Red Sea Biodiversity Surveys

Final Report of Phase I

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King Abdulaziz University, Jeddah, Saudi Arabia

and

Senckenberg Nature Research Society, Frankfurt, Germany

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Cover picture:
Pterois radiata Cuvier 1829. First fish species catalogued for the collection of the King Abdulaziz Marine Museum (KAUMM-1).

Table of Contents

Abstract **5**
1. Introduction **5**
1.1 Geophysical Setting of the Saudi Arabian Red Sea 5
1.2 Project Design and Strategy 6
1.3 Goal and Objectives 7
2. Project Activities **9**
2.1 Field Research Training Course 9
2.2 Sampling methods, shipping and storage 11
2.2.1 Triangular dredge 11
2.2.2 Hand-dredge / push-net 11
2.2.3 Yabbie-pump (*Callianassa*-pump) 12
2.2.4 Traps 12
2.2.5 Stone turning/washing 12
2.2.6 Coral sampling under water 13
2.2.7 Fish market 14
2.2.8 Fish trawling 14
2.2.9 Cast-net fishing 15
2.2.10 Shipping and storage 16
2.3 Field Surveys 17
2.3.1 First Red Sea Biodiversity Survey (RSS1-2011) 17
2.3.2 Second Red Sea Biodiversity Survey (RSS1-2012) 17
2.3.3 Third Red Sea Biodiversity Survey (RSS1-2013) 19
3. Project Results **22**
3.1 Collections and taxonomic research 22
3.2 Molecular genetics research 23
3.2.1 Fish 23
3.2.2 Sponges 25
3.3 Crustacean Research 25
3.4 Planning the KAU Marine Museum 27
3.5 Collection Database 27
3.6 Project homepage 30
3.7 Publications / Conference presentation 31

4. Project Benefits 33
5. Executive Summary 35
5.1 Background 35
5.2 Project Design and Strategy 35
5.3 Project Activities 36
5.4 Project Results and New Discoveries 37
5.5 Red Sea Specimen Collection at KAU 38
5.6 Collection Database 38
5.7 Project Homepage 39
5.8 Publications 39
5.9 Project Benefits and Future Prospects 39
6. References 40
7. Appendices 42
7.1 List of Project Scientists (in alphabetical order by last name) 42
7.1.1 Field Survey Participants, Representing King Abdulaziz University (KAU) and the Senckenberg Research Institute (SRI) 42
7.1.2 Taxonomic specialists contributing to project from their home laboratories . 42
7.1.3 Project Steering Committee Members 43
7.1.4 Project Coordinators 43
7.2 First Survey (RSS1-2011) 43
7.2.1 RSS1-2011: Annotated list of collecting sites 43
7.3 Second Survey (RSS1-2012) 44
7.3.1 RSS1-2012: Annotated list of collecting sites 44
7.3.2 RSS1-2012: List of trawling stations 47
7.4 Third survey (RSS1-2013) 47
7.4.1 RSS1-2013: Annotated list of collecting sites 47
7.4.2 RSS1-2013: List of trawling stations 49
Gallery 50

Abstract

In March 2011, the King Abdulaziz University (KAU) and the Senckenberg Research Institute (SRI) entered into a scientific research cooperation to assess marine biodiversity of the Saudi Arabian sector of the Red Sea. During the first phase of this project, the main goal was to conduct baseline biological research, to document patterns and processes of the area's coastal and marine biodiversity and to identify gaps in knowledge, and opportunities and priorities for future research. A team of 39 researchers was mobilised by KAU and SRI to conduct field collections and research during three surveys, where a total of ca. 2,000 species was collected. With 219 stations visited during the three field surveys, a total of ca. 1,300 species were already identified at least to genus level. All animals were shipped to SRI in Frankfurt, were they were studied by project scientists and 18 specialised taxonomists from 12 countries. A database of specimens to be deposited at the King Abdul Aziz Marine Museum (KAUMM) was established on the basis of the Senckenberg collection database SeSam. Thus far, more than 550 specimen from 107 species have been catalogued for KAUMM. To date, results have been published in 11 (+1 accepted, +3 submitted) papers in international journals. One crustacean and six fish species were described as new to science. The most outstanding discoveries are two genera new two science, the crustacean genus *Eneosesarma* and the fish genus *Gymnoxenisthmus*. More descriptions of new species are in press, submitted for publication, or in preparation.

1. Introduction

1.1 Geophysical Setting of the Saudi Arabian Red Sea

The Kingdom of Saudi Arabia has a coastline of 1840 km along the Red Sea. As of the Palaeocene, the Arabian plate split away from the African shield along the Red Sea rift. The Tertiary faulting in the area between Africa and Arabia resulted in the formation of the Red Sea rift. During the Eocene and Oligocene eras, a branch of the Tethys Sea extended into the northern Red Sea depression, while the southern Red Sea rift valley contained freshwater lakes. During the Pliocene the Indian Ocean broke through the Strait of Bab al-Mandab, giving rise to the present-day Red Sea. Along its eastern shores three fault-bounded blocks arose: The Midian block in the north, an inhomogeneous block in the central area (Hijaz Mountains) and the Asir block in the south. The Red Sea Mountains are characterised by a steep western edge and the gently eastward tilted Arabian shield.

The land mass is situated in a predominantly arid area between a mid-latitude climate, which relies on winter rainfall in the north and the monsoon winds in the south. Extreme variation in annual precipitation is to be attributed to a wide range of topographic elevations. Absolute maximum temperatures in summer may exceed 50 ºC, and the range of winter temperatures is generally 19 ºC to 27 ºC on the Red Sea coast (Edwards & Head 1987, Sheppard et al. 1992).

The Red Sea belongs to one of the most extreme environments on earth with regards to its climate. Limited amounts of freshwater in combination with very high summer temperatures, high evaporation rates and limited connection with the Indian Ocean lead to an approximately 4% higher salinity (ca. 39‰) than the world ocean average. Approximately 40% of the Red Sea is quite shallow (less than 100 m), and about 25% is below 50 m. The maximum depth in the central median trench is 2211m. Sea surface water temperatures remain relatively constant at 21–25 °C throughout the year.

1.2 Project Design and Strategy

Many species occurring in the Red Sea have not yet been described or have never been studied in detail, and the effects of their demise on the quality of human life remains unknown. For meaningful biodiversity conservation, it becomes necessary to know where biodiversity occurs, at what frequency and abundance.

Modern studies of Arabian zoology and biodiversity go back to the 18th century. The Zoological Survey of Saudi Arabia, which was initiated in the 1970s and continues until today, and the results of which are published in “Fauna of Arabia” (www.senckenberg.de/fauna_arabia) increased our knowledge about animal diversity considerably. Through the Zoological Survey, the Kingdom, which had previously been the least explored country in the region, today is reaching a high standard in biodiversity documentation. An international network of about 400 taxonomists specialised on a wide range of animal taxa occurring in Arabia recorded some 35,000 animal species, including about 1700 taxa being new to science. Despite these impressive achievements, it is assumed that only a small portion of the Arabian fauna has actually been documented thus far. The area was colonised by faunal elements of Palaearctic, Afro tropical and Oriental origin. Additionally, many new species evolved in Arabia and a large portion of today's fauna is endemic.

In order to document the present state of knowledge on the marine biodiversity of selected localities of the Saudi Arabian Red Sea coast, in particular of the intertidal zone and to gain an understanding of ecological systems, how they function and which services they provide, a project agreement between the King Abdulaziz University in Jeddah and the Senckenberg Research Institute in Frankfurt am Main was signed in March 2011. Three field surveys to that area were conducted during Phase I (2011-2014).

During the first survey in 2011, the entire Red Sea coast of Saudi Arabia, including the Farasan Islands was visited. This survey was used to get a detailed overview of the localities and to identify “biodiversity hotspots” where exceptional concentrations of rare and endemic species occur, and where threatened species are undergoing exceptional habitat losses.

The following two surveys focused on the southern part of the eastern Red Sea coast in 2012 (Farasan Islands, Al Qunfudah and Al Lith), and on the northern part in 2013 (Al Wajh, Duba and Al Alkhuraybah).

According to the current status of species identifications, more than 1300 species of nine marine taxa were collected during the surveys between 2011 and 2013; seven of them are new for science. The number of species will increase with ongoing taxonomic research. All specimens are preserved and stored for further examination at the Senckenberg Research Institute in Frankfurt, while about half of the collection will be integrated into the collection of KAUMM after identification to species level.

1.3 Goal and Objectives

According to the Project Agreement, the overall goal of Phase I of the Red Sea Biodiversity Survey is:

“To conduct baseline biological research in the Saudi Arabian sector of the Red Sea, documenting patterns and processes of the area’s coastal and marine biodiversity, and to identify gaps in knowledge, and opportunities and priorities for future research."

The objectives were defined in the Project Agreement as follows:

- To collate existing information on the coastal and marine biodiversity of the Saudi Arabian sector of the Red Sea, based on published literature and reports;
- To identify gaps in information on genetic, species and ecosystem biodiversity;
- To prepare a comprehensive national assessment of patterns and processes of biodiversity in the area, filling existing gaps;
- To conduct field research with a team of taxonomists, who are specialists of key taxa, sampling specimens and data on a pre-agreed set of biotic and abiotic parameters of the marine environment at each sampling site;
- To conduct qualitative and semi-quantitative biodiversity assessments using standardised survey methods and comparing areas based on biodiversity indices;
- To identify needs in human capacity building; and to transfer knowledge through training of scientific and technical personnel;
- To establish an operating framework for future field work, sampling, preparation, and deposition of specimens;
- To make research results available through publication for the advancement of science, and for the benefits of conservation and sustainable use of biodiversity including equitable sharing of benefits from use of genetic resources;
- To provide science-based tools to decision makers for regulating resource use and development activities.

Available information on the coastal and marine biodiversity of the Saudi Arabian sector of the Red Sea, based on published literature and reports was compiled in order to identify gaps in information on genetic, species and ecosystem biodiversity. Three field surveys were conducted by a team of taxonomists, sampling specimens and data on a pre-agreed set of biotic and abiotic parameters of the marine environment at each sampling site along the Red Sea coast of Saudi Arabia. This approach also implied the use of standardised survey methods and the comparison of sectors of the Red Sea coast based on quantitative and semi-quantitative biodiversity indices. Another prerequisite for successful performance in the field was to identify a team of scientific experts for sampling and identification of species and to transfer knowledge through the training of scientific and technical personnel. Hence, the goal to establish an operating framework for future field work, sampling, sample preparation, and deposition of specimens was achieved. By fulfilling all these objectives, we were able to make research results available through several publications for the advancement of science and for the benefits of conservation, providing a platform for the sustainable use of biodiversity including the equitable sharing of benefits from the use of genetic resources. Finally, the project aims to provide science-based tools to decision makers for regulating resource use and development activities in the Red Sea coastal areas of Saudi Arabia.

2. Project Activities

2.1 Field Research Training Course

In preparation of the Red Sea Biodiversity Surveys, an extensive training-course for all participants was held at the Marine Station in Obhur north of Jeddah ahead of the first survey (Fig. 1). The three-day training course started with a general introduction into the marine environment of the Red Sea. Presentations focused on general information on the Red Sea (e.g. geography and geological history) and on selected animal groups, their diversity and ecology. In consideration of the surveys, specific equipments for collecting and monitoring were demonstrated and discussed.

Fig. 1 Presentation of Red Sea animal taxa and methods for sampling and identification

The course provided a deeper understanding of marine biodiversity, and principles and methods of assessing and monitoring biodiversity and ecosystem health.

Special attention was given to correct labelling of samples, one of the most important issues for subsequent analyses.
The labels must include

- Survey label number (e.g. RSS1-2011; RSS1-2012; RSS1-2013; …)
- Station and sample number (e.g. # 1, sample 2)
- Date of collecting (e.g. mm-dd-yyyy)
- Short description of the collecting site (e.g. Al Lith, shallow water)
- Collection method (e.g. push-net)
- Water depth in m (if applicable)
- Name of the collector(s)
- Further details for identification (e.g. Xanthidae and Portunidae)

An example is given below (Fig. 2)

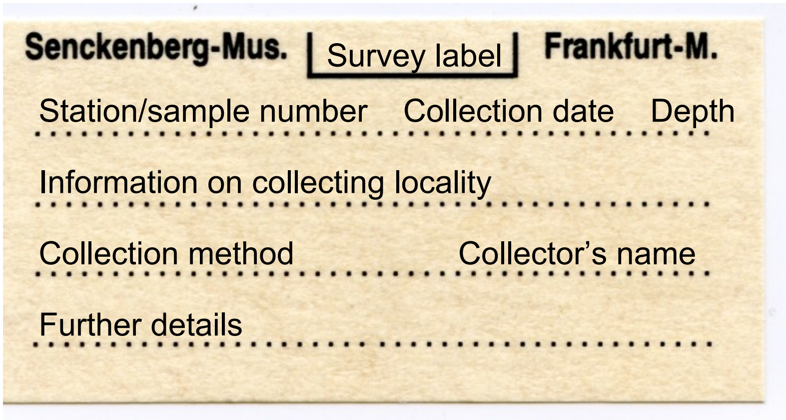

Fig. 2 Standard label used for in-field-labelling of samples during the Red Sea Surveys

Further information on additional marine taxa (macroalgae, sea grass, sponges, polychaetes, turtles and marine mammals) was given on the second day of the training course. The final part of the course focused on corals, bryozoans, molluscs, fish and crustaceans of the Red Sea, presented by the survey-participants of the Senckenberg Research Institute. During a final discussion, details of the first survey (e.g. expected localities, transportation and accommodations) were discussed.

2.2 Sampling methods, shipping and storage

2.2.1 Triangular dredge

For the surveys, technical drawings of two types of dredges were sent to KAU and constructed in local workshops. The dredges (in particular the triangular dredge) were used for trawling a net with a boat, at depths of 3 - 20 m. because of its small size, this dredge is easy to handle. Depending on the sea bottom structure, the dredge entered into the sediment for a few centimetres. Species occupying burrows are also caught by this method.

Fig. 3 Triangular dredge for sampling of benthic animals

Fig. 4 Dredging of benthic animals off Al Lith

2.2.2 Hand-dredge / push-net

A hand-dredge (Fig. 5) was used in shallow water, allowing the collection of small burrowing animals (e.g. molluscs and crustaceans). In contrast, the push-net was used in a forward movement over sandy substrate to collect epibenthic animals.

Fig. 5 Hand-dredging at Farasan Island (left) and hand-dredging at Al Qunfudah (right).

2.2.3 Yabbie-pump (*Callianassa*-pump)

Fig. 6 Yabbie pump

The Yabbie pump or *Callianassa*-pump (Fig. 6) is used for collecting burrowing animals (in particular ghost shrimps and burrowing Brachyurans). The pump is placed over the opening of a burrow, the handle is pulled up and sediment with animals are retrieved.

2.2.4 Traps

Traps (Fig. 7) were placed in deeper water up to 5 m deep, baited with shrimp-flesh. Before the first use, the traps were placed in sea water for at least two weeks in order to loose their smell.

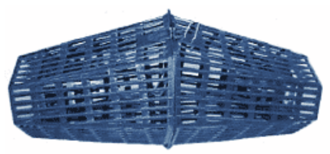

Fig.7 Plastic trap

2.2.5 Stone turning/washing

Stone turning: After stones in the intertidal zone (occasionally also subtidal) were turned, and animals collected immediately. Afterwards, the stones were placed back in their original position to save the remaining fauna.

