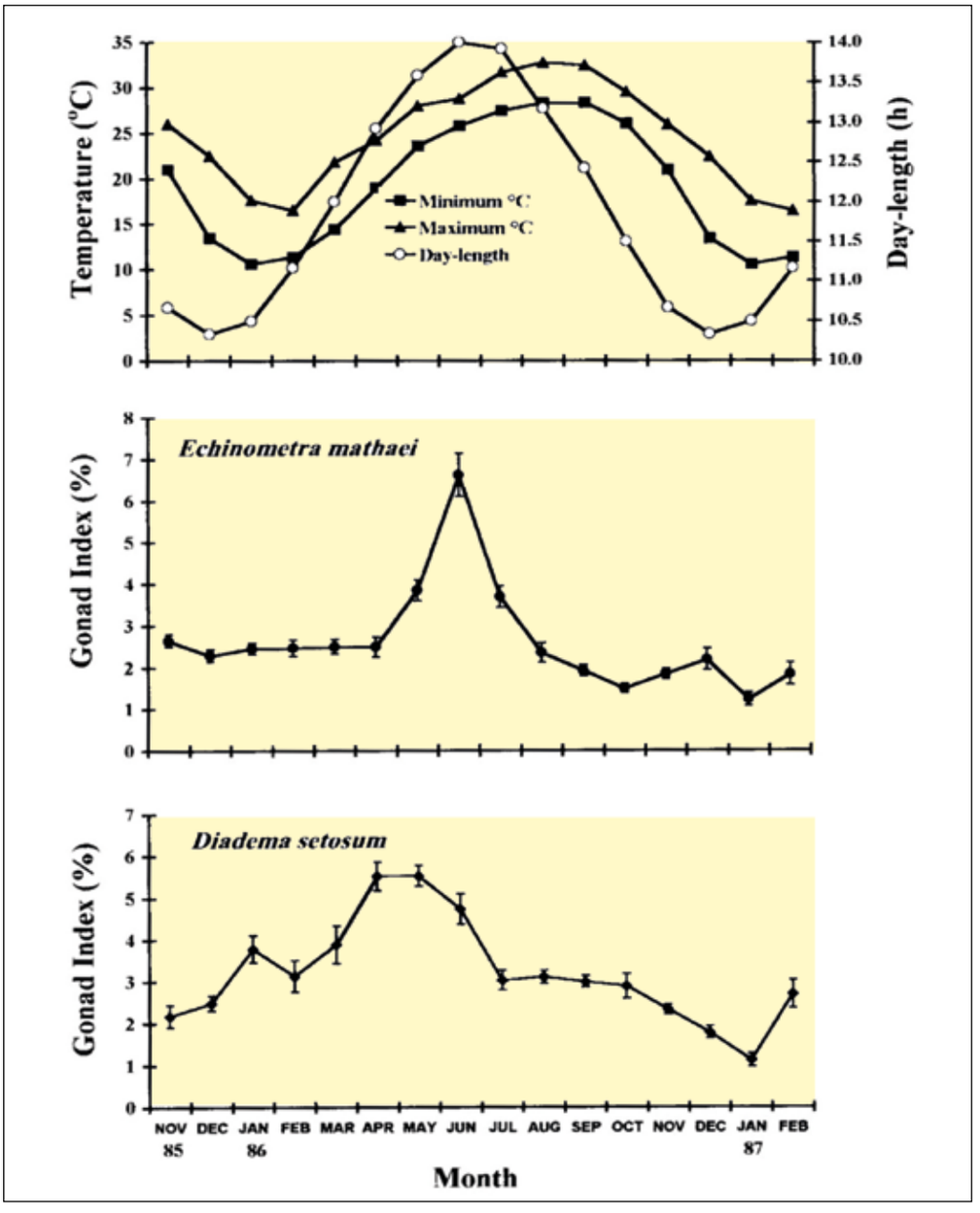

FIGURE 4.36. *Minimum and maximum water temperature, day-length and mean gonad index (percentage of drained body weight ± SE) of* Echinometra mathaei *and* Diadema setosum *between November 1985 and February 1987. Means are based on, at least, 20 sea urchins each month (Alsaffar and Lone, 2000).*

Phylum Bryozoa

Unfortunately, in most parts of the world, bryozoans have received scant attention from marine scientists and taxonomists (Richmond, 2001). While it is argued that the western Indian Ocean may host around 500 species, such an estimation remains uncertain due to the lack of studies on these colonial organisms (Hayward and Yonow, 1997). KFUPM/RI (1987) reported the occurrence of 23 species in seagrass beds of the northwestern coasts of Saudi Arabia.

Phylum Chordata

Ascidians or sea squirts are the largest and most diverse class of the sub-phylum Tunicata (also known as Urochordata). Based on the recently published review of Shenkar and Swalla (2011), there are 2,815 valid species, of which 1,480 species (~50%) belong to the order of Aplousobranchia. Most of the described ascidian species are colonial (1,730 species, ~61.5%), in particular in tropical areas where around 80% of the ascidian community are colonial (Kott, 1981; Monniot and Monniot, 1985, 1987 and 2001; Primo and Vazquez, 2004). In contrast, solitary ascidians comprise 52% to 75% in temperate waters (Van Name, 1945; Monniot and Monniot, 2001, 2003).

Adult ascidians are sessile, inhabiting soft as well as hard substrates, and can also be encountered as foulers on artificial substrata such as jetties, ship hulls, floating docks and other man-made structures (Lambert, 2001, 2005).

To our knowledge, only very few attempts have been made to study the taxonomy and biology of the ascidians of the Arabian Gulf. Monniot and Monniot (1997) reported, in Bahraini waters, the occurrence of 15 species belonging to the Polyclinidae, Didemnidae, Perophoridae, Styelidae, Ascididae and Pyuridae families (Appendix II). Among these latter 15 species, the occurrence of two species, *Polyclinum constellatum* and *Phallusia nigra* (Figure 4.37), has been confirmed in Kuwaiti coastal waters by Al-Yamani, et al. (2012).

According to the latter authors, these species occur mainly in hard substrata of the intertidal zones. The lower number of ascidians species recorded in the western Arabian Gulf is probably due to the very

FIGURE 4.37. *Photo of the ascidian species* Phallusia nigra*, taken in the Saudi waters of the Arabian Gulf. (Photo taken by R.T. Lindo).*

few or even nonexistent studies dealing with this zoological group. Although a complete list of ascidians living in the Gulf is still inexistent, it is expected that the diversity of ascidians will be very poor compared to other tropical areas, mainly because of harsh conditions reigning in the Arabian Gulf, in particular the high salinity, which exceeds 44. In fact, it is reported that only few ascidian species can survive in such a high level of salinity (Gab-Alla, 2008; Shenkar and Swalla, 2011).

Conclusions

Though the biodiversity of macroinvertebrates (more than 1,520 species, Appendix II) is very important in the western Arabian Gulf, many groups are still not studied. For instance, very little is known about sponges, bryozoans and ascidians, compared to the other zoological groups (i.e., annelids, crustaceans, molluscs and echinoderms). In addition, even for these latter taxa, only limited data are known on the biology, reproduction, trophic behavior and interspecific relationships as well as on the ecological role of the species in their habitats. Various pressures, including habitat destruction (e.g., destruction of mangrove forests), pollution and climatic changes, are acting on the Arabian Gulf ecosystems, leading to the loss of biodiversity in the area (e.g., coral bleaching and its consequences). Therefore, we encourage taxonomical, ecological and biological studies on macro-invertebrates and their habitats to enhance our knowledge of the biodiversity and to better understand the macro-invertebrate community structure in the Arabian Gulf.

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APPENDIX I

Environmental Studies
of the Sustaining Research Project Conducted by Research Institute of King Fahd University of Petroleum and Minerals (KFUPM/RI) and Funded by Saudi Arabian Oil Company (Saudi Aramco).

Project	Project Title	Project Start	Project End
GST E-4009	Meteorological and Oceanographic Data Report	01-Sep-77	01-Mar-79
CEW0000	Preliminary Benthic Biology Survey	01-Jan-80	01-Jan-12
24004	Simulation of an Oil Spill in the Arabian Gulf	01-Jul-80	31-Dec-80
TC-4030	Pollutant Pathways Characterization in Shallow Bay Systems	01-Jul-81	01-Jul-83
24010	Ambient Air Suspended Particulate Sampling and Characterization	01-Oct-81	30-Nov-82
TSI 57-111	An Analysis of the Impact of the Ghazlan Generating Station on Benthic Marine Communities	01-Dec-81	01-Jan-82
RP878-1	Methodology for Evaluation of Multiple Cooling System Effects	01-Jan-82	01-Jan-83
24011	Trace Metals in Marine Sediments and Water Columns	20-Feb-82	30-Nov-82
AER-5229	A Survey of Infaunal Communities of the Western Arabian Gulf	01-Jun-82	01-Jun-83
TC-3598	Marjan Offshore Gas/Oil/Pipeline Current Data Analysis and Numerical Simulation	01-Oct-82	01-Oct-83
24028	Estimating Oil Spill Size by Visual Observation	13-Nov-82	15-May-83
24038	Ballast Discharge Evaluation at Yanbu' Natural Gas Liquids Facility	01-Nov-83	13-Jul-85
24058	Mixing Heights for Three Cities in the Eastern Province	01-Jan-84	30-Jun-85
24059	Marine Environmental Investigation in the Arabian Gulf with Emphasis on the Northern Area of Saudi Arabia	01-Feb-84	30-Sep-86
24065	Solid Waste Planning Guide	01-Mar-84	31-Dec-84
24079	Saudi Aramco Sustaining Research Project Marine Environmental Studies I	01-Oct-84	30-Oct-90
GST E-4032	Sampling and Monitoring Report	10-Nov-84	11-Nov-84
24108	Marine Environmental Effect of the Abu Ali-Berri Causeway Extension	01-Aug-87	28-Feb-88
24114	Groundwater Resources Evaluation in the Eastern Province of Saudi Arabia	31-Dec-87	31-Mar-88
24120	Wave Climate Study in the Arabian Gulf	15-Aug-89	15-Aug-91
24129	Marine Environmental Study at the Safaniyah GOSP-4 Offshore Facility	11-Dec-89	30-Sep-90

