FAUNA OF ARABIA **21**: 11–32 Date of publication: 30.03.2006

Zoological survey in the Red Sea coastal zone of Yemen

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Abstract: Although some of the earliest biological studies in the Arabian Peninsula were carried out in the Red Sea coastal zone of Yemen, our knowledge about the biodiversity of this area remains fragmentary. This paper reports on a zoological survey undertaken in March and April 2004, with the objective of documenting coastal, marine and freshwater biodiversity and the distribution of selected animal taxa in the Yemeni Red Sea and the Tihamah coastal plain. The history of zoological research in the study area is reviewed and the main characteristics of key ecosystems and biota are outlined. Sampling methods are described and an annotated gazetteer of the sampling stations provided. Lists of birds and reef fish observed and of Decapoda (Crustacea) and Odonata collected during the survey are given.

المسح الحيواني في المنطقة الساحلية للبحر الأحمر من اليمن

فريدهلم كروب ومايكل ابل وعارف حمود وولفاجانج شنايدرو اوفي زايونز

خلاصة: على الرغم من القيام بدراسات بيولوجية سابقة في شبه الجزيرة العربية في المنطقة الساحلية للبحر الأحمر من اليمن، لا تزال معرفتنا بالتنوع الحيوي لهذه المنطقة محدودة. يتناول هذا البحث تقريراً حول مسح حيواني نفذ خلال شهري آذار ونيسان لعام ٢٠٠٤ بهدف توثيق التنوع الحيوي الساحلي والبحري وفي المياه العذبة ودراسة توزيع بعض الأنواع الحيوانية في الجزء اليمني للبحر الأحمر وسواحل سهول تهامة. تم عمل مراجعة تاريخية للدراسات السابقة كما تم تحديد أنظمة بيئية وموائل ممثلة. تم وصف طرق جمع العينات بالإضافة إلى إعطاء معجم جغرافي لأماكن جمع العينات. كذلك تم إعطاء قوائم تتضمن أنواع الطيور والأسماك المرجانية والقشريات وعشرية الأرجل والرعاشات التي تم جمعها خلال المسح الحيواني.

INTRODUCTION

Yemen's Red Sea coastline extends for over 760 km from the border with Saudi Arabia at Oreste Point to the Strait of Bab al-Mandab. It accounts for almost 30 % of the eastern seaboard of the Red Sea. A dry coastal plain, the Tihamah, which is wider here than in areas further north, rises abruptly to a mountainous interior. Biological information on coastal, marine and freshwater habitats of this stretch of coastline is still very limited, even though it was one of the first areas in the

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Arabian Peninsula to be studied by European scientists. In January 1761, a Danish expedition, the "Arabiske Rejse", left Copenhagen, reaching Yemen via Istanbul and Cairo in December 1762. The Swedish naturalist Pehr Forsskål (1732-1763), a student of Carolus Linnaeus, participated in this mission and to him we owe the first collections and descriptions of terrestrial and marine plants and animals, particularly fish, most of which were new to science (FORSKÅL 1775). In May 1763, the ill-fated expedition lost its Arabist Friedrich Christian von Haven, who died in al-Mukha. Only a few weeks later Forsskål himself succumbed to malaria in Yarim. Of the six team members only Carsten Niebuhr survived and returned to Copenhagen in 1767. He worked for ten years publishing the results of the expedition, including Forsskål's work (HANSEN 1964). Collections and notes of the Arabiske Rejse have been deposited in the Zoological Museum of Copenhagen.

Subsequent biological expeditions to the Red Sea mainly visited areas further north and on the African coast, with only sporadic research work in Yemen. During a cruise in 1897-98, members of the Austrian expedition on board the research vessel "Pola" conducted the first oceanographic studies in the southern Red Sea. The expedition focused on the Eritrean coast and the deep central part of the Red Sea, but visited al-Mukha and the islands Kamaran, Zuqar, az-Zubair and Perim briefly. Specimens collected during the Pola expedition are deposited in the Natural History Museum in Vienna, Austria (SCHEFBECK 1991). Between 1900 and 1910, scientists on board the Italian ship "Scilla" carried out hydrographic studies in the southern Red Sea. Collections from the western and eastern coast are in the Natural History Museum of Genoa, Italy. On its way to the Indian Ocean, the "John-Murray Expedition" (1933-1934), on board the Egyptian research vessel "Mabahith", collected marine fauna at a few sampling stations in the southern Red Sea. The collections are in the Natural History Museum in London, UK. In 1987, the team of the research vessel "Meteor" took samples in the southern Red Sea, including five stations in the territorial waters of Yemen. Most of their collections are deposited in the Zoological Museum of Hamburg, Germany.

The first extensive study of coastal and marine habitats, ecosystems and biota covering the entire Read Sea coast of Yemen was carried out in 1985 by The World Conservation Union (IUCN) on behalf of the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA). Only very few specimens were collected and deposited at Sana'a University (IUCN/PERSGA 1987). In 1993 and 1994, Sana'a University conducted an ecological survey of two sectors of the Red Sea coast of Yemen: al-Urj to as-Salif and Dhubab to Yakhtul (RUSHDIE et al. 1994).

In 1996, the United Nations Development Programme (UNDP) and the Ministry of Fish Wealth, Republic of Yemen, initiated the project "Protection of Marine Ecosystems of the Red Sea" with the overall objective of increasing the national capacity for the conservation and sustainable use of marine resources, especially with regard to fisheries and coral reefs. This project, which was funded by the Global Environment Facility (GEF), undertook surveys of coastal and marine habitats, biodiversity and fisheries, identified potential sites for protection and monitored the state of the environment along the Red Sea coast of Yemen. Results were entered into a database and analysed using a Geographical Information System (GIS).

Very little research has been undertaken on the freshwater fauna of the Tihamah coastal plain. In 1938, the British Museum (Natural History) Expedition to South-West Arabia briefly visited the Tihamah before leaving the country via al-Hudaidah (SCOTT 1942). In 1965, Guiseppe Scortecci of the University of Genoa collected animal specimens in Yemen, including the Tihamah coastal plain. He published a description of the biological environment of Yemen (SCORTECCI 1966) and his collections, most of which are deposited in the Natural History Museum in Genoa, were subsequently studied by taxonomists (e.g. KRUPP 1983, BALLETTO et al. 1985).

During the Danish expedition in 1762-63 and a few subsequent ship-based missions, biological specimens were collected and deposited in natural history museums, whereas most of the more recent surveys have relied mainly on visual observations, without depositing voucher specimens in scientific collections.

In March and April 2004 we undertook surveys in the Red Sea area and the Tihamah coastal plain of Yemen, with the objectives to document coastal, marine and freshwater biodiversity and the distribution of selected taxa; to compile ecological information at each sampling station; and to contribute to an assessment of coastal, marine and freshwater ecosystems for management and conservation.

Published information on freshwater and marine ecosystems of the Red Sea coast of Yemen is very scarce and most data are hidden in unpublished reports. For this reason we provide a brief outline of the key features of the marine and limnetic ecosystems of the area. The main purpose of this report is to review briefly the available bio-physiographic information about the area, to describe the sampling stations visited during our surveys and to publish our initial results.

PHYSICAL FEATURES, AQUATIC ECOSYSTEMS AND BIOTA

Topography

The central part of Yemen is characterised by mountains up to 3760 m high. To the west, the mountain ridge drops sharply to a low and flat coastal plain, the Tihamah, which runs parallel to the Red Sea and is between 20 km and 50 km wide. Soils in this zone consist of alluvial fans, coarse inter-wadi sediments and dune formations. The Tihamah is an important agricultural area and soils with high loam and silt content are used to grow cereals, vegetables and fruit (Plate 1). The mainland coastline is characterised by sand and pebble beaches, while rocky outcrops are rare. The continental shelf, which ranges between widths of 20 km near al-Mukha and 80 km near al-Fazah, is wider in this area than in the central and northern parts of the Red Sea. Some 100 low-lying nearshore islets and islands, such as Kamaran Island and Uqban Island (Fig. 1, Plate 2), are located on the continental shelf. A deep sea basin, up to 1600 m in depth, separates them from a group of offshore islands of volcanic origin. The two largest are Zuqar Island, with a maximum elevation of 624 m, and Hanish al-Kabir Island (Fig. 1, Plates 3-4), which reaches 407 m altitude (Edwards & Head 1987, DouAbul & Haddad 1999).