Stone washing: This is a simple method to collect a great variety of small invertebrates. Stones are collected by hand and washed in a bucket containing sea water. The collected animals were concentrated by sieving.

2.2.6 Coral sampling under water

Corals were sampled using SCUBA diving equipment and a set of basic tools (Fig. 8), such as hammers, chisels and forceps. For transportation, samples were put into plastic bags or boxes and kept in an underwater dive bag or in a bucket. Sample sizes usually ranged between 10 and 20 cm, consisting of either an entire colony or representative pieces cut out of larger colonies.

All coral colonies were documented by photographs in situ prior to the sampling. Overview photographs were taken with a wide angle compact digital camera (e.g. Canon Powershot S100) and close-up pictures with a professional 100 mm macro lens (e.g. Canon EOS 50D with Canon 100mm 2.8 LMacro IS USM). Both cameras were placed in underwater housings (e.g. Ikelite) and equipped with sub strobes (e.g. Ikelite) for proper illumination. Depth was recorded along with standard labelling (see 2.1 and Fig.1) for each sample.

Fig. 8 Divers during coral sampling and documentation

The coral samples were transported to the field lab in sea water, where they were labelled with a Senckenberg ID tag (see 2.1). Subsequently, a tissue sample of 0.1 - 0.5 mm² was either cut out of the coral, scratched off the surface or pieces were removed (e.g. branch tips). The tissue samples were stored in 96% pure ethanol in

2 ml tubes at -18° C. After the DNA-samples were taken, the remaining coral tissue was removed using a 50% aqueous solution of commercial hypochlorite (Clorox) and an incubation time of 12-24 hours.

The bare coral skeletons were subsequently transferred into boxes with freshwater for 1 - 2 hours and subsequently washed under running freshwater to remove remaining hypochlorite. Afterwards, coral skeletons were dried for at least 12 hours before packing.

Coral Identification: The preliminary identification was based on “Keys Coral ID Version 1.1 (VERON 2000, WALLACE 1999) and other basic literature (DITLEV 1980, SCHEER & PILLAI 1983, SHEPPARD & SHEPPARD 1991).

2.2.7 Fish market

Fish markets at Jeddah and Jizan (Fig. 9) offered good opportunities acquire information on local fish diversity. Often, the geographical origin of these fishes can be comprehended with the aid of local fishermen.

Fig. 9 Left: Tilman Alpermann with two rays acquired at a landing site. Right: Fish diversity at the fish

2.2.8 Fish trawling

During the RSS1-2012-survey, project scientists boarded a fish trawler for three days (Fig. 10), focusing on bycatch. The animals collected, sometimes from deeper waters, extended our knowledge about species diversity outside the intertidal and shallow subtidal zone.

A second trawling survey was conducted at the end of the third Red Sea biodiversity survey (2013).

Fig. 10 Fish-Trawler in Jizan, used for additional collections.

Fig. 11 Left: Beam trawl catch at a commercial fish trawler. Right: Dr. Alperman and colleagues sorting, identifying and preserving fish samples

2.2.9 Cast-net fishing

This simple device was particularly effective in catching small bait or foraging fish. Lead weights were placed around the edge at about 1.5 kg/m. The person casting the net held the hand line with one hand with the net draped over the other arm, in order for the weights to dangle. The net was then thrown into the water, using both hands, in a circular motion (Fig. 12). A hand line was attached to the net, one end held by hand as the net is thrown. After the net reaches the ground, a retrieval clamp, which works like a wringer on a mop, closes the net around the fish. The net is then retrieved by pulling on the hand line. The net is lifted into a bucket and the clamp is released, dumping the fish caught into the bucket. The net can be cast from a boat, from the shore, or while wading in shallow water.

Fig. 12 Cast net fishing at Al Lith

2.2.10 Shipping and storage

In order to prepare for the transport of the material collected to the SRI, all samples were stored in 70% ethanol or in a formaldehyde-seawater-solution (ca. 5%) depending on their further processing. In addition, samples for molecular barcording were stored in absolute ethanol. To prevent damage of fragile samples like corals or bryozoans, all samples were packed in pliable plastic bubble wrap and stowed in metal boxes (Fig. 13). The transportation of the collection to the SRI in Germany was done by air cargo together with all relevant certification.

Fig. 13 Metal transport boxes after their arrival

The material collected is currently under joint study by members of the two partner organisations and additional international specialists.
As stipulated in the project agreement, all samples will be shared between KAU and SRI.

2.3 Field Surveys

2.3.1 First Red Sea Biodiversity Survey (RSS1-2011)

The first Red Sea Biodiversity Survey (27.03. – 22.04.2011) covered the entire Saudi Arabian Red Sea coastline (Fig. 14). Its mission was to identify marine habitats with high species diversity, which should be studied during subsequent surveys. Finally, eight localities for sampling were selected and studied. The list of participating scientists (7.1.1) and an annotated station list (7.1.2) are appended to this report.

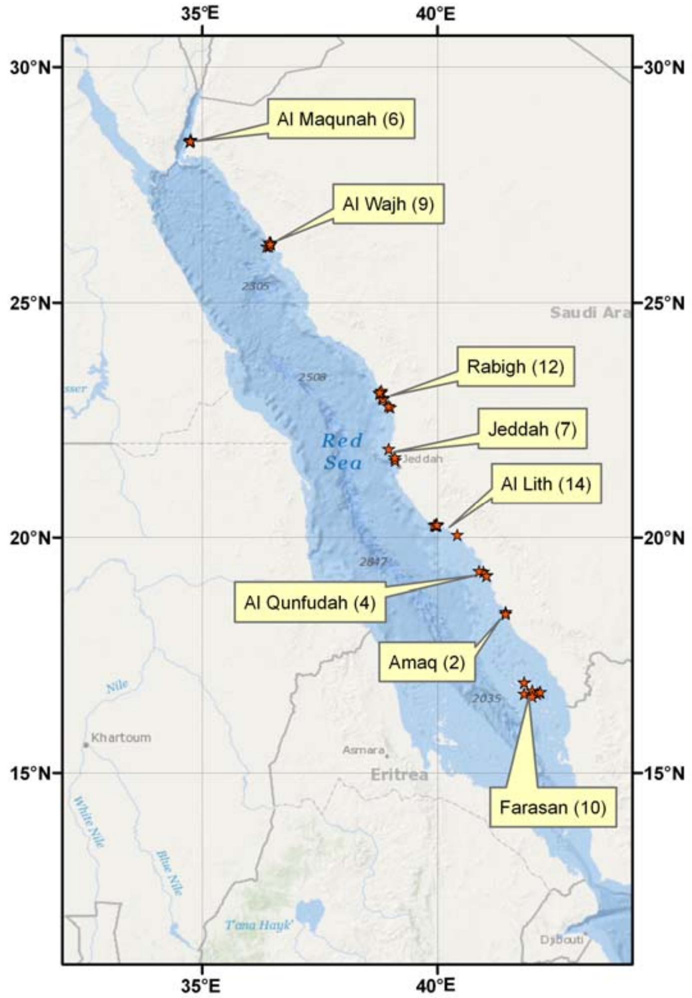

Fig. 14 Station map of first Red Sea Biodiversity Survey (RSS1-2012). The number of survey sites for each area

2.3.2 Second Red Sea Biodiversity Survey (RSS1-2012)

The second Red Sea Biodiversity Survey (Figs 15 and 16) too place from February 13 to March 12, 2012. The number of different localities was reduced in order to focus on the different habitats of the Farasan Islands, with 44 stations being the centre of this expedition. All in all, 83 sites were visited on this survey, some of them several times. The list of participating scientists (Fig. 17, 7.2.1) and an annotated list of sampling sites (7.2.2), together with a list of the trawling locations (7.2.3) are appended to this report.

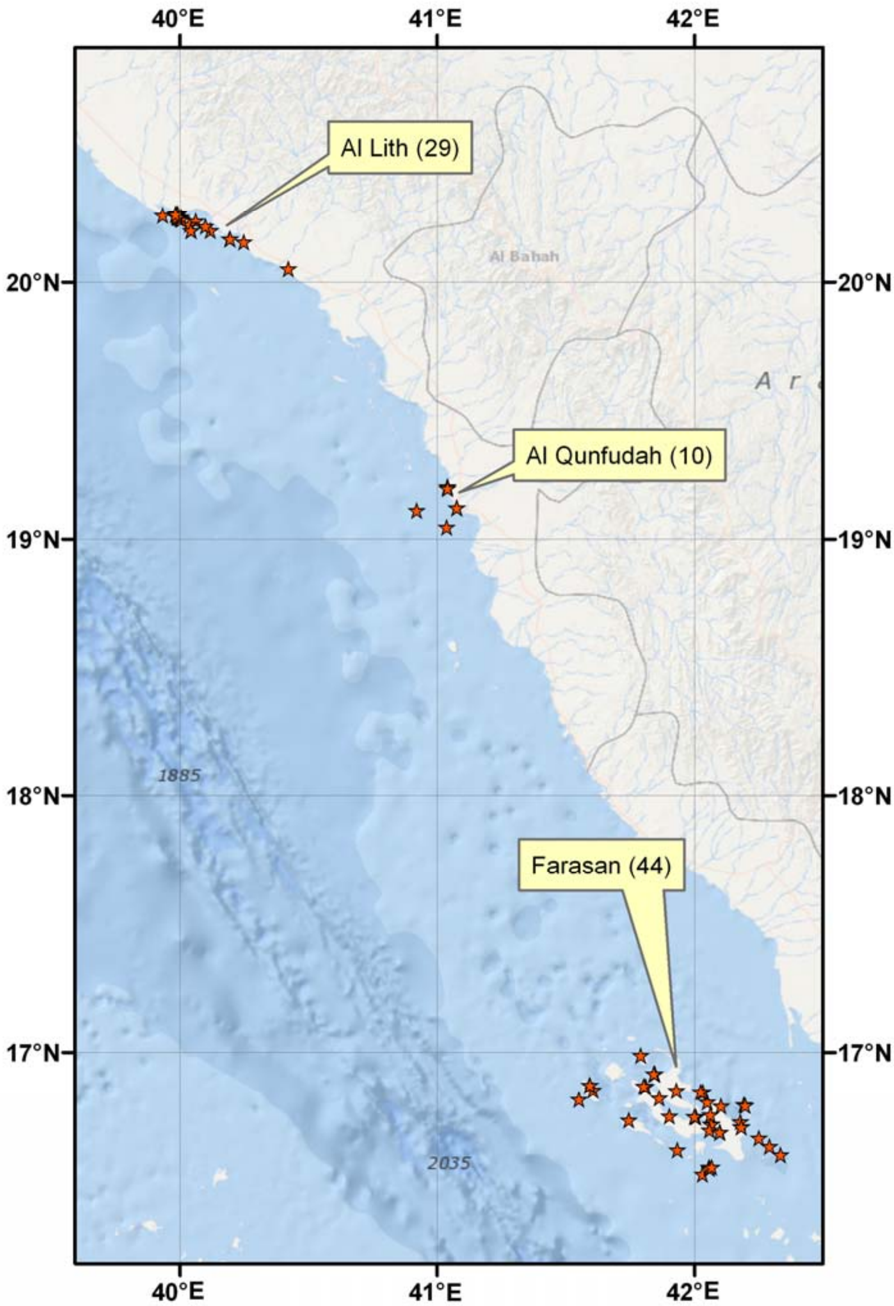

Fig. 15 Survey sites of the second Red Sea Biodiversity Survey in 2012. The number of survey sites per location is given in parentheses.

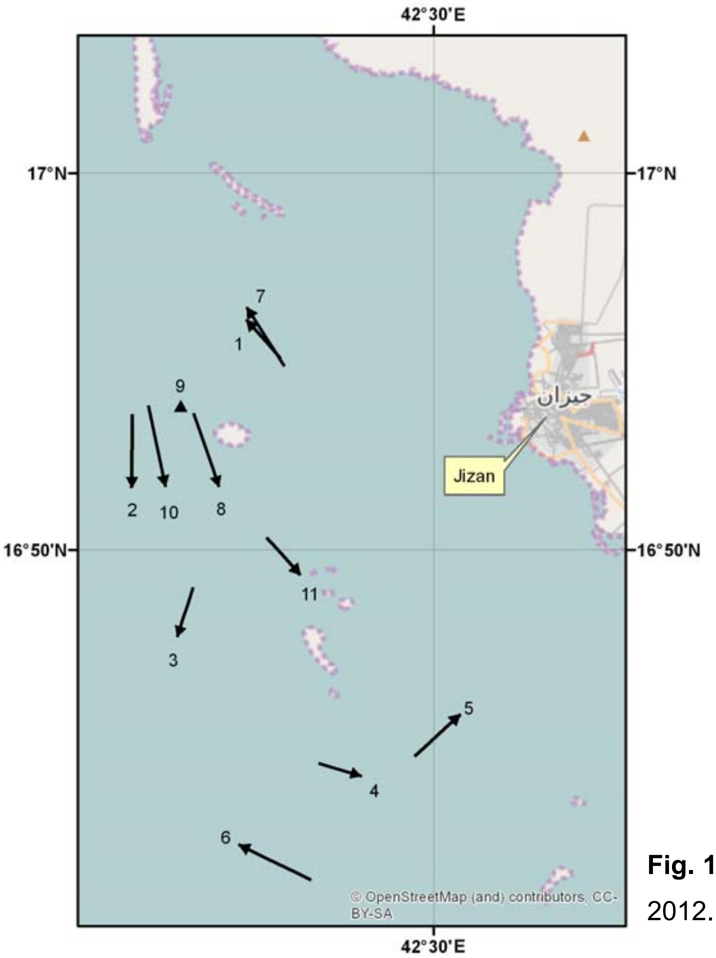

Fig. 16 Trawling sites during RSS1-2012.

2.3.

Fig. 17 Participants of the second Red Sea biodiversity survey in 2012 (location: Al Lith, Prawn-Company)

The third Red Sea Biodiversity Survey (June, 07th – 28th, Fig. 18) focused on the exploration of the northern part of the Saudi Arabian Red Sea coastline particularly the Al Wajh-, Duba- and Alkhuraybah areas. A total of 46 stations were visited. Again, a fish trawler in the Jizan area (Fig. 19) was boarded by project scientists. a list of participating scientists (Fig. 20, 7.3.1), an annotated list of collecting sites (7.3.2), and a list of the trawling stations (7.3.3) are appended to this report.