Project	Project Title	Project Start	Project End
24131	Sustaining Research Project Marine Environmental Studies	18-Aug-90	30-Sep-94
24137	Gulf Atmospheric Pollution 1991	01-Feb-91	30-Sep-92
24138	Arabian Gulf Oil Spill Research Program 1991 (also called Gulf Atmospheric Pollution 1991)	01-Feb-91	30-Sep-92
24142	Ras Tanura Refinery/Terminal Upgrade: Environmental Impact Assessment	15-Aug-92	15-Apr-93
21132	Solubility of Calcium Carbonate in Synthetic and Natural Oil Field Brines	01-Apr-94	31-Mar-96
24150	Contaminant Transport Model for the Ras Tanura Groundwater Investigation	22-Aug-94	15-Dec-95
24154	Sustaining Research Project Marine Environmental Studies Phase III	01-Jul-95	31-Mar-01
24162	Investigation of Ambient Concentrations of Automotive Emissions in Three Major Cities	01-May-97	30-Apr-98
24164	Development of Red Sea Biotope Maps Using Remote Sensing Imagery	01-Jul-97	30-Jun-99
CEW2217	Marine Biological and Oceanographic Database Development	15-Nov-00	15-Nov-02
CEW2236	Environmental Impact Assessment for Abu Safah Offshore AM Producing Facilities	01-Jun-01	31-Jul-01
CEW2233	Saudi Aramco/KFUPM-RI Sustaining Research Project Marine Environmental Studies Phase IV	01-Oct-01	30-Sep-06
CEW2242	Conceptual Estimate of Environmental Impacts of Existing and New Arabia-Bahrain Pipeline Routings	28-Oct-01	24-Apr-02
CEW2259	Duba Marine Terminal Permanent Berth (BI-8232) Environmental Impact Assessment for the Construction and Removal of Temporary Roads	15-Jan-03	31-Oct-06
CEW2269	Offshore MP Facilities Berri-119 Pipeline (BI-8294) Environmental Impact Assessment Study	01-Apr-03	31-Oct-03
CEW2278	Offshore MP Facilities 15 kV Cable (BI-8294) Environmental Impact Assessment	15-Sep-03	31-Dec-03
CEW2285	Environmental Impact Assessment North Safaniyah Artificial Lift (BI-10-0047)	12-Jul-04	09-Feb-05
CEW2287	Offshore MP Facilities Qatif QV Cable (BI-8294) Environmental Impact Assessment	26-Jul-04	29-Sep-04
CEW2310	Environmental Impact Assessment of the New Khursaniyah 30” Dia. Pipeline (BI-10-08022)	04-Jun-05	30-Nov-05
CEW2311	Environmental Impact Assessment Upgrade Northern Area Oil Operations Offshore Platforms Wastewater (BI-01-00197).	13-Jun-05	31-Oct-05
CEW2303	Environmental Impact Assessment for the Berri Causeway and Associated Drill Site Landfilling	24-Dec-05	12-Apr-06
CEW2325	Operational Marine Modeling System (OMMS)	01-Jan-06	31-Dec-08
CEW2328	Environmental Impact Assessment for Manifa Field Development (NAFD/L-001-06): Causeway Construction	11-Mar-06	30-Sep-06
CEW2329	Environmental Impact Assessment for Abu Ali Flanks Scraped Water Handling (BI-10-00220)	01-Apr-06	31-Jul-06
CEW2338	Environmental Impact Assessment for Manifa Field Development Program: Platforms, Pipelines and Submarine Cables (BI-01-00452 and BI-01-00453)	11-Nov-06	30-Jun-07
CEW2336	Marine Environmental Monitoring of the New Khursaniyah 30” Dia. Pipeline (BI-10-08022) Project	01-Jan-07	31-Dec-09
CEW2345	Environmental Impact Assessment for the King Abdullah University of Science & Technology Development Project	02-Jun-07	30-Jul-08
CEW2342	Marine Environmental Monitoring of the Manifa Causeway	12-Jun-07	30-Jun-10
CEW2343	Assessment of Ras Tanura Marine Environment and Bioaccumulation Monitoring along the Saudi Coastal Waters of the Arabian Gulf	21-Jul-07	30-Dec-10
CEW2350	Environmental Impact Assessment for Tanajib Channel and Basin Dredging	31-Jul-07	31-Oct-07

Project	Project Title	Project Start	Project End
CEW2344	Saudi Aramco/KFUPM-RI Sustaining Research Project, Marine Environmental Studies Phase V	15-Aug-07	16-Aug-12
CEW2353	Biodiversity of the Offshore Saudi Islands of the Arabian Gulf	21-Oct-07	31-Jul-11
CEW2354	The Western Arabian Gulf Ecosystem: A Reference for Researchers, Planners and Environmental Managers	21-Oct-07	31-Jul-11
CEW2355	Marine Atlas of the Western Arabian Gulf Phase I: Coastal and Marine Surveys and Photo Documentation	21-Oct-07	31-Jul-11
CEW2352	Environmental Impact Assessment for a Seawater Reverse Osmosis Water Treatment Plant at King Abdullah University of Science and Technology	03-Nov-07	31-Mar-08
CEW2343-01	Assessment of Ras Tanura Marine Environment and Bioaccumulation Monitoring along the Saudi Coastal Waters of the Arabian Gulf Additional Scope	01-Jan-08	30-Nov-08
CEW2357	Environmental Impact Assessment for Karan Platforms, Power (BI-10-00579) and Pipelines (BI-10-00580) Construction	01-Jan-08	31-Aug-08
CEW2359	Environmental Impact Assessment for Drill Cutting Disposal at Manifa	01-Jun-08	31-Dec-08
CEW2360	Environmental Impact Study for Channel Dredging at Safaniyah	07-Jun-08	31-Dec-08
CEW2370	Environmental Impact Assessment for Land Filling and Reclamation at Ras Tanura Refinery	15-Nov-08	31-Dec-09
CEW2373	Environmental Impact Assessment for the Upgrade of Crude Gathering and Power Supply Facilities Phase I: Safaniyah Field	27-Jun-09	31-Mar-10
CEW2380	Conduct LC-50 Drilling Fluid Sampling and Toxicity Testing	11-Nov-09	31-Dec-11
CEW2379	Environmental Impact Assessment for Installing Instrument Scraping Facilities at Zuluf and Marjan Oil Fields (BI-10-00187)	20-Feb-10	20-Apr-10
CEW2381	Environmental Impact Assessment for Upgrade of the Fire Protection System, Ju'aymah Offshore Platform (BI-10-00185)	24-Apr-10	31-Aug-10
CEW2382	Environmental Impact Assessment for Arabiyah-Hasbah Platforms, Power (BI-10-00916) and Subsea Pipelines (BI010-00917)	19-Jun-10	19-Dec-10
CEW2374	Fisheries Program: Population Dynamics and Stock Assessment of the Major Fisheries Resources in Saudi Arabian Waters	01-Jan-11	30-Nov-13
CEW2375	Fisheries Program Assessment and Management of Essential Fish Habitats in Saudi Arabian Waters	01-Jan-11	30-Nov-13
CEW2376	Fisheries Program Environmental Impacts of Fishing Methods in Saudi Arabia: Toward Mitigation and Management	01-Jan-11	30-Nov-13
CEW2377	Fisheries Program Development of a Strategic Framework for Fisheries Management in Saudi Arabia	01-Jan-11	30-Nov-13
CEW2385	GMARS Development of GIS Compatible Marine Database and Analysis System (GMARS)	01-Feb-11	31-Jul-12
CEW2389	Red Sea Environmental Impact Assessment for Drilling Exploration in the Shallow Waters of the Northern Red Sea	11-Jun-11	03-Jun-12
CEW2390	Tarut Bay Environmental Assessment Report for Tarut Bay Pipelines & Structural Support System	02-Jul-11	31-Dec-11
CEW2392	Safaniyah Pier Environmental Assessment for the Safaniyah Pier Trestle Replacement	23-Jul-11	31-Mar-12
CEW2399	Environmental Impact Assessment for Dredging (Category III) for Upgrade of Electrical Power Supply to Abu Ali Plants	15-Feb-12	15-Aug-12