Climate and oceanography

The climate in the Red Sea coastal plain is hot and humid, with a mean annual temperature of 29 °C; maximum temperatures exceed 40 °C in July and August. Annual rainfall ranges between 50 mm and 200 mm, the average at al-Hudaidah being 85 mm, with rain falling on about 11 days a year only. The southern part of the Tihamah is under the influence of the biannual monsoon cycle, which brings rains in late summer and during spring, resulting in seasonal flash-floods. Average humidity is about 60 %. These conditions are unfavourable for an extensive growth of vegetation. From May to September a NNW wind regime, typical for the northern Red Sea, prevails in the south. In October winds gradually change to the SSE and retain this direction until April. During the winter there is an intermediate zone between the NNW winds of the northern Red Sea and the SSE winds of the south, which is characterised by areas of low pressure resulting

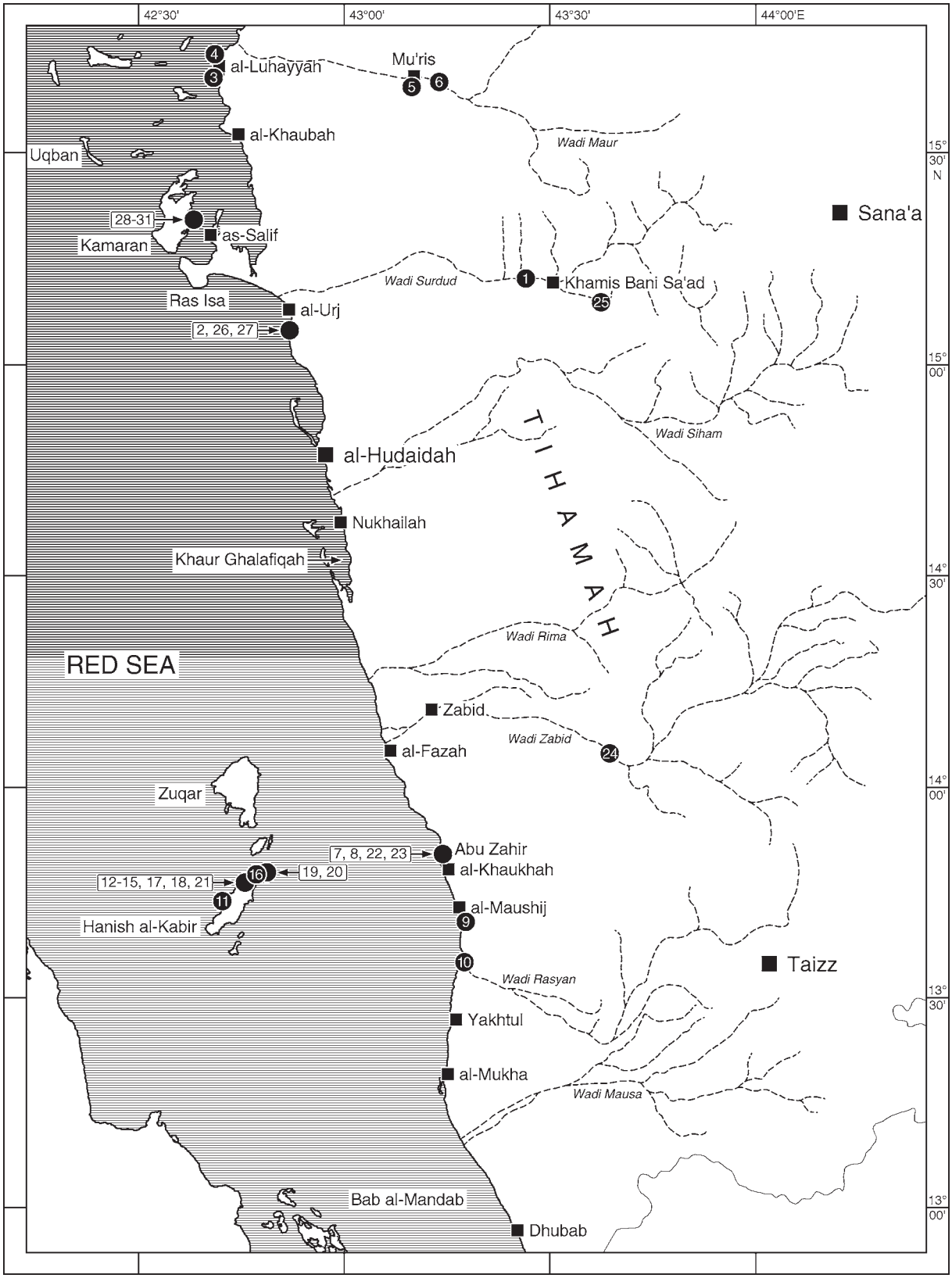

Fig. 1: Map of the Red Sea area of Yemen and the Tihamah coastal plain between al-Luhayyah and al-Mukha, showing the sampling sites (indicated by their numbers without the prefix "YEM-04") of the zoological survey in spring 2004.

in calm conditions. This zone varies in size and oscillates in position. By the beginning of summer it moves gradually to the south, giving way to a transition as the prevailing wind changes from SSE to NNW. Most of the coastline lies exposed, limiting the growth of mangroves and seagrass beds (SCOTT 1995, HADDAD et al. 2001).

Tides are of limited magnitude and seasonal tidal movements are more significant than diurnal or semi-diurnal tides. At al-Hudaidah the diurnal tidal range is about 0.5 m, while the monthly mean varies between 1.3 m in January and 1.0 m in July. Wind-driven water currents along the exposed sandy beaches are stronger than those in the central and northern Red Sea, resulting in sea level fluctuations due to strong persistent onshore winds. The seasonal influx of waters from the Gulf of Aden through the Strait of Bab al-Mandab results in relatively lower sea surface salinities and higher levels of nutrients (EDWARDS & HEAD 1987, IUCN/PERSGA 1987, HADDAD et al. 2001).

Soft-sediment habitats and sabkhas

Soft sediments cover about 75 % of the coastline. The exposure of much of this coastline to strong seasonal winds, resulting in unstable sediments, limits opportunities for colonisation by marine organisms. This condition particularly applies to south-westerly facing shores, which are among the least productive benthic habitats. In some areas promontories and islands provide sheltered conditions (IUCN/PERSGA 1987).

Low rainfall combined with high evaporation rates result in polyhaline soils (solonchaks) and salt crusts are a common feature, forming salt pans or sabkhas. Much of the low-lying, seasonally inundated coastal areas are covered by coastal sabkhas, which may extend up to one kilometre inland. On the seaward side, they extend into the lower intertidal where salinity stress is minimised by tidal flushing. Sabkhas are densest in the northern areas. They are surrounded by salt marsh vegetation (AL-GIFRI & GABALI 2002).

Freshwater-dependent vegetation

In the arid coastal zone, freshwater-dependent vegetation is rather limited in extent and consists mainly of palm trees which tolerate some salinity and of reed swamps, occurring in areas of regular tidal fluctuations of the freshwater-seawater interface. Freshwater is supplied by underground seepage from major wadi systems, which often reach the surface near the shore, sustaining dense groundwater-dependent vegetation. About 9 % of the coastline supports dense palm growth and at another 5 % sparse plant cover is found. Areas of dense freshwater-dependent vegetation are scattered along the central part of the coastline, particularly in the vicinity of al-Urj (Plate 5), Abu Zahir (Plate 6) and Yakhtul. Doum palms (*Hyphaene thebaica*) are restricted to areas north of al-Hudaidah, while date palms (*Phoenix dactylifera*) are also found further south. Reeds are particularly common in semi-enclosed lagoons, where they are often associated with grasses (IUCN/PERSGA 1987).

