PERSGA

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden

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The Status of Coral Reefs in the Red Sea and Gulf of Aden: 2009

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The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)

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PERSGA – *"The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden"* is an intergovernmental organization dedicated to the conservation of the coastal and marine environments in the region.

The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) 1982 provides the legal foundation for PERSGA. The Secretariat of the Organization was formally established in Jeddah following the Cairo Declaration of September 1995. The PERSGA member states are Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan, and Yemen.

PERSGA, P.O. Box 53662, Jeddah 21583, Kingdom of Saudi Arabia
Tel.: +966-2-657-3224. Fax: +966-2-652-1901. E-mail: information@persga.org

Website: http://www.persga.org

This report was prepared by: Dr. Mohammed M.A. Kotb, PERSGA Regional Coordinator of Biodiversity and Marine Protected Areas Programme.

Note: *The comments expressed in this document represent the opinion of the author acting in his own capacity and do not necessarily represent the views of PERSGA or the national agencies.*

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FOREWORD

PERSGA took the initiative during the execution of the Strategic Action Programme for the Red Sea and Gulf of Aden (SAP) to underline the importance of conserving regional habitats and biodiversity. The Habitats and Biodiversity Conservation component of the SAP developed a strategy that contained five clear steps: (i) develop a set of standard survey methods (SSMs) for the region, (ii) train national specialists to use these methods, (iii) execute regional surveys, (iv) prepare conservation plans, and (v) implement the plans. In order to evaluate and monitor the status of marine habitats and biodiversity within the Red Sea and Gulf of Aden, surveys must be undertaken that are comparable in extent, nature, detail and output. Standardising survey methodology within the region is essential to allow valid comparison of data, and for the formulation of conservation efforts that are regionally applicable.

A guide—Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden—was prepared following a review of the methods currently in use around the world. PERSGA conducted a series of training courses for regional specialists to teach them some of these specific methods. The training courses were also used as tools to evaluate the methods and to determine their applicability to our region.

PERSGA has conducted two regional coral reef surveys. The first followed the preparation of the SSM guide in 2002 and the second survey took place in 2008. Results show that the reefs surveyed in the RSGA region are in a broadly similar condition to reefs in the Indo Pacific region in spite of local stress from anthropogenic sources and from climate change. Reefs still sustain healthy coverage of corals, fishes and other marine biodiversity and have shown resilience over time and space.

This current status report forms a milestone publication for Red Sea and Gulf of Aden coral reef environmental evaluation. It will help with an assessment of the efficiency of ongoing conservation efforts in the region and assist in the development and improvement of such efforts for the sustainability of regional marine resources.

Prof. Dr. Ziad Abou Ghararah
Secretary General
PERSGA

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ABBREVIATIONS AND ACRONYMS

ALECSO	The Arab League Educational, Cultural and Scientific Organization
ANOVA	analysis of variance
ASEZA	Aqaba Special Economic Zone Authority (Jordan)
COTS	crown-of-thorns starfish
EEAA	Egyptian Environmental Affairs Agency
EMARSGA	Emergency Mutual Aid Centre for the Red Sea and Gulf of Aden
EPA	Environment Protection Authority (Yemen)
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GIS	geographic information system
GPS	global positioning system
HBC	Habitats and Biodiversity Conservation
HCENR	Higher Council for Environment and Natural Resources (Sudan)
ICRAN	International Coral Reef Action Network
ICRI	International Coral Reef Initiative
IMO	International Maritime Organization
IUCN	International Union for the Conservation of Nature
ICZM	integrated coastal zone management
MHUEAT	Ministry of Housing, Urbanism, Environment and Land Use Planning (Djibouti)
MOU	memorandum of understanding
MPA	marine protected area
NAP	national action plan
NGO	non governmental organization
NIA	nutrient indicator algae
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PME	Presidency of Meteorology and Environment (Saudi Arabia)

RMP	regional master plan
RMS	regional monitoring sites
ROPME	Regional Organization for the Protection of the Marine Environment (Arabian Gulf)
RSGA	Red Sea and Gulf of Aden
SAP	Strategic Action Programme for the Red Sea and Gulf of Aden
SOMER	State of the Marine Environment Report
SSMs	standard survey methods
UKHO	United Kingdom Hydrographic Office
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-ROWA	UNEP-Regional Office for West Asia
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCPA	World Commission on Protected Areas (IUCN)

EXECUTIVE SUMMARY

The Red Sea and Gulf of Aden (RSGA) are globally distinguished by their great diversity of marine environments, the number of unique species, and the importance of marine resources to the social and economic development of the region. However, the RSGA region has experienced rapid coastal development in the past four decades. This has been followed, in some places, by degradation of the marine and coastal environments and loss of its potential to sustain the livelihoods of coastal populations. The nations of the region have acted to conserve these environments. PERSGA was established for organizing regional activities, initiatives, and efforts for the conservation and sustainable use of natural resources.

Great advances have been made during the last two decades in management and in the knowledge that has been gained about the marine environment of the RSGA. Data has been collected, and reviews and reports prepared to assist decision making and conservation measures.

Monitoring programmes for sensitive ecosystems were established during the Strategic Action Programme (SAP) in order to standardize data collection and survey methodology, and to compare the region's status to similar regions in the world. Standard Survey Methods (SSMs) were prepared for the region followed by training of national teams of experts in these methods for accuracy, comparability, and the assurance of future surveys and data collection exercises. PERSGA participated with member countries in two regional surveys of coral reef ecosystems, the first during 2002 and the second during 2008. The two surveys followed the designated SSMs; the latter survey also aimed to determine the minimum number and location of sites for a long-term, regional, coral reef monitoring network.

This report presents data from the 2008 survey. A total of 36 sites (5 in Djibouti, 8 in Egypt, 3 in Jordan, 9 in Saudi Arabia, 4 in Sudan, and 7 in Yemen) were chosen by PERSGA and national team experts. The sites were selected to ensure they demonstrated a range of essential characteristics. These were based on their suitability for long-term monitoring activities and included: accessibility of the sites for future surveys, safety measures, national capabilities of team members, and logistics required in relation to the national facilities available.

Full Reef Check survey protocols, one of the PERSGA-SSMs, were used during the 2008 regional monitoring survey. This survey methodology is designed to provide a rapid, broad scale assessment of the distribution and abundance of a number of fish and invertebrate species that are known to be either indicators of reef health or susceptible to the effects of fishing or collection. The method also provides a quantitative assessment of sessile benthic cover, including corals. In addition, this survey method collects data concerning different types of impact or impact symptoms, such as trash, coral damage, and coral bleaching.

In order to fix the survey location at each site for comparable long-term monitoring, a detailed mapping of the exact position of each reef site was made in advance with the aid of Google-Earth images, GPS, in-situ photographs, and Admiralty charts. The mapped positions were adjusted, or fine-tuned, directly after the field visit to each site. A test of the ease of relocating the reef sites using the revised maps was done during the survey period in consultation with national team members.

Data from the regional survey of 2002 (from 52 sites) was reviewed and standardised to be comparable with the 2008 data. This step was essential as the data sheets of the Reef Check

were modified in 2006 by changing some indicator species and methods of data analysis and interpretation. Comparisons between data of 2002 and of 2008 were carried out to detect spatial and temporal changes. A one-way ANOVA test was performed for the abundance/coverage of each indicator using compiled data for the different countries to detect any regionally significant differences ($p = 0.05$). Data gathered during the two regional surveys (2002 and 2008) were compiled for each country and are included in the appendices at the end of this report. Furthermore, detailed maps of the surveyed locations and bottom profiles of each site are also included. Comparisons with similar data gathered from other regions of the world were carried out. The key findings of the analysis for the whole RSGA region are as follows:

- Butterflyfish, indicators of the ornamental fish trade and overfishing, showed a mean abundance slightly increased in 2008 over 2002. These abundance levels however, were found to be lower than those recorded for the Indo-Pacific region as a whole during 1997-2001.
- Sweetlips (Haemulidae), used as an indicator for line-fishing and spear-fishing, showed similar abundances in the 2008 and 2002 surveys. These abundances were found to be higher than those recorded for the Indo-Pacific region during 1997-2001.
- Grouper (with length greater than 30 cm), indicators for overfishing by line-fishing and spear-fishing close to reef areas, showed mean abundances slightly decreased in 2008 compared to 2002. However these levels were higher than the recorded abundances for the whole Indo-Pacific region during 1997-2001, but lower than those recorded for the Red Sea in the same period.
- Snapper, an indicator for overfishing by nets close to reefs, showed a sharp decrease in mean abundance in the 2008 surveys compared to 2002. These abundance levels were still much higher than the abundances recorded for the whole Indo-Pacific region in 1997-2001.
- Parrotfish, an indicator for overfishing and controlling algal growth over coral reefs, had similar mean abundances in 2008 and 2002. Similar abundance was recorded for the whole Indo-Pacific region in the 1997-2001 surveys.
- Lobsters, an indicator for overfishing through direct collection from reefs, were not found at 94% of sites during either the 2008 or 2002 surveys, indicating severe overfishing. Absence of lobster records in 90% of the sites was recorded for the whole Indo-Pacific region during 1997-2001 surveys.
- Long-spined sea urchins, *Diadema*, an indicator of problems with reef health if in high abundance, showed a decrease in mean abundance in 2008 from 2002. Higher abundances were recorded for the whole Indo-Pacific region in 2000 than in the RSGA during 2008.
- Triton gastropods, an indicator of curio collection, were not found at about 90% of sites during either the 2008 or 2002 surveys, indicating severe collection of this shell. A similar situation was recorded for the whole Indo-Pacific region during 1997-2001.
- Giant clams, indicators for collection as food, curio, and ornamental shellfish, were recorded at about 70% of the surveyed sites during 2002 and 2008. The recorded shells were <20 cm in length, which are difficult sizes for collection. Higher abundances were recorded for the whole Indo-Pacific region in the 1997-2001 period.
- Sea cucumbers, an indicator for collection as exported food, were recorded in more sites during 2008 than in 2002, but with smaller sizes (mostly ≤10 cm), which might reflect the disappearance of the large, commercial-sized individuals that are targeted by fishermen. Most areas of the Indo-Pacific region were cleaned-out of sea cucumbers by 2001.
- Crown-of-thorns starfish (COTS), which can cause major damage to reef corals during outbreak periods, were detected at around 35% of the surveyed sites in both 2002 and 2008, and with higher abundances toward the southern end of the Red Sea. Lower abundances were recorded for the whole Indo-Pacific region during 1997-2001 surveys.

- Similar mean percentage cover of hard corals was recorded in 2008 and 2002 for the whole RSGA region. Most of the sites had 10-50% coverage. Only 4 sites out of 36 (2008) and 7 sites out of 52 (2002) showed hard coral coverage of 50-70%. Similar percentage covers were recorded for the Indo-Pacific region during 1997-2001.
- Nutrient indicator algae (NIA), an indicator of high nutrient input to the sea, showed a sharp decrease in its coverage in 2008 from 2002. According to other global monitoring data, the RSGA region showed lower symptoms of high nutrient loads, such as from sewage pollution.

Some recommendations are suggested as priority actions to ensure better monitoring of the coral reef environment which will help in the evaluation of conservation measures taken at national and regional levels. These recommendations are:

1. Long-term coral reef environmental monitoring programmes should be developed at the national level (in countries where such programmes are not yet executed), so that monitoring resources can be allocated in a logical manner that best supports management's goals and ensures monitoring continuity.
2. For all countries, PERSGA recommends setting up a network of monitoring sites using Reef Check methodology as a first step towards "regional and globally comparable" national monitoring programmes. When this network can be successfully funded and maintained, then sites where more detailed monitoring is suitable can be added as financial and scientific personnel become available.
3. An "ideal" two-level monitoring programme would have a few high-resolution sites using more detailed survey methods such as those given in English et al. (1997), and a larger number of lower-resolution sites monitored using the Reef Check method. Such methods are included in the PERSGA-SSMs so that more detailed monitoring protocols can be added when national teams have sufficient capacities and facilities.
4. Due to the fact that the Reef Check protocol is based on community participation and volunteer work, PERSGA and the official environmental authorities in each country can use NGO support to engage volunteers in regular monitoring surveys. Reef Check teams can then be mobilized to survey many more sites than is currently possible. Accordingly, national teams can focus on more intensive methods at the high-resolution sites, which are much more costly to survey, and each country can define the number of high-resolution sites according to its capabilities and needs.
5. PERSGA should facilitate the cooperation of regional scientists with international networks of scientists that are engaged in monitoring global sea water temperatures for early warning signs of coral bleaching.
6. PERSGA maintains such integration with global initiatives but further efforts should be advanced at the national level. National monitoring programmes should be designed and implemented. In addition, networking national monitoring programmes and including all data within the PERSGA database will facilitate the preparation of regular regional status reports, allow regional and global comparisons to be made, and assist in appropriate decision making and conservation efforts.