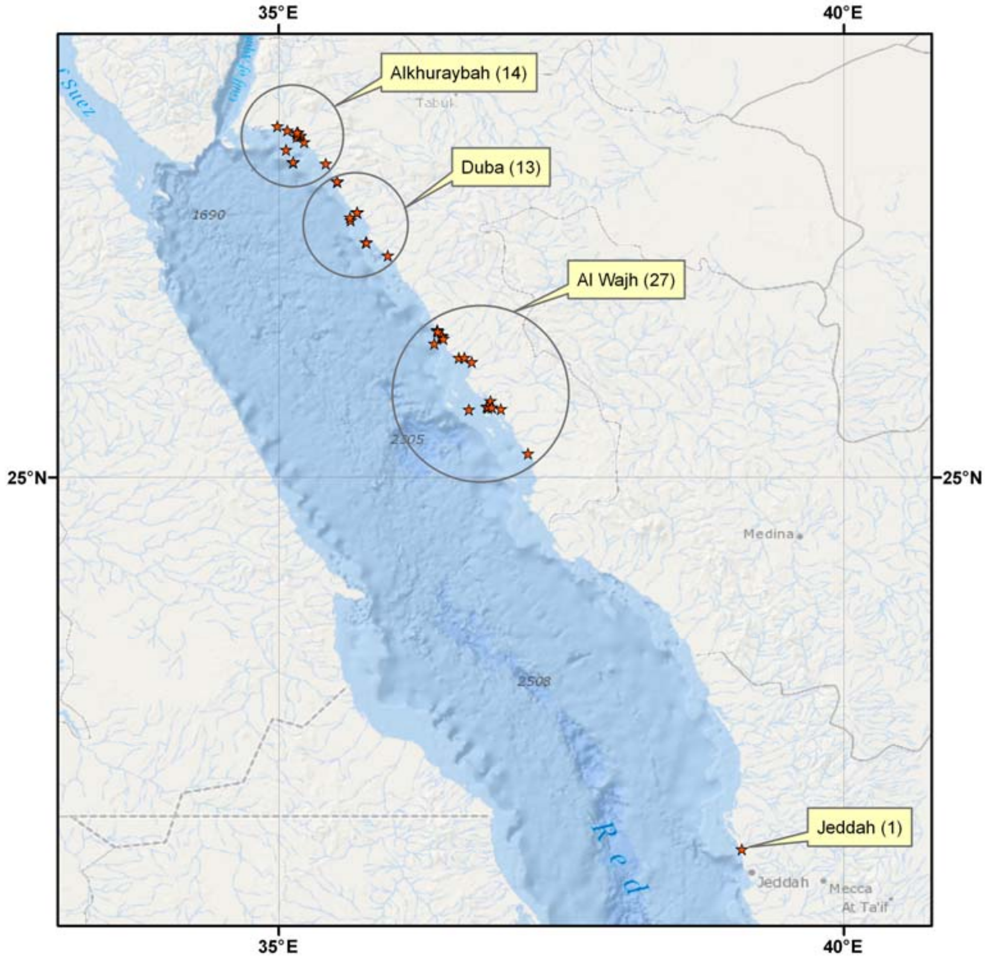

Fig. 18 Survey sites of the third Red Sea Biodiversity Survey in 2013.

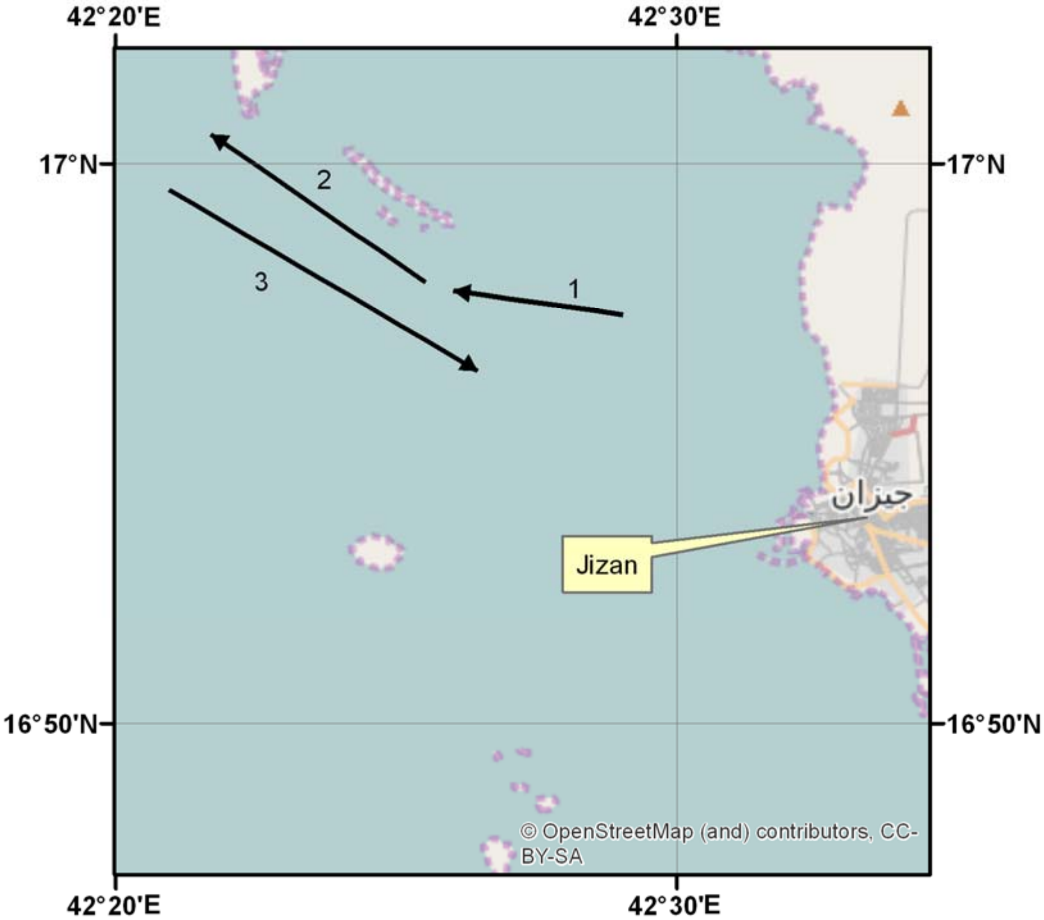

Fig. 19 Trawling locations of the accompanied commercial fish trawl during RSS1-2013.

Fig. 20 Participants RSS1-2013 (Locality: Al Wajh, in front of the hotel).

3. Project Results

3.1 Collections and taxonomic research

The KAU-SRI Red Sea surveys focused on the collection of shallow water fauna covering a wide range of habitats. The intertidal and the sublittoral fauna accessible by snorkelling or SCUBA-diving were sampled. All 216 sampling stations, including the trawl locations of 2012 and 2013 are shown in Fig. 21.

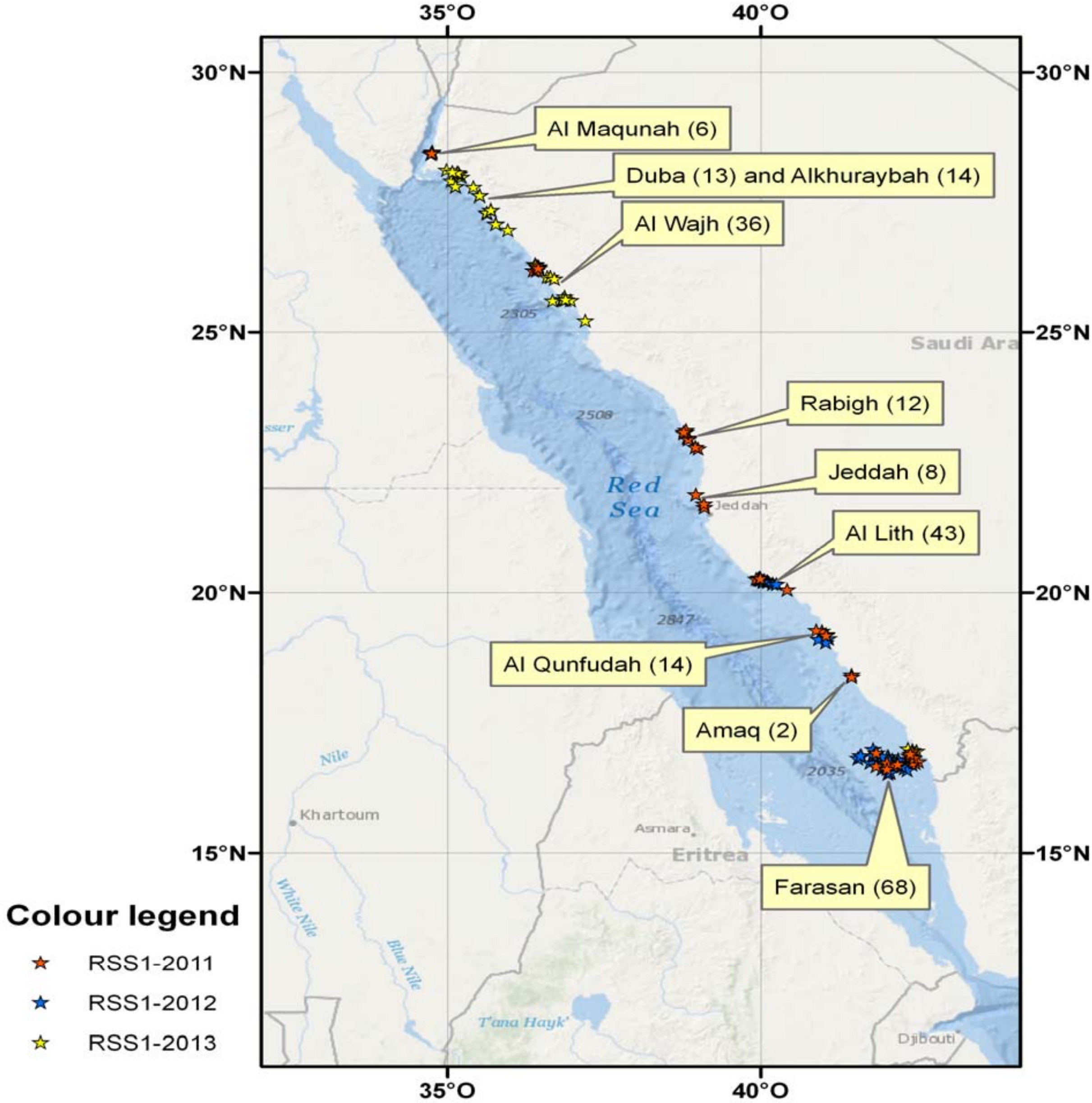

Fig. 21 Areas surveyed and collecting sites during the Red Sea Biodiversity Surveys in 2011 - 2013. Numbers in parentheses indicate the number of stations in each area.

At the SRI in Frankfurt, Germany (see 2.2.10), expert taxonomists of the SRI, together with KAU and external taxonomic scientists investigate the respective marine animal groups (Sponges, Stone and Soft Corals, Polychaetes, Crustaceans, Molluscs, Bryozoans, Echinoderms and Fish). A preliminary list of the number of collected animal taxa during Project Phase I is given in Table 1. A preliminary species list can be found in the Appendix to Chapter 7.4.

Table 1 Preliminary numbers of species collected during RSS1-2011 to RSS1-2013

Taxon	2011	2012	2013	Total Species
Sponges	---	24	50	**47**
Stony Corals	152	98	---	**193**
Soft Corals	---	---	50	**49**
Polychaetes	---	70	---	**70**
Crustaceans	50	57	54	**108**
Molluscs	169	213	217	**424**
Bryozoans	22	42	---	**46**
Echinoderms	---	---	26	**26**
Fish	195	327	136	**390**
Total Per Year	**588**	**831**	**533**	**~1300**

3.2 Molecular genetics research

3.2.1 Fish

During the surveys, tissue samples of more than 2,000 fish specimens were collected. Tissue samples were taken from fresh specimens and preserved in 96% ethanol (molecular biology grade) and stored at 4 °C (or –20°C if possible). The respective specimens were either preserved separately from other specimens or labelled individually in order to distinguish them from the remaining sample. If tissue was removed, the specimens were usually photo-documented. The tissue samples were transferred to the SRI and stored at –25 °C. A few small-sized specimens (<2 cm), where it was difficult to extract tissue samples under field conditions, were preserved in 96% ethanol and treated like tissue samples (see here above).

Until May 2014, DNA was extracted from some 1,400 tissue samples. DNA was purified either by a standard single column protocol (Qiagen DNeasy Blood & Tissue

Kit) or a standardised 96-well plate protocol that was developed for DNA barcoding of animals (IVANOVA et al. 2006). Quality and quantity of extracted DNA was always inspected on agarose DNA gels. DNA barcoding was performed by PCR amplification of mitochondrial DNA (mtDNA) and in most cases by partial amplification of mitochondrial cytochrome oxidase I gene with a combination of primers specifically developed for PCR amplification of this gene from a systematically wide variety of fish species (IVANOVA et al. 2007, GEIGER et al. 2014). Other mitochondrial genes were PCR amplified in specific taxonomic groups such as rays, where the mitochondrial NADH dehydrogenase subunit 2 (NADH2) gene was established as a barcoding region (NAYLOR et al. 2012). PCR amplified barcoding regions were sequenced from both ends after purification of PCR products at the laboratory of the Biodiversity and Climate Research Centre (BiK-F) of Senckenberg. More than 400 taxa have been DNA barcoded so far.

Barcoding sequences were analysed jointly with publicly available data from other barcoding initiatives that were retrieved mostly from GenBank (www.ncbi.nlm.nih.gov/genbank/) or the Barcode of Life Data Systems (www.boldsystems.org). Phylogenetic analyses of the barcoding region of fish from the Red Sea and available sequences from several other regions of the Indian and Pacific Oceans revealed distinctive phylogeographic patterns (ALPERMANN et al. 2013). In their extremes, Red Sea species with broad Indo-Pacific distribution showed either no marked diversification when compared with their conspecifics from nearby or distant locations. Alternatively, they showed patterns of strong evolutionary divergence, separating for example Red Sea populations from the most closely located populations from the Indian Ocean or showing no marked evolutionary divergence of Red Sea and Indian Ocean populations, but showing evidence of a marked divergence from their Pacific conspecifics. Hence, the genetic information from DNA barcoding can be incorporated in future taxonomic studies. It will also be used to correlate phylogeographic patterns with taxonomic information on morphological divergence at the subspecific level. Results of such analyses are expected to contribute to an integrated taxonomic perspective. Publications in preparation include a manuscript summarising the barcoding initiative (for Molecular Ecology Resources), a manuscript detailing diversification patterns and the general evolutionary insights obtained from DNA barcoding plus several studies in which analyses of barcoding genes are incorporated into integrative taxonomic studies (IVANOVA et al. 2006 & 2007, NAYLOR et al. 2012). Examples of these studies, most of which are currently in preparation for publication, are the description of a new species of pempherid fish (RANDALL et al. 2013) and the novel record for the Red Sea of a myliobatid ray (BOGORODSKY et al. 2014).

3.2.2 Sponges

During the surveys in 2012 and 2013 samples of tissue of more than 400 sponge specimens were collected. Tissue samples were taken from fresh material and preserved in 96% ethanol at the Department of Earth and Environmental Sciences Palaeontology & Geobiology (Ludwig-Maximilians-University Munich) in order to separate the different species through DNA barcoding analyses. In a first step, all tissue samples were amplified with a fast marker (28S, PCRed), all successful amplifications were barcoded. Now, the genotypes are CO1-sequenced to determine the species.

Thus far, some 400 sponge samples have been barcoded and 23 calcareous sponge species (Calcarea), together with 64 28S-Demospongia genotypes have been identified. Exact numbers, as well as a species list will be available after CO1 sequencing is finished. Classic taxonomic work will start upon the finalisation of species separation through DNA barcoding. Publication of the results is in preparation; a results presentation will also be given at the International Conference on the Marine Environment of the Red Sea (November 10th to 13th, 2014 in Jeddah). The sponge barcodes will be available online at the Sponge Barcoding Database (www.spongebarcoding.org) after the publication of results.