Mangroves and halophytes

About 12 % of the coast supports mangrove stands, which are rather common in the northern part, become rare in the central section and are again more common in the south. North of al-Urj,

and particularly between al-Luhayyah and Midi (Plate 7), the shoreline is fringed with mangrove stands, which are up to 200 m wide with trees reaching up to 5 m in height. Only two species of mangrove occur in the area, *Avicennia marina* and *Rhizophora mucronata*, although the latter is only known from the north-eastern part of Kamaran Island, from a single site on al-Gandala Island, from Khaur al-Kathib (north of al-Hudaidah), and from a few scattered sites near the shore. The diversity of mangrove-associated flora and fauna is rather low compared to that of more humid parts of the tropics.

Salt marsh vegetation is found on alluvial deposits near the sea shore and is rather limited in extent, occurring mainly south of as-Salif and particularly in areas where sandy beaches are backed by dunes (Plate 8). The species composition of these communities depends on the amount of dew available. Most halophytes are succulents (e.g. *Suaeda fruticosa* and *Zygophyllum album*), although dune grasses also occur in the coastal zone. *Arthrocnemum glaucum* and *Halopeplis perfoliata* are usually found closest to the beach (IUCN/PERSGA 1987, Haddad et al. 2001).

Seagrass beds

Although most of the intertidal and shallow subtidal areas consist of soft substrates, seagrasses are not particularly widespread, because of unstable conditions at the exposed shorelines and high water turbidity. As a result of the restricted diurnal tidal range and seasonal changes in mean sea level, seagrasses do not occur in the intertidal zone. Still, seagrass beds are found along about 40 % of the coastline, mainly in shallow and sheltered areas. They are most extensive between Midi and al-Urj, between an-Nukhailah and Khaur Ghalafiqah, and south of al-Mukha. Nine species of seagrass have been recorded from the Yemeni Red Sea (IUCN/PERSGA 1987).

Hard substrates

The rarity of hard substrates and the relatively high turbidity of the waters covering the wide and shallow continental shelf create unfavourable conditions for coral growth. Hard substrates are often covered by macroalgae, mainly *Sargassum* spp., and calcareous algae.

Plates 1-8: 1: Fertile alluvial sediments make the Tihamah an important area for agriculture, which is heavily dependent on irrigation. This photograph shows henna fields near Wadi Maur. **2:** Aerial view of Uqban al-Kabir (foreground) and Uqban as-Saghir (background, right). These low-lying islands are typical of the northern continental shelf area of Yemen. They are fringed by coral reefs, which are best developed on the eastern (seaward) shores. **3:** Hanish al-Kabir Island is of volcanic origin and composed predominantly of basalt. The black volcanic rocks contrast sharply with the light ochre to almost white sand. This photograph shows the base camp area used during the survey at sampling site YEM 04-13. **4:** Hanish al-Kabir Island has no surface water and the vegetation, which is largely dew-dependent, is very scarce. These dwarf mangrove (*Avicennia marina*) shrubs occur at sampling station YEM 04-11. **5:** Semi-enclosed bay at "Kilo 20", south of al-Urj, with large intertidal mudflat. Freshwater-dependent vegetation consists of doum palms (*Hyphaene thebaica*) above the high-tide line and rush (*Juncus* sp.) at the intertidal fringe. A few mangroves (*Avicennia marina*) occur in the intertidal zone, particularly along low-tide channels. Sampling stations YEM 04-02 and 26 are in this area. **6:** On the landward side, the wide intertidal mudflat of Abu Zahir, north of al-Khaukhah, is fringed by dense date palm (*Phoenix dactylifera*) groves. Sampling stations YEM 04-07, 08, 22 and 23 are in the vicinity of this site. **7:** A wide band of mangroves (*Avicennia marina*) fringes the shoreline of al-Luhayyah. This photograph shows an intertidal mudflat with mangroves near sampling station YEM 04-04. **8:** Sandy beach backed by dunes with halophyte vegetation and brackish water pool near al-Maushij, sampling station YEM 04-09. (See also Fig. 1 and Table 1; photos: F. Krupp).

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Coral communities

Only 25 % of the coastline supports coral growth. In the area between al-Khaukhah and the Strait of Bab al-Mandab, nearshore fringing reefs are more extensive and diverse than further north and live coral cover is higher. Most reefs occur in very shallow water and their seaward margin typically drops to ca 3 m. They are mainly composed of the genera *Acropora*, *Porites* and *Stylophora*. Additionally, about ten other genera of scleractinians have been recorded by TURAK & BRODIE (1999). West of al-Hudaidah, south of Ras Isa Peninsula and in the southern Farasan Islands, submerged patch reefs dominate in terms of abundance and cover. Their shallower parts are mostly 6-8 m deep and *Porites* are the dominant corals.

The best-developed reefs occur offshore, mainly in the vicinity of islands (Plate 2) and around Ras Isa Peninsula (U.Z., pers. obs.). Hanish al-Kabir and other offshore islands support extensive true coral reefs developed on biogenic calcium carbonate and also non-reefal coral communities with a high scleractinian diversity (Plates 9-11). Coral cover is highest in the upper five metres. At drop-offs below 10 m depth, scleractinians are rare and encrusting sponges, ascidians, horny and soft corals dominate (Plate 12). *Porites* and *Acropora* are the dominant coral genera. Similar diversity of scleractinians occurs in coral communities on midwater pinnacles of volcanic origin, such as Avocet Rock south of al-Hudaidah, rising from a depth of more than 40 m.

TURAK & BRODIE (1999) recorded 176 species of stony corals from the Yemeni Red Sea. *Porites* is by far the most common genus of reef-building coral in the area and the main reef framework builder. *Stylophora pistillata* and *Platygyra daedelea*, which are found in a wide range of habitats, are the other two most common corals (SHEPPARD & WELLS 1988, SHEPPARD & SHEPPARD 1991, SHEPPARD et al. 1992, TURAK & BRODIE 1999, PILCHER & DEVANTIER 2001).

Red algal reefs associated with corals occur in semi-sheltered, low-energy coastal waters north of Ras Isa Peninsula. These reefs, which are found at depths of less than 6 m, support limited coral reef development. They are mainly built by coralline algae of the genera *Porolithon* and *Lithothamnium* (TURAK & BRODIE 1999).

Fish and fisheries

Several (mainly unpublished) species lists of fishes from the Yemeni Red Sea have been compiled. However, many identifications are at best doubtful and usually records cannot be verified, because no voucher specimens have been deposited in scientific collections. During the most comprehensive survey conducted to date, BRODIE et al. (1999) recorded 229 species of fishes during underwater visual censuses on 59 coral reefs. The most common families were Caesionidae, Lutjanidae, Acanthuridae, Pomacentridae, Haemulidae and Scaridae. Despite their importance in terms of fisheries, no systematic study of pelagic fish has been conducted.

Compared to other parts of the Red Sea, the shallow, nutrient-rich waters above the continental shelf of Yemen are rich fishing grounds. Fisheries resources are exploited by artisanal subsistence fishermen (Plate 13), local commercial fisheries (Plate 14) and foreign industrial fisheries targeting invertebrates, demersal finfish and pelagic finfish. Most of the resource information from this area dates back to the 1970s and early 1980s, focusing on demersal fishes and shrimps. Estimates of standing stocks and maximum sustainable yields (MSY) are based on landing statistics. According to SANDERS & KEDIDI (1981), trawlable grounds cover about 6200 km^2, of which 550 km^2 are shrimping areas. SANDERS & MORGAN (1989) estimated standing stocks in the Yemeni Red Sea at roughly 23,000-32,000 metric tons. No more recent data on stocks are available.