APPENDIX II

Checklist of marine invertebrates

*Checklist of marine invertebrates occurring in the area of the Arabian Gulf. Bold Arabic numbers (**1** to **34**) indicate the references of record of the species. Note that the list represented in this appendix has been modified from those published in the references used. Some non-identified species or only identified to the order/family level were excluded from the present list. Taxa identified to only genus level (noted as Genus sp.) were kept but they may refer to one or many species (belonging to the same genus) recorded in one or various references; more details about this can be obtained from the original references of record. The species belonging to each class are listed in alphabetic order.* **1** Price (1991), **2** KFUPM/RI (1987), **3** Al-Yamani et al. (2012), **4** Hasam (1994), **5** Al-Naser et al. (2010), **6** Nithianandan (2012), **7** Smythe (1972), **8** Al-Khayat and Al-Ansi (2008), **9** Tehranifard and Dastan (2011), **10** Al-Khayat (2008), **11** Roper et al. (1984), **12** Sheppard and Borowitzka (2012), **13** Al-Yamani et al. (2011), **14** Carpenter et al. (1997), **15** KFUPM/RI (2003), **16** Apel and Türkay (1999), **17** Hogart and Tigar (2002), **18** Al-Sayed and Zainal (2005), **19** Al-Khayat and Al-Maslamani (2001), **20** KFUPM/RI (1990), **21** Grabe et al. (2004), **22** Murano (1998), **23** Razzaq (1991), **24** Abdulqader (1999), **25** Price and Jones (1975), **26** Enomoto (1971), **27** Hosny (2007), **28** Badawi (1975), **29** Chen et al. (2013), **30** Monniot and Monniot (1997), **31** KFUPM/RI (2006a), **32** KFUPM/RI (2013), **33** KFUPM/RI (2006b), **34** Njinkoué et al. (2006).

PHYLUM PORIFERA
Class Demospongiae
Adocia sp. **2**
Aplysina sp. **2**
Axinella sp. **2**
Biemna sp. **2**
Cacospongia sp. **2**
Gelliodes cf. *incrustans* **34**
Callyspongia cf. *siphonella* **34**
Callyspongia sp. **2, 34**
Choristida sp. **2**
Cinachyra sp. **2**
Ciocalypta sp. **2**
Cliona schmidti **2**
Cliona sp. **2**
Cliona vastifica **2**
Coelosphaera sp. **2**
Dysidea sp. **2**
Europon sp. **2**
Fasciospongia sp. **2**
Gelliodes cf. *incrustans* **34**
Gelliodes sp. **2**
Halichondria sp. **2**
Haliclona sp. **2**
Haliclona sp. **2**
Mycale sp. **2**
Niphates sp. **34**
Spongia sp. **2**
Tedania sp. **2**
Tethya aurantium **2**
Tethya sp. **2**
Tetilla sp. **2**

PHYLUM CNIDARIA
Class Anthozoa
Acanthastrea echinata **12**
Acropora clathrata **12**
Acropora downing **12**
Acropora horrida **12**
Acropora pharaonis **12**
Acropora valenciennesi **12**
Actiniaria sp. **2**
Anemonactis sp. **2**
Anomastrea irregularis **12**
Blastomussa merleti **12**
Coscinaraea monile **12**
Culicia rubeola **12**
Cyphastrea micropthalma **12**
Cyphastrea serialia **12**
Echinophyllia aspera **12**
Favia favus **12**
Favia pallida **12**
Favia speciosa **12**
Favites chinensis **12**
Favites pentagona **12**
Heterocyathus aequicostatus **12**
Hydnophora exesa **12**
Leptostrea inaequalis **12**
Leptostrea purpurea **12**
Leptostrea transversa **12**
Madracis kirbyi **12**
Montipora circumvallata **12**
Montipora spumosa **12**
Paracyathus sp.12
Pavona cactus **12**
Pavona diffluens **12**
Pavona explanulata **12**
Pavona varians **12**
Platygyra daedalea **12**
Platygyra sinensis **12**
Plesiastrea versipora **12**
Pocillopora damicornis **12**
Porites compressa **12**
Porites harrisoni **12**
Porites lutea **12**
Porites murrayensis **12**
Porites nodifera **12**
Psammocora contigua **12**
Psammocora haimeana **12**
Psammoseris sp. **12**
Pseudosiderastrea tayamai **12**
Siderastrea savignyana **12**
Stylophora pistillata **12**
Tubastraea aurea **12**
Turbinaria mesenterina **12**
Turbinaria peltata **12**
Class Hydrozoa
Aequorea pensilis **13**
Aglaura hemistoma **13**
Amphinema rugosum **13**
Campanularia crenata **2**
Clytia cf. *gravieri* **2**
Clytia discoida **13**
Clytia gravieri **2**
Clytia latitheca **2**
Corynactis sp. **2**
Cunina octonaria **13**
Cytaeis nassa **2**
Diphyes chamissonis **13**
Dynamena cornicina **2**
Dynamena crisioides **2**
Dynamena quadridentata **2**
Eirene viridula **13**
Eudendrium capillare **2**
Eudendrium sp. **2**
Eutima gegenbauri **13**
Gonionemus murbachi **2**
Halocordyle disticha **2**
Hydractinia cf. *diogenes* **2**
Liriope tetraphyla **13**
Obelia bispinosa **2**
Obelia cf. *dichotoma* **2**
Obelia sp. **13**
Octophialucium funerarium **13**
Plumularia cf. *setacea* **2**
Plumularia sp. **2**
Podocoryne sp. **13**
Rhizorhagium robustum **2**
Sanderia malayensis **13**
Sertularia distans **2**
Sertularia longa **2**
Solmundella bitentaculata **13**
Staurocladia vallentini **2**
Thyroscyphus fruticosus **2**

PHYLUM ANNELIDA
Class Polychaeta
Aglaophamus sp. **2**
Amaeana sp. **2**
Ampharete acutifrons **31**
Ampharete sp. **15**
Amphicteis gunneri **15**
Amphicteis sp. **2**
Amphiglena mediterranea **15**
Amphiglina sp. **2**
Amphinome sp. **15**
Amphisamytha sp. **2**
Amphitrite pauciseta **31**
Amphitrite sp. **15**
Anaitides sp. **2**
Ancistargis sp. **2**
Ancistrosyllis constricta **15**
Ancistrosyllis parva **15**
Ancistrosyllis sp. **15**
Aonides oxycephala **15**
Aonides sp. **2**
Aphrodita sp. **2**
Arabella iricolor iricolor **15**
Arabella sp. **2**
Aricidea curviseta **31**
Aricidea fauveli **15**
Aricidea jeffreysi **31**
Aricidea longobranchiata **15**
Aricidea sp. **15**
Aricidea suecica simplex **31**
Armandia intermedia **15**
Armandia sp. **2**
Asclerocheilus capensis **31**
Asclerocheilus sp. **2**
Autolytus prolifer **2**
Autolytus sp. **15**
Axiothella sp. **2**
Bhawania goodie **31**
Brada sp. **2**
Brada villosea capensis **32**
Branchiomma sp. **2**
Brania sp. **2**
Cabira sp. **2**
Capitella sp. **2**
Capitomastus sp. **2**
Caulleriella sp. **2**
Ceratocephale sp. **2**
Ceratonereis erythraeensis **2**
Ceratonereis mirabilis **2**
Ceratonereis sp. **2**
Chaetoparia sp. **2**
Chaetopterus sp. **15**
Chaetopterus variepedatus **31**
Chaetozone sp. **2**
Chane sp. **2**