RESUME DU RAPPORT

La mer Rouge et le golfe d'Aden forment une région exceptionnelle dans le monde par sa grande diversité de son milieu marin, par le nombre d'espèces uniques et par l'importance de ses ressources marines pour le développement social et économique de la région. Cependant, la région a connu une urbanisation rapide dans ces zones côtières au cours des quatre dernières décennies suivi par une dégradation des milieux marins et côtiers et une perte de son potentiel de subvenir comme moyens de subsistance pour les populations côtières. Les nations de la région ont agi pour préserver ces milieux en mettant en place l'Organisation Régionale pour la Conservation de l'Environnement de la mer Rouge et du golfe d'Aden – PERSGA qui représente l'une des majeures réalisations en matière de la conservation de l'environnement marin dans la région.

Dans cette région, des remarquables progrès ont été accomplis au cours de deux dernières décennies en matière de la gestion et de la prise de connaissance du milieu marin. Des revues, des rapports et des collections de base des données ont été produits pour permettre la prise de bonnes décisions et des actions adéquates pour la conservation.

Au cours du Programme d'Action Stratégique du 1999 à 2004, PERSGA a jeté les bases pour une conservation régionale durable. Des programmes de surveillance pour les écosystèmes sensibles, l'évaluation de l'état environnemental de la région à l'instar des régions similaires dans le monde ainsi qu'une normalisation de la collecte des données et la méthodologie de l'enquête sont les majeures réalisations de ce période. Une guide standard des méthodes d'enquête a été préparée par PERSGA suivi d'une formation des équipes nationales des experts sur ces méthodes qui couvre l'exactitude, la comparabilité et l'assurance des futures enquêtes et collections de données. PERSGA a aussi réalisé avec les pays membres deux enquêtes régionales sur les récifs coralliens en 2002 et en 2008 qui ont suivi les principes du guide des méthodes ci-dessus mentionné. La dernière enquête visait à déterminer et fixer un certain nombre de sites pour constituer le réseau régional des sites de suivi des récifs coralliens.

Le présent rapport présente des données d'une enquête menée en 2008. Un total de 36 sites (5 à Djibouti, 9 en Arabie Saoudite, 4 au Soudan et 7 au Yémen) ont été choisis par des experts du PERSGA en collaboration avec des experts nationaux pour valider les sites identifiées en fonction d'un certain nombre des critères telle que la durabilité des activités de surveillance, l'accessibilité du site pour des futures enquêtes, les mesures de sécurité, les capacités des membres des équipes nationales chargées de suivi ainsi que la logistique nécessaire en fonction de la disponibilité des matériels dans chaque pays.

Protocole d'enquête du Reef Check semblable au guide standard des méthodes d'enquête adopté par PERSGA, a été utilisé pendant l'enquête de suivi régionale du 2008. Cette méthode d'enquête est conçue pour fournir une évaluation rapide et à grande échelle de la distribution et l'abondance d'un certain nombre de poissons et d'invertébrés connus en tant que indicateurs de la santé des récifs ou leur sensibilité aux effets de la pêche et de la collecte. La méthode fournit aussi une évaluation quantitative de la couverture benthique sessile y compris les coraux.

En outre, cette méthode d'enquête permet de recueillir des données variables sur différents types d'incidence ou l'incidence des symptômes, tels que les ordures, les dommages et le blanchissement des coraux.

Afin d’atteindre les objectifs de fixer les sites enquêtées, une cartographie détaillée a été utilisée pour la localisation exacte de chaque sites avec l’aide de Google Earth image, GPS, des photographies in situ et des cartes amirauté et réajusté après la visite de terrain de chaque site.

Les données de l’enquête du 2002 (de 52 sites) ont été revues et standardisée pour être comparables à des données de 2008. Cette étape était indispensable lorsque les fiches de données de la Reef Check ont été modifiées en 2006 avec la modification de certaines espèces indicatrices et le mode de l’analyse des données et l’interprétation. Une comparaison entre les données du 2002 et du 2008 a été menée pour détecter les changements spatiaux et temporels. Une manière de faire ce test ANOVA a été réalisée pour l’abondance / la couverture de chaque indicateur en utilisant les données compilées pour les différents pays afin de détecter toute différence régionale significative (p = 0,05). Les données recueillies au cours des deux enquêtes régionales (2002 et 2008) ont été calculées, pour chaque pays, et inclus dans les annexes du présent rapport. En outre, des cartes détaillées dans les localités étudiées ainsi que les profils bas de chaque site sont aussi bien inclus dans les annexes. Une comparaison avec la disposition «similaire» des données recueillies dans d’autres régions du monde a été effectuée. Les principales conclusions de l’analyse pour toute la région RSGA étaient les suivantes:

- Poissons Chaetodou comme indicateur pour le commerce des poissons d'ornement et de la surpêche, qui avait abondance moyenne a légèrement augmenté en 2008 qu'en 2002. Ces abondances jugée inférieure à celles enregistrées pour l'ensemble de l'Indopacifique pendant la période 1997-2001
- Les poissons Sweetlips (Haemulidae), comme indicateur pour une ligne de pêche de ligne et chasse sous-marine, a montré abondances similaires en 2008 et 2002. Ces abondances sont avérées plus élevés que celles enregistrées pour l'ensemble de l'Indopacifique au cours de 1997-2001.
- Les poissons mérou (avec une longueur supérieure à 30 cm), comme indicateur de la surpêche à la linge et chasse sous – marin aux zones proches des coraux avait une abondance moyenne légèrement diminué en 2008 qu'elle ne l'était en 2002. Ces abondances étaient plus élevées que les abondances enregistrées pour l'ensemble de l'Indopacifique au cours de 1997-2001, mais inférieur à celles enregistrées pour la mer Rouge, dans la même période.
- poissons Vivaneau, comme indicateur de la surpêche par des filets de près des récifs, a démontré une forte diminution de l'abondance moyenne pendant l'année 2008 qu'elle ne l'était en 2002. Ces abondances sont beaucoup plus élevées que les abondances enregistrées pour l'ensemble de l'Indopacifique pendant la période 1997-2001.
- Les poissons perroquets, comme indicateur de la surpêche et à contrôler la croissance des algues sur les récifs coralliens, avaient les mêmes abondances moyennes en 2008 et 2002. Abondance similaire ont été enregistrée pour l'ensemble de l'Indopacifique pendant la période 1997-2001.
- Les homards comme indicateur de surpêche à travers la collecte directe des coraux, n'a pas été constaté dans 94% des sites au cours des deux enquêtes du 2008 et du 2002 qui ont tous les deux montré une grave surexploitation. Zéro constant des homards dans 90% des sites a été enregistrée pour l'ensemble de l'Indopacifique pendant la période 1997-2001 enquêtes
- Long épineux oursins *Diadema* noir, comme indicateur de problèmes dans des conditions de santé des récifs, a démontré diminution de l’abondance moyenne au cours de 2008 que c’est au cours de 2002. Abondance plus importante a été enregistrée pour l’ensemble de l’Indopacifique en 2000 qu’il ne l’était en RSGA en 2008.
- Triton gastéropode, comme indicateur pour la collecte des curiosités, n'ont été constatée chez environ 90% des sites étudiées durant les deux enquêtes. Situation similaire a été enregistrée pour l'ensemble de l'Indopacifique pendant la période 1997-2001 enquêtes.

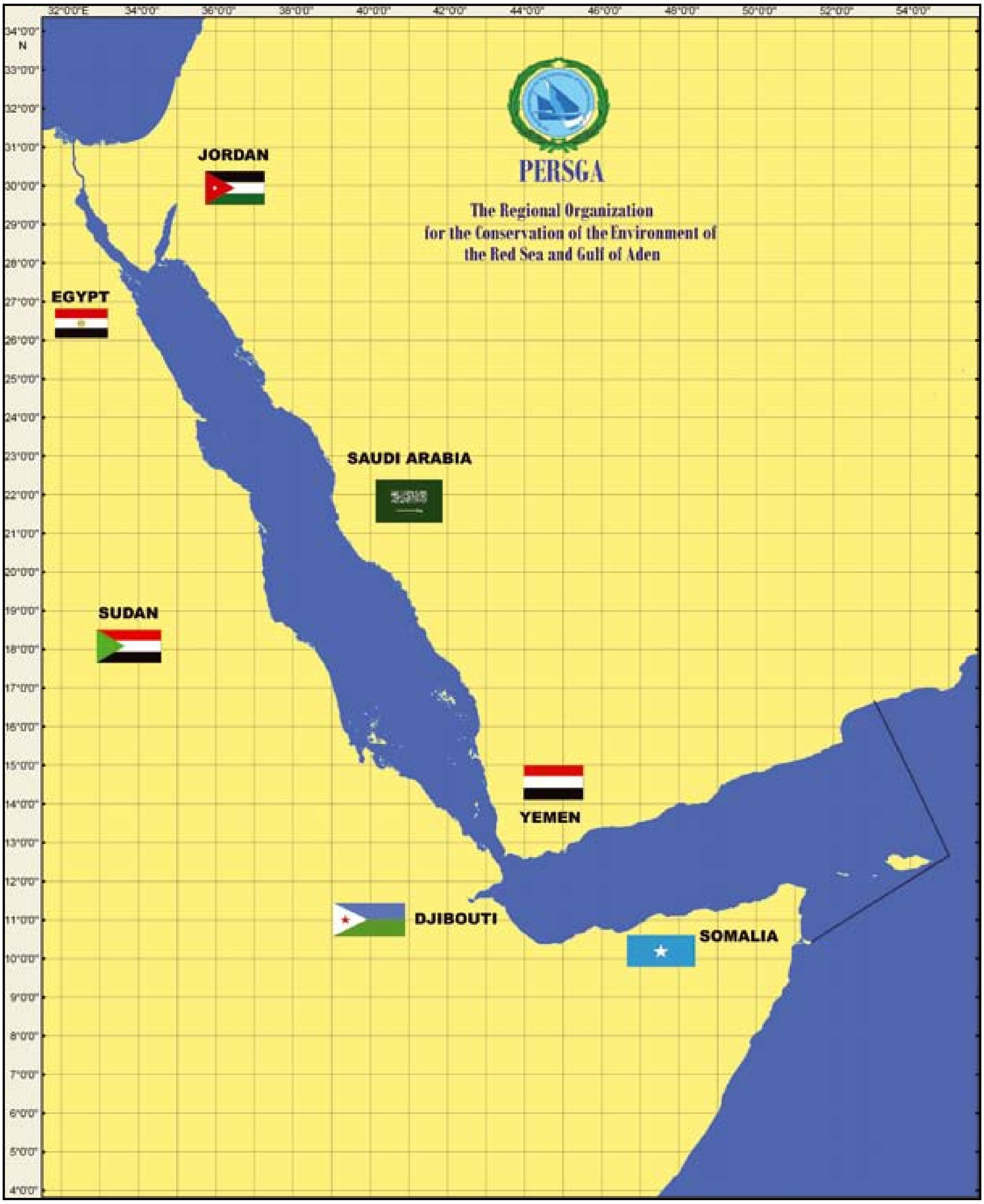
- Les bénitiers, comme indicateur pour la collecte de nourriture, de curiosité et de coquillage d'ornement, ont été enregistrés dans près de 70% des sites étudiées durant les deux enquêtes. Les obus ont été enregistrées <20 cm de longueur qui sont de tailles palourdes difficile pour la collecte. Abondances plus élevées ont été enregistrées pour l'ensemble de l'Indopacifique en période de 1997-2001.
- Concombre de mer, comme indicateur de collection comme denrées alimentaires exportées, ont été enregistrées en plus de sites en 2008 qu'elle ne l'était en 2002, avec les petites tailles (principalement ≤ 10 cm) ce qui pourrait refléter la disparition de la taille des grandes entreprises commerciales ciblées par les pêcheurs. La plupart des régions de l'Indopacifique ont été nettoyés de concombre de mer en 2001.
- Couronne d'épine étoile de mer, comme indicateur pour ses principaux effets néfastes sur les coraux pendant les périodes des flambées, ont été détectées chez environ 35% des sites étudiées durant les deux enquêtes avec des abondances élevées aux régions sud de la mer Rouge. Abondances plus faibles ont été enregistrées pour l'ensemble de l'Indopacifique pendant la période 1997-2001 enquêtes.
- pourcentage moyen similaire couvre de coraux durs ont été enregistrées en 2008 et 2002 pour toute la région RSGA. La plupart des sites avaient 10–50% de couverture avec seulement 4 sites (sur 36) et 7 sites (sur 52) respectivement, ont montré la couverture des coraux dur de 50–70%. Couvre près le même pourcentage ont été enregistrées pour l'ensemble de l'Indopacifique au cours de 1997-2001.
- Des éléments nutritifs des algues indicateurs, comme indicateur d'apport de nutriments à la mer, a montré une forte diminution de la couverture en 2008 qu'elle ne l'était en 2002.Selon les conclusions d'autres données de surveillance mondiale, la région RSGA présentaient des symptômes inférieure de recevoir des charges en éléments nutritifs tels que de la pollution des eaux usées.