Fishermen operate from bases and landing sites spread along the mainland coastline and from a number of islands. There are five main landing centres along the Red Sea coast of Yemen: Midi, al-Khaubah, al-Hudaidah (Plate 14), al-Khaukhah, and al-Mukha. Fish are auctioned and sold by the bundle, by specimen or by size in the case of larger fishes, while shrimps are sold by weight. Some fishery products, particularly sea cucumbers, are not recorded because they are processed and sold directly to fish traders for export markets. Fisheries statistics are generally unreliable (HADDAD et al. 2001, HARIRI et al. 2002). Shark fisheries for the East Asian shark fin market are of major concern, and shark populations in the Yemeni Red Sea are on the verge of collapse (KRUPP 1998, 2004).

Turtles, seabirds and marine mammals

The status of marine turtles along the Red Sea cost of Yemen remains insufficiently known. Only two species have been recorded from the area, the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*). GASPERETTI et al. (1993) reported two sight records of green turtles from near al-Hudaidah and one nesting record from Jabal Aziz Island in the Strait of Bab al-Mandab.

The Red Sea coastline of Yemen, with its numerous islands, provides prime feeding and breeding sites for seabirds such as crab plover (*Dromas ardeola*), Persian shearwater (*Puffinus persicus*), red-billed tropicbird (*Phaethon aethereus*), brown booby (*Sula leucogaster*), sooty gull (*Larus hemprichii*), white-eyed gull (*Larus leucophthalmus*), lesser crested tern (*Sterna bengalensis*) and white-cheeked tern (*Sterna repressa*), to name only a few. Important coastal and island bird areas are found between al-Luhayyah and Midi, the islands north of al-Hudaidah, Ras Isa Peninsula, az-Zubair Island, al-Urj, an-Nukhailah, al-Fazah, Hanish al-Kabir Island, the area between al-Mukha and al-Khaukhah, and around Bab al-Mandab (EVANS 1994).

Information on marine mammals is very limited. During the IUCN survey (IUCN/PERSGA 1987), only the humpback dolphin (*Sousa chinensis*) was observed along the Red Sea coast, although the common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Tursiops truncatus*) are expected to occur in the area as well. In August 1987, four whales, probably Bryde's whales (*Balaenoptera edeni*), were observed during an aerial survey of the Farasan Islands nearby in Saudi Arabia (PREEN 1989). There are no confirmed records of dugong (*Dugong dugong*), although there are suitable habitats and the species is likely to occur in low population densities (IUCN/PERSGA 1987).

Freshwater ecosystems

Wadis (seasonally dry stream beds) and estuaries in the Tihamah are highly productive ecosystems, harbouring unique plant and animal species assemblages and sustaining the freshwater-dependent vegetation in the coastal zone. At the same time they are particularly sensitive to human disturbance, above all because they are located in an arid zone. They exhibit a marked seasonality of river flow, with concomitant salinity regimes. Their faunas are not particularly diverse, but the adaptation of biota to constantly changing environmental conditions is remarkable and of great scientific interest.

The relatively high rainfall in the Yemen mountains feeds a number of streams, which descend in wadis towards the coastal plains. Many wadis are perennial in their upper reaches and retain water in isolated pools along their central and lower courses. No surface stream discharges into the Red Sea except after flash-floods following torrential rains. In some wadis this may be as infre-

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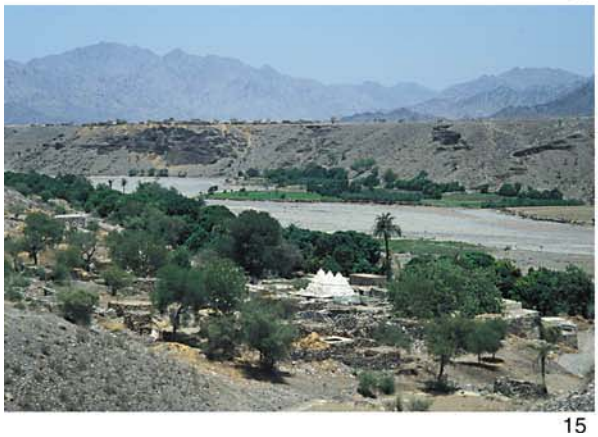

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quent as once in more than 50 years. During the dry season, groundwater continues to flow below the surface. This seepage is estimated at about 390 million cubic metres per year (DHV 1993). Much of this groundwater occurs close to the surface and is lost by evaporation. The most important wadi systems draining towards the Red Sea are, from north to south: Wadi Maur, Wadi Surdud, Wadi Siham, Wadi Rima, Wadi Zabid, Wadi Rasyan and Wadi Mausa (SCOTT 1995, see also Fig. 1).

MATERIALS AND METHODS

Thirty-one stations along the Red Sea coast, at nearshore and offshore islands and in the Tihamah coastal plain were selected for biological sampling (Table 1, Fig. 1). Subtidal marine sites were sampled by SCUBA diving with hand-held nets and a small trap. At a few selected reef sites, fishes were collected using rotenone. Shallow nearshore areas, brackish pools and freshwater streams were sampled with cast net, beach seine, hand nets of various mesh sizes and mosquito-mesh fry nets. Additionally, some specimens were bought from local artisanal fishermen at landing sites. A small experimental trawl was conducted near Kamaran Island. Arthropods were collected, mainly in the vicinity of freshwater bodies, by hand-held insect nets and barber traps. In intertidal areas specimens were dug out from the sediment using cores and spades.

At each sampling station, notes on biotic and abiotic ecological parameters were taken; these included floral and faunal assemblages, substrate, water depth, turbidity and temperature. Geographical coordinates were recorded with a hand-held Global Positioning System (GPS: Garmin e-trex) to the nearest one-thousandth minute (values in Table 1 are given rounded to the nearest one-hundredth minute). Altitudes were recorded with GPS devices and water depths with dive computers.

Colouration was documented by photographs of live and freshly dead specimens. Most fishes and marine invertebrates were preserved in 10 % formaldehyde (= 4 % formalin). A few samples were preserved in 70 % or absolute ethanol for DNA studies. Arthropods and molluscs were preserved in 70 % ethanol or dried. Specimens were shipped to Germany and sorted to appropriate taxonomic levels at the Senckenberg Research Institute and Natural History Museum in Frankfurt (SMF), except for arthropods, which were sorted at the Hessian State Museum in Darmstadt (HLMD). After identification, 50 % of the specimens of each species collected will be returned to Yemen to be deposited in the Natural History Collection of Yemen (NHCY). Voucher specimens have been deposited at the Marine Research Centre in al-Hudaidah.

Plates 9-16: 9-10: Examples of non-reefal coral communities with high scleractinian diversity on basaltic rock at depths of 2-5 m at Hanish al-Kabir Island. *Acropora*, *Porites* and *Platygyra* are the dominant coral genera. Fish diversity is also high. The photographs show sampling station YEM 04-12, where 70 species of reef-associated fishes were recorded. **11:** Shallow-water coral community at Addar Ali Island near Hanish al-Kabir Island with crown-of-thorn starfish (*Acanthaster planci*). In this area more than six *A. planci* per hectare were found feeding during daytime, which may be indicative of an outbreak. **12:** Drop-off at Addar Ali Island at 15 m depth. The wall is covered with a colourful mixture of calcareous algae, sponges, tunicates and xeniids. **13:** The fishing sector in the Yemeni Red Sea is dominated by multi-species artisanal fisheries with small boats operating in nearshore areas. Boats come to shallow waters and the catches are carried to the shore. **14:** Al-Hudaidah fishing harbour was constructed in 1983, has 140 m of berth and 2.5 m minimum dredged depth. It is the Red Sea's centre for small boat (sambuk) fishing and is used to full capacity. Mainly large pelagic fishes and sharks are landed here. **15:** Wadi Zabid is one of the main streams running from the Yemen highlands across the Tihamah towards the Red Sea. Here, the biannual monsoon cycle brings heavy rains in late summer and lighter rains during spring, resulting in seasonal flash-floods in the otherwise largely dry wadi. Since ancient times Wadi Zabid has been colonised by humans, who turned the area into a man-made landscape. Water is used for irrigation, and surface run-off has been reduced to a minimum. **16:** Wadi Zabid at adh-Dhuhra. The riverbed is filled with water after rainfall in March 2004. The photograph shows sampling station YEM 04-24. (See also Fig. 1 and Table 1; photos: F. Krupp)

RESULTS AND OBSERVATIONS

Sampling stations of the present survey are listed in an annotated gazetteer in Table 1 and shown on a map of the area in Figure 1. The decapod Crustacea collected during the survey are listed in Table 2. Some additional information on selected study sites and general observations is provided in the following.