Chloeia sp. **15**
Chone collaris **31**
Chone filicaudata **31**
Chone sp. **2**
Chrysopetalum sp. **2**
Cirratulus chrysoderma **15**
Cirratulus cirratus **15**
Cirratulus filiformis **15**
Cirratulus sp. **15**
Cirriformia filigera **31**
Cirriformia sp. **2**
Cirrophorus branchiatus **31**
Cirrophorus sp. **2**
Clymenella sp. **2**
Cossura coasta **15**
Dasybranchus caducus **15**
Dasybranchus sp. **2**
Decamastus sp. **2**
Diopatra sp. **2**
Dioplosyllis sp. **2**
Dispio sp. **31**
Dorvillea angolana **15**
Dorvillea rubrovittata **31**
Dorvillea rudolphi **15**
Drilonereis monroi **31**
Drilonereis sp. **2**
Drilonerels filum **2**
Ehlersia cornuta **2**
Ehlersia sp. **2**
Epidiopatra sp. **31**
Eteone foliosa **31**
Eteone sp. **2**
Euchone rosea **15**
Euchone sp. **2**
Euclymene lombricoides **31**
Euclymene luderitziana **15**
Euclymene oerstedi **31**
Euclymene sp. **2**
Eulalia sp. **2**
Euleanira sp. **15**
Eumida sp. **2**
Eunice antennata **15**
Eunice australis **15**
Eunice indica **2**
Eunice sp. **15**
Eunice vittatta **31**
Eunoe sp. **2**
Euphrosine capensis **15**
Euphrosine foliosa **15**
Euphrosine myrtosa **15**
Eurythoe parvencarunculata **15**
Eurythoe sp. **15**
Exogone clavator **15**
Exogone cornuta **2**
Exogone gemmifera **15**
Exogone normalis **15**
Exogone sp. **15**
Exogone verugera **2**
Filograna implexa **31**
Flabelligera affinis **31**
Genetyllis sp. **2**
Glycera longipinnis **31**
Glycera rouxi **2**
Glycera sp. **2**
Glycera spongicola **32**
Glycera tesselata **31**
Glycinde sp. **2**
Glyphanostomum abyssale **31**
Goniada congoensis **32**
Goniada emerita **31**
Goniada maculata **15**
Goniada sp. **2**
Goniadella gracilis **31**
Grubeulepis sp. **2**
Gyptis capensis **15**
Haplosyllis spongicola **2**
Harmothoe sp. **2**
Hesionides sp. **2**
Heteroclymene cf. *Quadrilobata* **2**
Heteromastus filiformis **15**
Heteromastus sp. **2**
Hipponoa gaudichaudi agulhana **31**
Hipponoa sp. **31**
Horstileanira sp. **2**
Hyalinocecia tubicola **31**
Hyboscolex longiseta **15**
Hydroides heteroceros **31**
Hydroides homaceros **2**
Hydroides monoceros **15**
Hydroides norvegica **2**
Hydroides sp. **2**
Hydroides uncinata **2**
Hypsicomus phaetonia **15**
Isolda pulchella **31**
Isolda sp. **2**
Jasmineira elegans **31**
Jasminiera sp. **2**
Laeonereis ankyloseta **31**
Lanice conchilega **15**
Laonice cirrata **31**
Laonome sp. **2**
Leiochrus sp. **2**
Leocrates claparedeii **15**
Leodora sp. **2**
Leonnates jonaseaumei **2**
Leonnates persica **2**
Lepidonotus sp. **2**
Linopherus sp. **15**
Loimia medusa **2**
Lumbrineriopsis sp. **2, 15**
Lumbrineris aberrans **15**
Lumbrineris albidentata **15**
Lumbrineris brevicirra **31**
Lumbrineris heteropoda **2**
Lumbrineris inflata **15**
Lumbrineris latrielli **15**
Lumbrineris megalhaensis **15**
Lumbrineris meteorana **31**
Lumbrineris simplex **15**
Lygdamis murata gilchrisi **15**
Lygdamis sp. **15**
Lysidice collaris **15**
Lysidice longiceps **15**
Lysidice sp. **2**
Lysilla sp. **2**
Magelona cincta **15**
Magelona papillicornis **31**
Malacoceros indicus **15**
Manayunkia sp. **2**
Marphysa bifurcata **15**
Marphysa sp. **2**
Marphysia mossambica **31**
Mastobranchus sp. **2**
Mediomastus capensis **31**
Mediomastus sp. **2**
Megalomma quadriculatum **15**
Megalomma sp. **2**
Melinna cristata **32**
Melinna monoceroides **15**
Melinna sp. **2**
Melinopsides capensis **31**
Mesochaetopterus minutus **15**
Mesochaetopterus sp. **15**
Mesospio sp. **2**
Micromaldane sp. **2**
Micronephtys spaerocirrata **2**
Mysta sp. **2**
Mystides angolensis **31**
Myxicola sp. **2**
Nainereis laevigata **2**
Neanthes sp. **2**
Neanthes unifasciata **2**
Nematonereis unicornis **15**
Nephtyis lyrochaeta **15**
Nephtyis sphaerocirrata **15**
Nephtys dibranchis **15**
Nephtys hombergi **15**
Nephtys polybranchia **15**
Nephtys tulearensis **2**
Nereimyra sp. **2**
Nereis coutierei **2**
Nereis persica **2**
Nereis sp. **15**
Nereis trifasciata **2**
Nicolea macrobranchia **15**
Ninoe sp. **2**
Nothria sp. **2**
Notomastus aberrans **31**
Notomastus fauveli **31**
Notomastus latericeus **31**
Notomastus sp. **2**
Odontosyllis polycera **2**
Onuphis eremita **15**
Onuphis geophiliformis **15**
Onuphis holobranchiata **15**
Onuphis sp. **15**
Ophelia sp. **2**
Ophelina acuminata **15**
Ophelina sp. **2**
Ophiodromus angustifrons **15**
Ophiodromus berristordei **15**
Ophiodromus sp. **15**
Orbinia angrapequensis **31**
Orbinia sp. **2**
Oriopsis bansei **31**
Oriopsis neglecta **31**
Oriopsis sp. **15**
Owenia fusiformis **31**
Owenia sp. **2**
Paleanatus chrysolepis **31**
Paleanatus debilis **31**
Panthalis sp. **2**
Paraamphinome indica **15**
Paralacydonia paradoxa **15**
Paralepidonotus ampulliferus **2**
Paranaites sp. **2**
Paraonides lyra lyra **31**
Paraonides sp. **15**
Paraonis gracilis graicilis **15**
Paraonis gracilis oculata **15**
Paraschlerocheilus capensis **15**
Pectinaria antipoda **2**
Pectinaria capensis **31**
Pectinaria crassa **15**
Pectinaria koneri koneri **31**
Pectinaria neopolitana **31**
Pectinaria papillosa **15**
Pectinaria sp. **15**
Perenereis cultrifera **15**
Peresiella acuminatobranchiata **2**
Peresiella sp. **2**
Petaloproctus terricola **2**
Pherusa monroi **15**
Pherusa sp. **15**
Pholoe sp. **2**
Phyllochaetopterus elioti **31**
Phyllocomus hiltoni **31**
Phyllodoce capensis **15**
Phyllodoce castanea **31**
Phyllodoce longipes **31**
Phyllodoce malmgreni **15**
Phyllodoce sp. **15**
Phyllodoce tubicola **31**
Phylo capensis **15**
Phylo sp. **15**
Pilargis sp. **2**
Pionosyllis sp. **2**
Piromis arenosus **15**
Piromis sp. **2**
Pista brevibranchia **15**
Pista cristata **31**
Pista dibranchis **15**
Pista macrolobata **15**
Pista medusaera **2**
Pista sp. **15**
Pista typha **2**
Platynereis dumerilii **2**
Platynereis isolita **33**
Platynereis pulchella **2**
Platynereis sp. **15**
Podarke sp. **2**
Podarkeopsis sp. **2**
Poecilochaetus serpens **15**
Poecilochaetus sp. **2**
Polycirrus aurantiacus **31**
Polycirrus cf. *haematodes* **15**
Polycirrus plumosus **31**
Polycirrus sp. **2**
Polydora capensis **15**
Polydora ciliata **15**
Polydora kempi **31**
Polydora sp. **2**
Polyodontes sp. **2**
Polyophthaimus sp. **2**
Polyphysia crassa **15**
Pomatoleios kraussii **15**
Potamila linguicollaris **31**
Potamila reniformis **31**
Potamilla sp. **15**
Potamilla tanelli **15**
Praxillella sp. **2**
Prionospio bocki **15**
Prionospio cirrifera **31**
Prionospio cirrobranchiata **15**
Prionospio ehlersi **15**
Prionospio pinnata **15**
Prionospio sexoculata **15**
Prionospio sp. **2**
Procerastea perrieri **31**
Protodorvillea biarticulata **15**
Protodorvillea egena **2**
Pseudoclymene sp. **2**
Pseudomalacoceros sp. **2**
Pseudonereis anomala **2**
Pseudopolydora antennata **2**
Pseudopolydora sp. **2**
Pulliella armata **15**
Pycnoderma congoense **31**
Pygospio elegans **15**
Rhamphobrachium capense **31**
Rhamphobrachium sp. **15**
Rhodine sp. **2**
Rynchospio glutaea **15**
Sabella sp. **15**
Sabellaria intoshi **31**
Sabellaria sp. **31**
Sabellaria spinulosa alcocki **15**
Sabellides capensis **31**
Sabellides luderitzi **31**
Sabellides octocirrata **31**
Sabellides sp. **15**
Schistomeringos neglecta **2**
Schistomeringos rudolphi **2**
Scolelepis lefebvrei **15**
Scolelepis sp. **15**
Scoloplos armiger **15**
Scoloplos johnstonei **15**
Scoloplos johnstonei **31**
Scoloplos sp. **15**
Scyphoproctus djiboutiensis **31**
Serpula vermicularis vermicularis **15**
Sigambra sp. **2**
Sphaerodoridium benguellarum **15**
Sphaerodoropsis sp. **2**
Sphaerosyllis brenicirrus **2**
Sphaerosyllis capensis **2**
Sphaerosyllis semiverucossa **15**
Sphaerosyllis sp. **2**
Sphaerosyllis sublaevis **15**
Spherodoridium capens **31**
Spio filicornis **15**
Spio sp. **15**
Spiochaetopterus sp. **2**
Spiophanes bombyx **15**
Spiophanes soderstromei **31**
Spirobranchus tetraceros **15**
Spirorbis sp. **15**
Sternaspis scutata **15**
Sthenelais sp. **2**
Streblosoma hesslei **15**
Streblosoma persica **31**
Streblosoma sp. **2**
Syllides fulva **2**
Syllides sp. **2**
Syllidia armata **15**
Syllidia sp. **15**
Syllis exilis **15**
Syllis longissima **15**
Syllis sp. **15**
Syllis spongicola **31**
Tauberia sp. **2**
Terebella pterochaeta **15**
Terebella sp. **2**
Terebellides sp. **2**
Terebellides stroemi **2**
Thalenessa sp. **2**
Tharyx filibranchia **15**
Tharyx marioni **31**
Tharyx sp. **2 15**
Thelepus plagiostoma **15**
Thelepus sp. **15**
Timarete sp. **2**
Trichobranchus sp. **2**
Trypanosyllis zebra **2**
Typosillis prolifera **2**
Typosyllia sp. **2**
Typosyllis armillaris **2**
Typosyllis hyaline **2**
Vermiliopsis glandigerus **2**
Vermiliopsis pygidialis **15**
Vermiliopsis sp. **15**
Zeppelina sp. **2**