Certaines recommandations ont été avancées comme des actions prioritaires dans le future pour assurer un meilleur suivi pour les coraux; ce qui aidera l'évaluation des mesures de conservation mise en place au niveau national et régional. Ces recommandations sont les suivantes:

1. Développer un programme de suivi des coraux au niveau national en particulier aux pays qui n'ont pas encore mis en place ce genre de programme. En effet, les ressources financières pourraient être utilisée efficacement et assurer ainsi un programme de suivi durable.
2. Mettre en place un réseau des sites identifiées pour la surveillance en utilisant la méthodologie Reef Check comme un étape vers un programme national de suivi comparable à ces des autres pays du monde.
3. Le programme de suivi régulier des coraux devrait composer de deux grandes parties: suivi à une haute résolution et une méthode détaillé sur un nombre limité des sites et une faible résolution pour un large nombre des sites.
4. Engager la société civile et les amateurs des coraux dans le programme de suivi régulier. Les experts nationaux vont se vocaliser sur les sites qui demande beaucoup des efforts et des ressources financières.
5. PERSGA doit faciliter la coopération des chercheurs scientifiques de la région avec les réseaux des chercheurs scientifiques internationaux engagés dans le programme mondiale de suivi de la température de la mer pour les signes d'alerte d'un blanchissement des coraux.
6. Le programme de suivi des coraux au niveau national doit alimenter les bases des données du PERSGA pour pouvoir inclure tous les informations dans un rapport régional sur la statut des coraux de la région de la mer Rouge et du golfe d'Aden et pour aider les décideurs politiques.

INTRODUCTION

The Red Sea and Gulf of Aden region, which includes the Gulfs of Aqaba and Suez, the Red Sea and the Gulf of Aden (Map 1), contains unique coastal and marine environments. Among the most notable is the extraordinary system of coral reefs and their associated animals and plants. Surrounded by arid terrestrial environments, which are themselves unique, these marine environments support rich biological communities and representatives of several endangered species. The natural resources



Map 1: PERSGA Red Sea and Gulf of Aden region and countries

have supported coastal populations for thousands of years, and nourished the development of a maritime and trading culture linking Arabia and Africa with Europe and Asia.

In the last three decades, all countries surrounding in the Red Sea and Gulf of Aden (the Region) have had to address the challenges of environmentally and socially sustainable development. In addition, political, economic, environmental and social problems, demographic changes and pressures have remained major constraints. In spite of the significant differences between countries in their economic, social, and political status and development, the countries of the Region share several common environmental problems and threats. These shared concerns have provided a firm justification for regional collaborative efforts.

It is imperative that national efforts to improve institutional, policy and legislative capacity for environmental protection be fully supported. The cooperating parties have, in varying ways, included sustainable development as a key goal in most of their national development plans and strategies even though coastal and marine environmental considerations still need to be fully addressed in sectoral development programmes.

The nations of the Region have approved many new environmental laws and standards in the last decade and particularly since the adoption of the Jeddah Convention and establishment of PERSGA. In their determination to strengthen participation in regional and international agreements, the cooperating parties have signed or ratified a number of conventions. In parallel there have been fruitful international efforts and cooperation with the Region that have focused on critical areas such as capacity building, institutional development and information services.

The present report reviews the recent and current status of coral reef communities in the Red Sea and Gulf of Aden, based on data from the regional monitoring survey carried out during 2008 led by PERSGA experts in collaboration with national expert teams from the PERSGA member states. This survey and its report are built on the foundations of earlier studies. It is the first report to provide comparative data on the status of coral reefs since the establishment of the regional standard survey methodologies and the training of the national teams of experts on these methodologies. It also bears the distinction of being the crucial programme needed to establish the regional network of long-term coral reef monitoring sites.

The report describes in chapter 1 the uniqueness of this marine environment and the endemism of the organisms in the Region. Chapter 2 deals briefly with the different anthropogenic threats to these coastal and marine environments. Chapter 3 recounts progress in marine conservation efforts achieved by PERSGA and its member states. Chapter 4 describes the regional monitoring programme and the survey methodologies used. Chapter 5 explains the results of the recent survey and compares the data temporally and spatially with coral reef reports from other parts of the world. Finally, Chapter 6 recommends some priority actions which should be adopted at national or regional levels to improve the efficiency and support the sustainability of marine conservation achievements.

1. THE UNIQUENESS OF THE MARINE ENVIRONMENTS IN THE REGION

1.1 A REPOSITORY OF BIODIVERSITY

The Red Sea is one of the most important repositories of marine biodiversity in the world. Its relative isolation and physical conditions, which range from near-shore shallows to depths of over 2,000 meters in the central rift, have given rise to an extraordinary range of ecosystems and biological diversity. Its most renowned expression is the elaborate system of coral reefs. There are also mangroves, seagrass beds, algal reefs, and intertidal habitats. Species endemism in the Red Sea is extremely high, particularly among some groups of reef fishes and reef-associated invertebrates.

The Gulf of Aden is strongly influenced by the upwelling of cool, nutrient rich waters during the south-west and north-east monsoons and is characterized by a prevailing high energy climate. These pose major constraints on coral reef development, hence only 5 percent of the Yemeni Gulf of Aden coast is lined with fringing reefs. Rocky cliffs alternating with long stretches of littoral and sub-littoral sand along coastal plains dominate the coastline. Some of the sandy beaches, notably Ras Sharma and Dhobbah (Ash Shihr) of Yemen, form major nesting sites for green turtles in the Region. Little is known about the coastal and marine resources of the Gulf of Aden coast of Somalia although recent visits have revealed the occurrence of previously unknown coral reefs and mangrove stands.

The Socotra Archipelago (Yemen) situated at the eastern extreme of the Gulf of Aden (Map 1), is of global significance for island biodiversity and species endemism. Over one third of its plants are endemic to the archipelago, making it one of the top ten island groups in the world in terms of endemism. Many of these endemics are remnant of an ancient flora which long ago disappeared from the African-Arabian mainland. Unlike many island groups in the world, Socotra has remained virtually untouched by modern development and there is no evidence of recent extinction or large-scale changes in the vegetation. The marine environments of the Socotra Archipelago remain largely in a pristine state, unaltered by coastal pollution or over-exploitation.

1.2 MAJOR MARINE ENVIRONMENTS

The coastal and marine environments of the RSGA consist of a range of ecosystems: an arid coastal zone, coastal wetlands, mangroves, seagrasses, and coral reefs. These contrasting ecosystems are the basis of much of the Region's rich and unique biodiversity, its fisheries production, its conservation and recreational values. They are also vital to the livelihood of the coastal populations. They stabilize and protect

the coastline, and buffer changes in water quality. These ecosystems are linked by the movement of water through them, and a decline in the health of one will have an impact on the others. The aridity of the coastal zone has historically concentrated human settlement near available water supplies and created a traditionally heavy reliance on the marine environment as a source of food.

Seagrasses inhabit shallow and sheltered waters throughout much of the Region. The productivity of seagrass beds is greater than comparable areas of both coral reefs and mangroves. Seagrass roots stabilize sediments, and in conjunction with nearby mangroves, protect the coastline. Water currents are reduced in the vicinity of seagrass beds leading to the deposition of fine sediments and the clarifying of surrounding waters. Many marine animals rely upon seagrass beds for shelter and food including water birds, fish and crustaceans, and the internationally important dugong and green turtles. Commercially important fish and crustaceans use seagrass beds as nursery grounds. There are strong connections between seagrass beds and nearby coral reefs; nocturnally active fish migrate at night from the reefs to the seagrass beds to feed; dead seagrass leaves carried offshore in currents become food for animals inhabiting deeper marine habitats.

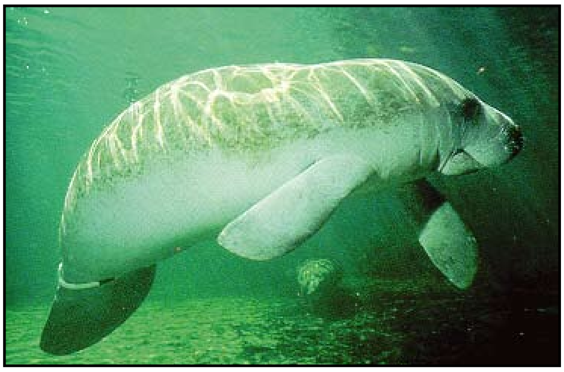
The coral reefs of the Region are composed of approximately 200 species of stony corals, representing the highest diversity in any section of the Indian Ocean. The warm water and absence of freshwater input provide very suitable conditions for coral

reef formation adjacent to the coastline. In the northern Red Sea the coast is fringed by an almost continuous band of coral reef, which physically protects the nearby shoreline. This beautiful environment is extremely attractive as a tourist resource and is currently visited by hundreds of thousands of people each year, who dive, walk, and swim in the waters adjacent to the reefs. Further south the coastal shelf becomes much broader and shallower and the fringing reefs gradually disappear to be replaced by shallow, sandy shorelines and mangroves. Coral reefs become more numerous offshore in this part of the Region. Coral reefs also occur as offshore patch reefs and reefs fringing islands. They provide food and shelter for a large and diverse fauna and flora. Most fishing activities in the Region occur in shallow waters in the vicinity of coral reefs.

Corals require a range of physical conditions for healthy growth and reproduction, all of which can be influenced by human activities. Physical destruction, changes in water quality—such as raised nutrient levels, changes in salinity and temperature, high levels of sedimentation and changes in water currents, can all damage coral reefs. Recovery, through new growth and larval settlement, requires a considerable amount of time and freedom from chronic stress.

1.3 MARINE ENDEMISM AND BIODIVERSITY

The waters of the RSGA support many internationally important species, notably marine mammals, sea turtles and seabirds. Marine mammals in the Region are represented by cetaceans such as dolphins,



whales and dugong. Although dugong were hunted in the past by artisanal fishermen, this is no longer the case and where surveys of their populations have been done, such as in Saudi Arabian waters, the populations are healthy. In the absence of major human impacts, conservation of dugong is directed towards conservation of their feeding habitats, the seagrass beds. Sea turtles feed and nest in the Region and at least three species have been observed. They rely on seagrass, algae, corals and invertebrates for their food. Information on their status is generally lacking and hunting by humans continuous in some parts of the Region.

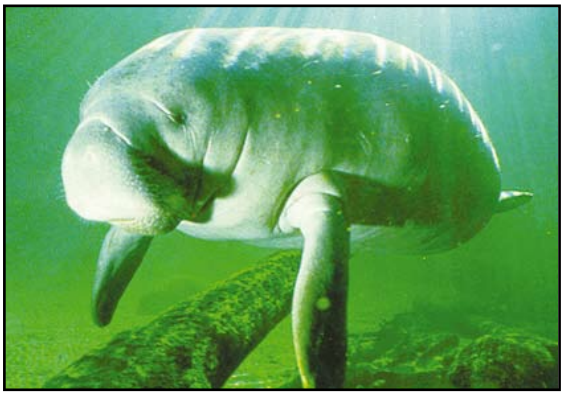
One consequence of the diversity of habitats in the Red Sea and Gulf of Aden is the great richness of marine flora and fauna. Much of the available information is based on research in the Red Sea, especially the northern Red Sea; far less is known of the flora and fauna of the Gulf of Aden (Kemp, 2000). The richness of hermatypic corals in the Red Sea has been estimated to be 180-200 species (Sheppard and Sheppard, 1991; Sheppard et al., 1992). However, a recent extensive study of the central-northern Red Sea coastline of Saudi Arabia increased this to a probable 260, based on recently described species and range extensions (De Vantier et al., 2000a). About 6% of Red Sea coral species are believed to be endemic (Sheppard et al., 1992). Approximately 200 species of scleractinian corals have been reported from the Socotra Archipelago in the Gulf of Aden. This is significant for the conservation value of the Socotra Archipelago, given the small area of coral communities, and the similarity in richness to the entire Red Sea (De Vantier et al., 2000b). One hundred and seventy species of echinoderms have been reported from the Red Sea, of which just over 5% are endemics (Sheppard et al., 1992). About 500 species of benthic algae have been recorded from the Red Sea (Sheppard et al., 1992). Ormond and Banaimoon (1994) report 160 species of macroalgae from the Hadramaut region of the Gulf of Aden coastline of Yemen. Planktonic organisms in the Red Sea include 88 species of dinoflagellates and 60 species of calanoid copepods in the southern Red Sea and 46 in the north (Sheppard et al., 1992).