3.3 Crustacean Research

Crustacean research focused mainly on two fragile environments, coral reef associates and the littoral fringe in the intertidal and supratidal zone. Both environments can be affected by coastal development and therefore knowledge about their pristine fauna is essential.

In the coral reef environment the crab genus *Cymo* was studied, whose members are facultative associates of acroporid and pocilloporid reef corals. Crabs of this genus have always been difficult to identify and the discrimination characters were not clear. The main target was therefore to analyse the specifity and variability of taxonomic characters and their usefulness for species discrimination. Besides this, the distribution of the species along the Saudi Arabian Red Sea coast was recorded. The study resulted in clear definitions of four species distributed throughout the Red Sea, including a new record from that area. A key was provided that will help in the identification of specimens for ecological and environmental studies.

Another priority project was the analysis of the grapsoid and ocypodoid crab fauna, which is characteristic for coastal environments as sandy or rocky beaches and mangroves. These crabs were collected along the whole stretch of the Saudi Arabian coast. One of these species proved to belong to a new genus that was described recently under the name *Eneosesarma* including a single species: *Eneosesarma azizi*. This species is so far restricted to the Islands Farasan and Saso of the Farasan Archipelago. During the survey of Farasan it could only be found on these two islands and therefore its exact distribution range has still to be established. It occurs in crevices and funnels of fossil rock 1-3m above the water line which is a very unusual environment for sesarmid crabs. The remaining grapsoid and ocypodoid shore crabs have been identified to species and taxonomic details are being studied presently.

Besides the two main subjects also the swimming crabs (Portunidae) of the Red Sea have been studied in detail together with Dr. Vassily Spiridonov from the Shirshov Institute of the Russian Academy of Sciences in Moscow. Dr. Spiridonov is a world specialist in portunids and has also joint the last Red Sea survey in the framework of the project. The joint study collated, besides the analysis of the collected material, all published and unpublished information on Red Sea portunids resulting so far in more than 60 species, which will be characterised and described in detail. Among these crabs there are also commercially exploited species as the large *Portunus segnis* (formerly referred to as *P. pelagicus*).

Ghost shrimps (Callianssidea) as part of the intertidal fauna have been studied together with Prof. Katsushi Sakai, a world specialist of this group. A total of four species have been collected at the Saudi Arabian coast during our surveys of which one, *Neocallichirus mucronatus*, is new for the Red Sea. By the occasion of this study all information on the ghost shrimps of the Red Sea was collated and presented. Together with the new record, so far 32 species are known from the area. For most areas of the coast there is still much work to do in the shallow subtidal environments in order to get a complete picture of ghost shrimp ecology and distribution. Nothing is known from greater depths about occurrences of these crustaceans.

3.4 Planning the KAU Marine Museum

The King Abdulaziz University is planning to establish a marine museum, combined with an aquarium (Fig. 22). According to original plans, 400 m² were allocated for marine biological collections, but according to recommendations by the SRI, a floor space of 900 m² is now considered. A sample sorting lab (ca. 80 m²) will be used for watering of formalin-preserved material and the subsequent transfer to ethanol. A laboratory for preliminary identifications, labelling and cataloguing of samples (ca. 40 m²), and a storage area of approximately 780 m² are proposed.

Fig. 22 Future outline of the King Abdulaziz Marine Museum in Jeddah

With this project, KAU is setting a milestone towards sustainable, systematic research on the marine environment of the Red Sea. It also enhances public awareness by disseminating science to a wider audience.

3.5 Collection Database

One of the most important achievements of the project is the establishment and maintenance of the KAUMM database (http://kaumm.senckenberg.de) (Fig. 23) for all specimens collected and identified that will be transferred to the KAUMM after completion (see 3.3). If a collection object is linked to a recent publication, this is mentioned in the database.

For a large portion of species in the database, reference pictures were made (Fig. 24 and 25). Some are already in the KAUMM database, others will be added later. High resolution pictures are usually not included in the database in order to avoid non-authorised use by anonymous downloaders. High resolution pictures are available on demand.

As for crustaceans, 64 series have been catalogued until today, containing 114 porcellanids, 20 sesarmids, including the newly described sesarmid species (BRÖSING et al. 2014), 17 trapeziids, 16 portunids, 12 ocypodids, 7 xanthids and 2 oziids. Most of the remaining crustacean species identified will be added soon. Regarding fish, 134 series containing 364 specimens from 44 families are already catalogued in the KAUMM database.

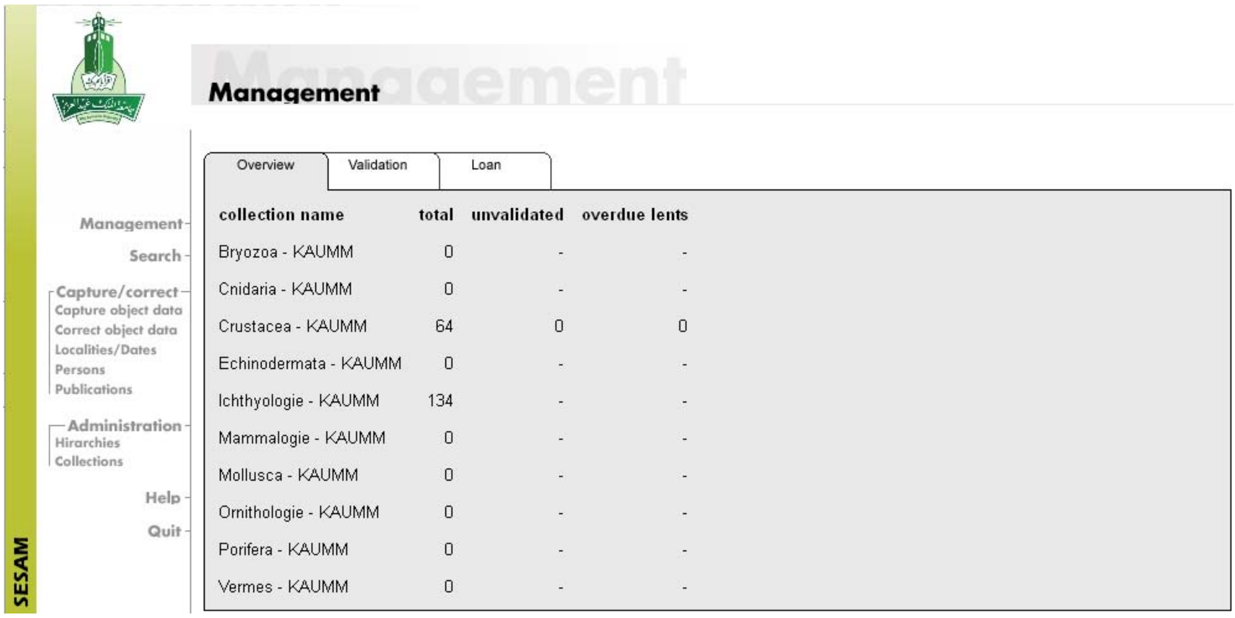

Fig. 23 Main window with overview of the KAUMM-Database (http://kaumm.senckenberg.de/)

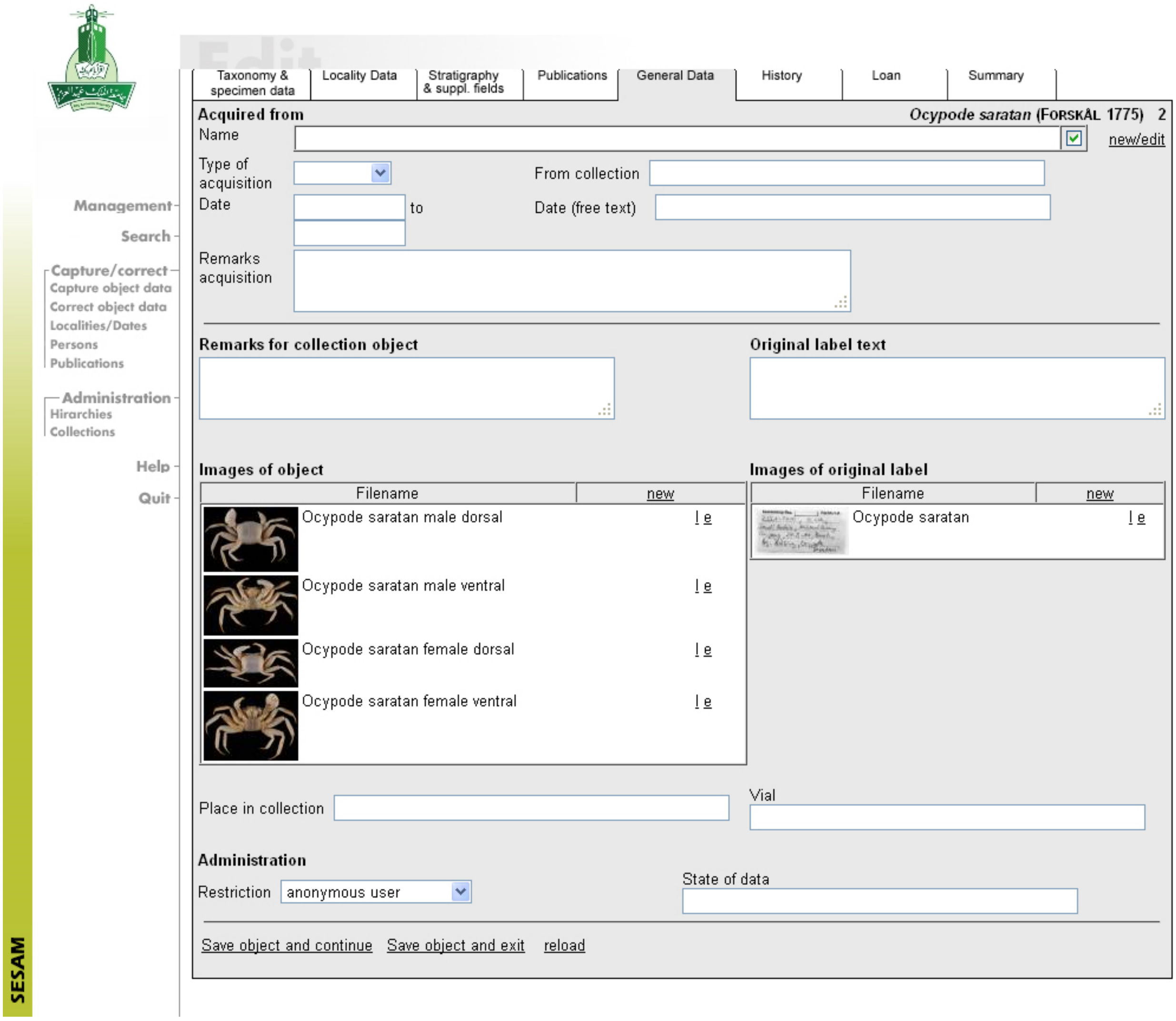

Fig. 24 Tab on general data of *Ocypode saratan* in the KAUMM database. Pictures and original label are deposited here.

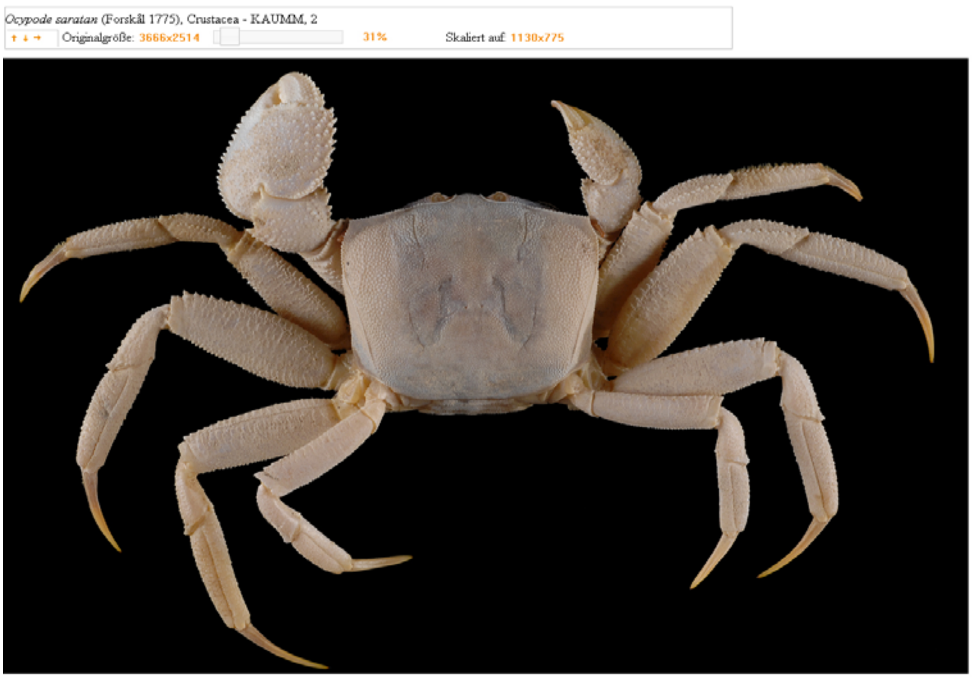

Fig. 25 Image viewer for image files deposited at the KAUMM-database, with *Ocypode saratan* as an example.

3.6 Project homepage

The project homepage (Fig. 26) is accessible at www.redseabiodiversity.org. Following a general introduction into the project, the user can browse:

- *Current Events*: Recent news, like the International Conference on the Marine Environment of the Red Sea, held in Jeddah, November 10 - 13, 2014
- *Scientific Background*: Information on the geology and oceanography of the Red Sea
- *KAU-SRI Red Sea Surveys*: Detailed overview of the three surveys of Phase I, including download links to station data
- *Habitats*: Overview of habitats that were visited during the surveys, including coordinates
- *Steering Committee*: Members of the RSS steering committee and contact information of the project coordinator
- *Gallery*: Impressive mix of in-vivo documentation imagery
- *Publications*: List of all publications produced by the RSS-project, with continuous updating
- *Database*: Introduction and link to the SeSam and the KAUMM databases
- *Contact*: Project contact information
- *Legals*: Legal details, copyright and disclaimer

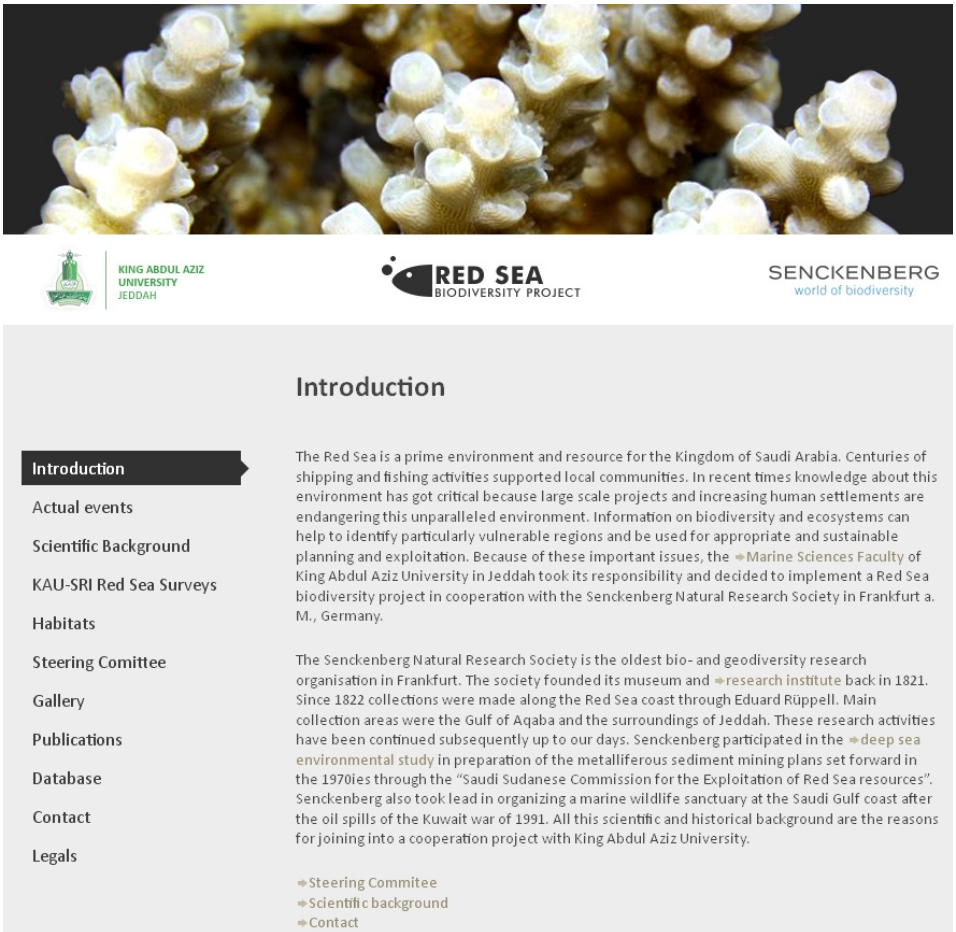

Fig. 26 Layout of the main page of www.redseabiodiversity.org.