Class Oligochaeta

Bathydrilus adriaticus **2**
Bathydrilus sp. **2**
Duridrilus tectus **2**

Heterodrilus maccaini **2**
Heterodrilus sp. **2**
Inanidrilus sp. **2**
Limnodriloides appendiculatus **2**
Limnodriloides bipapillatus **2**
Limnodriloides tenuiductus **2**
Limnodriloides sp. **2**
Olavius manifae **2**
Olavius verga **2**
Paranais litoralis **2**
Phallodrilus sp. **2**
Tectidrilus arabicus **2**
Tubificoides sp. **2**
Class Sipunculidea
Apionsoma trichocephalus **2**
Aspidosiphon sp. **2**
Phascolapsis sp. **2**
Phascolion convestitum **2**
Phascolion valdiviae var. sumatrense **2**
Phascolion sp. **2**
Phascolosoma sp. **2**
Siphonosoma sp. **2**
Class Echiura
Anelassorhynchus branchiorhynchus **3**
Listriolobus brevirostris **3**
Ikeda pirotansis **3**

PHYLUM ARTHROPODA
Class Crustacea
Acanthephyra sp. **13**
Acetes Japonicus **13**
Aeginella sp. **15**
Aeginellopsis arabica **15**
Aglaiocypris sp. **2**
Alocopocythere reticulate **2**
Alpheus sp. **13**
Ampelisca brevicornis **2, 15**
Ampelisca hemigera **15**
Ampelisca insignis **2, 15**
Ampelisca scabripes **2, 15**
Ampelisca sp. **2, 3**
Ampelisca tulearensis **2, 15**
Amphiascopsis subdebilis **20**
Amphiascus minutus **20**
Amphiascus sp. **2**
Amphilochus neapolitanus **2**
Amphilochus sp. **2**
Ampilochus hemigera **15**
Ampilochus neopolitanus **15**
Ampithoe falsa **2, 15**
Ampithoe ramondi **2, 15**
Ampithoe sp. **2, 3, 15**
Apanthura africana **2**
Apanthura sandalensis **3**
Apseudopsis sp. **2, 3**
Arabanthura enigmatica **2**
Arcturinoides sp. **2**
Astacilla mediterranea **2, 20**
Asteropterrgion sp. **2**
Atergatis integerrimus **3**
Azotostoma sp. **15**
Balanus amphitrite **3, 13, 19, 20**
Balanus sp. **3**
Balanus venustus **2, 20**
Biancolina sp. **15**
Bodotria parva **15**
Bodotria siamensis **15**
Bodotria similis **2, 15, 20**
Bodotria sp. **3**
Bodotria sublevis **15**
Branchinella spinosa **17**
Branchipus schaefferi **18**
Brianola sp. **2**
Bulbamphiascus inermis **2, 20**
Byblis sp. **3, 15**
Calanopia parathompsoni **20**
Calanopia sp. **2**
Callianassa sp. **13**
Callistocythere cf. *flavidofusca intricatoides* **2, 23**
Callistocythere cf. *intricatoi* **2**
Campylaspis glabra **15**
Campylaspis sp. **2, 3, 15**
Canuella furcigera **2, 20**
Canuella sp. **2**
Caprella danilevskii **2, 15**
Caprella sp. **15**
Carinocythereis batei **23**
Carinocythereis hamata **2**
Ceradocus rubromaculatus **2, 15**
Ceradocus serratus **2, 15**
Ceradocus sp. **2, 3**
Cerapus sp. **2**
Cerapus tubularis **2**
Cheiriphtis sp. **3**
Cheirocratus intermis **2**
Cheirocratus unidentatus **2**
Cheirophotis megacheles **2, 15**
Chiromantes boulengeri **16**
Cirolana parva **2**
Cirolana sp. **2**
Cirolana sulcata **2**
Cleistostoma sp. **3**
Cletodes cf. *dissimilis* **2**
Colomastix pusselia **2**
Corophinum sp. **3**
Cumella forficula **2, 15, 20**
Cumella nispida **15, 20**
Cumella sp. **2, 3, 15**
Cumopsis sp. **3**
Cyclaspis cingulate **20**
Cyclaspis hornelli **2, 15, 20**
Cyclaspis picta **2, 15, 20**
Cyclaspis sp. **3, 15**
Cyclopoid sp. **2**
Cyelaspis cingulate **2**
Cylindroleberis sp. **2**
Cymadusa filosa **2, 15**
Cymadusa sp. **3**
Cymodoce sp. **2**
Cypridina sp. **2**
Cypridinodes minuta **2**
Cyproidea sp. **3**
Cyproidea tecticauda **2, 15**
Cytherella sp. **2, 15**
Cytherelloidea sp. **2**
Dactylopodia sp. **2**
Darcythompsonia sp. **2**
Dardanus sp. **13**
Diogenes sp. **13**
Diosaccid sp. **2**
Dotilla blanfordi **16**
Dotilla sulcata **16**
Dulichiella appendiculata **2**
Ebalia sp. **13**
Ectinosoma sp. **2**
Elasmopus pectinicrus **15**
Elasmopus rapax **15**
Eocuma affine **2, 3, 15, 20**
Eocuma rosae **3**
Eocuma sarsi **2, 3, 20**
Eocuma sp. **3, 15**
Eocuma taprobanicum **2, 15**
Epixanthus frontalis **3**
Erichhonius sp. **3**
Erichthonius brasiliensis **2**
Erythrops minuta **21**
Eudactylopus andrewi **2, 20**
Euphilomedes sp. **2**
Euraphia withersi **3**
Euroides caesaris **2, 15**
Eurycarcinus orientalis **3**
Euryte pseudorobusta **20**
Euterpina acutifrons **20**
Eviopisa sp. **3**
Exanthura filiformis **20**
Eyakia sp. **2 15**
Galathea sp. **13**
Gammaropsis atlantica **2, 15**
Gammaropsis sp. **2, 15**
Gastrosaccus kempi **15, 22**
Gibboborchella alata **23**
Gibboborchella venosa **23**
Gigacuma sp. **2**
Gitanopsis gouriae **15**
Gitanopsis sp. **15**
Gnathia africana **2**
Gnathia sp. **2 3**
Gonodactylus demanii **2, 29**
Grandidierella bonnieroides **2, 15**
Grandidierella exilis **2, 15**
Guernea rhomba **2**
Gumella hispida **2**
Gynodiastylis sp. **2, 15**
Halectinosoma sp. **2**
Haliophasma sp. **2**
Haplostylus bengalensis **21**
Haplostylus parerythraeus **22**
Harpacticoid copepodites **20**
Harpacticus nicaeensis **20**
Heppomedon longimanus **2**
Heppomedon normalis **2**
Hersiliodes latericia **20**
Heterocuma andamani **15, 20**
Heterocuma sp. **15**
Heteromysis proxima **22**
Hippolyte sp. **2**
Hornella incerta **2, 15**
Hyale grandicornis **2**
Hyale sp. **2**
Hyograpsus paludicols **16**
Idunella lindae **2**
Idunella similis **2**
Idunella sp. **2, 15**
Ilyoplax frater **13, 16**
Ilyoplax sp. **3**
Ilyoplax sulcata **16**
Indischnopus herdmani **15**
Indomysis annandalei **21, 22**
Iphimedia sp. **2**
Iphinoe crassipes **15**
Iphinoe ischnura **20**
Iphinoe maeotica **3**
Iphinoe sp. **3, 15**
Jainella karwarensis **2**
Kainomatomysis foxi **21**
Kalliapseudopsis mauritanicus **2**
Keijella darwini **2**
Lankacxthere coralloides **2**
Lanocira gardineri **2**
Lanocira glabra **2**
Laomedia sp. **13**
Laophonte cornuta **20**
Laophonte inornata **20**
Laophonte sp. **2**
Laophontopsis lamellifera **20**
Latreutes pygmaeus **2, 15**
Latreutes sp. **13**
Lemboides ofer **2**
Lembos sp. **2**
Lembos teleforus **2**
Leptochela aculeocaudata **2**
Leptochela sydniensis **2, 15**
Leptochelia lifuensis **2**
Leptochelia minuta **2**
Leptochelia savignli **2**
Leptochelia sp. **2**
Leptochryseus kuwaitense **16**
Leucosia sp. **13**
Leucothoe lesson **2**
Leucothoe sp. **2, 15**
Leucothoe spinicarpa **2**
Leucothoella bannwarthi **2, 15**
Leucothoella sp. **15**
Leucothoides sp. **15**
Leucothrals sp. **2**
Liljeborgia sp. **2**
Limbos leptocheirus **2**
Longipedia sp. **2**
Lourinia armata **2**
Loxoconcha amygdalanux **2**
Loxoconcha gurneyi **2**
Loxoconcha indica **23**
Loxoconcha multiornata **23**
Loxoconcha ornatovalvae **2**
Lucifer hanseni **13**
Lucifer typus **13**
Lycomysis platycauda **21**
Lysianassa cinghalensis **2, 15**
Lysianassa coelochir **2**
Lysmata sp. **13**
Lyssianassa sp. **2**
Macrophthalmus (Macrophthalmus) laevis **16**
Macrophthalmus (Macrophthalmus) sulcatus **16**
Macrophthalmus (Mareotis) depressus **16**
Macrophthalmus (Venitus) dentipes **3, 16**
Maera hemigera **15**
Maera pacifica **2, 15**
Maera quadrimana **2, 15**
Maera sp. **2, 15**
Maera tenella **2, 15**
Malacanthura africana **20**
Malacanthura mombasa **2, 20**
Manningia sp. **2**
Manningis arabicum **16**
Maua sp. **2**
Medaeops granulosus **3**
Megabalanus sp. **3**
Megabalanus tintinnbulum **3**
Melita sp. **2, 3**
Metamphiascopsis hirsutus **20**
Metapenaeopsis mogiensis **24**
Metapenaeopsis stridulans **24, 25, 26**
Metapenaeus affinis **25, 27**
Metapenaeus stebbingi **24, 25, 27, 28**
Metaplax indicus **16**
Metaprotella sandalensis **2, 15**
Metopograpsus messor **3, 16**
Metopograpsus thukuhar **16**
Microasteropteron bacescui **2**
Microlysias denoceras **2**
Microlysias sp. **2**
Microphotis blachei **3**
Microsetella norvegiga **20**
Mycrolysias xenoceras **2**
Mysidopsis kempi **21**
Nannastacus gibbosus **15**
Nannastacus gurneyi **15, 20**
Nannastacus inflatus **2, 15, 20**
Nannastacus lepturus **2, 15, 20**
Nannastacus lepturus **20**
Nannastacus sp. **2, 15**
Nannastacus stebbingi **2, 15, 20**
Nannastacus zimmeri **15**
Nannastacuss gurneyi **2**
Nanosesarma minatum **3**
Nasima ditilliformis **16**
Natarajphotis manieni **15**
Natatolana neglecta **2, 20**
Nebalia marerubri **2**
Nebalia sp. **2**
Neomonoceratina sp. **23**
Neonesidea schulzi **2**
Nitocrella sp. **2**
Nitrocra sp. **2**
Ocyode rotundata **16**
Oediceroides cinderella **2**
Orchomene sp. **3**
Pachcheles sp. **13**
Paguristes sp. **13**
Pagurus sp. **13**
Palaemon sp. **13**
Panulirus versicolor **14**
Paracytheridea sp. **2**
Paradexamine sp. **2**
Paradiastylis brachyura **2, 15, 20**
Paradiastylis culicoides **2**
Paradiastylis sp. **2, 15**
Paralaophonte congenera **20**
Paralaophonte mediterranea **20**
Paralaophonte sp. **2**
Paranamixis sp. **2**
Parapenaeopsis stylifera **13, 26**
Parasesama plicatum **16**
Parathalestris sp. **2**
Paratymolus sp. **2**
Parhyale sp. **15**
Paromoera capensis **15**
Parthenope sp. **13**
Penaeus japonicus **26, 27**
Penaeus latisulcatus **24, 25, 27**
Penaeus semisulcatus **25, 26, 28**
Periclimenes sp. **13**
Perioculodes aequimanus **3**
Perioculodes longimanus **2**
Perioculodes pallidus **2**
Perioculodes sp. **3**
Philyra platychira **2**
Philyra sp. **3**
Photis digitata **15**
Photis dolicammota **2**
Photis longimanus **2, 15**
Photis sp. **2**
Pilumnopeus sp. **2**
Pilumnus vespertilis **3**
Pinnixa sp. **2**
Platyisohnopus herdmani **3**
Podocerus brasiliensis **2**
Poecilostomatoida sp. **2**