About 1,350 species of fishes are known from the Red Sea (Goren and Dor, 1994). Distinct assemblages of fishes occur in the Gulf of Suez; the Gulf of Aqaba and the central and northern Red Sea; the southern Red Sea and the Gulf of Aden (Sheppard et al., 1992). The level of endemism amongst Red Sea fishes is about 17%; however, as Sheppard et al. (1992) point out, this average value has a great range. For example, the level of endemism amongst small benthic, territorial groups such as dottybacks (Pseudochromidae) and triple fins (Tripterygiidae) is about 90%, while

endemics are almost absent amongst pelagic species. Of the fauna associated with deep sea sediments in the Red Sea (i.e. at least 2,000 m), 30% are believed to be endemic (Chiffings, 1995). There are very few accounts of the ichthyofauna of the Gulf of Aden. Al-Sakaff and Essen (1999) listed 195 species of fishes caught in commercial trawlers from the Gulf of Aden and Arabian Sea coastline of Yemen. Kemp (2000) surveyed the ichthyofauna of the Shabwa and Hadramaut provinces of the Republic of Yemen and recorded 267 species, including eight new records.

The Red Sea and Gulf of Aden are important for a number of significant marine species. Three species of sea turtle are known to feed and nest in the Region: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*). Important nesting grounds are located in the Tiran Islands, Wajh Bank and Farasan Islands (Saudi Arabia); the south Sinai of Egypt (PERSGA, 2006); Dahlak Islands (Eritrea); Ras Sharma and Dhobah (Yemen) (Miller, 1989; PERSGA, 1998). The Ras Sharma nesting site for green turtles is internationally significant with about 10,000 females nesting there each year, making it the second largest in the Arabian region. In addition, the region between Jabal Aziz Island and Perim is the most important nesting ground for hawksbill turtles in the Arabian region (PERSGA, 2006).

Surveys by Preen (1989) estimated that there were 4,000 dugong (*Dugong dugon*) within the Red Sea. They are dependent on healthy seagrass beds for food. Important areas for dugong within the Red Sea include the Tiran Islands, Wajh Bank, Farasan Islands and Jizan (Saudi Arabia) (Preen, 1989; Sheppard et al., 1992). A separate review (Marsh et al., 2002 —cited in PERSGA/GEF, 2002a as 'in press') confirms the presence of dugong along other parts of the Saudi Arabian coast (Sharm Munaibara, Qirshan Island) and the existence of common populations between Saudi Arabia and Egypt around Tiran Islands and in the Gulf of Aqaba (Nabq and Abu Galum Marine Park). Dugongs are also found along the African coast of Egypt (south of Quseir) and of Eritrea (Dahlak National Park) (Marsh et al., 2002).



Thirteen species of cetacean have been reported from the Red Sea and Gulf of Aden, including dolphins, toothed and baleen whales. There have been few systematic surveys making the identification of significant sites for cetaceans difficult (Gladstone and Fisher, 2000). Important nesting and feeding grounds for seabirds occur on the Gulf of Aden coast of Somalia (Mait Island, Aibat, Saad ad-Din Island, Saba Wanak); the Farasan Islands of Saudi Arabia (Gladstone, 2000) and the Aden wetlands in Yemen (PERSGA, 2006).

2. THREATS TO COASTAL AND MARINE ENVIRONMENTS

2.1 A RANGE OF THREATS

The important coastal and marine environments and resources of the Red Sea and Gulf of Aden are subject to a series of individual and cumulative threats which have significant short- or long-term consequences for sustainable development in the Region. The threats include habitat destruction, over-exploitation of living marine resources, environmental degradation from petroleum development, significant risks from marine transport, pollution from industrial activities, diverse environmental impacts from urban and tourism development and a series of emerging environmental issues associated with new types of economic developments and use of new technologies, as well as threats of a global nature such as climate change. Some of the major threats to coral reef environments in the Region that could escalate from existing activities will be discussed here briefly. More information will be presented in a new report from PERSGA titled – State of the Marine Environment 2010 (in preparation).

2.2 CLEARING AND DEGRADATION OF MANGROVES

Mangroves are prone to degradation or removal due to development and exploitation. Mangroves are destroyed by land-filling and are cleared for the construction of shrimp ponds. In coastal areas, where the human population is increasing rapidly, mangroves are cut for firewood and for construction. Grazing by camels reduces the height of mangrove trees, their productivity, and their reproductive capacity. Degradation in mangroves leads to impacts on fish and crustacean catches. These impacts are compounded by a lack of awareness about the importance of mangroves to the coastal and marine environments, especially the relationship between mangroves and fisheries, and by the limited use of environmental assessment procedures.

2.3 LOSS OF SEAGRASS BEDS

Their location in shallow waters close to the shoreline renders seagrasses very susceptible to activities related to unplanned and unmanaged urban, industrial, tourism, and fishing activities. Seagrasses are destroyed directly by dredging and land-filling. Productivity is degraded by changes in water flow caused by coastal construction, by excessive sediment in the water reducing available light, and by the impacts of increased nutrients in the water from sewage disposal. These problems are compounded by a lack of information on their distribution in some areas. Although legally protected, seagrass beds are destroyed by illegal trawling because of difficulties in enforcement. Impacts on seagrass beds affect the fauna which depend upon them, most importantly turtles, dugong, commercial fish and crustaceans, and birds.

2.4 DESTRUCTION OF CORAL REEFS

Coral reefs throughout the Region are being damaged by a variety of coastal developments, such as land-filling for urban expansion and tourist facilities. Construction activities alter the flow of clear seawater that corals need to survive. Corals are affected by reduced light levels and sometimes smothered by sediment from dredging. Release of semi-treated and untreated sewage directly onto coral reefs causes a proliferation of algae that can overgrow corals. Although coral reefs are attractive to tourists, unmanaged diving and reef-walking activities, and anchors from boats destroy corals. Spoilt areas become unattractive and the number of animals living there declines. Damage to coral reefs is further compounded by the limited use of environmental assessment for developments and low enforcement of the existing regulations. A lack of awareness about the importance of coral reefs and their sensitivity puts them further at risk.

2.5 OVER-EXPLOITATION OF RESOURCES

Over-exploitation of species, destruction of spawning, nursery and feeding grounds, improper resource management and inadequate fisheries regulations, in conjunction with a lack of law enforcement, are barriers to sustainable development of the Region's rich living marine resources. Ultimately, this poses a serious threat to the biological diversity and productivity of the Region, and puts at risk the livelihoods of people engaged in potentially sustainable activities, such as fisheries, aquaculture and tourism.

2.6 OVERFISHING

The status of fisheries in some nations of the Region is unknown, because of a lack of stock assessments and incomplete fisheries statistics. Reported declines in catches and average size of fish landed are possible indicators of overfishing. Besides finfish, catches of lobster and strombids are rapidly declining. Cuttlefish stocks in major fishing grounds have completely collapsed. Although in some areas shrimp catches have grown recently due to an increase in fishing effort, in other areas there are indications of stock depletion. The present situation is attributed to destructive fishing practices, possible exploitation beyond maximum sustainable yield, the absence of fisheries management plans, and a lack of surveillance and enforcement of existing regulations. Large amounts of by-catch from net fishing, including turtles, dolphins and finfish are discarded, almost invariably dead.

2.7 UNREGULATED SHARK FISHERIES

As top predators, sharks are critical to the health of the Region's marine ecosystems. Populations can only increase slowly as sharks produce a small number of offspring each year. Hence they are very vulnerable to stock collapse from overfishing, and recovery takes several decades. The traditional artisanal fishery in the Region used to catch only small numbers of sharks and the whole animal was utilized. However, more recently, to meet the Asian demand for shark-fins shark fishing has increased and there are reports that fins are removed, often while the shark is still alive, and the body is thrown back into the sea

or deposited on offshore islands. Fins are dried and sold to foreign vessels waiting in international waters, thus escaping control. Sharks are generally caught by lines but also by nets which damage coral reefs.

2.8 CAPTURE OF MARINE TURTLES

Throughout the southern Red Sea and Gulf of Aden, turtles are caught either accidentally or intentionally by fishermen. Turtle oil, meat and eggs are eaten and the shells are sold to tourists. Capture of turtles, together with egg collection and disturbance or destruction of nesting sites and nesting beaches, has resulted in a decline in nesting populations. In areas with poor finfish resources, fishermen often depend on turtles for subsidiary food. Stray dogs that feed on turtle eggs and hatchlings aggravate the problem in some areas. The light coming from nearby urban areas and coastal highways has a distorting effect on the navigation system of newly hatched turtles (they are attracted towards the light and away from the sea) causing massive casualties.

2.9 THREATS TO MARINE MAMMALS

Knowledge of species composition and population sizes of marine mammals in the Region is limited. Detailed studies of dugong, which are considered vulnerable to extinction on a worldwide scale, exist only for Saudi Arabia and Egypt. The Red Sea population is estimated at up to 4,000 dugong. It seems that they are no longer hunted systematically, but are frequently taken as by-catch in trawls and nets. Their meat is used for human consumption. Destruction of seagrass beds poses an additional threat. As slow swimmers living in shallow water, dugong also suffer from the increasing use of motor boats, which may easily injure them near the water's surface.

2.10 PETROLEUM AND MARITIME TRAFFIC

The global importance of petroleum and

the resulting maritime traffic poses a serious threat to the fragile coastal and marine environments of the semi-enclosed waters of the Region. Routine operational leaks and spills from the production and transport of oil constitute the major source of marine pollution. At the same time, the growing risk of oil traffic-related accidents urgently requires emergency response plans combined with management skills, to minimize risks and manage major spills.

2.11 MAJOR SOURCES OF MARINE POLLUTION

In contrast to other regional seas around the world where most pollution comes from land-based activities, the main source of marine pollution in the Region is from ship-based sources, oil exploitation and offshore oil production. While production and transport of oil continue to play a critical role in the Region's economy, they also constitute major sources of marine pollution. The marine pollution could be derived through the discharge of oily ballast water and tank washings by vessels, operational spills from vessels loading or unloading at port, accidental spills from foundered vessels, and leaks from vessels in transit.

2.12 MUNICIPAL WASTEWATER

The discharge of municipal wastewater continues to present considerable management problems, despite the significant progress made over the last decade through investments to control pollution from this source. Considerable progress has been made in the Region in the collection and treatment of municipal wastewater. However, investments continue to be required for extension of collection networks, expansion and upgrading of treatment facilities, and development of safe wastewater reuse and disposal systems. Serious efforts are also needed to ensure proper operation and maintenance and reliable performance of existing treatment facilities. While levels of discharge into the waters of the Region are not as acute as in other regional seas given the limited number of major population centres, results are cumulative and add to the stress already imposed on fragile coastal habitats by oil and other forms of marine pollution.

2.13 DREDGING AND FILLING

Dredging and filling operations associated with urban expansion, industrial development and tourism along the coast are a significant source of environmental degradation in some areas of the Region. Sedimentation from these operations suffocates the surrounding coral reef communities and has an adverse effect on other ecosystems to which currents transport the suspended sediment. The net results are the irreversible loss of the most productive coastal ecosystems (mangroves, seagrass beds, and coral reefs and their dependent marine communities) and the potential for local extinction of endemic species, along with declines in the productivity of surrounding areas such as shrimp grounds and other demersal fisheries. Dredging and filling also alter shorelines, leading to erosion in some sites and accretion in others.

2.14 IMPACTS FROM TOURISM

There are negative impacts of coastal tourism in some parts of the Region. These impacts include physical destruction of coastal habitats by construction works, dredging, and reclamation; anchor damage to corals by tourist boats and coral breakage by divers; pollution from wastewater discharge from coastal resorts; over-exploitation of fish and shellfish to meet increased demand from the food and souvenir markets; disturbance to wildlife such as nesting turtles and seabirds leading to higher mortality and decreased fecundity. The massive planned expansion of tourism for both domestic and foreign visitors in coastal areas throughout the Region creates a significant and vital demand for effective integration of environmental concerns into the planning of government-supported infrastructure and private sector-supported tourism facilities. Actions should be taken over the short and medium term to avoid potentially significant adverse impacts which would undermine the ability of the coastal and marine environments to attract tourists to the Region.