3.7 Publications / Conference presentation

An extensive publication output is one of the essential requirements of the project and the basis for a successful continuation. The following table indicates the current status of research papers which are published or in preparation.

List of publications (published, in press or submitted, updated on 1st June 2014):

Fish:

Holleman, W. & Bogorodsky; S. V. 2012. A review of the blennioid fish family Tripterygiidae (Perciformes) in the Red Sea, with description of *Enneapterygius qirmiz*, and reinstatement of *Enneapterygius altipinnis* Clark, 1980. Zootaxa 3152: 36–60.

Gon, O.; Bogorodsky; S. V. & Mal; A. O. 2013. Description of a new species of the cardinalfish genus *Pseudamiops* (Perciformes, Apogonidae) from the Red Sea. Zootaxa 3701(1): 93–100.

Randall, J. E.; Bogorodsky, S. V. & Mal, A. O. 2013. Four new soles (Pleuronectiformes: Soleidae) of the genus *Aseraggodes* from the western Indian Ocean. Journal of the Ocean Science Foundation 8: 1–17.

Gill, A.; Bogorodsky, S. V. & Mal, A. O. 2013. *Acanthoplesiops cappuccino*, a new species of acanthoclinine fish from the Red Sea (Teleostei: Plesiopidae). Zootaxa 3750(3): 216–222.

Randall, J. E.; Bogorodsky, S. V.; Alpermann, T. J.; Satapoomin, U.; Mooi, R. D. & Mal, A. O. 2013. *Pempheris flavicycla*, a new pempherid fish from the Indian Ocean, previously identified as *P. vanicolensis* Cuvier. Journal of the Ocean Science Foundation 9: 1–23.

Greenfield, D. W.; Bogorodsky, S. V. & Mal, A. O. 2014. Two new Red Sea Dwarfgobies (Teleostei, Gobiidae, Eviota). Journal of the Ocean Science Foundation 10: 1–10.

Gill, A.; Bogorodsky, S. V. & Mal, A. O. 2014. *Gymnoxenisthmus tigrellus*, new genus and species of gobioid fish from the Red Sea (Gobioidei: Xenisthmidae). Zootaxa 3755(5): 491–495.

Bogorodsky, S. V.; Last, P. R.; Alpermann, T. J.; & Mal, A. O. 2014. Records of *Himantura granulata* (Dasyatidae) and *Rhinoptera jayakari* (Rhinopteridae) from the Red Sea. Zoology in the Middle East 60(2): 144–153.

<u>Accepted:</u>

Fricke, R.; Bogorodsky, S. V. & Mal, A. O. Review of the genus *Diplogrammus* (Teleostei: Callionymidae) of the Red Sea, with description of a new species from Saudi Arabia. Journal of Natural History.

<u>Submitted:</u>

Smith, D. G.; Bogorodsky, S. V. & Mal, A. O. Submitted. New Records of *Kaupichthys atronasus* (Chlopsidae), *Phyllophichthus xenodontus* (Ophichthidae), and *Gorgasia preclara* (Congridae) from the Red Sea. Cybium.

Kovačić, M.; Bogorodsky, S. V. & Mal, A. O. A new species of *Hetereleotris* (Perciformes: Gobiidae) from Farasan Island (Red Sea). Zootaxa.

Bogorodsky, S. V.; Alpermann, T. J.; Mal, A. O. & Gabr, M. H. Survey of demersal fishes from southern Saudi Arabia, with five new records for the Red Sea. Zootaxa.

Crustaceans:

Brösing, A.; Spiridonov, V.; Al-Aidaroos, A. M. & Türkay. 2014. Description of a new genus, new species of Sesarmidae (Crustacea, Decapoda) from the Farsan Islands, Saudi Arabia, Red Sea. Journal of Crustacean Biology 34(2): 273-282.

Brösing, A.; AL-Aidaroos, A. M. & Türkay, M. 2014. The Red Sea species of Cymo de Haan, 1833 (Decapoda, Brachyura, Xanthidae), associates of scleractinian corals. Zootaxa. 3779 (2): 195–214.

Sakai, K.; Al Aidaroos, A. M.; Brösing, A.; Spiridonov, V.; Werding, B. & Türkay, M. 2014. A collection of Callianassidea Dana, 1852 (Decapoda, Pleocyemata) from the Saudi Arabian Red Sea coast with a check-list of all ghost shrimps (Thalassinidea and Callianassidea) known from the area. Crustaceana 87(4): 489-512.

Abstract:

Spiridonov, V., Türkay, M., Brösing, A. and Al-Aidaroos, A. 2013. Portunoid crabs as indicators of the Red Sea fauna history and endemism. Geophysical Research Abstracts, 15: EGU2013-3947.

4. Project Benefits

The Red Sea is the largest marine area adjacent to the Kingdom of Saudi Arabia. Its exclusive economic zone of covers ca. 185.000 km2 and an inshore fishing area of ca 58.000 km² (www.seaaroundus.org/eez/638.aspx). It provides tremendous natural treasures to the Kingdom, such as food resources, tourism opportunities and several other resources like oil and gas reservoirs or mineral deposits. In order to guarantee the sustainable use of these resources, the Red Sea with its rich biodiversity needs to be explored and patterns and processes of its ecosystems understood. In the long term, only healthy ecosystems can sustain their functions and services to society. Biodiversity has to be properly managed, with its scientific assessment as a basis for understanding how to achieve the sustainable use of its resources.

This project not only is a good example for international collaboration of top class researchers, but also lays the foundation for the first national and regional scientific reference collection for the Red Sea at the King Abdulaziz Marine Museum (KAUMM) in Jeddah. Thus, it forms part of Saudi Arabia's obligations to fulfil international conventions by generating essential knowledge towards the management of marine resources and environmental conservation as a platform for the sustainable cross-linkage of humankind and economy.

Within Phase I of the Red Sea Biodiversity Research Cooperation, impressive results have been achieved. In three years, 16 publications (12 published, 1 accepted, 3 submitted) have been produced. The project's taxonomic research provides the baseline for more detailed studies on systematics and phylogenetics, the results of which will be published in high impact journals. Thus far, more than 1,300 species have been identified, but the majority of species identifications is still pending.

Taxonomic research based on comparative morphology with the use of modern genetics is particularly promising. Future emphasis will be placed on continued DNA barcoding, genetic analyses for species/lineage identification with the support of traditional taxonomy based on comparative morphology. This approach will enable us to match larvae and adults of the same species. Studies of phylogeographic patterns and molecular evolution of Red Sea biota will be complemented by ecological studies, including the assessment of species distributions and richness, as well as studies on ecosystem vulnerability.

In summary, the continuation of the Red Sea Biodiversity Assessment is of high importance in order to understand the coherences between the Red Sea marine ecosystems, biodiversity and anthropogenic interactions as a basis for the sustainable use of renewable resources, assuring future economic benefits from this unique marine realm. This project forms the headstone for the collection of the King Abdulaziz Marine Museum. Initial investment by the King Abdulaziz University will amortise only, if the project – which in the proper sense only just began – is continued for at least another three-year phase.

Many more important research results and high impact publications, together with the analysis of further animal groups (sponges, hydroids, annelids, molluscs, echinoderms and bryozoans) are in progress. They can only be finalised, if the project continues on a solid basis with adequate financial support.

5. Executive Summary

5.1 Background

The Red Sea is a distinct biogeographic unit in the north-western part of the Indian Ocean with some of the world's most unique coastal and marine environments, and an extraordinary biodiversity. It is an important centre of speciation. Endemism – species that occur here and nowhere else – is particularly high, above all among reef-associated and deep-sea taxa. Adaptations of biota to unique physical features in an extreme environment are remarkable. With 1840 km, the Kingdom of Saudi Arabia has the longest coastline of any riparian country and the N-S gradient of ecologically important oceanographic features is more pronounced than anywhere else. Biodiversity is unevenly distributed across the Kingdom's seascape, varying greatly from area to area. Failing to take these parameters into account, earlier Red Sea biodiversity studies are inadequate and unbalanced, which underlined the need for more focused spatial biodiversity research.

5.2 Project Design and Strategy

King Abdulaziz University (KAU) entered into a strategic partnership with the Senckenberg Research Institute (SRI) of Frankfurt, Germany, a global leader in marine biodiversity studies with a research tradition of 200 years in the Red Sea region. The overall goal of the project's first phase (April 2011 to March 2014) was: "To conduct baseline research in the Saudi Arabian Red Sea, documenting patterns and processes of marine biodiversity, addressing gaps in knowledge and future research priorities". While large and conspicuous animals are fairly well documented, the discovery of the remaining species requires field research by specialist taxonomists. Consequently, KAU and SRI formed joint teams of 39 scientists and students, specialising in key marine taxa, who gathered baseline data on genetic, species and ecosystem diversity.

Since it was not possible for the field team to cover all areas of specialisation required, a support group of 18 scientists from 12 countries contributed to the project from their home laboratories. The project was coordinated by a Steering Committee of senior scientists from KAU and SRI. Best available, state-of-the-art technology was used for field and laboratory research. A formal course and on-the-job training were delivered for undergraduate and graduate students at KAU. Through the biodiversity surveys, scientists gained an understanding of Red Sea ecosystems, their components, how they function and which services they provide to society. By generating data needed for the management of renewable marine resources and environmental conservation, the project is of highest national priority, contributing to food security, ecosystem and human health.

In conclusion, the project is at the core of KAU's Mission: "To provide students with a quality education, conduct valuable research, serve the national and international societies and contribute to Saudi Arabia's knowledge society through learning, creativity, the use of current and developing technologies and effective international partnership."

5.3 Project Activities

In preparation of the field surveys, an initial course on Red Sea biodiversity, field research methods, and sample preparation was developed and delivered by Senckenberg scientists in March 2011 at KAU's Faculty of Marine Sciences in Obhur. Following an introduction to the Red Sea's unique oceanography and biophysico-chemical processes shaping biodiversity, the course familiarised participants with key marine biota and taxon-specific research, field collection, and preservation methods. Coursework was complemented by on-the-job training during the subsequent field research activities.

During the first project phase, three field surveys covered key animal taxa in all coastal and shallow subtidal marine habitat types, using a wide range of specialised research equipment. The first survey in March/April 2011 was a reconnaissance along the entire Saudi Arabian Red Sea coast including the Farasan Islands, identifying areas of special interest for biodiversity research. Eight areas were sampled and more than 650 species collected. During the second survey in February/March 2012, the number of areas visited was reduced, allowing for more intense research and sampling at 73 stations. Participation in commercial fish trawls for three days resulted in the collection of a significant number of additional species that were not covered by other sampling methods. The third survey in June 2013 covered 43 sites along the northern Red Sea coast.

Following field collection, the samples were labelled, preserved and subsequently packed for shipment. They were transferred to the SRI in Frankfurt, where they were sorted and distributed to scientists for identification and further research. SRI and KAU scientists with similar fields of specialisation (e.g. an interest in the same taxon) teamed up for joint field surveys in Saudi Arabia, laboratory research and data analysis in Frankfurt, and the writing up of joint research papers.

5.4 Project Results and New Discoveries

According to the current status of taxonomic research, 1360 species, representing nine key marine taxa, were collected during three surveys in 2011 – 13. The project substantially improved our knowledge on the geographical range of a large number of taxa. Several species were recorded for the first time from the Red Sea. One species of crustacean and six fish species were described as new to science (Appendix 3). More descriptions of new species are in press, submitted for publication, or in preparation. The most outstanding discoveries are two genera new two science, the crustacean genus *Eneosesarma* and the fish genus *Gymnoxenisthmus*.

During a survey of benthic fish off Jizan, 96 species were collected by trawling, five of which represent new records for the Red Sea. Additional specimens of other species, that were previously considered dubious, helped clarifying their taxonomic status.

Genetic analyses of voucher specimens allowed identifying patterns of genetic differentiation and diversification of Red Sea fish and Indian Ocean conspecifics and/or congenerics, revealing diverse patterns, including novel endemic Red Sea evolutionary lineages. Some represent species that are presently either undescribed or not recognised as valid. The genetic analyses support taxonomic studies by providing additional evidence for lineage separation and speciation.

Barcoding sequences were analysed jointly using publicly available data from other barcoding initiatives. Phylogenetic analyses of the barcoding region of fish from the Red Sea and sequences from several other regions of the Indian and Pacific Oceans revealed distinctive phylogeographic patterns. In their extremes, Red Sea species with broad Indo-Pacific distribution showed either no marked diversification when compared with their conspecifics from close or distant locations; or they showed patterns of strong evolutionary divergence, separating Red Sea populations from geographically very close populations in the Indian Ocean. Project outcomes include documentation of species and genetic diversity, based on comparative morphology and DNA studies; biodiversity baseline data feeding into other research and development projects; input into the identification of areas containing relict populations of national importance, and areas of environmental sensitivity.

5.5 Red Sea Specimen Collection at KAU

Specimen collections are important vouchers, documenting Saudi Arabia's national biodiversity. The establishment of a Red Sea Marine Museum at KAU has high priority, because there is no other such institution combining biodiversity research, documentation and education anywhere in Arabia. The Kingdom ratified the UN Convention on Biological Diversity, with an obligation to document its national biological diversity, and KAU has signed an agreement with PERSGA to establish a regional marine biological collection for the Red Sea and Gulf of Aden. Thus far, biological collections from Saudi Arabia, some dating back to the 18th century, are in Europe, North America or elsewhere outside the region. According to the General Project Contract between KAU and SRI, the establishment of a reference collection for the planned Red Sea Museum in Obhur is an important result of the project.