Portunus segnis (previously named P. pelagicus) **3**
Praniza (Gnathia) sp. **2**
Processa aequimana **2, 15**
Processa australiensis **2**
Processa japonica **2**
Psammameira reducta **20**
Pseudobradya sp. **2**
Pseudocaprellina pambanensis **15**
Pseudocyclops xiphophorus **20**
Pseudodiaptomus salinus **20**
Pseudodiaptomus sp. **2**
Pseudosympodomma indicum **2, 15, 20**
Reterocuma sndamani **2**
Rhepoxynius sp. **15**
Rhopalophthalmus sp. **21**
Robertgurneya ilievecensis **20**
Robertgurneya rostrata **20**
Rocinela orientalis **2**
Rutiderma sp. **2**
Sarsiella sp. **2**
Schizotrema bifrons **15, 20**
Schizotrema depressum **15**
Schizotrema sordidum **2, 15**
Schizotrema sp. **2, 15**
Scopimera crabricauda **16**
Scottolana longipes **2, 20**
Serenlla leachii **16**
Sergestes sp. **13**
Sinoediceros homopalmatus **3**
Siphonoecetes arabicus **2**
Siphonoecetes sp. **3**
Siriella affinis **21**
Siriella brevicaudata **15, 21, 22**
Siriella hanseni **15, 22**
Siriella sp. **21**
Solenocera crassicornis **27**
Solenocera hextii **13**
Stenhelia sp. **2**
Stenothoe adhaercus **2**
Stenothoe galensis **2**
Sunaristes sp. **2**
Synchelidium haplocheles **2**
Syncheliolium sp. **3**
Synelmis sp. **2**
Synssterope sp. **2**
Tanella cf. *gracilis* **23**
Tetraleberis sp. **2**
Thalamita poissoni **2**
Thalassocaris obscura **13**
Thenus orietalis **3, 13, 14**
Thompsonula sp. **2**
Tozeuma sp. **13**
Trachypenaeus curvirostris **13, 24, 25**
Trachypenaeus granulosus **25, 28**
Triliropus minutus **2, 15**
Tylodiplax indica **16**
Tylodiplax sp. **2**
Typhlamphiascus sp. **2**
Typhlocarcinus villosus **2**
Uca annulipes albimana **16**
Uca annulipes iranica **16**
Uca hesperiae **16**
Uca inversa **16**
Uca sindensis **16**
Uca tetragonon **16**
Upogebia sp. **13**
Urothoe grimaldi **2**
Urothoe sp. **2, 3, 15**
Urothoe spinidigitus **2, 15**
Urothoe tumorsa **2**
Vaunthompsonia arabica **2, 15, 20**
Vijaiella mandriensis **2**
Xantho (Leptodius) exaratus **3**
Xestoleberis rhomboidea **2**
Xestoleberis rotunda **2, 23**

Class Pycnogonida

Ammothella indica **2**
Anoplodactylus glandulifera **2**
Anoplodactylus sp. **2**
Ascorhynchus sp. **2**
Callipallene pectinata **2**