2.15 TOURISM IN SUPPORT OF CONSERVATION

Although tourism impacts are not as prominent in the whole region, growing tourism investment plans will potentially cause environmental impacts on a regional scale. The pressures from tourism are spreading to new areas as popular sites become over-used and as foreign tourists continue to seek new, more exotic destinations. However, when carefully managed, marine tourism can provide substantial revenue for conservation projects. In Ras Mohammed National Park in Egypt, fees collected from visitors and diving tourists exceed the operational cost of the marine park. In Jordan, there is the potential to absorb part of the growing revenue from the tourism industry in Aqaba to support conservation efforts.

2.16 ORNAMENTAL FISH COLLECTING

In recent years, the collection of reef fishes for the aquarium trade has gained increasing importance as a foreign currency earner. However, the maximum sustainable yields of the species collected are unknown and there is no monitoring of collecting methods. The survival rate of captured ornamental fish is often very low due to imperfect handling and transport (PERSGA/GEF, 2007). This low survival rate, together with demands from foreign markets and the depletion of species in many parts of Asia, escalates the pressure for exploitation. This practice can also be harmful to the reef environment if it involves the breaking of corals or the use of cyanide. There is need for further research into the effects of this activity and its management. Furthermore, some measures could be investigated to replenish the market, such as aquaculture for targeted ornamental fish species to reduce impacts on wild stocks.

3. TWO DECADES OF PROGRESS IN MARINE CONSERVATION

3.1 BACKGROUND

PERSGA can trace its origins back to the early 1970's. The Arab League Educational, Cultural and Scientific Organization, ALECSO, with the assistance of UNESCO, convened a meeting in Bremerhaven, Germany in 1974 where initial ideas for interdisciplinary research were discussed. Subsequent meetings identified key regional concerns and proposed plans of activity, which gave rise to the 'Programme for the Environment of the Red Sea and Gulf of Aden' known as "PERSGA". An interim secretariat was established in Cairo to implement this programme, under the auspices of ALECSO. The secretariat moved to Jeddah in 1980.

One of the most significant achievements of PERSGA has been the development of new international laws. In February 1982 the plenipotentiaries of the governments in the Region signed The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (the Jeddah Convention) along with a Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency. The main focus of the Convention concerns the prevention, reduction and fight against pollution. It also includes an Article directing the contracting parties to establish a regional organization to implement the agreement.

This regional organization was established in September 1995 under the umbrella of the Arab League. At the first Council Meeting in Egypt, the Cairo Declaration formally announced the creation of the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden, which keeps the title "PERSGA".

PERSGA is governed by a Council. This is composed of the Ministers in charge of the environment from each of the member states. The Council meets annually to approve technical and financial policies. The daily affairs are managed by the PERSGA Secretariat, a small but dedicated team of professionals drawn from the countries of the Region. The Kingdom of Saudi Arabia hosts the PERSGA Secretariat in Jeddah and all of the member states contribute to the budget.

PERSGA has implemented, and continues to implement, a large number of projects throughout the RSGA with funding from ALECSO, the Islamic Development Bank, the Global Environment Facility (GEF), other international donors, and member states.

The establishment of PERSGA has been a pivotal step in a regional approach to sustainable use and conservation of the marine resources and environments. A regional approach to the marine environment is essential given the semi-enclosed nature of the Red Sea and the transboundary nature of many issues.

One of the most ambitious programmes executed by PERSGA was the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden, planned from 1995 to 1998 and carried out between 1999 and 2003. The SAP was funded through the Global Environment Facility implementing agencies (UNDP, UNEP, and the World Bank), the Islamic Development Bank, and the PERSGA member states. The SAP's global objective was to safeguard the coastal and marine environments of the RSGA and ensure sustainable use of its resources. The SAP's activities were organised around the following objective-based components:

1. Institutional Strengthening to Facilitate Regional Cooperation;
2. Reduction of Navigation Risks and Maritime Pollution;
3. Sustainable Use and Management of Living Marine Resources;

4. Habitat and Biodiversity Conservation;
5. Development of a Regional Network of Marine Protected Areas;
6. Support for Integrated Coastal Zone Management;
7. Enhancement of Public Awareness and Participation; and
8. Monitoring and Evaluation of Programme Impacts.

The SAP was highly significant for the RSGA environment, for PERSGA member states' capacity for conserving the RSGA and managing its uses, and for the future socioeconomic development of the Region. Large projects funded by the international donor community and RSGA countries were implemented throughout the RSGA in the last decade, e.g. the Red Sea Regional Framework Project, and projects in the Socotra Archipelago, Djibouti, Egypt, Jordan, Saudi Arabia, and Yemen. These have provided a large amount of new scientific information and understanding about the RSGA, management actions, and capacity building.

3.2 REDUCTION OF NAVIGATIONAL RISKS

New charts of the southern Red Sea have been published for use by international shipping, based on a major new hydrographic survey of the area between the Hanish Islands and Bab el Mandeb that was initiated by PERSGA. These charts are designed improve the safety of navigation in this important area of the RSGA. A new chart of Port Sudan showing recent developments in the port has been produced by the United Kingdom Hydrographic Office (UKHO), based on data supplied through PERSGA. A new planning chart of Yemeni waters covering the area between the maritime border with Saudi Arabia to a line east of the Socotra Archipelago was published by the UKHO on 21 December 2006. This chart forms the basis of a Yemen Fisheries Chart covering the same area, which is marked with a grid dividing the area into squares covering 100 square nautical miles for the purpose of recording fish catches. Capacity building in navigation safety/hydrographic surveying and chart re-scheming, has been achieved through training workshops held throughout the Region. One or more new tide gauges in the Gulf of Aden will form part of a tsunami early warning system for the Indian Ocean. The proposed new tide gauge at Aden could provide vital information on long term sea level.

3.3 MANAGEMENT OF COASTAL AND MARINE RESOURCES

There has been recent, substantial progress in the management of the marine resources of the Red Sea and Gulf of Aden. A regionally applicable manual of standard survey methods for key habitats and key species in the Red Sea and Gulf of Aden has been produced. Collection of essential baseline data on key habitats and species (coral reefs, mangroves, seabirds, turtles) and preparation of up-to-date status reports has taken place. There have been substantial gains in scientific knowledge of Red Sea and Gulf of Aden corals, coral communities, and reefs. Regional Action Plans (following regional surveys) were developed for corals, mangroves, turtles and breeding seabirds and are being implemented nationally via national action plans. The signing of the Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas by PERSGA member states in December 2005 provides a regionally coordinated approach to conservation.

A Regional Master Plan for the Regional Network of Marine Protected Areas has been produced. Progress is occurring towards the complete establishment of the RSGA Regional Network of Marine Protected Areas: two proposed marine protected areas were officially declared in 2005 (Iles des Sept Frères and Ras Siyyan in Djibouti and Mukawwar Island and Dungonab Bay in Sudan) and management plans are being implemented in each one. A zoning plan was developed for the Socotra Archipelago Marine Protected Area. Survey design guidelines for marine protected areas (MPAs) have been prepared and ecological and socio economic surveys have been completed at four proposed MPAs. Site-specific master plans, with management guidelines, have been prepared for four proposed MPAs with the involvement and participation of local stakeholders. A large number of managers and scientists have been trained (via workshops and on-the-job training) in marine protected area management, field surveys, and monitoring techniques. There has been an international, regional and national exchange of experience.

Substantial progress has been made in the field of integrated coastal zone management (ICZM). This includes:

- Approval of ICZM plans for the Aden Governorate and their implementation;
- Completion of coastal profiles in Sudan and Djibouti and the preparation of an ICZM plan for Sudan;
- Establishment of a regional ICZM working group and raised awareness of the need for and use of this tool in coastal management;
- Improvements in regional capacity in remote sensing and geographic information system (GIS) applications;
- Design, creation and establishment of a GIS unit at PERSGA with global internet access; and
- Incorporation of all biodiversity, protected area, ICZM and other data from the Strategic Action Programme into the GIS for full programme integration.

PERSGA's environmental awareness programme concentrated on conservation including production of an Environmental Education Learning Supplement, and the implementation of more than 17 community participation projects. Five public environmental information centres and 150 school nature clubs have been established within the Region, with associated teacher training. These activities have resulted in raised awareness of PERSGA and its activities at the national, regional and international level.

3.4 CONTROLLING SEA-BASED ACTIVITIES AND SOURCES OF POLLUTION

In general, oil spills around the world are reducing due to initiatives by the International Maritime Organization (IMO) and other factors. PERSGA has achieved significant success in getting new routeing measures adopted for use by international shipping in the southern Red Sea. PERSGA has established a new lighthouse fitted with an Automatic Identification System on the Hanish Islands. Capacity building in combating oil pollution, in port state control, marine incident investigation, navigation safety/hydrographic surveying, contingency planning and ballast water management has been achieved through training workshops held throughout the Region. PERSGA has established the Emergency Mutual Aid Centre for the Red Sea and Gulf of Aden (EMARSGA, formerly known as the Marine Emergency Mutual Aid Centre or MEMAC) at Hurghada and this is receiving support from the IMO. National contingency planning in the Red Sea and Gulf of Aden has improved and national plans are now in place in all member states. The capacity to carry out port state control of ships has improved in recent years. On the other hand, the signing of two Protocols, i.e. "Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency–February 1982", and "Mobilization of Personnel, Equipment, and Material during Emergency–July 2009", by PERSGA member states provide a regionally coordinated approach to the prevention, reduction and fight against pollution in emergency cases.

3.5 CONTROLLING MARINE POLLUTION FROM LAND-BASED ACTIVITIES

Recent changes in management practices have led to some environmental improvements, especially on the coral reef adjacent to the Phosphate Port, Aqaba. The signing of PERSGA's "Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden" in September 2005, and the implementation of the Regional Environmental Monitoring Programme (concerning water quality parameters) are substantial outcomes. Capacity building has been achieved (via training workshops) in integrated coastal zone management, environmental impacts of development projects, management of solid wastes in industrial areas, environmental inspection, and improvement of wastewater management. National programmes of action for the protection of the marine environment from land-based activities have been prepared for Yemen and Jordan; programmes for the other countries are still in preparation. A preliminary and fund raising phase of the 'Regional Programme of Action for the Protection of the Marine Environment from Land-Based Activities' is being prepared for the Red Sea and Gulf of Aden, comprising the following:

- Collection of relevant information for the development of four projects in the following fields:
  - collection, treatment and disposal of municipal wastewater,
  - identification of pollution hot spots and sensitive areas,
  - management of marine litter, and
  - assessment of the quality of bathing waters and beaches;
- Production of the joint PERSGA/UNEP publication "Financing for the Environmental Conservation of the Red Sea and Gulf Aden"; and
- Organization of a regional training course on municipal wastewater treatment management.

There has been a rapid uptake of GIS technology (including a regional GIS database in PERSGA) to support risk assessments for pollution.

3.6 MANAGEMENT OF LIVING MARINE RESOURCES

The regional status of living marine resources in the Red Sea and Gulf of Aden has been assessed and baseline information has been collected. There has been a substantial rise in capacity in: fish stock assessment, data collection and analysis; environmentally sound aquaculture; fisheries management; and ornamental fish assessment and management. Two training facilities and a reference collection centre have been established and equipped, the first in Aden (Yemen) and the second in Jeddah (Saudi Arabia). There is increased awareness among decision-makers of the complementary linkages between conservation of the environment and sustainable development. A system is in place for the standardized collection and transfer of fisheries data. Information has been obtained for Egypt, Jordan, Djibouti, Saudi Arabia and Yemen on the trade in ornamental fishes and its impact on the environment. A management plan for ornamental fishes has been prepared (PERSGA/GEF, 2007). The management of elasmobranch fisheries has improved through: training; an identification guide; a management plan; and improved data collection. New fisheries regulations have been issued in Egypt, Saudi Arabia and Yemen. Additionally, fisheries management plans have been prepared for Socotra (Yemen) fisheries and rock lobsters.

3.7 REGIONAL AND NATIONAL CONSERVATION ACTION PLANS

PERSGA has prepared a Regional Action Plan (RAP) for the conservation of coral reefs in the Red Sea and Gulf of Aden region, as well as similar regional action plans for the conservation of marine turtles, mangroves, and seabirds. These four RAPs contain priority actions within these major fields:

- Integrated coastal zone management;
- Education and awareness;
- Marine protected areas;
- Ecologically sustainable reef fisheries;
- Impacts of shipping and marine pollution; and
- Research, monitoring and economic valuation.

Each RAP addresses specific actions, expected results, performance indicators and quality assurance through a set of priority actions for conservation and sustainable development within the Region.