5.6 Collection Database

A database of specimens to be deposited at the KAU Marine Museum was created, modelled on the Senckenberg collection database SeSam. This web-based system can be accessed anywhere with an internet browser (URL:

http://kaumm.sesam.senckenberg.de) using any system. KAUMM stands for “King Abdulaziz University Marine Museum”. Collections gathered during the project are currently stored at the SRI and will later on be transferred to KAU. They carry KAUMM-catalogue numbers. The database allows for full access to taxonomic and locality details. It includes illustrations of specimens. Thus far, 170 datasets (36 crustaceans, 134 fishes) have been entered.

The database has a label printing tool for collection management and allows for extracting data of a past search. Presently we are in the process of linking the KAUMM database to the GBIF and OBIS portals, which should be completed very soon, making it accessible through the two most significant international portals of marine biodiversity.

5.7 Project Homepage

To foster the exchange of information about the project, a project homepage has been designed (http://www.redseabiodiversity.org). It is currently available in English, but Arabic and German will be added soon. Provisions have been made for responsibility assignments, quality control, and hierarchy of access.

5.8 Publications

The primary aim of the project is sharing research results by publishing them in high impact, peer reviewed scientific journals. During the first project phase nine papers have been published, one has been accepted for publication, four others have been submitted, and many more are at various stages of preparation.

5.9 Project Benefits and Future Prospects

The Red Sea is a tremendous natural capital asset to the Kingdom, providing food resources and supporting tourism, among several other income-generating opportunities. This asset, however, depends on healthy ecosystems, which only keep functioning and providing their services to society, if their key component, biodiversity is properly managed. Management in turn must be science-based and this project is an outstanding example of international collaboration in world-class research. In addition, the project is in the process of establishing the first ever national and regional scientific reference collection in the Arabian Peninsula. It fulfils part the Kingdom's obligations under international conventions and generates essential data for renewable marine resources management and environmental conservation. As such, it makes an important contribution to sustainable human and economic development.

While impressive results have been generated during the first phase, the bulk of the species identifications still lie ahead. Taxonomic studies provide the baseline for more complex systematic and phylogenetic research that will be published in high impact journals. The project's approach of combining taxonomic research based on comparative morphology with genetics is particularly promising in this regard. Future directions include the completion of DNA barcoding, genetic analyses for species/lineage identification, supporting taxonomic research, e.g. allowing for the matching of larvae and adults of the same species. The studies also aim at analyses of phylogeographic patterns and molecular evolution of Red Sea biota.

The project team thus argues that amortisation of the initial investment into the project requires its continuation for at least another three-year phase. Many important research results and high impact publications are in the pipeline, but will only see the light of day, if the project continues.

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Bogorodsky, S. V.; Last , P.R.; Alpermann, T.J.; & Mal, A.O. (2014). Records of *Himantura granulata* (Dasyatidae) and *Rhinoptera jayakari (*Rhinopteridae) from the Red Sea. Zoology in the Middle East 60(2): 144–153.

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7. Appendices

7.1 List of Project Scientists (in alphabetical order by last name)

7.1.1 Field Survey Participants, Representing King Abdulaziz University (KAU) and the Senckenberg Research Institute (SRI)

Salman Al-Ahmadi, KAU
Ali M. Al-Aidaroos, KAU
Ahmad Alhaj, KAU
Tilman Alperman, SRI
Christian Alter (v. Mach), SRI
Anand Austin, KAU
Mohammad Baakdah, KAU
Jaafar Baomar, KAU
Temir Britajev, SRI
Andreas Brösing, SRI
Sergey Bogorodskiy, SRI
Hans Rudo von Cosel, SRI
Reny P. Devassy, KAU
Mohsen M. Elsherbiny, KAU
Dirk Erpenbeck, SRI
Mohamed H. Gabr, KAU
Andrei Grishchenko, SRI
Adel N. Guirguis, KAU
Philipp Kremer, SRI
Asaad Lahmar, KAU
Ahmed O. Mal, KAU
Adel Nageeb, KAU
Mustafa Qoukandi, KAU
Götz B. Reinicke, SRI
Adnan J. S. Salama, KAU
Abdulmohsin Al-Sofyani, KAU
Vassily Spiridonov, SRI
Peter Stahlschmidt, SRI
Sven Tränkner, SRI
Michael Türkay, SRI
Oliver Voigt, SRI
Bernd Werding, SRI
Gerald Wilson, KAU

7.1.2 Taxonomic specialists contributing to project from their home laboratories

Shane T. **Ahyong**, Australian Museum, Sydney, Australia
Matthew T. **Craig**, University of Puerto Rico, Mayagüez, Puerto Rico
Naomi R. **Delventhal**, University of Manitoba, Winnipeg, Canada
Ronald **Fricke**, State Museum of Natural History, Stuttgart, Germany
Anthony C. **Gill**, Macleay Museum, University of Sydney, Australia
Zdenek **Duris**, Department of Biology, University of Ostrava, Ostrava, Czech Republic
Ofer **Gon**, South African Institute for Aquatic Biodiversity, Grahamstown, South Africa
David W. **Greenfield**, California Academy of Sciences, San Francisco, USA
Wouter **Holleman**, South African Institute for Aquatic Biodiversity, Grahamstown, South Africa
Marcelo **Kovačić**, Prirodoslovni muzej, Rijeka, Croatia
Peter R. **Last**, CSIRO Marine & Atmospheric Research, Hobart, Australia
Colin **Mclay**, School of Biological Sciences, Canterbury University, Christchurch, New Zealand
Enrique **Macpherson**, Centro de Estudios Avanzados de Blanes (CSIC), Blanes, Spain

Randall D. **Mooi**, Manitoba Museum, Winnipeg, Canada

John E. **Randall**, Bishop Museum, Honolulu, Hawai'i, USA

Katsushi **Sakai**, Shikoku University, Tokushima, Japan

Ukkrit **Satapoomin**, Marine Biological Center, Phuket, Thailand

David G. **Smith**, Smithsonian Institution, Suitland, USA

7.1.3 Project Steering Committee Members

KAU: Ali M. Al **Aidaroos**, Abdulmohsin **Al-Sofyani**

SRI: Michael **Türkay**, Friedhelm **Krupp**

7.1.4 Project Coordinators

Andreas **Brösing** (up to April 30, 2014)

Moritz **Sonnewald**, SRI (since May 1, 2014)

7.2 First Survey (RSS1-2011)

7.2.1 RSS1-2011: Annotated list of collecting sites

Locality	Date	Station	GPS Data	Note
Al Lith	27.03.2011	1	N 20°16.003' E 039°59.443'	Beach, Hand-dredge
Al Lith	27.03.2011	2	N 20°15.773' E 039°59.544'	Snorkeling
Al Lith	27.03.2011	3	N 20°16.214' E 039°58.567'	Traps
Al Lith	28.03.2011	1	N 20°03.094' E 040°25.262'	Mangroves
Al Lith	28.03.2011	2	N 20°16.714' E 039°59.313'	Beach, Rocky shores
Al Lith	28.03.2011	3	N 20°15.111' E 039°57.825'	Diving 1
Al Lith	28.03.2011	4	N 20°15.055' E 039°57.725'	Diving 2
Al Lith	29.03.2011	1	N 20°16.003' E 039°59.443'	Beach
Al Lith	29.03.2011	2	N 20°16.003' E 039°59.443'	Snorkeling
Al Lith	29.03.2011	3	N 20°15.571' E 039°55.986'	Diving 1
Al Lith	29.03.2011	4	N 20°14.965' E 039°59.621'	Diving 2
Al Lith	29.03.2011	5	N 20°15.891' E 039°59.468'	Dredge, 3-5m
Al Lith	29.03.2011	6	N 20°15.773' E 039°59.544'	Traps
Al Lith	29.03.2011	7	N 20°15.771' E 039°59.544'	Rocky shores
Al Qunfudhah	30.03.2011	1	N 19°11.751' E 041°02.463'	Coast Guard station, Dredge 3-5m
Al Qunfudhah	30.03.2011	2	N 19°15.971' E 040°58.739'	Island, Beach & Dredge,12-15m
Al Qunfudhah	30.03.2011	3	N 19°16.813' E 040°53.265'	Diving
Al Qunfudhah	30.03.2011	4	N 19°10.620' E 041°02.675'	Rocky shores
Amaq	31.03.2011	1	N 18°25.428' E 041°27.147'	Mangroves
Amaq	31.03.2011	1b	no data available	Pier Coast Guard
Amaq	31.03.2011	2	N 18°22.948' E 041°26.965'	Diving site; Beach: Hand-collecting
Farasan	01.04.2011	1	N 16°42.102' E 042°10.462'	Mangroves
Farasan	01.04.2011	2	N 16°54.628' E 041°50.593'	Coast Guard station
Farasan	01.04.2011	3	N 16°40.623' E 041°50.592'	Beach & shallow water: Hand-collecting

Locality	Date	Station	GPS Data	Note
Farasan	02.04.2011	1	N 16°40.623' E 041°50.592'	Beach & shallow water: Hand-collecting
Farasan	02.04.2011	2	no data available	Rocky shores
Farasan	02.04.2011	3	N 16°54.933' E 041°50.761'	Diving; Snorkeling; Beach: Hand-collecting
Farasan	02.04.2011	4	N 16°44.466' E 042°0.789'	Beach: Hand-collecting
Farasan	02.04.2011	5	N 16°40.623' E 042°06.733'	Traps
Farasan	03.04.2011	1	no data available	Rocky shores
Farasan	03.04.2011	2	N 16°44.466' E 042°0.789'	Beach: Hand-collecting
Farasan	03.04.2011	3	N 16°36.811' E 042°01.081'	Divers
Farasan	03.04.2011	4	N 16°42.585' E 042°11.126'	Harbor: Seaturtle-observation
Jeddah	04.04.2011	-	N 21°42.459' E 039°05.821'	Sorting material
Jeddah	05.04.2011	-	N 21°42.459' E 039°05.821'	Sorting material
Rabigh	06.04.2011	1	N 22°47.123' E 038°57.507'	Beach: Hand-collecting
Rabigh	06.04.2011	2	N 22°45.251' E 039°00.361'	Mangoves, Beach, Shrimp pump
Rabigh	06.04.2011	3	N 22°47.123' E 038°57.507'	Diving 1
Rabigh	06.04.2011	4	N 22°47.123' E 038°57.507'	Diving 2
Rabigh	07.04.2011	1	N 22°58.054' E 038°50.030'	Coast Guard station, Hand-collecting
Rabigh	07.04.2011	2	N 22°58.007' E 038°51.106'	Diving 1
Rabigh	07.04.2011	3	N 22°55.925' E 038°50.674'	Dredge, 5m
Rabigh	07.04.2011	4	N 22°55.925' E 038°50.674'	Diving 2
Rabigh	08.04.2011	1	N 23°04.681' E 038°48.691'	Mangroves, Juppy pump, Masturah
Rabigh	08.04.2011	2	N 23°06.853' E 038°48.481'	Coast Guard station: Hand-collecting
Rabigh	08.04.2011	3	N 23°02.839' E 038°46.621'	Diving 1: Observation Seaturtle *Caretta*
Rabigh	08.04.2011	4	N 23°04.799' E 038°46.544'	Diving 2
Al Wajh	09.04.2011	1	N 26°15.636' E 036°27.830'	Beach: Hand-collecting in front of Hotel
Al Wajh	10.04.2011	1	N 26°13.604' E 036°27.596'	Harbor, Dredge, 3-5m
Al Wajh	10.04.2011	2	N 26°10.552' E 036°22.448'	Diving 1; Snorkeling, Island "Rykhah"
Al Wajh	10.04.2011	3	N 26°10.399' E 036°25.707'	Diving 2
Al Wajh	11.04.2011	1	N 26°13.604' E 036°27.596'	Harbor, Dredge, 5-9m
Al Wajh	11.04.2011	2	N 26°15.017' E 036°26.622'	Coast Guard station: Rocky shores
Al Wajh	11.04.2011	3	N 26°15.769' E 036°26.034'	shallow water, 30-50cm, Hand-collecting
Al Wajh	11.04.2011	4	N 26°13.775' E 036°27.263'	Diving 1
Al Wajh	11.04.2011	5	N 26°13.775' E 036°27.263'	Diving 2
Al Maqunah	12.04.2011	1	N 28°24.556' E 034°44.571'	shallow water: Hand-collecting
Al Maqunah	12.04.2011	2	N 28°27.239' E 034°45.799'	shallow water: Snorkeling & Hand-dredge
Al Maqunah	13.04.2011	1	N 28°24.556' E 034°44.571'	Shallow water: Hand-collecting
Al Maqunah	13.04.2011	2	N 28°27.239' E 034°45.799'	shallow water: Hand-collecting
Al Maqunah	13.04.2011	3	N 28°26.134' E 034°45.478'	Diving 1 & shallow water: Hand-collecting
Al Maqunah	13.04.2011	4	N 28°25.456' E 034°45.298'	Diving 2
Jeddah	17.04.2011	1	N 21°53.092' E 038°58.220'	shallow water: Hand-collecting
Jeddah	17.04.2011	2	N 21°38.676' E 039°06.059'	Diving 1
Jeddah	17.04.2011	3	N 21°38.676' E 039°06.059'	Diving 2
Jeddah	26.04.2011	1	N 21°42.538' E 039°05.786'	Night Snorkeling; Hand-collecting
Jeddah	26.04.2011	2	N 21°53.092' E 038°58.220'	shallow water: Hand-collecting

7.3 Second Survey (RSS1-2012)

7.3.1 RSS1-2012: Annotated list of collecting sites

Locality	Date	Station	GPS Data	Notes
Farasan Islands	19.02.2012	1	N16°54.935' E41°50.756'	Koteb, near coast guard station, diving, 3-4m, collecting animals from pocylophora colonies, 2 sponges
Farasan Islands	23.02.2012	1(2)	N16° 54.935' E41°50.756'	Diving