PHYLUM MOLLUSCA

Class Polyplacophora

Ischnochiton yerburyi **3**

Class Gastropoda

Acteon sp. **3**
Alaba virgata **7**
Amaea acuminata **4**
Ancilla castenea **4**
Ancilla castanea **3 8**
Ancilla cinnamomea **7**
Ancilla fasciata **7**
Ancilla sp. **8**
Architectonica perspectiva **4**
Architectonica sp. **3**
Atys cylindrica **4, 7**
Atys pellyi **3**
Atys sp. **3**
Babylonia spirata **4**
Bittium sp. **3**
Bulla ampulla **3, 4, 7**
Bullia mauritiana **4**
Bullaria ampulla **8**
Calyptraea pellucida **3, 4**
Calyptraea sp. **3**
Caecum sp. **3**
Casmaria ponderosa **3**
Cantharus wagneri **3**
Cellana rota **3**
Cerithidea cingulata **3 4**
Cerithidea sp. **8**
Cerithium caeruleum **3**
Cerithium morus **7**
Cerithium petrosum **7**
Cerithium rugosum **7**
Cerithium ruppelli **7**
Cerithium scabridum **3, 4, 7, 8**
Cerithidium cerithinum **3**
Cerithideopsis cingulatus **7**
Chicoreus (Hexaplex) kusterianus **7**
Cerithiopsis (Seila) hinduorum **7**
Cerithiopsis sp. **3**
Chromodoris annulata **6, 8**
Chromodoris obsoleta **6**
Chrysallida sp. **3**
Clanculus pharaonis **3**
Clypeomorus bifasciatus **3**
Clypeomorus bifasciatus bifasciatus **3**
Clypeomorus clypeomorus **5**
Conus sp. **3, 9**
Conus milesi **8**
Costellaria sp. **3**
Crepidula walshii **3, 4**
Cronia konkanensis **3, 8**
Cuthona albocrusta **3**
Cylichna collyra **3**
Cylichna cylindracea **3**
Cylichna sp. **3**
Cymatium sp. **3**
Cypraea arabica **4**
Cypraea chinensis **4**
Cypraea gracilis **7**
Cypraea grayana **3, 4**
Cypraea lamarckii **3**
Cypraea lentiginosa **3**
Cypraea pulchra **3**
Cypraea tardus winkworthi **4**
Cypraea turdus **3, 7**
Dendrodoris fumata **6**
Dendrodoris cf. *nigra* **6**
Diala sulcifera **7**
Diala semistriata **7**
Diodora funiculata **3, 4, 7, 8**
Diodora funiculata subsp. **7**
Diodora quadriradiata **7**
Diodora rueppellii **3, 7, 8**
Doriopsilla cf. *miniata* **6**
Doto kya **3**
Drupa tuberculata **7**
Duplicaria duplicata **4**
Ellobium sp. **3**
Eurobranchus misakiensis **3**
Euchelus asper **3, 5, 7**
Echinolittorina arabica **3**
Epitonium sp. **3**
Ethminolia degregorii **3**
Flabellina amabilis **3**
Flabellina bicolor **6**
Fusinus arabicus **3, 4, 7**
Gibberula mazagonica **3**
Glossaulax didyma **3**
Glossodoris cf. *pallida* **6**
Granulina oodes **3**
Haminoea vitrea **3**
Hastula sp. **8**
Heliacus sp. **3**
Hexaplex kusterianus **3, 4, 5, 8**
Hypermastus epiphanes **3**
Hypermastus sp. **8**
Hypselodoris dollfusi **6**
Hypselodoris maculosa **6**
Leucotina gratiosa **3**
Lunella coronata **3**
Marginella (Persicula) mazagonica **7**
Melanella cumingi **3**
Melanella sp. **3**
Minolia holdsworthiana **7**
Mitrella blanda **3, 4, 7, 8**
Monilea chiliarches **3, 4**
Monilea gradata **4**
Monilea obscura **7**
Monodonta nebulosa **3**
Murex malabricus **4**
Murex scolopax **3, 4, 7**
Murex tribulus **5**
Nassarius albescens **3**
Nassarius albescens gemmuliferus **4, 8**
Nassarius arcularis plicatus **4, 8**
Nassarius arcularius **5**
Nassarius coronatus **4**
Nassarius concinnus **3**
Nassarius emilyae **3**
Nassarius frederici **3**
Nassarius marmoreus **3**
Nassarius persicus **3**
Nassarius pullus **7**
Nassarius sp. **3, 8**
Natica pulicaris **4**
*Natica vitel*lus **4, 8**
Natica sp. **8**
Nerita albicilla **4**
Nerita sp. **3**
Neverita didyma **4**
Niso venosa **4**
Nodilittorina subnodosa **7**
Odostomia eutropia **3**
Odostomia sp. **3**
Oliva bulbosa **4**
Omalogyra sp. **3**
Perinella caillaudi **7**
Perinella conica **7**
Peristerina nassatula forskalii **4**
Peronia peronii **3**
Phasianella jaspidea **7**
Phasianella solida **8**
Phyllidia (Fryeria) rueppelii **6**
Phyllidia sp. **8**
Pirenella conica **4**
Pisania sp. **8**
Placida daguilarensis **3**
Planaxis sulcatus **3, 4, 7**
Plocamopherus ocellatus **6**
Polynices tumidus **4**
Potamides conicus **3, 8**
Priotrochus obscurus **3**
Pseudodaphnella daedala **3**
Pseudonoba alphesiboei **3**
Pseudonoba columen **3**
Pupa affinis **3**
Pyramidella sp. **3**
Ranularia boschi **4**
Rapana bulbosa **4**
Rapana rapiformis **3**
Rapana venoza **3**
Retusa sp. **3**
Rhinoclavus fasciatum **7**
Rhinoclavus fasciata **8**
Rhinoclavis kochi **3**
Ringicula propinquans **3**
Rissoina sp. **3**
Rissoina distans **7**
Salinator fragilis **4**
Scabricola desetangsii **3**
Sebadoris fragilis **6**
Semicassis faurotis **4**
Serpulorbis variabilis **3**
Siphonaria belcheri **3**
Siphonaria laciniosa **4**
Siphonaria rosea **7**
Siphonaria savignui **3**
Siphonaria tenuicostulata **4**
Splendrillia sp. **3**
Stomatella auricula **3**
Strombus decorus **3**
Strombus decorus pericus **4 7**
Strombus fasciatus **4**
Strombus gibberulus **4**
Strombus persicus **3, 8**
Strombus plicatus sibbaldi **4**
Strombus sp. **8**
Syrnola aclys **3**
Syrnola brunnea **3**
Syrnola sp. **3**
Terebralia palustris **4**
Terebellum terebellum **3**
Terebellum sp. **8**
Terebra sp. **3, 8**
Thais carinifera **7**
Thais margariticola **7**
Thais mutabilis **4**
Thais pseudohippocastanum **7**
Thais savigny **3, 4, 8**
Thais sp. **5, 8**
Thais tissoti **4, 7, 8**
Thaisella lacera **3**
Thaisella tissoti **3**
Tibia fusus **4**
Tibia insulaechorab curta **4**
Tibia insulaechorab **3**
Tonna dolium **4**
Tornatina inconspicua **3**
Tornatina persiana **3**
Tornatina sp. **3**
Tricolia fordiana **7**
Tricolia sp. **3**
Trochus sp. **8**
Trochus fultoni **3**
Trochus erythraeus **3, 4, 7, 8**
Turbo coronatus **7**
Turbo radiatus **4**
Turbonilla icela **2 7**
Turbonilla linjaica **3**
Turbo radiatus **3**
Turitella cochlea **4, 8**
Turitella fultoni **8**
Turitella turulosa **4**
Turitella sp. **8**
Umbonium vestiarum **3, 4, 7**
Vanicoro sp. **3**
Vermetus sulcatus **4, 7, 8**
Vexillum acuminatum **4**
Vexillum asiridis **3**
Vexillum diaconalis **3**
Volema pyrum **4**
Zafra selasphora **3**
Ziba sp. **8**
Ziba pretiosa **8**

Class Bivalvia

Acar abdita **3**
Acar plicata **3, 4**
Acrosterigma sp. **8**
Amiantis umbonella **3, 4**
Amphilepida faba **3**
Amphilepida peilei **3**
Amphilepida sp. **3**
Anadra ehrenbergi **8**
Anadra birleyana **8**
Anadara ehrenbergi **3, 4**
Anadara erythraeonensis **3**
Anadara uropigimelana **4**
Anadara sp. **3**
Anodontia edentula **3, 7**
Anomia laqueata **4**
Anomia sp. **8**
Apolymetis dubia **4**
Arca lacerata **7**
Arca plicata **7, 8**
Arca uropigmelana **7**
Arca sp. **3, 8**
Asaphis deflorata **4**
Asaphis violascens **3**
Barbatia fusca **2**
Barbatia decussata **3, 8**
Barbatia foliata **3**
Barbatia fusca **3**
Barbatia helblingi **4, 7**
Barbatia obliquata **4**
Barbatia parva **8**