Birds recorded during the present survey are listed in Table 3. In the al-Luhayyah area, it is common that migratory birds are trapped during late spring for human consumption. Bird collectors operate from hide-outs built of mangrove branches (Fig. 2) and birds are caught with nets. This kind of bird collecting is called "said al-jarajih" and at the peak of the bird-hunting season in May a bird festival ("mussim") is celebrated. According to local people, birds with rings from northern Europe are found occasionally. The rings are discarded, because people lack information on how to return them.

Since the time Eritrea returned the Hanish Islands to Yemeni sovereignty they are uninhabited, except for military personnel and temporary visits by fishermen. There is no surface freshwater and the dew-dependent vegetation is extremely scarce. In shallow waters near the shore, diverse non-reefal coral communities grew on basaltic rock. In total, 70 fish species have been recorded at this coral assemblage (Table 4). The small Addar Ali Island, in close vicinity to Hanish al-Kabir Island, had reefs and non-reefal coral communities. Shallow-water reefs were dominated by the genera *Acropora*, *Platygyra* and *Porites*. Table *Acropora* more than 2 m in diameter occurred. The dominance of reef-building corals declined with increasing depth. The highest live coral cover was found in 3-5 m depths. Hermatypic coral growth usually stopped at about 10 m. A drop-off below 10 m was mainly covered with encrusting calcareous algae and invertebrates (Plate 12). At a depth of 25 m, the hard substrate ended and the seabed sloped gently into a plateau with sandy substrate. In general, reefs were in a healthy condition with live coral cover ranging between 20 and 50 %. There were no signs of bleaching-related coral mortality.

Fishing pressure for sea cucumbers is obviously on the increase. Fishermen in the Hanish area and elsewhere collect sea cucumbers operating from small boats (Fig. 3). While diving, they breathe air from car tyre compressors in the boats without using regulators. They wear weights and tennis shoes with plastic discs attached to the soles to walk on the reef. This collecting method must be considered harmful to both the sea cucumber stocks and the reef, and it is certainly very risky for the fishermen.

The Tihamah received moderate rainfall before our survey started and some heavy rain during our fieldwork, hence wadis were filled with water. Water for irrigation and households is extracted by pumping, which was observed in all wadis visited. Eutrophication from sewage and fertilisers was particularly evident in the lower reaches of Wadi Maur. Cars are frequently washed in the wadis, which is another source of pollution. The small water storage reservoir in Wadi Maur was filled with sediment.

Among freshwater invertebrates, the Odonata of the area have received more attention than any other group (WATERSTON 1980, 1984 a, 1984 b; SCHNEIDER 1987; AL-SAFADI 1990; DUMONT & AL-SAFADI 1991, 1993; SCHNEIDER & KRUPP 1993; BRADSHAW 1996; SCHNEIDER & PARR 1998). A list of damselflies and dragonflies collected during the present survey is given in Table 5.

In all wadis visited, three fish species were found: *Barbus arabicus* and *Garra tibanica* (Cyprinidae) and *Aphanius dispar* (Cyprinodontidae). Only *A. dispar* occurred in the lower reaches of Wadi Maur, the two cyprinids being restricted to the dam area, where conditions were obviously stressful with high water temperatures, low oxygen supply and limited food availability. By contrast,

2

3

Figs 2-3: 2: Hide-out used by bird hunters in a mangrove area north of al-Luhayyah. **3:** Fishermen near Zuqar Island collecting sea cucumbers from a small boat. A car tyre compressor provides air for dive operations. (Photos: F. Krupp).

conditions for fish in deep pools of the Wadi Surdud catchment (sampling station YEM 04-25) were favourable and fish showed a normal size distribution, while in most other sites only small specimens occurred. The specimens of *G. tibanica* found at this location are the largest on record, with a specimen of 170 mm standard length, while the species had previously only been known to reach 100 mm. The state of the gonads indicated that reproduction is likely to occur during this season (late spring). It is, however, unknown how many times a year *G. tibanica* reproduces. Freshwater fish are used for human consumption, and in adh-Dhuhra there is a professional fisherman who catches fish in Wadi Zabid.

ACKNOWLEDGEMENTS

We express our gratitude to Eng. Mahmoud M. Shidiwah, Chairman, and the staff of the Environment Protection Authority (EPA) for granting research permits. Our sincere thanks go to Murtada A. Alwan, Director General of the Marine Research Centre, al-Hudaidah Branch, for his advice and dedicated support of our survey activities. We acknowledge Rebecca Klaus for her help and advice during our fieldwork. We are particularly grateful to our colleagues at the Marine Research Centre, who guided and accompanied us during our fieldwork: Yahya Abuzaid, Anwar Al-Abdali, Walid Al-Dheeb, Sami Al-Muslimany, Abdulghani Al-Ramanah, Mohammed H. Athim, Haza'a Kadaf, Nawaf Mohammed, Ali Saeed, Hisham Saeed, Khalid Y.M. Salim and Fahad S. Zab'an. Their skills, knowledge and enthusiasm were a great asset to the project. Makki Saddiq extended his hospitality and support to us during our stay in al-Luhayyah. The Yemeni Armed Forces kindly provided permits, transport and logistics during our trip to Hanish al-Kabir Island. We are very grateful to Prof. William Büttiker and Dr Robert Güsten for reviewing the manuscript.

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Manuscript submitted: 09 November 2004
Manuscript accepted: 26 April 2005.

APPENDIX

Table 1: Annotated gazetteer of sampling stations.