Locality	Date	Station	GPS Data	Notes
Farasan Islands	19.02.2012	2	N16°44.788' E42°0.389'	pier in the lagoon, near the bridge, intertidal bryozoans
Farasan Islands	19.02.2012	3	N16°44.893' E42°0.002'	Bridge
Farasan Islands	19.02.2012	4	N16°45.019' E41°54.175'	Beach
Farasan Islands	19.02.2012	5	N16°37.946' E42°17.548'	Diving 1
Farasan Islands	19.02.2012	6	N16°35.939' E42°20.076'	Diving 2
Farasan Islands	20.02.2012	7	N16°47.345' E42°06.248'	Mangrove 1
Farasan Islands	20.02.2012	8	N16°48.321' E42°03.000'	Mangrove 2
Farasan Islands	20.02.2012	9	N16°42.518' E42°10.962'	Jizan Port, Coast Guard
Farasan Islands	20.02.2012	10	N16°43.083' E42°03.934'	Beach Snorkeling
Farasan Islands	23.02.2012	10(2)	N16°43.130' E42°03.902'	Beach Snorkeling, dead corals, diving
Farasan Islands	20.02.2012	11	N16°43.083' E42°03.934'	Beach Diving
Farasan Islands	20.02.2012	12	N16°39.915' E42°15.034'	boat dive, shallow reef, moderate sand slope, patchy good coral cover
Farasan Islands	21.02.2012	14	N16°54.912' E41°50.578'	Khotib Habour
Farasan Islands	21.02.2012	14(2)	N16°54.912' E41°50.578'	Khotib, right pier, constructed of coral rocks, intertidal bryozoa from undersides of rocks
Farasan Islands	21.02.2012	15	N16°50.664' E42°2.002'	Boatdive 1
Farasan Islands	21.02.2012	16	N16°50.664' E42°1.44'	Boatdive 2
Farasan Islands	21.02.2012	17	N16°51.050' E41°36.431'	Saso Island, Mangrove 1
Farasan Islands	21.02.2012	18	N16°52.211' E41°35.545'	Saso Island, bench with coral heads, 0,5-2m
Farasan Islands	21.02.2012	19	N16°48.904' E41°33.078'	Beach, Big Saso Island
Farasan Islands	21.02.2012	20	N16°52.176' E41°35.635'	Saso Island, Mangrove 2
Farasan Islands	22.02.2012	21	N16°47.655' E42°11.506'	Diving 1
Farasan Islands	22.02.2012	22	N16°47.451' E42°11.838'	Diving 2
Farasan Islands	22.02.2012	23	N16°41.749' E42°03.566'	Beach (Matufa) Rasgrun
Farasan Islands	22.02.2012	24	N16°44.959' E42°0.0235'	small pier, east from the bridge, intertidal Bryozoa from undersides of rocks
Farasan Islands	23.02.2012	25	N16°49.220' E41°51.836'	Snorkeling
Farasan Islands	24.02.2012	27	N16°45.315' E42°03.694'	Mangoves (Majidae)
Farasan Islands	24.02.2012	28	N16°43.715' E42°10.768'	Diving close to habour
Farasan Islands	24.02.2012	29	N16°50.988' E41°55.795'	small pier, intertidal Bryozoa under rocks/ and beach drift from beach
Farasan Islands	24.02.2012	30	N16°41.176' E42°6.0336'	drift grit and rocky shore
Farasan Islands	25.02.2012	31	N16°51.957' E41°48.589'	Diving from land, dead reef, overgrown by algae
Farasan Islands	25.02.2012	32	N16°51.864' E41°48.645'	Beach and Snorkeling
Farasan Islands	25.02.2012	33	N16°42.495' E42°10.914'	Intertidal Bryozoa
Farasan Islands	26.02.2012	34	N16°31.478' E42°01.927'	Dive on fringing reef of Dumsuk Island, Fishes and Crustacea
Farasan Islands	26.02.2012	35	N16°33.091' E42°03.439'	Dive in the long bay of Dumsuk Island, Fishes and Crustacea
Farasan Islands	26.02.2012	36	N16°44.092' E41°44.679'	Zufaf Island, Shallow water, mud crabs
Farasan Islands	27.02.2012	37	N16°37.123' E41°56.038'	Abqar Island, Diving
Farasan Islands	27.02.2012	38	N16°59.160' E41°47.456'	Aboshok Island

Locality	Date	Station	GPS Data	Notes
Farasan Islands	27.02.2012	39	N16°41.217' E42°05.927'	New pier, desalination plant, intertidal Bryozoa
Farasan Islands	28.02.2012	40	N16°32.749' E42°03.496'	Boatdredging in the bay of Dumsuk Island, Coast Guard, 4-6m, large dredge
Farasan Islands	28.02.2012	41	N16°33.089' E42°04.032'	Dredging along deep sandy slope at the entrance to the long bay of Dumsuk Island
Farasan Islands	28.02.2012	42	N16°51.863' E41°48.643' N16°52.061' E41°48.239'	Beach with "waste crab", Saia Beach, both localities are 100m from each other
Al Qunfudah	01.03.2012	43	N19°11.766' E041°02.428'	Coast Guard station, Qunfudah, Handdredging, 0,5-1m, Seagrass
Al Qunfudah	01.03.2012	44	N19°12.117' E41°02.475'	Mangroves, about 500m in the north of Coast Guard, *Uca*, *Dotilla*, Handdredging
Al Qunfudah	02.03.2012	44(2)	N19°12.117' E41° 2.475'	Mangroves , *Dotilla*, *Uca*
Al Qunfudah	01.03.2012	45	N19°07.163' E41°04.619'	Night snorkeling in front of lab
Al Qunfudah	02.03.2012	45(2)	N19°07.163' E41°04.619'	Snorkeling in front of lab, *Sepia*, shipwreck
Al Qunfudah	02.03.2012	45(3)	N19°07.163' E41°04.619'	Night snorkeling in front of lab
Al Qunfudah	03.03.2012	45(4)	N19°07.163' E41°04.619'	Snorkeling in front of lab
Al Qunfudah	01.03.2012	46	N19° 2.6832' E41° 2.22'	Boat dive, freenging reef, 20m
Al Qunfudah	02.03.2012	47	N19°11.766' E41°02.428	Coast Guard Station, Diving
Al Qunfudah	03.03.2012	48	N19°06.602' E40°55.218'	Boat Diving, Qunfudah
Al Lith	04.03.2012	49	N20°15.922' E39°59.496'	Al Lith, Beach, Shallow water, 0.5m, Handdredging
Al Lith	05.03.2012	50	N20°15.818' E39°59.119'	Pier diving
Al Lith	06.03.2012	50(2)	N20°15.818' E39°59.119'	Night snorkeling Vassily
Al Lith	07.03.2012	50(3)	N20°15.818' E39°59.119'	Diving from pier, Christian
Al Lith	07.03.2012	50(4)	N20°15.818' E39°59.119'	Al Lith, Night snorkeling Vassily
Al Lith	08.03.2012	50(5)	N20°15.818' E39°59.119'	Night snorkeling, Sergey
Al Lith	05.03.2012	51	N20°14.725' E40°00.057'	Boat Diving
Al Lith	05.03.2012	52	N20°15.188' E39° 59.404'	Andrei pier
Al Lith	05.03.2012	53	N20° 15.231' E39° 59.352'	Andrei reef flat
Al Lith	05.03.2012	54	N20°15.784' E39°59.541'	Pier, snorkeling, Handdredging
Al Lith	05.03.2012	55	N20°15.803' E39°59.094'	Boat Dredging in front of Prawn Company
Al Lith	06.03.2012	56	N20°15.170' E40°0.371'	Mangroves on the lagoon of the Island
Al Lith	06.03.2012	57	N20°14.192' E40°03.741'	Mangrove on the seaside of the Island
Al Lith	06.03.2012	58	N20°12.012' E40°07.104'	Pier Reeftop on Island
Al Lith	06.03.2012	59	N20°10.036' E40°11.713'	beach drift north end of the Island
Al Lith	06.03.2012	60	N20°11.947' E40°02.681'	Boat dive 1, reef slope 10-12m, reef wall 12-25m
Al Lith	06.03.2012	61	N20°13.371' E40°02.295'	Boat dive 2, passage with current 15m, reef slopes
Al Lith	06.03.2012	62	N20°10.025' E40°11.781'	mangroves long Island, *Ocypode*, great *Macrophthalmus*
Al Lith	06.03.2012	63	N20°13.042' E40°05.992'	Mangroves, long Island
Al Lith	07.03.2012	64	N20°15.143' E39°59.357'	Dive from the pier, 9m, mixed corals at sand flat
Al Lith	07.03.2012	65	N20°03.067' E40°25.349'	Mangroves in south of Al Lith
Al Lith	07.03.2012	66	N20°11.975' E40°02.653'	Boat diving, Oliver, Peter, Philipp, 8m
Al Lith	07.03.2012	67	N20° 14.567' E40° 0.367'	Pier "Long Island", Andrei

Locality	Date	Station	GPS Data	Notes
Al Lith	07.03.2012	68	N20°14.965' E39°59.621'	Boat diving, Tilman, Sergey
Al Lith	07.03.2012	69	N20°15.922' E39°59.496'	Beach Al Lith, evening, *Ocypode cordimana*
Al Lith	08.03.2012	70	N20°15.211' E39°59.380'	Dobble pier Al Lith, Entrance to farm
Al Lith	08.03.2012	71	N20°09.283' E40°14.985'	Prawn Company, Outlet bay with sand and stones
Al Lith	08.03.2012	72	N20°15.554' E39°55.994'	Dive, 4-8m, slope with coral rocks and coral sand pockets
Al Lith	08.03.2012	73	N20°15.823' E39°59.006'	Boat dredging, triangular dredge, 3-7m

7.3.2 RSS1-2012: List of trawling stations

Station	Date	Time	Lat begin	Long begin	Lat end	Long end	Depth in m
1	29.02.2012	17.00-17.35	16 55.078	42 25.945	16 56.116	42 25.027	21-22
2	29.02.2012	18.40-19.30	16 53.601	42 22.013	16 51.630	42.21.993	58-63
3	29.02.2012	21.15-21.50	16 49.004	42 23.619	16 47.684	42 23.199	47-51
4	29.02.2012	23.16-24.00	16 44.320	42 26.941	16 43.986	42 28.095	42
5	01.03.2012	01.15-02.00	16 44.508	42 29.497	16 45.632	42 30.713	18.5 -21.5
6	01.03.2012	03.03-4.10	16 41.215	42 26.750	16 42.167	42 24.825	55.5
7	01.03.2012	16.24-17.05	16 54.869	42 26.044	16 56.448	42 25.038	21
8	01.03.2012	18.30-19.10	16 53.621	42 23.633	16 51.654	42 24.311	25,5-28
9	01.03.2012	22.00-22.40	No data	No data	16 53.822	42 23.30	32
10	01.03.2012	23.10-23.55	16 53.830	42 22.428	16 51.658	42 22.893	52-53
11	01.03.2012	00.52-01:25	16 50.336	42 25.568	16 49.330	42 26.469	20-25

7.4 Third survey (RSS1-2013)

7.4.1 RSS1-2013: Annotated list of collecting sites

Locality	Date	Stations	GPS	Notes
Al Wajh	11.06.2013	1	N26°03'29.80" E36°35'41.00"	Reef flat, algae, sandy bottom with fossil rocks
Al Wajh	11.06.2013	2	N25°36'52.98" E36°51'13.08"	Sandy slope with coral patches 0-33%
Al Wajh	11.06.2013	3	N25°37'20.88" E36°50'27.24"	Sandy slope with coral patches
Al Wajh	11.06.2013	4	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom, 0-0.5m
Al Wajh	12.06.2013	4(2)	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom, 0-0.5m
Al Wajh	13.06.2013	4(3)	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom,

Locality	Date	Stations	GPS	Notes
				0-0.5m
Al Wajh	14.06.2013	4(4)	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom, 0-0.5m
Al Wajh	17.06.2013	4(5)	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom, 0
Al Wajh	17.06.2013	4(6)	N26°14'47.80" E36°26'47.80"	Rocky shore, shallow water, sandy bottom, 0
Al Wajh	11.06.2013	5	N25°40'25.20" E36°52'34.38"	Beach in inner coast Al Wajh banks
Al Wajh	12.06.2013	6	N25°36'08.40" E36°57'57.90"	Mangroves, shallow water, 0-0.5m, sandy bottom
Al Wajh	12.06.2013	7	N25°35'52.86" E36°41' 01.80"	Seaward slope of Island, Sediment with coral patches
Al Wajh	12.06.2013	8	N25°37'30.40" E36°51'14.10"	Fringing reef, 3-8m
Al Wajh	12.06.2013	9	N25°37'01.80" E36°53'17.20"	Fringing reef, 3-8m
Al Wajh	14.06.2013	9(2)	N25°37'01.80" E36°53'17.20"	Fringing reef, 3-8m
Al Wajh	16.06.2013	9(3)	N25°37'01.80" E36°53'17.20"	Fringing reef, 3-8m
Al Wajh	13.06.2013	10	N26°18'12.80" E36°24'13.50"	Rocky shores, under stones, shallow water, 0-0.5m
Al Wajh	14.06.2013	11	N25°12'39.50" E37°12'22.20"	Vulcanic seashore, shallow water, near Umluj
Al Wajh	14.06.2013	12	N26°03'30.36" E36°38'34.98"	Reef crest, slpoe to 6m, then sand and coral patches
Al Wajh	16.06.2013	12(2)	N26°03'32.30" E36°38'37.20"	Reef flat, 3-5m, rocky and sandy bottom
Al Wajh	14.06.2013	13	N26°15'13.60" E36°26'27.30"	Reef flat
Al Wajh	15.06.2013	14	N26°17'55.10" E36°24'19.50"	Reef flat, shallow water, rocky bottom, 0.5m
Al Wajh	15.06.2013	15	N26°01'13.80" E36°42'30.18"	Mangroves
Al Wajh	17.06.2013	17	N26°17'18.00" E36°24'35.80"	Fringing/slope reef, 40m+// shallow water and rocky shore
Al Wajh	17.06.2013	18	N26°13'33.37" E36°27'33.56"	Pier of coast guard station Al Wajh
Al Wajh	17.06.2013	19	N26°10'59.05" E36°22'46.84"	Rykhah Island, opposite to Al Wajh
Al Wajh	16.06.2013	20	N25°37'01.80" E36°53'17.20"	Lagoon close to station 9
Duba	18.06.2013	21	N27°20'39.70" E35°41'41.50"	Rocky shore, shaloow water, 0.5m, in front of Hotel in Duba
Duba	21.06.2013	21(2)	N27°20'39.70" E35°41'41.50"	Rocky shore, shaloow water, 0.5m, in front of Hotel in Duba
Duba	22.06.2013	21(4)	N27°20'39.70" E35°41'41.50"	Reef edge in front of Hotel in Duba, night snorkeling
Duba	19.06.2013	22	N27°37'7.20" E35°31'10.80"	About 35 km north of Duba, Inlet, Diving
Duba	19.06.2013	23	N27°36'50.30" E35°31'14.60"	About 35 km north of Duba, Inlet, seasite, snorkelling
Duba	19.06.2013	24	N27°04'52.74" E35°46'25.92"	Sandy slope with corals
Duba	19.06.2013	25	N27°04'43.08" E35°46'40.80"	Reef edge slope, 10m, sandy slope with coral patches
Duba	19.06.2013	26	N27°37'07.20" E35°31'10.80"	Handdredging in Lagoon
Duba	20.06.2013	27	N27°16'30.30" E35°38' 24.30"	Reef edge slope to sandy bottom with reef patches
Duba	20.06.2013	28	N27°18'02.52" E35°38'0.06"	Reef edge slope to sandy terrase, 20m, then sand slope
Duba	20.06.2013	29	N26°57'47.00" E35°57'59.20"	Inlet + sea site, 0.5-10m
Duba	21.06.2013	30	N27°20'34.80" E35°41'41.70"	Reef slope in front of Hotel in Duba into sandy fore reef
Duba	21.06.2013	31	N27°20'44.22" E35°41'42.12"	Reef slope of inlet to Duba fish port + slope sandy fore reef
Alkhuraybah	22.06.2013	32	N28°01'25.62" E35°11'31.56"	Sandy lagoon, 0.5m, snorkeling
Alkhuraybah	23.06.2013	33	N27°47'07.08" E35°07'48.00"	Diving on reef NW coast of Yabua Island
Alkhuraybah	23.06.2013	34	N28°01'22.70" E35°11'23.10"	Shallow water, sandy bottom, 0.5m
Alkhuraybah	23.06.2013	35	N28°00'50.40" E35°09'47.10"	Shallow water, sandy bottom, 0.5m
Alkhuraybah	23.06.2013	36	N27°58'02.32" E35°13'39.01"	Shallow water, sandy bottom, 0.5m
Alkhuraybah	23.06.2013	37	N28°06'27.60" E34°59'27.20"	Shallow water, sandy bottom, with coral rocks