The RAP for coral reefs was developed in recognition of the great economic, ecological, and aesthetic importance that these reef ecosystems provide and in response to the serious existing threats posed by increasing human and natural impacts. Many of the region's reefs are growing near the climatic extremes of reef development and are particularly vulnerable to any increase in disturbance. The seriousness of the threat was demonstrated by major coral reef bleaching in 1997 and 1998, causing massive death of corals and other reef organisms in the Gulf of Aden and parts of the Red Sea. Over the next several decades, predicted increases in these disturbances may cause major disruptions in reef function and the loss of associated resources for human use.

Given the differences in priorities, capacities and other aspects among the RSGA countries, the coral reef RAP needed to be adapted to suit each particular country. Therefore national action plans (NAPs) were developed for the countries to facilitate implementation of actions at the national level. This was achieved by identifying national stakeholders, mechanisms, institutions, etc., and integrating RAP activities into existing national ICZM plans. In individual countries, implementation will occur through integrated networks of national and local working groups, government departments, agencies and personnel, non-governmental organisations and other stakeholders. Therefore, NAPs provides a set of priority actions for the conservation and sustainable development of coral reefs taking into consideration the priorities of the concerned countries.

The implementation of NAPs and RAPs in the Region has varied according to the national capacities, constraints and priorities. However, the support of the international agencies and donors is much appreciated and has assisted in overcoming these constraints. PERSGA has integrated the implementation of RAPs and NAPs into the 2004–2014 strategic plan and established an On-Ground Activities Programme to directly support the implementation of NAPs according to resource availability.

3.8 STATE OF THE MARINE ENVIRONMENT REPORTING IN THE RED SEA AND GULF OF ADEN

It is clear that managing human use of the marine and coastal environments of the RSGA will be most effective when based on a solid foundation of knowledge. This knowledge that has been built up by a long history of endeavour in the bio-physical and social sciences, allows managers, scientists, decision-makers and the wider community to devise appropriate management strategies that respond to the impacts of human uses confronting them. It also provides them with the hard evidence needed to assess the effectiveness of their decisions. A major problem has been that the available information was available in fragmented sources. No baselines had been established against which the success, or otherwise, of management could be gauged. The absence of long-term monitoring limits the understanding of the magnitude of natural variations in marine ecosystems and consequently the ability to interpret the meaning of changes due to human activities.

PERSGA published the “State of the Marine Environment Report for the Red Sea and Gulf of Aden” (SOMER) in 2006. This report (PERSGA, 2006) was based on recently collected data, results and analysis of the surveys from the regional monitoring programme, and various activities carried out by PERSGA and its member states before and during the SAP project (1996-2003). Furthermore, the materials reviewed in SOMER included a large number of papers from the published scientific literature. The SOMER also points to the need for continued action in many priority areas, and aims to support continuing efforts towards the sustainable use and conservation of the Red Sea and Gulf of Aden.

Since the publication of SOMER, it is evident that this report has provided a foundation for improved decision making at all levels, and increased awareness and understanding of environmental trends and conditions (their causes and consequences) among all stakeholders and internationally. The report also provided source material for academic studies and a baseline of integrated information against which future assessments can be compared. Accordingly, PERSGA plans to prepare a new SOMER on a regular basis every four years.

3.9 ESTABLISHING A REGIONAL NETWORK OF MARINE PROTECTED AREAS

During the initial PERSGA-SAP it was decided that an ecosystem approach to conservation and management was most appropriate to ensure long-term sustainability of the Region's critical habitats and populations of globally important species. This would be achieved by establishing an integrated regional network of marine protected areas (MPAs) supported by effective integrated management and planning. Sites were selected to be representative of the region's biogeography (and include representative habitat types and species as well as bird and turtle nesting sites, and seagrass beds used by dugong) and cultural heritage, and include feeding, breeding and roosting sites, larval sources and sinks, and migratory routes of key biota.

When all MPAs in the RSGA region are counted, 75 have been established or recommended. Twelve MPAs were selected by PERSGA regional and national experts during the SAP for the regional network: Iles des Sept Frères and Ras Siyyan (Djibouti); Ras Mohammed National Park; Straits of Gubal (Egypt); Aqaba coral reefs (Jordan); Straits of Tiran; Wajh Bank, Sharm Habban and Sharm Munaybirah; Farasan Islands (Saudi Arabia); Aibat and Sa'adadin Islands, Saba Wanak (Somalia); Sanganeb Marine National Park; Mukawwar Island and Dungonab Bay (Sudan); Socotra Islands; Belhaf and Bir Ali area (Yemen).

There are a number of issues of concern relating to the existing and proposed MPAs. Few of the declared MPAs are managed appropriately. There is limited technical capacity and experience throughout the Region in MPA management. Some countries lack the necessary pool of experts to provide the knowledge, training and skills necessary for MPA management. Much of the existing capability in MPA management is at the Ras Mohammad National Park (Egypt), the best example of a fully functional MPA in the Region. Lack of surveillance and enforcement of regulations in MPAs is widespread in the RSGA. There are gaps within existing MPAs in representation of regionally significant and representative habitats.

PERSGA-SAP has delivered specific training to MPA managers, scientists and rangers from the Region to address the lack of expertise in MPA management. Courses have covered management issues, marine and coastal surveys and monitoring, SCUBA diving, ranger duties, policing and public relations. The first course was held at the Ras Mohammad National Park.

The Regional Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas requires contracting parties to:

(i) protect, preserve and manage in an environmentally sound and sustainable manner areas that are unique, highly sensitive or regionally representative, notably by the establishment of protected areas; and
(ii) adopt appropriate planning, management and supervision including legislation and monitoring measures for the protected areas.

In addition nations shall draw up a "List of Protected Areas of Importance to the PERSGA Region". Contracting parties are also required to develop management plans and a list of sites of special importance for possible future declaration as MPAs. PERSGA's, in progress, 'Framework of Action for 2006–2010' lists activities to implement the Protocol. These include actions to verify critically threatened areas and to establish monitoring programmes for habitats and biodiversity.

A Regional Master Plan (RMP) for the MPA network was produced (PERSGA/GEF, 2002a) that included guidelines for the development of individual site-specific management plans. This RMP facilitates the endeavours of individual countries to select and manage their MPAs. In addition, survey designs for proposed MPAs were published in 2002 (PERSGA/GEF, 2002b) to assist the national teams in decision making.

3.10 REGIONAL RESPONSES FOR MONITORING THE MARINE ENVIRONMENT

In 2001 PERSGA began the preparation of a manual of standard survey methods (SSMs) covering methods of rapid assessment, and methods for the detailed assessment of intertidal habitats and mangroves, corals and coral communities, seagrass and seaweeds, subtidal habitats, reef fishes, marine turtles, seabirds, and marine mammals (PERSGA/GEF, 2004). The development of standard survey methods facilitates the acquisition of population data and monitoring.

Training and capacity building in these methods followed the first steps of the SSMs manual and has produced national and regional specialist teams competent to carry out the standard survey methods. Regional training workshops were held for mangroves and intertidal habitats; turtles; ornamental fishes; data collection and analysis of the trade in ornamental fishes; corals; seagrass and algae; breeding seabirds; elasmobranch identification, sampling and stock assessment methods.

Sixteen surveys were conducted within the Region, executed by regional specialists trained through the SAP, in order to evaluate the present status of habitats and species and prepare the groundwork for conservation plans.

Pilot surveys of the status of coral reefs in PERSGA countries were undertaken (PERSGA, 2001). Detailed assessments of the coral reefs of PERSGA countries were undertaken and a regional status report (PERSGA/GEF, 2003b) and regional action plan (RAP) were produced (PERSGA/GEF, 2003a). Furthermore, a regional survey for coral reef status carried out during 2002 engaged all the trained national experts in the field surveys, and a regional report was prepared, 'Status of coral reefs in the Red Sea and Gulf of Aden' (Hassan et al., 2002a).

National monitoring programmes for coral reef communities have not yet taken place in most of the PERSGA member states, except for Egypt and Jordan. In Egypt, intensive monitoring programmes, led by the EEAA, were established for both the Sharm El-Sheikh and Hurghada-South areas in the late 1990s. To meet the objectives of the national monitoring programme these programmes use very advanced methodologies (i.e. fixed photo-quadrat techniques) and require competent, experienced personnel (Kotb et al., 2001). In Jordan, the Marine Science Station of Aqaba are carrying out a monitoring programme using the line transect technique as a routine reef monitoring protocol at some sites along the southern part of the Aqaba reefs. Furthermore, some irregular monitoring efforts take place in Yemen, Saudi Arabia, and Sudan through some of the national scientists, but the irregularity of the data, surveyed sites, and the different methodologies used make the data non-comparable.

There have been a number of responses to coral damage caused by dive tourism in Egypt. Installation of mooring buoys has helped reduce anchor damage on dive sites all round the Egyptian Red Sea. Further management responses, such as additional rangers, intensive patrolling, awareness materials, entrance fees, and diver management plans, have significantly reduced the impacts of divers and diving boats.

The need to avoid anchoring on coral reefs is emphasised in Admiralty Sailing Directions, which lists the positions of anchoring points, and on charts of the RSGA. For example, Admiralty Chart 159, Red Sea, Suez to Berenice, contains the following note: Protected Reefs: Vessels should only use the fixed moorings on or adjacent to coral reefs in Egyptian coastal waters between:

a) latitudes 26° 37' N and 27° 02' N,
b) latitudes 27° 08' N and 27° 26.3' N,
c) locations around the Strait of Tiran and in the Gulf of Aqaba (stated in the note),
d) reefs surrounding El-Akhawain (26° 19' N, 34° 33' E) are also protected

and damage to the coral may lead to prosecution. For further information see Admiralty Sailing Directions.

Damage to coral reefs due to ship grounding incidents on the reefs has also occurred in various parts of the RSGA, including the waters of Egypt, Saudi Arabia, Sudan and Yemen. In most cases the ships causing the damage are prosecuted by the relevant national authorities. PERSGA published, in 2009, guidelines to assist the member countries to establish national legislation and a system for compensation for reef damage by ship grounding (PERSGA, 2009). The different national compensation regulations and experience in the RSGA countries were assessed and recommendations for establishing, improving and standardizing of such regulations were emphasised.

A regional database for key habitats and species, a Biodiversity Information System, provides information for decision-makers and researchers about the status of marine species in the RSGA and is established at PERSGA headquarters.

A Regional Reference Collection Centre was set up in early 2003 within the premises of the Faculty of Marine Science, King Abdulaziz University in Jeddah, Saudi Arabia. A training course for the managers of the Centre was held in the Senckenberg Museum (Frankfurt, Germany). On-the-job-training was provided for the technicians working in the Centre.

Continued progress will be underpinned by the implementation of PERSGA's Framework of Action for 2006–2010, which outlines specific programmes to be carried out.

3.11 ON-THE-GROUND ACTIVITIES PROGRAMME

In the years since the Strategic Action Program (SAP), the Region has witnessed appreciable progress in its capacity for sustainable management of coastal and marine environments. The most prominent developments have been the preparation and adoption of knowledge-based, specific, and long-term Regional and National Action Plans (RAPs and NAPs) for the management of important marine habitats (coral reefs, mangroves, seagrass beds), species (seabirds, marine turtles and mammals), marine protected areas, living marine resources and coastal zones. Despite the considerable and continuous efforts made through the PERSGA-Training Programme, the existence of some gaps in the technical know-how, together with shortages in finance represent the major constraints impeding proper implementation of the action plans developed. The idea of establishing an On-the-Ground Activities Programme emerged as an outstanding down-to-earth approach to assist the member states. The programme was then initiated by PERSGA with the objective of supporting national on-ground projects addressing sustainable development and implementation of the action plans.

The national projects of the On-the-ground Activities Programme focus on various topics of national concern, such as: protecting or rehabilitating coastal/marine habitats, removing threats to coastal environments, and supporting implementation of national conservation management plans, education and training activities that raise community awareness, knowledge or skills on coastal/marine conservation issues. The programme has proved to be one of the most effective and rewarding programmes implemented by PERSGA, because of the tangible achievements attained in all member states, despite the fact that a relatively short period of time has elapsed since it was launched in 2006. The On-ground Projects that have been implemented prior to the preparation of this report are:

- Support to ICZM in Sudan – 2006/2007;
- Education for sustainable development, Jordan – 2006/2007;
- Establishment of a regular water quality monitoring programme, Jordan – 2008/2009;
- Ecotourism and management of mangrove areas in Hamata, Egypt – 2007/2008;
- Public awareness and participation in coastal environmental protection,

Djibouti – 2007/2009;
- Coral reef conservation in Jeddah, Saudi Arabia (KSA) – 2007/2008;
- Support to ICZM planning in Jizan and Asir, KSA – 2007/2008;
- Rehabilitation and management of sea-cucumber fishery, Yemen – 2007/2008;
- Management of reef recreation activities on the Aqaba coast, Jordan – 2009.