Station Date	Locality	Latitude Longitude	Altitude or depth [m]	Description
YEM 04-01 29.III.2004	Wadi Surdud, upper course	15°11.37'N 43°26.74'E	380	Several small, slow flowing water courses and irrigation channels in wide wadi bed, perennial; mostly shallow, up to 1 m deep; substrate: sand, mud and gravel; few filamentous algae, riparian vegetation: *Tamarix*, grass
YEM 04-02 01.IV.2004	"Kilo 20", ca 5 km S of al-Urj (Plate 5)	15°06.29'N 42°52.31'E	Sea level	Large, shallow lagoon with wide intertidal area; substrate: mud and silt in the intertidal zone, supratidal zone sandy; vegetation: *Enteromorpha*, *Avicennia marina*, *Juncus*, *Desmostachya bipinnata*, *Hyphaene thebaica*, low levels of pollution and eutrophication
YEM 04-03 01.IV.2004	S of al-Luhayyah	15°41.97'N 42°42.34'E	Sea level	Wide intertidal mudflat and tidal channels with extensive mangrove area north of al-Luhayyah, dense stand of *Avicennia marina*, shrubs up to 2 m high
YEM 04-04 02.IV.2004	Al-Luhayyah (Plate 7)	15°42.42'N 42°41.38'E	Sea level	Upper eulittoral at the fringe of the mangrove area at al-Luhayyah; substrate: silt and sand; dhau-building workshops, polluted by solid waste and sewage
YEM 04-05 02.IV.2004	Wadi Maur, at al-Hudaidah to Mu'ris road bridge	15°39.76'N 43°10.58'E	136	Small water course, up to 4 m wide, 20 cm deep, perennial; water clear, flowing at medium speed; substrate: sand with scattered stones, in places steep banks; vegetation: filamentous algae, *Tamarix*
YEM 04-06 02.IV.2004	Sadd Wadi Maur	15°39.85'N 43°13.65'E	176	Pools below storage lake, stagnant, up to 2 m deep; water courses further downstream, ca 3 m wide and up to 0.6 m deep, water turbid, flowing at medium speed; substrate: mud and stones; no riparian vegetation except for isolated stands of grass
YEM 04-07 03.IV.2004	Abu Zahir, N of al-Khaukhah (Plate 6)	13°49.50'N 43°14.14'E	Sea level	Lagoon with extensive intertidal flats with sand and muddy sand in the eulittoral zone, freshwater seepage; vegetation: *Cyperus laevigatus*, *Aeluropus lagopoides*, *Phoenix dactylifera*, *P. caespitosa*
YEM 04-08 04.IV.2004	Abu Zahir, near al-Khaukhah	13°49.50'N 43°14.14'E	Sea level	Upper eulittoral and supratidal zone, sand with grass, influx of freshwater; collections at night
YEM 04-09 05.IV.2004	Near al-Maushij (Plate 8)	13°42.44'N 43°16.85'E	Sea level	Small brackish water pool in dune area near the coast; clear, stagnant water, up to 40 cm deep; substrate: mud with sandy patches; vegetation: *Chara*, *Salicornia*, grass
YEM 04-10 05.IV.2004	S of al-Maushij	13°35.68'N 43°17.52'E	Sea level	Hypersaline pool near the coastline with red algal bloom; substrate: silt and mud; riparian vegetation: *Juncus* and date palms

Station Date	Locality	Latitude Longitude	Altitude or depth [m]	Description
YEM 04-11 06.IV.2004	Hanish al-Kabir Island (Plate 4)	13°43.85'N 42°42.41'E	Sea level	Bay on western side of the island with white sand interspersed with black volcanic rock and boulders; vegetation: some isolated mangroves
YEM 04-12 06.IV.2004	Hanish al-Kabir Island (Plates 9-10)	13°46.30'N 42°46.34'E	–2 to –5	Shallow coral assemblage at NW coast of the island with a variety of massive and branching stony corals, about 60 % live coral coverage, corals in healthy condition, base of coral assemblage at 5 m depth
YEM 04-13 06.IV.2004	Hanish al-Kabir Island (Plate 3)	13°46.30'N 42°46.34'E	0 to –10	Sandy beach, supratidal zone and black volcanic rock on NW coast of the island; very sparse vegetation of desert sedges
YEM 04-14 06.IV.2004	Small island near Hanish al-Kabir Island	13°46.49'N 42°45.25'E	–5 to –30	Rocky slope with stony, horny and some soft corals; collections mainly among dead corals and coral rubble
YEM 04-15 06.IV.2004	Hanish al-Kabir Island	13°46.30'N 42°46.34'E	Sea level	Sandy beach on NW coast of the island
YEM 04-16 07.IV.2004	Jabal al-Haj near Hanish al-Kabir Island	13°47.51'N 42°47.32'E	–1 to –5	Rocky slope with stony, and soft corals
YEM 04-17 07.IV.2004	Hanish al-Kabir Island	13°46.86'N 42°46.70'E	–3 to –5	Rocky subtidal area covered with macroalgae
YEM 04-18 07.IV.2004	Hanish al-Kabir Island	13°46.62'N 42°46.43'E	–2 to –4	Diverse coral communities, mainly stony corals; collections from coral rubble and dead corals
YEM 04-19 07.IV.2004	Addar Ali Island	13°47.55'N 42°48.43'E	–10 to –20	Reef flat with up to 40 % live coral coverage, decreasing with increasing depth, many *Acanthaster*; rocky drop-off with isolated stony and soft corals below reef edge at 10 m depth, diverse fish assemblage; rotenone station at 15 m depth
YEM 04-20 08.IV.2004	Addar Ali Island	13°47.55'N 42°48.43'E	–10 to –30	Same as previous, collections among coral rubble; rotenone station at drop-off, in 12-15 m depth, *Eretmochelys imbricata* observed
YEM 04-20 a 08.IV.2004	Addar Ali Island	13°47.55'N 42°48.43'E	–3 to –6	Same as previous, collections in dead and live corals (*Stylophora* sp.) in shallow water
YEM 04-20 b 08.IV.2004	Addar Ali Island	13°47.55'N 42°48.43'E	Sea level	Same position as previous, rocky eulittoral
YEM 04-21 08.IV.2004	Hanish al-Kabir Island	13°46.30'N 42°46.34'E	–2 to –5	Same position as YEM 04-12, shallow reef area and adjacent sandy areas, night dive

Station Date	Locality	Latitude Longitude	Altitude or depth [m]	Description
YEM 04-22 09.IV.2004	Abu Zahir, near al-Khaukhah	13°49.50'N 43°14.14'E	Sea level	Same position as YEM 04-07; brackish lagoon with small pools
YEM 04-22 a 09.IV.2004	Abu Zahir, near al-Khaukhah	13°49.50'N 43°14.14'E	Sea level	Same position as YEM 04-07; gravel beach on seaward side of lagoon
YEM 04-22 b 09.IV.2004	Abu Zahir, near al-Khaukhah	13°49.50'N 43°14.14'E	Sea level	Same position as YEM 04-07; gravel beach on seaward side of lagoon (carapaces washed ashore)
YEM 04-23 10.IV.2004	Abu Zahir, near al-Khaukhah	13°49.50'N 43°14.14'E	Sea level	Same position as YEM 04-07; lagoon with freshwater influx, mid- and upper eulittoral
YEM 04-24 10.IV.2004	Wadi Zabid at adh-Dhuhra (Plate 16)	14°04.35'N 43°39.01'E	449	Wide water course in wadi bed following rainfall, water turbid, up to 40 cm deep, flowing at medium speed with some almost stagnant areas; substrate: gravel and boulders of various sizes; no aquatic vegetation, irrigated gardens on banks with *Nerium oleander*
YEM 04-25 11.IV.2004	Tributary to Wadi Surdud E of Khamis Bani Sa'ad	15°08.33'N 43°36.55'E	ca 500	Gorge with series of pools below waterfall, connected with each other by small water courses; water in pools turbid, up to 2.5 m deep in largest pool, substrate: sand with large boulders; fairly dense vegetation of grasses and *Tamarix*, cast net
YEM 04-26 12.IV.2004	"Kilo 20", ca 5 km S of al-Urj	15°06.29'N 42°52.31'E	Sea level	Same area as YEM 04-02; mangrove area at low tide, with pools and tidal channels; substrate: sand and mud; isolated stands of mainly old *Avicennia marina*, dead trunks and branches, partly buried in the mud
YEM 04-27 12.IV.2004	"Kilo 20", ca 5 km S of al-Urj	15°06.29'N 42°52.31'E	Sea level to –1.8	Same area as YEM 04-02; shallow subtidal on seaward side of lagoon, substrate: sand and gravel; seagrass beds, slow tidal current, water slightly turbid; cast net
YEM 04-28 12.IV.2004	Kamaran Island	15°20.35'N 42°38.16'E	–20	E coast of the island; trawl over silty substrate; large numbers of irregular sea urchins
YEM 04-29 12.IV.2004	Kamaran Island	15°22.02'N 42°37.78'E	–8 to –15	E coast of the island; trawl over sand and shell bottom, sponges very common
YEM 04-30 12.IV.2004	Kamaran Island	15°22.45'N 42°37.79'E	–5 to –12	E coast of the island; trawl over sandy and silty substrate with numerous sponges
YEM 04-31 12.IV.2004	Kamaran Island	15°22.30'N 42°37.79'E	Sea level	E coast of the island; rocky eulittoral

Table 2: List of thalassinid, anomuran and brachyuran species (Crustacea: Decapoda) recorded during the survey by Michael Apel (see Table 1 for details on sampling stations).