Locality	Date	Stations	GPS	Notes
Alkhuraybah	23.06.2013	38	N27°53'58.98" E35°04'05.04"	Seaward slope with corals, 12-30m
Alkhuraybah	23.06.2013	39	N27°47'24.66" E35°07'53.40"	Backward slope, strong sediment impact
Alkhuraybah	24.06.2013	40	N28°01'35.87" E 35°11'32.64"	Dredging, large dredge, 19m, 5 minutes, sand with mud
Alkhuraybah	24.06.2013	41	N28°02'59.82" E35°10'22.14"	Dredging, large dredge, 19m, 5 minutes, sand with mud
Alkhuraybah	24.06.2013	42	N28°02'36.12" E35°09'27.90"	Dredging, large dredge, 19-20m, 10 minutes, sand with mud
Alkhuraybah	24.06.2013	43	N28°03'12.48" E35°10'03.12"	Dredging, small dredge, 18-19m, 5 minutes, sand with mud
Alkhuraybah	24.06.2013	44	N27°46'41.50" E35°25'06.20"	Sandy + rocky bottom, coral patches, coral reef, 0.5-1m
Alkhuraybah	24.06.2013	45	N28°04'11.70" E35°04'48.72"	In lagoon, large reef flat, sandy slope to great depth
Jeddah	26.06.2013	46	N21°42'32.28" E39°05'47.16"	Shallow water, 0.5-1m, in front of Marine Station in Obhur

7.4.2 RSS1-2013: List of trawling stations

Station	Date	Time	Start	End	Depth in m
1	28-06-2013	23:20-00:20	16 57 294 N 042 29 045 E	16 57 725 N 042 26 013 E	13-15
2	29-06-2013	01:25-02:57	16 57 873 N 042 25 523 E	17 00 528 N 042 21 699 E	16-19
3	29-06-2013	05:58-08:30	16 59 534 N 042 20 949 E	16 56 288 N 042 26 453 E	27-19

Gallery

Plate I

Sponges from the Red Sea

1. *sp. indet*.
2. *Stylissa carteri* (Dendy, 1889)
3. colonial ascidian, *sp. indet*, under revision
4. *Clathrina sp.*
5. *Clathrina sp.*
6. *Clathrina sp.*
7. *sp*. indet.
8. *Hyrtios erectus* (Keller, 1889)
9. *sp. indet*.
10. *sp. indet*.
11. *sp. indet*.
12. colonial ascidian (*sp. indet*.)
13. *sp. indet*, under revision


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Plate II

Corals from the Red Sea

1. *Acropora robusta* (Dana, 1846)
2. *Seriatopora caliendrum* Ehrenberg, 1834
3. *Seriatopora dendritica* Veron, 2002
4. *Acropora sp.*
5. *Stylophora kuehlmanni* Scheer and Pillai, 1983
6. *Acropora pharaonis* (Milne Edwards & Haime, 1860)
7. *Acropora gemmifera* (Brook, 1892)
8. *Acropora sp.*
9. *Acropora maryae* Veron, 2002
10. *Acropora selago* (Studer, 1878)
11. *Acropora sp.*
12. *Seriatopora caliendrum* Ehrenberg, 1834


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Plate III

Corals from the Red Sea

1. *Goniopora sp*.
2. *Favia helianthoides*
3. *Porites solida* (Forskal, 1775)
4. *Turbellaria sp*.
5. *Favia matthei* Vaughan, 1918
6. *Diaseris sp.*
7. *Favia sp.*
8. *Cyphastrea chalcidicum* (Forskal, 1775)
9. *Symphyllia sp.*
10. *Platygyra sinensis* (Milne Edwards & Haime, 1849)
11. *Cyclolithes sp.*
12. *Fungia sp.*
13. *Mycedium elephantotus* (Pallas, 1766)
14. *Echinopora forskaliana* (Milne Edwards & Haime, 1850)
15. *Ctenactis crassa* (Dana, 1846)
16. *Platygyra sp.*
17. *Favites complanata* (Ehrenberg, 1834)
18. *Porites sp.*
19. *Lobophyllia hemprichii* (Ehrenberg, 1834)
20. *Montipora sp.*
21. *Hydnophora exesa* (Pallas, 1766)
22. *Siderastrea savignyana* Milne Edwards & Haime

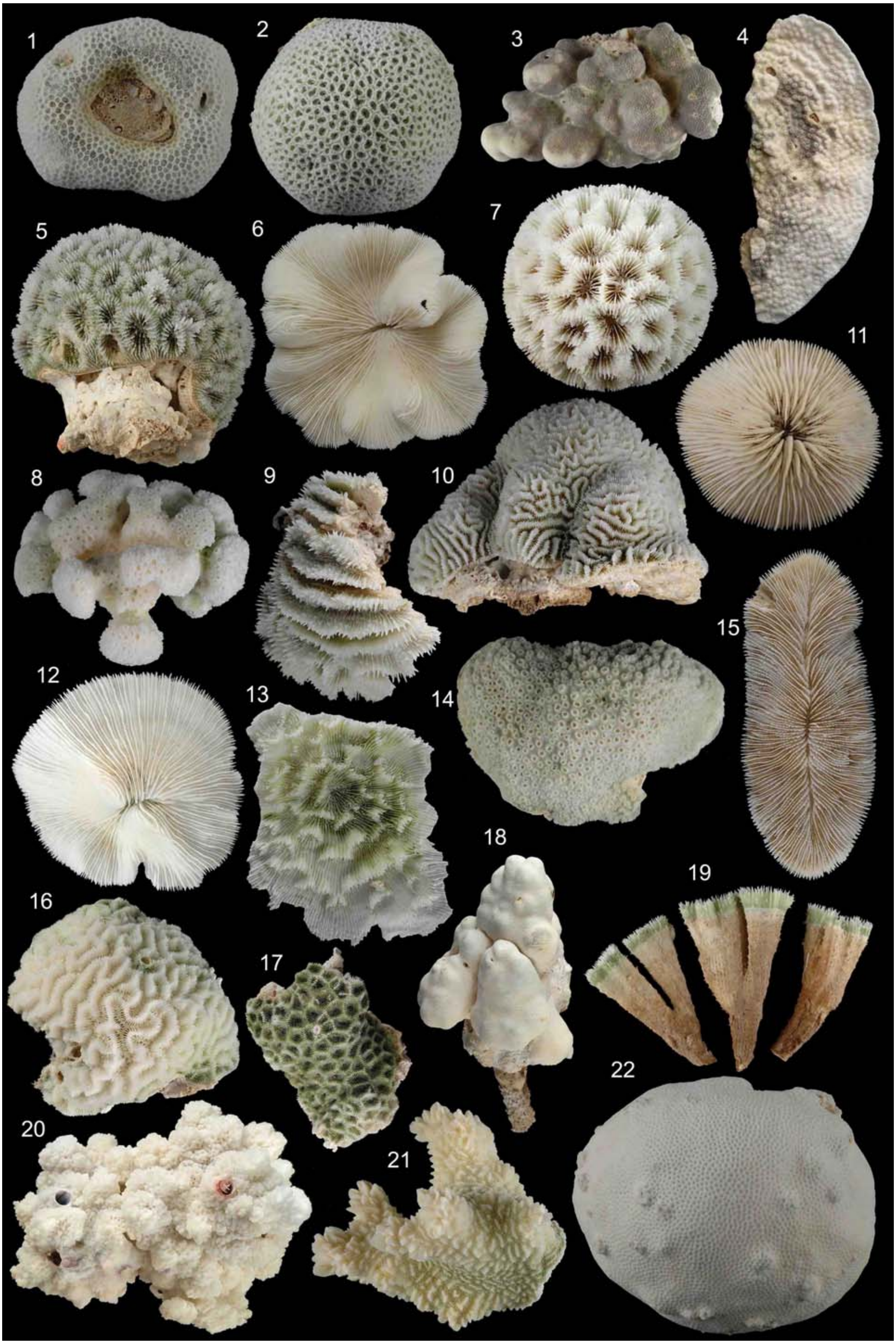
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Plate IV

Polychaetes from the Red Sea

1. Nereidae
2. Trichobranchidae
3. Sabellidae
4. Polynoidae
5. Nereidae
6. Terebellidae
7. Chaetopteridae
8. Pectinariidae
9. indet. (under revision)
10. Sabellidae
11. under revision
12. Terebellidae
13. Polynoidae
14. Oligochaeta


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Plate V

Crustaceans from the Red Sea

1. *Tetralia glaberrima* (Herbst, 1790)
2. *Trapezia cymodoce* (Herbst, 1801)
3. *Trapezia tigrina* Eydoux & Souleyet, 1842
4. *Scylla serrata* (Forskål, 1775)
5. *Thalamita crenata* Rüppell, 1830
6. *Matuta victor* (Fabricius, 1781)
7. *Schizophrys aspera* (H. Milne Edwards, 1834)
8. *Trapezia* sp.
9. *Elamena mathoei* (Desmarest, 1823)
10. *Huenia heraldica* (De Haan, 1837)
11. *Micippa philyra* (Herbst, 1803)
12. *Leucosia sp.*
13. Leucosiidae
14. Leucosiidae


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Plate VI

Crustaceans from the Red Sea

1. *Metopograpsus messor* (Forskål, 1775)
2. *Metopograpsus messor* (Forskål, 1775)
3. *Pseudograpsus elongates* (A. Milne-Edwards, 1873)
4. *Uca* (*Cranuca*) *inversa* (Hoffmann, 1874)
5. *Uca* (*Cranuca*) *inversa* (Hoffmann, 1874)
6. *Scopimera globosa* (De Haan, 1835)
7. *Macrophthalmus sp*.
8. Ocypodidae
9. *Eneosesarma azizi*, Brösing et al 2014
10. *Metopograpsus messor* (Forskål, 1775)
11. *Metopograpsus messor* (Forskål, 1775)
12. *Perisesarma guttatum* (A. Milne-Edwards, 1869)
13. *Perisesarma guttatum* (A. Milne-Edwards, 1869)
14. *Plagusia squamosa* (Herbst, 1790)
15. *Sarmatium crassum* Dana, 1851
16. *Grapsus albolineatus* Latreille, in Milbert, 1812
17. *Grapsus albolineatus* Latreille, in Milbert, 1812


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Plate VII

Molluscs from the Red Sea

1. Nudibranchia sp.
2. Nudibranchia sp.
3. Nudibranchia sp.
4. *Chromodoris obsolete* (Rüppell & Leuckart, 1831)
5. *Chromodoris africana* Eliot, 1904
6. Nudibranchia sp.
7. *Phyllidiella nigra* (van Hasselt, 1824)
8. Nudibranchia sp.
9. Nudibranchia sp.
10. *Hypselodoris infucata* (Rüppell & Leuckart, 1831)
11. Gastropoda

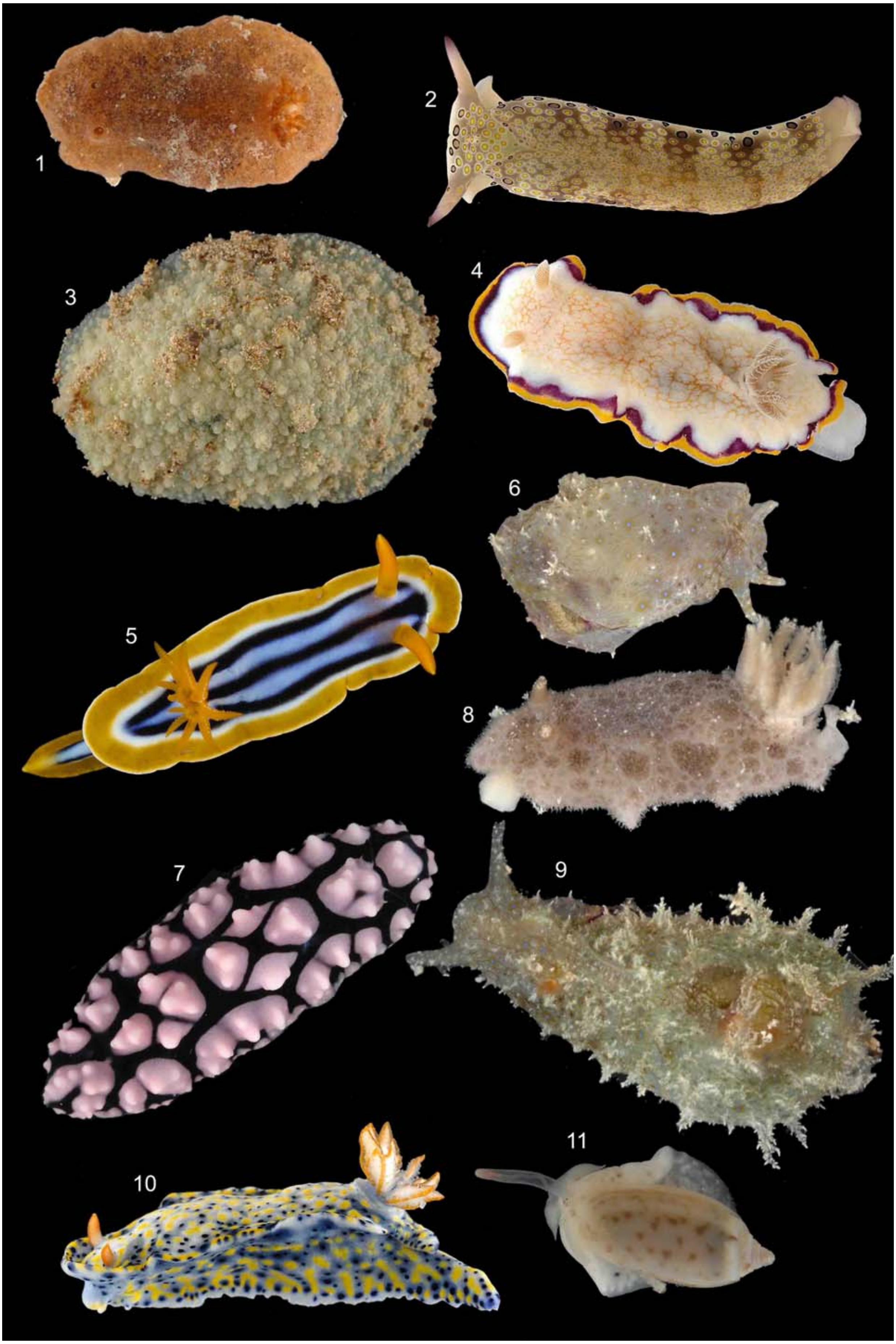
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Plate VIII

Fish from the Red Sea

1. *Pterois radiata* Cuvier, 1829
2. *Wetmorella nigropinnata* (Seale, 1901)
3. *Sufflamen albicaudatum* (Rüppell, 1829)
4. *Gobiodon quinquestrigatus* (Valenciennes, 1837)
5. *Scorpaenodes guamensis* (Quoy & Gaimard, 1824)
6. *Chaetodontoplus mesoleucus* (Bloch, 1787)
7. *Paragobiodon xanthosoma* (Bleeker, 1853)
8. *Aeoliscus punctulatus* (Bianconi, 1854)
9. *Sebastapistes strongia* (Cuvier, 1829)
10. *Ostracion cubicus* Linnaeus, 1758
11. *Pomacanthus asfur* (Forsskål, 1775)
12. *Arothron hispidus* (Linnaeus, 1758)
13. *Thalassoma lunare* (Linnaeus, 1758)
14. *Sargocentron rubrum* (Forsskål, 1775)


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