3.12 SUSTAINABLE FINANCING OF CORAL REEF CONSERVATION

The wide range of coral reefs and their ecological and economic importance to the Region mandate that special attention be given to development of sustainable financing mechanisms for their conservation. Key to success is establishing the principle that coral reefs are economic resources and that their users should pay fees, where appropriate. PERSGA in cooperation with UNEP-ROWA are preparing guidelines for the 'Economic Evaluation of the Marine and Coastal Resources in the RSGA Region', (in-press). The guidelines will assist the nations of the Region to calculate the value of their natural resources and provide a regional perspective.

A few successful models for self-financing of coral reef conservation efforts are found in the Region and are taken by PERSGA to be replicated elsewhere. For example there is the innovative work undertaken by Egypt in the Egyptian Red Sea reefs for the conservation of these resources that includes the use of an "Environmental Cost Recovery Charge". Non-traditional financial resources can be used to support implementation at the regional and national level; for example, the Saudi Environmental Awareness Programme is funded jointly by the government and the private sector.

3.13 STRENGTHENING REGIONAL AND INTERNATIONAL COOPERATION

PERSGA member states have approved many new environmental laws and standards in the last two decades, and since the adoption of the Jeddah Convention and the establishment of PERSGA. In their determination to strengthen participation in regional and international agreements, the cooperating parties have signed or ratified a number of conventions. In addition, a number of GEF-supported projects have been launched in cooperating countries. International efforts and cooperation with the Region have focused on a number of critical areas, such as capacity building and institutional development, environmental baseline data, and information services.

Especially during the last decade, PERSGA has initiated and established cooperation with many international and regional organizations including United Nations Industrial Development Organization (UNIDO), IMO, World Bank, UNEP, ALECSO, Arab League, ROPME, IUCN, Islamic Development Bank, and Reef Check. PERSGA has also succeeded in establishing a number of Memoranda of Understanding with many of these organizations.

PERSGA contributed to the global reports "Status of Coral Reefs of the World" with the Red Sea and Gulf of Aden chapters during 2000, 2002, 2004, and 2008 published by the Australian Institute of Marine Science (Pilcher and Al-Suhaibany, 2000; Hassan et al., 2002b; Kotb et al., 2004; Kotb et al., 2008), and is continuing cooperation with several other global reports concerning the RSGA region. Moreover, PERSGA is considered the focal point for the RSGA for several international initiatives and organizations, such as the Global Coral Reef Monitoring Network (GCRMN), International Coral Reef Initiative (ICRI), International Coral Reef Action Network (ICRAN), World Commission on Protected Areas–Marine (IUCN), and it cooperates to present RSGA environmental status and information to the international community.

4. REGIONAL MONITORING PROGRAMME AND SURVEY METHODOLOGY

4.1 AIMS OF THE MONITORING PROGRAMME

The Habitats and Biodiversity Conservation (HBC) component of the PERSGA-SAP developed a strategy that contained five clear steps: (i) develop a set of standard survey methods (SSMs) for the Region consistent with global methods, (ii) train national specialists to use these methods, (iii) execute regional surveys, (iv) prepare conservation plans, and (v) implement the plans.

Effective reef management needs accurate information on the status of the ecosystem, both for ICZM and MPA planning, and for the assessment and monitoring of reef status and reef fisheries, as well as to evaluate the effectiveness of the management itself. To be most effective, research and monitoring are integrated into a logical overall framework of action providing scientifically robust management-oriented information, including data for:

1. Planning and development of MPAs, such as distribution of habitats, biodiversity and socio-economics;
2. Monitoring ecosystem properties and the status of biological, ecological, oceanographic and socio-economic parameters for ICZM and MPA management;
3. Environmental and socio-economic impact assessments, both before and after development takes place, and economic valuations of different courses of action;
4. Assessing the health status of the ecosystems in terms of global-scale disturbances, such as occurred with coral bleaching in 1997 and 1998;
5. Reef fisheries stock assessment and monitoring.

Most nations in the Region have initiated reef research and monitoring programmes, although major differences exist in national logistics capacities in relation to different levels of finance, manpower and expertise. Until recently, there had been only limited success in pooling national data to provide regional insights. This was addressed through the regional initiatives to develop the SSMs and the training programmes.

A number of management initiatives have been set up in the Red Sea and Gulf of Aden region that will require regular monitoring to assess their effectiveness, including the RSGA Regional Network of Marine Protected Areas (PERSGA/GEF, 2002). Monitoring of natural systems and species of interest will generate feedback to managers on the outcomes of management strategies and provide fundamental information on natural dynamics. Obviously, the quality of the monitoring information is crucially important for ecologically and socially sustainable management. Monitoring programmes implemented at the scale of a country or region can be expensive and logistically difficult to implement. The monitoring methods must be time and cost-effective, whilst fulfilling the information needs of managers and being appropriate to the species of interest.

Accordingly, PERSGA is planning to conduct regional monitoring for the status of the coral reefs on a regular basis every 2 years. Monitoring data will be valuable for alerting governments to disturbances affecting reefs of the Region, and will complement (and ground-truth) the wide range of recently launched satellite-borne sensors, which provide data at regional and global scales.

4.2 STANDARDIZING THE REGIONAL SURVEY METHODOLOGY

In order to evaluate and monitor the status of marine habitats and biodiversity within the Red Sea and Gulf of Aden, surveys must be undertaken that are comparable in extent, nature, detail and output. Standardizing survey methodology within the Region was essential to allow valid comparison of data, and for the formulation of conservation efforts that are regionally applicable. The Reef Check protocol was adopted in the SSMs as a regional reef survey method.

The preparation of the "Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden" guide was initiated following a review of the methods currently in use around the world. Contextual SSMs were then drafted for each of the relevant fields: subtidal, coral reefs, seagrass beds, inter-tidal, mangroves, as well as for important groups such as reef fish, marine mammals, marine turtles and seabirds. The SSMs guide was discussed at a regional workshop in September 2000 held in Sharm El-Sheikh where scientists from both inside and outside the region reviewed the first drafts and provided useful comments.

The SSMs were drafted and tailored to suit the conditions of the Region, taking into account the geographical variation within the Red Sea's northern, central, and southern sectors. The methods were designed to be simple and straightforward, suitable for use in surveys, monitoring, and as a training guide. Though user-friendly, they are of sufficiently high quality to provide the minimum requirements needed to assess the status and health of environments and their constituent populations, and are able to account for bias introduced when different people, with different capacities and levels of training, conduct surveys. The SSMs also allow for integration between surveys wherever possible.

4.3 REGIONAL TRAINING FOR THE NATIONAL TEAMS

From 2001 onwards PERSGA conducted a series of training courses for regional and national specialists to teach them these specific methods. The training courses were also used as tools to evaluate the methods and to determine their applicability to the RSGA region. More than 115 national and regional specialists have been trained. The results of the evaluations given by the specialists recognized the suitability of these SSMs for the Region due to a combination of factors: their widespread use, their simplicity and the particular adaptations made to suit the Region, and the variability of national capabilities.

4.4 MONITORING SURVEY METHODOLOGY

Herein, a brief description for the methodology used (Reef Check) during the 2008 regional monitoring survey. Detailed descriptions and photographs of the field and analytical methods can be found in the PERSGA manual of SSMs (PERSGA/GEF, 2004) and at PERSGA (www.persga.org) or Reef Check (www.reefcheck.org).

In the SSMs reef communities are assessed in three categories: sessile benthic cover, invertebrate abundance, and fish abundance. These categories are assessed in reef locations chosen because they demonstrate several specific key criteria.

Site selection: The criteria used during site selection included: ease of relocation, accessibility, representativeness, present status, and depth profile. Sites should be easy to find on the next survey/monitoring occasion using maps, navigation charts, landmarks, compass bearings, portable Global Positioning System (GPS) units, and Google Earth. Sites should be easily and safely accessible, based on a realistic assessment of logistic and budgetary constraints, weather and exposure to prevailing sea conditions, and the capabilities of the working-team. As much as is practicable, given logistic constraints, sites should be representative of the different reef types, biotopes and community types present. Similarities and variety in habitat and environmental attributes, known histories of the sites including effects of disturbance, likely future disturbances and any zoning management implications in terms of marine protected areas (MPAs) all need to be considered in site selection.

In addition, sites should cover the range of different conditions in terms of human or natural disturbances, from recently impacted to pristine, rather than concentrating only on reefs in good condition. This is not to downplay the importance of surveying sites in excellent or pristine condition. In case of limited funding, facilities, time, or diver experience, the work-team must survey the most pristine site in the area when it is not possible to survey more than one site.

The SSMs recommend that selection can be aided by initial synoptic surveys using manta-tow or similar methods. For the present monitoring survey however, site selection was made primarily by consulting the opinions and experiences of the national team members from each respective country.

Depth selection: As far as practical, survey sites should be within one or two standard depth ranges. The two standard depth ranges for surveys are 2–6 m and 7–12 m, consistent with the Reef Check and GCRMN recommendations for a depth-stratified sampling design. It is important that samples (replicate transects) within each of these two depth ranges are positioned randomly within homogeneous habitats, rather than across different habitats. Where particular site characteristics preclude the use of the standard depth regimes (e.g., too shallow, different coral community depth distributions or geo-morphological characteristics, etc.), then the precise depth range selected is at the discretion of the survey team. For example, some shallow reefs in the RSGA region are less than 7 m in depth, with major changes in cover and community structure occurring at around 3 m depth. In such circumstances, shallow sites should be in the 1–3 m depth range and deep sites from 4–6 m. The depths selected at all sites, whether following the standard recommendations or with site-specific alterations, should always be clearly documented on the field data sheets. If two depth ranges are to be surveyed in a single dive, deeper surveys should always be conducted first, within conservative dive-time limits in accordance with safe diving practice. In particular, great care regarding dive times should be taken at any sites below 10 m depth, especially when repetitive diving over several days is taking place. Careful adherence to conservative diving tables and/or dive computers is mandatory during all diving operations.

Fish abundance: The SSMs recommend a number of different underwater visual survey methods for reef fishes: Reef Check, Rapid Visual Counts, Stationary Point Counts, and Video Counts. They provide for rapid, broad scale assessments of reef fish status, detailed information on the population structure of a large number of key species, biodiversity assessments of regional fish fauna, and assessments of the impacts of aquarium fish collecting. Choice of method will depend on the reason that information is required, the use to which this information will be put and on technical and logistical capabilities.

The Reef Check 3D belt-transect (i.e. the record of fish during the survey carried out within a 5 m imaginary cube—2.5 m either side of the transect centre-line), as a quantitative assessment, was applied in the 2008 survey. The Reef Check survey methodology is designed to provide a rapid, broad scale assessment of the distribution and abundance of a number of fish species (Plate 1) known to be either indicators of reef health (for example chaetodontids) or susceptible to the effects of fishing (for example serranids and scarids). It is a rapid approach to surveys of reef fishes that can be undertaken with a minimum of training.

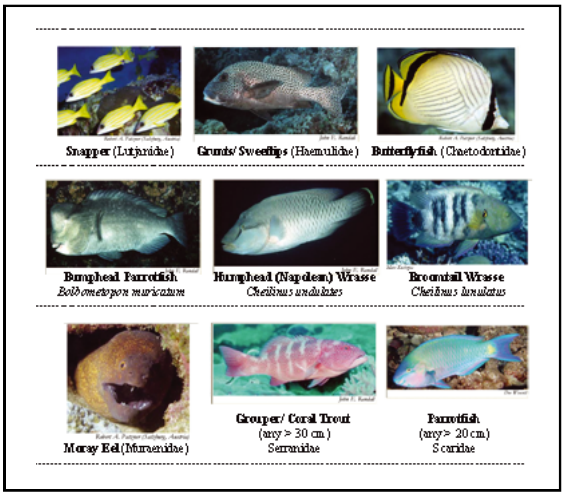


Plate 1: The fish indicator species assessed during the survey (after Reef Check, 2006).

The Reef Check methodology is included here because of its value in obtaining broad scale snapshots of the status of reef fish, and its potential to provide more frequent surveys of specific sites. The methodology has provided information on the global status of coral reefs and trends in reef status over recent years. It is worth mentioning that size minimums have been placed on two families of food fish (greater than 30 cm for grouper, and greater than 20 cm for parrotfish). Grouper and parrotfish smaller than these lengths are not counted. Given these limits and the magnifying effect of the water, divers should practice estimating size before attempting the fish surveys.