Thalassinidea

Callianassidae

1. *Lepidophthalmus socotrensis* Sakai & Apel, 2002: YEM 04-02, 07, 23, 26

Upogebiidae

2. *Upogebia savignyi* (Strahl, 1862): YEM 04-29

Anomura

Galatheidae

3. *Galathea aegyptiaca* Paulson, 1875: YEM 04-19

Coenobitidae

4. *Coenobita scaevola* (Forsskål, 1775): YEM 04-22 a

Diogenidae

5. *Calcinus latens* (Randall, 1840): YEM 04-12, 16, 17, 18, 20 a
6. *C. rosaceus* Heller, 1861: YEM 04-19
7. *Clibanarius signatus* Heller, 1861: YEM 04-11
8. *Dardanus lagopodes* (Forsskål, 1775): YEM 04-20 a
9. *D. tinctor* (Forsskål, 1775): YEM 04-20 a, 21, 29, 30
10. *Diogenes costatus* Henderson, 1893: YEM 04-29, 30
11. *D. gardineri* Alcock, 1905: YEM 04-29
12. *Paguristes* sp.: YEM 04-19

Paguridae

13. *Cestopagurus coutieri* Bouvier, 1897: YEM 04-14, 18, 20, 20 a

Porcellanidae

14. *Aliaporcellana pygmaea* (de Man, 1902): YEM 04-29, 30
15. *Petrolisthes rufescens* (Heller, 1861): YEM 04-11, 14, 31
16. *Pisidia* sp.: YEM 04-18
17. *Polyonyx* sp.: YEM 04-14

Brachyura

Calappidae

18. *Calappa hepatica* (Linnaeus, 1758): YEM 04-29

Majidae

19. *Schizophrys aspera* (H. Milne Edwards, 1834): YEM 04-20 a
20. *Tylocarcinus styx* (Herbst, 1803): YEM 04-20 a

Parthenopidae

21. *Parthenope* sp.: YEM 04-19

Portunidae

22. *Charybdis orientalis* Dana, 1852: YEM 04-22 b
23. *Portunus alcocki* (Nobili, 1905): YEM 04-29
24. *P.* cf. *iranjae* Crosnier, 1962: YEM 04-21
25. *P. pelagicus* (Linnaeus, 1758): YEM 04-03
26. *Scylla serrata* (Forsskål, 1775): YEM 04-08
27. *Thalamita admete* (Herbst, 1803): YEM 04-20 a
28. *T.* cf. *integra* Dana, 1852: YEM 04-21
29. *T. iranica* Stephensen, 1945: YEM 04-30
30. *T. savignyi* A. Milne Edwards, 1861: YEM 04-19, 20 a
31. *Thalamitoides tridens* A. Milne Edwards, 1869: YEM 04-14

Xanthidae

32. *Actaea jacquelinae* Guinot, 1976: YEM 04-29, 30
33. *A. savignyi* (H. Milne Edwards, 1834): YEM 04-29
34. *Actaeodes hirsutissimus* (Rüppell, 1830): YEM 04-20 a
35. *Chlorodiella cytherea* (Dana, 1852): YEM 04-18, 19
36. *C.* cf. *laevissima* (Dana, 1852): YEM 04-18
37. *Cymo quadrilobatus* Miers, 1884: YEM 04-20 a
38. *Euxanthus* sp.: YEM 04-30 (fragmentary carapax only)
39. *Leptodius sanguineus* (H. Milne Edwards, 1834): YEM 04-12, 17
40. *Phymodius granulatus* (Targioni Tozzetti, 1877): YEM 04-19, 20, 20 a
41. *Pilodius spinipes* Heller, 1861: YEM 04-19, 20 a

Pilumnidae

42. *Actumnus* sp. 1: YEM 04-29
43. *Actumnus* sp. 2: YEM 04-30
44. *Halimede tyche* (Herbst, 1801): YEM 04-29
45. *Pilumnus savignyi* Heller, 1861: YEM 04-29, 30

Trapeziidae

46. *Trapezia cymodoce* (Herbst, 1801): YEM 04-16, 19, 20 a
47. *T. tigrina* Eydoux & Souleyet, 1842: YEM 04-16, 19, 20 a

Carpiliidae

48. *Carpillius convexus* (Forsskål, 1775): YEM 04-21

Menippidae

49. *Epixanthus corrosus* A. Milne Edwards, 1873: YEM 04-11
50. *E. frontalis* (H. Milne Edwards, 1834): YEM 04-11
51. *Lydia tenax* (Rüppell, 1830): YEM 04-20 b

Grapsidae

52. *Grapsus albolineatus* Lamarck, 1818: 20 b
53. *G.* cf. *granulosus* H. Milne Edwards, 1853: YEM 04-11 (very small specimens)
54. *Helice leachii* Hess, 1865: YEM 04-07
55. *Ilyograpsus paludicola* (Rathbun, 1909): YEM 04-02, 07, 08
56. *Metopograpsus messor* (Forsskål, 1775): YEM 04-02, 03, 08
57. *Sesarma guttatum* A. Milne Edwards, 1869: YEM 04-03, 08

Ocypodidae

58. *Dotilla sulcata* (Forsskål, 1775): YEM 04-02, 03, 07, 23
59. *Macrophthalmus depressus* Rüppell, 1830: YEM 04-02, 03, 04, 07, 23, 8
60. *M. grandidieri* A. Milne Edwards, 1867: YEM 04-02
61. *Ocypode saratan* (Forsskål, 1775): YEM 04-02, 09, 11 a, 12 a
62. *Serenella leachii* (Audouin, 1826): YEM 04-03, 07
63. *Uca annulipes albimana* (Kossmann, 1877): YEM 04-03, 04, 07, 23
64. *U. hesperiae* Crane, 1975: YEM 04-07
65. *U. inversa* (Hoffmann, 1874): YEM 04-04, 07
66. *U. tetragonon* (Herbst, 1790): YEM 04-07, 23

Table 3: Occasional bird observations (see Table 1 for details on sampling stations). Recorders: Aref Hamoud and Wolfgang Schneider.

Pelicans – Pelecanidae	
1. Pink-backed pelican – *Pelecanus rufescens*	YEM 04-02 (white and dark phase)
Herons – Ardeidae	
2. Night heron – *Nycticorax nycticorax*	YEM 04-04 (juvenile)
3. Western reef heron – *Egretta gularis*	YEM 04-02
Storks – Ciconiidae	
4. Hamerkop – *Scopus umbretta*	YEM 04-24
5. Abdim's stork – *Ciconia abdimii*	between al-Husainiya and Zabid (04.IV.2004)
Ibises, Spoonbills – Threskiornithidae	
6. Eurasian spoonbill – *Platalea leucorodia*	YEM 04-02, YEM 04-07
Swans, Geese and Ducks – Anatidae	
7. Pintail (female) – *Anas acuta*	YEM 04-07
Plovers – Charadriidae	
8. Oystercatcher – *Haematopus ostralegus*	YEM 04-07
9. Black-winged stilt – *Himantopus himantopus*	YEM 04-02
10. Crab plover – *Dromas ardeola*	YEM 04-02, YEM 04-04, YEM 04-07
11. Ringed plover – *Charadrius hiaticula*	YEM 04-02, YEM 04-07
12. Kentish plover – *Charadrius alexandrinus*	YEM 04-02, YEM 04-07
13. Lesser sand plover – *Charadrius mongolus*	YEM 04-07
14. Spur-winged plover – *Hoplopterus spinosus*	YEM 04-02, YEM 04-09 (breeding pair), YEM 04-10
15. Temminck's stint – *Calidris temminckii*	YEM 04-10
16. Curlew sandpiper – *Calidris ferruginea*	YEM 04-02
17. Broad-billed sandpiper – *Limicola falcinellus*	YEM 04-10
18. Redshank – *Tringa totanus*	YEM 04-07, YEM 04-10
19. Greenshank – *Tringa nebularia*	YEM 04-07, YEM 04-10
20. Terek sandpiper – *Xenus cinereus*	YEM 04-02
21. Common sandpiper – *Actitis hypoleucos*	YEM 04-02, YEM 04-07
Gulls – Laridae	
22. Sooty gull (Hemprich's gull) – *Larus hemprichii*	YEM 04-07
23. White-eyed gull – *Larus leucophthalmus*	YEM 04-07
24. Lesser black-backed gull – *Larus fuscus*	YEM 04-07
Terns – Sternidae	
25. Caspian tern – *Sterna caspia*	YEM 04-07
26. Gull-billed tern – *Gelochelidon nilotica*	YEM 04-07
Starlings – Sturnidae	
27. Amethyst starling – *Cinnyricinclus leucogaster*	Wadi Zabid between al-Hudaidah and sampling station YEM 04-25 (11.IV.2004)