Barbatia plicata **8**
Barbatia setigera **3, 8**
Barbatia sp. **3, 8**
Bassina callophyla **3, 4, 8**
Bassina foliacea **8**
Brachiodontes variabilis **3, 4, 7**
Brachiodontes sp. **8**
Brachidontes variabilis **8**
Brachidontes sp. **8**
Callista erycina **4**
Callista florida **3, 8**
Callista multiradiata **4**
Cardita bicolor **4**
Cardita gubernaculum **4**
Carditella sp. **3**
Cardites bicolor **3**
Cardites sp. **3**
Cardium sp. **8**
Chama asperella **8**
Chama brassica **3**
Chama pacifica **4**
Chama reflexa **3, 8**
Chama sp. **3, 8**
Chlamys livida **3, 8**
Chlamys ruschenbergii **4, 7, 8**
Chlamys senatorius **4, 7, 8**
Chlamys sp. **8**
Circe corrugata **4, 8**
Circe intermedia **3, 8**
Circe scripta **7, 8**
Circentia callipyga **4**
Circenita callipyga **8**
Codakia tigerina **4**
Corbula sulculosa **3, 4**
Corbula taitensis **3, 8**
Cuna sp. **7**
Curvimysella sp. **3**
Decatopecten plica **4**
Didimacar tenebrica **3**
Diplodonta ravayensis **4**
Diplodonta sp. **3**
Divaricella cumingiana **4**
Donax cuneatus **4**
Donax scalpellum **4**
Donax sp. **3**
Dosinia alta **3, 4**
Dosinia erythraea **3**
Dosinia tumida **4**
Dosinia sp. **3, 8**
Ervilia sp. **3**
Fulvia fragile **3**
Fulvia australe **8**
Gafrarium arabicum **7**
Gafrarium callipygeum **7**
Gafrarium divaricatum **7**
Gafrarium pectinatum **4**
Gafrarium sp. **8**
Gari maculosa **3, 8**
Gari sp. **3**
Gari (Psammobia) occidens **7**
Glycemeris lividus **4**
Glycemeris livida **3**
Glycemeris pectunculus maskatensis **4, 8**
Glycemeris pectunculus **3**
Gregariella simplicifilis **3**
Hiatula ruppelliana **3**
Hyotissa hyotis **8**
Irus irus **4**
Isognomen legumen **7**
Isognomon sp. **8**
Kellia sp. **3**
Laevicardium papyraceaum **4, 7**
Lima sowerbyi **4**
Lioconcha ornata **3, 8**
Lithophaga cumingiana **4**
Lithophaga robusta **3**
Loripes sp. **3**
Loripes fisheriana **7**
Loxoglypta rhomboides **3**
Lucina dentifera **8**
Lutraria philippinarum **4**
Mactra glabrata glabrata **4**
Mactra lilacea **3**
Mactra olorina **7**
Mactrinula sp. **3**
Malleus malleus **8**
Malleus regula **4, 7**
Malleus sp. **8**
Malvifundus normalis **3**
Malvufundus normalis **8**
Malvufundus regula **8**
Marcia ceylonensis **4**
Marcia hiantina **4**
Marcia marmorata **3**
Marcia opima **3**
Marikellia sp. **3**
Meretrix metretrix **7**
Modiolus ligneus **8**
Musculista senhousia **3**
Musculus sp. **8**
Mytilicardita (Beguina) gubernaculum **7**
Nemocardium sp. **8**
Nemocardium aurantiacum **8**
Nucula inconspicua **3**
Nucula sp. **3**
Nuculoma layardii **3**
Ostrea cristagalli **4**
Ostrea cucullata **4**
Ostrea sp. **3**
Paphia gallus **4**
Paphia sulcaris **4**
Paphia textile **3, 4**
Paphia sp. **3**
Parviperna dentifera **7**
Pecten erythraeensis **4**
Periglypta reticulata **4**
Periploma indicum **3**
Phaxas cultellus **4**
Pinctada margarinifera **3**
Pinctada margaritifera **4**
Pinctada radiata **3, 4, 7, 8**
Pinctada sp. **8**
Pinna atropurpurea **7**
Pinna bicolor **3, 8**
Pinna muricata **4**
Pinna sp. **8**
Plicatula imbricata **4**
Plicatula plicata **7**
Protapes cor **3**
Protapes sinuosa **3**
Pteria marmorata **4**
Saccostrea cucullata **3**
Sanguinolaria cumingiana **4**
Scintilla sp. **3**
Semele scabra **4**
Semele sinensis **4**
Solen brevis **4**
Solen dactylus **3**
Soletellina rosea **3**
Spondylus aculeatus **7**
Spondylus exilis **4, 8**
Spondylus gloriandus **7**
Spondylus marisrubri **3**
Spondylus townsendi **7**
Spondylus variegatus **3**
Streptopinna saccata **4**
Sunetta effosa **4, 7, 8**
Syndesmya sp. **3**
Tapes texturata **4**
Tapes bruguierei **3**
Tapes sulcarius **3, 8**
Tellina arsinoensis **3**
Tellina donacina **3**
Tellina foliacea **4**
Tellina inflata **4**
Tellina methoria **3**
Tellina valtonis **3**
Tellina vernalis **3**
Tellina sp. **3, 8**
Theora cadabra **3**
Timoclea sp. **3, 7**
Tivela adamoides **4**
Trachycardium assimile **3**
Trachycardium lacunosum **3, 4, 7, 8**
Trachycardium maculosum **7**
Trachycardium rubicundum **3, 4**
Trapezium sublaevigatum **3, 7**
Tridacna maxima **4**
Turtonia minuta **3**
Turtonia sp. **3**
Venerupis deshaysei **7**
Venerupis rugosa **3**
Yoldia tropica **3**
Class Cephalopoda
Loligo duvauceli **11**
Octopus cyaneus **10, 11**
Sepia pharaonis **9, 10, 11**
Sepia arabica **11**
Sepia latimanus **11**
Sepia murrayi **11**
Sepia prashadi **11**
Sepia savignyi **11**
Sepiella inermis **11**
Sepioteuthis lessoniana **11**
Class Scaphopoda
Cadulus euloides **3**
Dentalium octangulatum **3, 8**
Laevidentalium longitrorsum **8**
Tesseracme quadrapicalis **3**
Class Amphineura
Chiton sp. **8**

PHYLUM ECHINODERMATA
Class Crinoidea
Amphilycus scripta **1**
*Amphiodia (Amphiodia) **obtecta*** **1**
Amphioplus (Amphioplus) seminudus **1**
Amphioplus (Lymanella) hastatus **1**
Amphipholis squamata **1**
Amphiura (Amphiura) crispa **1**
Amphiura (Amphiura) fasciata **1**
Amphiura (Amphiura) sp **1**
Amphiura (Amphiura) sp. *nov.* **1**
Asterina burtoni **1**
Asteropsis carinifera **1**
Astropecten indicus **1**
Astropecten monacanthus **1**
Astropecten polyacanthus phragmorus **1**
Astropecten polyacanthus polyacanthus **1**
Astropecten pugnax **1**
Decametra mollis **1**
Euretaster cribrosus **1**
Leiaster leachi **1**
Linckia multifora **1**
Luidia hardwicki **1**
Luidia maculata **1**
Macrophiothrix elongata **1**
Macrophiothrix sp. aff. Hirsuta cheneyi **1**
Macrophiotrix sp. **1**
Ophiactis savignyi **1**
Ophionereis dubia **1**
Ophiothela danae **1**
Ophiothela venusta **1**
Ophiothrix savignyi **1**
Ophiura kinbergi **1**
Paracrocnida persica **1**
Pentaceraster mammillatus **1**
Class Echinoidea
Brissopsis persica **1**
Clypeaster humilis **1, 2**
Clypeaster reticulatus **1, 2**
Clypeaster savignyi **2**
Clypeaster sp. **2**
Diadema setosum **1, 2**
Dougaloplus echinatus **2**
Dougaloplus personatus **2**
Echinodiscus auritus **1**
Echinodiscus auritus **2**
Echinoidea sp. **2**
Echinoidea unid. **2**
Echinometra mathei **1**
Lovenia elongata **1, 2**
Metalia sternalis **1, 2**
Metalia townsendi **1**
Prionocidaris baculosa **1**
Temnopleurus toreumaticus **1, 2**
Temnotrema siamense **1**
Temnotrema sp. **2**
Class Holothurioidea
Holothuria (Cystipus) rigida **1**
Holothuria (Halodeima) atra **1**
Holothuria (Halodeima) edulis **1**
Holothuria (Mertensiothuria) leucospilota **1**
Holothuria (Thymiosycia) arenicola **1, 2**
Holothuria (Thymiosycia) hilla **1**
Holothuria (Thymiosycia) impatiens **1, 2**
Holothuria sp. **2**
Labidodemas semperianum **1**
Leptosynapta chela **1, 2**
Ohshimella ehrenbergi **1**
Protankyra pseudodigitata **1, 2**
Stichopus variegatus **1**
Thone sp. **1**
Thyone dura **2**
Class Asteroidea
Asterina burtoni **2**
Astropecten hemprichi **2**
Astropecten monacanthus **2**
Astropecten polyacanthus **2**
Astropecten pugnax **2**
Astropecten sp **2**
Class Ophiuridea
Amphiodia microplax **2**
Amphiodia obtecta **2**
Amphiodia sp. **2**
Amphioplus hastatus **2**
Amphioplus personatus **2**
Amphioplus seminudus **2**
Amphipholis squamata **2**
Amphiura crispa **2**
Amphiura fasciata **2**
Amphiura sp. **2**
Amphiura tennis **2**
Ophiactis savignyi **2**
Ophiocentrus asper **2**
Ophiomyxa sp. **2**
Ophioneries dubia **2**
Ophiothrix savignyi **2**
Ophiura kinbergi **2**
Paracrocnida persica **2**

PHYLUM BRYOZOA
Class Gymnolaemata
Aeverrillia setigera **2**
Antropora minor (Antropora marginella) **2**
Crisia elongata **2**
Hippodiplosia otto-mulleriana **2**
Jellyella (Membranipora) tuberculata **2**
Microporella orientalis **2**
Nellia quadrilatera **2**
Parasmittina cf *tropica* **2**
Parasmittina dentigera **2**
Parasmittina egyptica **2**
Parasmittina gnata **2**
Parasmittina parsevali **2**
Parasmittina raigii **2**
Parasmittina signata **2**
Parasmittina unispinosa **2**
Patinella (Lichenopora) radiata **2**
Rhynchozoon larreyi **2**
Schizoporella unicornis **2**
Thalamoporella gothica **2**
Thalamoporella indica **2**
Watersipora subtorquata **2**
Class Stenolaemata
Celleporaria (Holoporella) labelligera **2**
Celleporaria labelligera **2**

PHYLUM CHORDATA
Subphylum Cephalochordata
Branchiostoma lanceolatum **2**
Subphylum Tunicata (Class Ascidiacea)
Aplidium rubripunctum **30**
Botryllus gregalis **30**
Botryllus niger **30**
Didemnum obscurum **30**
Didemnum yolky **30**
Diplosoma listerianum **30**
Ecteinascidia thurstoni **30**
Eusynstyela hartmeyeri **30**
Herdmania momus **30**
Lissoclinum fragile **30**
Phallusia nigra **30**
Polyclinum constellatum **30**
Styela canopus **30**
Symplegma bahraini **30**
Symplegma brakenhielmi **30**

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