Table 4: List of fishes recorded at a shallow-water coral assemblage near Hanish al-Kabir Island, sampling station YEM 04-12, on 06 April 2004 (Plates 9-10). Records are based on visual observations and underwater photography. Recorders: Friedhelm Krupp, Khalid Y.M. Salim and Fahad S. Zab'an.

Acanthuridae

1. *Acanthurus gahhm*
2. *Acanthurus sohal*
3. *Ctenochaetus striatus*
4. *Zebrasoma desjardinii*
5. *Zebrasoma xanthurum*

Apogonidae

6. *Apogon cyanosoma*
7. *Cheilodipterus macrodon*

Balistidae

8. *Sufflamen albicaudatus*

Blenniidae

9. *Ecsenius aroni*
10. *Ecsenius frontalis*
11. *Ecsenius midas*

Bothidae

12. *Bothus pantherinus*

Carangidae

13. *Carangoides bajad*

Caesionidae

14. *Caesio striatus*
15. *Pterocaesio chrysozona*

Chaetodontidae

16. *Chaetodon fasciatus*
17. *Chaetodon mesoleucos*
18. *Chaetodon semilarvatus*
19. *Chaetodon larvatus*
20. *Heniochus intermedius*

Dasyatidae

21. *Taeniura lymma*

Gobiidae

22. *Cryptocentrus lutheri*
23. *Istigobius ornatus*

Haemulidae

24. *Plectorhynchus gaterinus*
25. *Plectorhynchus schotaf*

Holocentridae

26. *Myripristis murdjan*
27. *Myripristis xanthacrus*
28. *Neoniphon sammara*

Labridae

29. *Bodianus axillaris*
30. *Bodianus diana*
31. *Cheilinus lunulatus*
32. *Epibulus insidiator*
33. *Gomphosus caeruleus*
34. *Halichoeres hortulanus*
35. *Halichoeres marginatus*
36. *Labroides dimidiatus*
37. *Larabicus quadrilineatus*
38. *Pseudocheilinus hexataenia*
39. *Thalassoma lunare*

Lethrinidae

40. *Lethrinus nebulosus*

Lutjanidae

41. *Lutjanus argentimaculatus*
42. *Lutjanus ehrenbergii*
43. *Lutjanus fulviflamma*

Malacanthidae

44. *Malacanthus latovittatus*

Mullidae

45. *Parupeneus forsskali*

Nemipteridae

46. *Scolopsis ghanam*

Ostraciidae

47. *Ostracion cyanurus*

Pempheridae

48. *Pempheris vanicolensis*

Pinguipedidae

49. *Parapercis hexophthalma*

Pomacentridae

50. *Abudefduf sexfaciatus*
51. *Abudefduf vaigiensis*
52. *Amphiprion bicinctus*
53. *Chromis viridis*
54. *Dascyllus marginatus*
55. *Dascyllus trimaculatus*
56. *Neopomacentrus cyanomos*
57. *Pomacentrus leptus*
58. *Pomacentrus sulfureus*

Pseudochromidae

59. *Pseudochromis flavivertex*
60. *Pseudochromis olivaceus*
61. *Pseudochromis sankeyi*

Scaridae

62. *Scarus ferrugineus*
63. *Scarus sordidus*

Serranidae

64. *Aethaloperca rooga*
65. *Cephalopholis argus*
66. *Cephalopholis hemistiktos*
67. *Epinephelus malabaricus*
68. *Epinephelus tauvina*

Sphyraenidae

69. *Sphyraena barracuda*

Synodontidae

70. *Synodus variegatus*

Table 5: List of Odonata collected during the survey (see Table 1 for details on sampling stations). Specimens will be shared between the HLMD and the NHCY. Recorder: Wolfgang Schneider.

Zygoptera – Damselflies

1.	*Ischnura senegalensis* (Rambur, 1842)	YEM 04-02 (1 ♀, HLMD-Odo-756)
2.	*Ceriagrion glabrum* (Burmeister, 1839)	YEM 04-05 (1 ♀, 1 ♂, HLMD-Odo-757; 2 ♀♀, HLMD-Odo-758; 1 ♀, HLMD-Odo-759), YEM 04-24 (3 ♀♀, HLMD-Odo-760)
3.	*Pseudagrion hamoni* Fraser, 1955	YEM 04-01 (2 ♀♀, HLMD-Odo-761), YEM 04-24 (4 ♀♀, HLMD-Odo-762), YEM 04-25 (2 ♀♀, HLMD-Odo-763; 1 ♀, HLMD-Odo-764; 4 ♀♀, HLMD-Odo-765)
4.	*Pseudagrion sublacteum* (Karsch, 1893)	YEM 04-01 (3 ♀♀, HLMD-Odo-766), YEM 04-24 (1 ♀, HLMD-Odo-767; 3 ♀♀, HLMD-Odo-768; 1 ♀, 1 ♂, HLMD-Odo-769)

Anisoptera – Dragonflies

5.	*Nesciothemis farinosa* (Förster, 1898)	YEM 04-24 (1 ♀, 1 ♂, HLMD-Odo-770)
6.	*Orthetrum chrysostigma* (Burmeister, 1839)	YEM 04-24 (1 ♀, HLMD-Odo-771; 1 ♀, HLMD-Odo-772; 1 ♀, HLMD-Odo-773), YEM 04-25 (2 ♀♀, HLMD-Odo-774; 1 ♀, HLMD-Odo-775; 1 ♀, HLMD-Odo-776)
7.	*Orthetrum sabina* (Drury, 1773)	YEM 04-02 (1 ♀, HLMD-Odo-777; 1 ♀, HLMD-Odo-778)
8.	*Crocothemis erythraea* (Brullé, 1832)	YEM 04-05 (1 ♀, HLMD-Odo-779), YEM 04-24 (1 ♂, HLMD-Odo-780)
9.	*Trithemis annulata* (Beauvois, 1807)	YEM 04-24 (2 ♀♀, HLMD-Odo-781)
10.	*Trithemis arteriosa* (Burmeister, 1839)	YEM 04-25 (2 ♀♀, HLMD-Odo-782 and 783)
11.	*Trithemis* aff. *donaldsoni* (Calvert, 1899)	YEM 04-25 (5 ♀♀, HLMD-Odo-784 to 788)
12.	*Trithemis kirbyi* Selys, 1891	YEM 04-01 (1 ♀ observed), YEM 04-24 (1 ♀, 2 ♂♂, HLMD-Odo-789)
13.	*Zygonyx torridus* (Kirby, 1889)	YEM 04-25 (2 ♀♀, HLMD-Odo-790 and 791)