The fish belt transect surveys should be done at a standard time of day, for example between 9 a.m. and 10 a.m., to overcome any bias that could occur from differences in fish species behaviour. It is important to note the time you conduct the survey on the data sheet. After the transect has been deployed, the divers wait 15 minutes in a location away from the transect before starting the survey. This waiting period is necessary to allow fish to resume normal behaviour after being disturbed by the divers deploying the transect. The maximum height above the transect to record fish is restricted to 5 m in the water column. This can be estimated as two body lengths including outstretched arms and fins. Each diver assigned to count fish swims slowly along the transect counting the indicator fish. The diver stops every 5 m, and then waits one minute (as recommended in Reef Check, 2006) for indicator fish to come out of hiding before proceeding to the next 5 m stop point. The fish are counted while swimming and while stopped along the entire length of each 20 m transect and recorded on the under-water data sheet (Appendix 2).

This is a combined timed and area restricted survey: four segments 20 m long by 5 m wide = 400 m^2. Between each segment there are 5 m gaps where no data are collected. At each depth contour, there are sixteen “stop-and-count” points, and the goal is to complete the entire 400 m^2 belt transect in one hour.

A note should be made of any sightings of what are now becoming rare animals such as manta rays, sharks and turtles, but if these are off-transect records, they should be recorded at the bottom of the data sheet under “Comments”. It is recommended that the survey team should remember to include off-transect records of humphead-wrasse (Napoleon) and bumphead parrotfish as these species roam near reefs rather than being strictly resident species.

Sessile benthic cover: For the sessile benthic cover, the SSMs contain a tiered set of three standard quantitative methods for assessment: Reef Check line transects (Reef Check), Lifeform line transects (GCRMN), and video belt transects (AIMS). This set of methods provides a range of options in terms of logistic capacity and expertise, and the amount and detail of data collected. With increasing expertise, it is recommended that national teams progress from the simplest Reef Check method to the more complex and data-rich Lifeform and video belt methods.

The Reef Check point intercept line transect, as a quantitative assessment, was applied in the 2008 survey. This assessment records 10 categories of sessile benthos. Four 20 m line transects are laid parallel to the selected depth contours at two depths at each site. The depth ranges surveyed are 7–12 m and 2–6 m below the chart datum of low water (low tide mark or reef crest where no chart datum is available). Some sites may not be deep enough to survey both depths.

Surveys are conducted by SCUBA using a 100 m long transect tape laid along the selected depth contour from a haphazardly or randomly selected starting point on the reef slope, with the first 20 m transect starting from the beginning of the tape. The second transect starts after an interval of 5 m from the end of the first transect (i.e. start at 25 m) and similarly for the third (start at 50 m) and fourth transects (start at 75 m). Deep transects are surveyed first, in accordance with safe diving practice.

The 10 categories of benthos (substrate) recorded in transects are listed in the field data sheets (Appendix 2). On each transect, a point sampling method is employed where the substrate located under the transect tape at 50 cm intervals is recorded on a waterproof data sheet. This method provides a rapid means of acquiring quantitative estimates of percentage cover of the main structural components of the coral reef.

Invertebrate abundance: The SSMs recommend the Reef Check survey methodology for other benthos (other than the sessile benthos). The survey is designed to provide a rapid, broad scale assessment of the distribution and abundance of a number of invertebrate species (Plate 2) known to be either indicators of reef health (for example crown-of-thorns or pencil urchins) or susceptible to the effects of collecting (for example, giant clams and giant triton).

The abundance of selected benthic organisms is assessed in four belt transects 20 m long and 5 m wide (100 m^2) centred on the Reef Check line transects (2.5 m either side of the line) at each site. The organisms include: giant clams (*Tridacna* spp.), pencil urchins (*Heterocentrotus mammillatus*), long-spined urchins (*Diadema* spp.), sea cucumbers (edible species only), crown-of-thorns starfish (*Acanthaster planci*), giant triton (*Charonia tritonis*), banded coral shrimps (*Stenopus hispidus*) and lobsters.

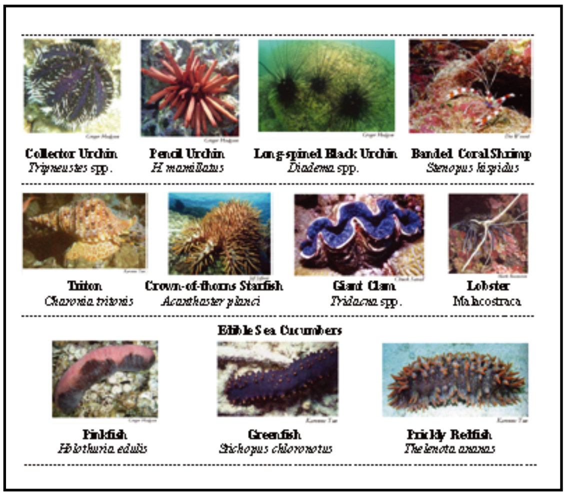


Plate 2: The invertebrate indicator species assessed during the survey (after Reef Check, 2006).

Each belt transect is 5 m wide (2.5 m on either side of the transect line). The total survey area is 20 m x 5 m = 100 m^2 for each segment and 400 m^2 for one complete transect of 4 segments for each depth contour, (800 m^2 per complete survey including the two depths). The invertebrate survey is similar to the fish survey; however, the diver does not need to stop every 5 m but each diver should swim slowly along the transect counting the invertebrate indicators, and record them on the underwater data sheet (Appendix 2).

It is best to adopt the face down, feet up position to ensure all parts of the transect are explored. It is extremely important to look in cracks and under large coral heads and overhangs to search for cryptic species such as lobster and banded coral shrimp. But do not pick up or move rocks or coral heads to look under them. It is recommended that one buddy records invertebrates on the left side of the transect while the second buddy surveys the right side. There are many other ways to perform this survey, each with its own advantages. It is very important to ensure that the team members are sufficiently prepared to identify the animals before surveys begin.

In addition: Each team records the level of bleaching and the presence of coral disease, trash and coral damage in the survey area. Corals that are still alive, but bleached should be recorded as live coral (HC) on the line transect. If bleaching is present, two estimates are made. First, teams estimate the percentage of all corals on the transect that are bleached. Second they estimate the mean percent of each individual colony that is bleached (Appendix 2). For example, the estimate might be 30 out of 100 corals (30%) along the transect are bleached but of the colonies bleached, the mean level of bleaching per colony is 80%. Coral disease is noted as present or absent and the type of coral disease should be noted in the comment box (if identified) on the data sheet. Note that many diseases are difficult to identify without a high level of training. All cases of suspected coral disease should be compared with the Reef Check ID cards and confirmed by the team scientist. A photo should be taken if possible.

Data about trash is separated (in the data sheet) into general and fish nets/traps, while coral damage is separated into boat/anchor, dynamite, and other (Appendix 2). Damage and trash should be rated as follows: None = 0; one piece/damage per transect of any type is Low = 1; two to four pieces/damage per transect is Medium = 2; and more than four pieces/damage is High = 3.

5. RSGA CORAL REEF MONITORING SURVEY: 2008

5.1 VERIFICATION OF THE WORK DONE

The full Reef Check survey protocol (i.e. for benthic cover, invertebrate and fish abundances) was applied in the 2008 regional monitoring survey (April 2008 to January 2009). It is not yet appropriate to apply the more complex survey methodologies given in the SSMs at a regional scale, especially for the sessile benthic cover and fish census, due to constraints related to the variability in the experience of the national teams.

As is now clearly apparent, the Reef Check method has proved its validity as a simple monitoring protocol, robust enough that results are able to detect ecologically and statistically significant changes to coral reefs caused by human activities (www.reefcheck.org). A set of biological indicators was chosen, each to serve as an indicator of a specific type of anthropogenic impact, and collectively as a proxy for ecosystem health. Table 1 lists these indicator species and the ecological changes they detect both at the regional and global scale. These organisms were chosen both for their ecological and economic value, and together to provide an eco-holistic representation of key coral reef fish, invertebrates and plants.

Some countries in the Region and some of the selected reef areas are not yet popular as dive-tourism destinations, so data supply through Reef Check volunteer work cannot be achieved solely from community-based activities throughout the whole Region. Accordingly, regional monitoring tasks have to be carried out through the official national agencies and their mandates in cooperation with PERSGA, using the most applicable survey methodology.

The following points deserve emphasis:

- There is no regular flow of data available from all countries for regional assessments as most PERSGA member states lack a regular, national monitoring programme. Egypt and Jordan carry out regular surveys, the former using more advanced techniques.
- National team members are also responsible for other tasks which can affect the implementation of a regular, synchronized, regional monitoring programme.
- There is considerable variation in the level of experience in diving and underwater survey techniques within and across national teams.

All of these factors have to be considered when preparing a long-term regional monitoring programme and choosing the survey methodology.

Site selection was done taking into consideration the national teams' capabilities and the funding available to continue the monitoring on a long-term, regular basis. Sites were chosen to be visited and re-surveyed with minimum logistics taking into consideration the SSMs and Reef Check site specifications for long-term monitoring sites. The number of sites chosen (36 sites within the RSGA region, with the lowest number in Jordan at 3-sites and highest number of 9-sites in Saudi Arabia) is acceptable to give data for monitoring coral reef status at the regional scale, but more fixed sites in each country will need to be

Table 1: The chosen species as ecological indicators for: overfishing (OF), blast fishing (BF), poison fishing (PF), aquarium fish collecting (AF), nutrient pollution (NP), and curio collection (CC); (after Reef Check, 2006).

Scale	Indicator Organism	Indicator for					
		OF	BF	PF	AF	NP	CC
GLOBAL	Banded coral shrimp (*Stenopus hispidus*)				X		
	Butterflyfish (*Chaetodon* spp.)	X		X	X		
	Crown-of thorns-starfish (*Acanthaster planci*)	X					
	Fleshy algae					X	
	Grouper (>30 cm) (Serranidae)	X	X	X			
	Hard coral		X	X		X	
	Lobster	X					
	Long-spined black sea urchins (*Diadema* spp.)	X				X	
	Moray eel (Muraenidae)	X			X		
	Parrotfish (>20 cm) (Scaridae)	X	X	X	X		
	Pencil urchin						X
	Recently killed coral		X	X		X	
	Snapper (Lutjanidae)	X	X				
	Sponge					X	
	Sweetlips (Haemulidae)	X	X	X	X		
	Triton (*Charonia* spp.)	X					X
RSGA Region	Broomtail Wrasse (*Cheilinus lunulatus*)	X	X	X	X		
	Bumphead parrotfish (*Bolbometopon muricatum*)	X	X	X	X		
	Giant clams (*Tridacna* spp.)	X					X
	Humphead wrasse (*Cheilinus undulatus*)	X	X	X	X		
	Sea cucumber (*Thelenota ananas, Stichopus chloronotus, Holothuria edulis*)	X					

surveyed and monitored if coral reef status has to be assessed at the national scale. For more details on long-term monitoring see Reef Check Survey Manual and PERSGA SSM (Reef Check, 2006; PERSGA/GEF, 2004).

Regardless of these considerations, some countries (Djibouti, Yemen, and Saudi Arabia) do not have the necessary manpower to continue to carry-out the monitoring tasks regularly with their current capacity, so PERSGA support will be needed; this was considered during 2008 when selecting the minimum representative number of sites and locations in each country, and has been considered in PERSGA's agenda for future monitoring activities. Adding extra sites, or increasing the number of replicate transects at each depth zone is advantageous and should be considered if the opportunity becomes available; however the present sites should be considered as the basic/core regional monitoring sites for all future surveys.

During the 2008 survey, detailed mapping of the exact location of each site/reef was carried out with the aid of Google-Earth images, GPS, in-situ photographs, and Admiralty Charts. These location data were checked (fine-tuned) directly after field visits to each site. The ability to re-locate each survey site using this mapping-data was verified during the survey period in consultation with the national team members.

This ability to accurately find the survey site location was developed because permanent transect marks are not applicable in most of the reefs visited. Divers or fishermen tend to remove or manipulate the transect marks. Secondly, searching underwater for permanent markers is time-consuming, especially for new divers and there is a high probability that the members of the survey team will change with time.

During the 2008 regional monitoring survey, refreshment on Reef Check methodology for the experienced work-team members, as well as training for the new team members was done as on-the-job-training. Appendix 1 gives details on the level of experience of individual team members. This initial training was essential to ensure that all team members were familiar with the methodology and the identification of the different categories of fauna and flora, and were therefore able to collect high quality data. Dive-skill training was included to raise the competency level of some of the team members.

5.2 LOGISTICS FOR FIELDWORK

The regional monitoring survey of 2008 was carried out as a cooperative work-plan between PERSGA and the national authorities in charge of environmental affairs. The national authorities are: in Djibouti, Ministère de l'Habitat, de l'Urbanisme, de l'Environnement et de l'Aménagement du Territoire (MHUEAT); in Egypt, Ministry of Environment (specifically EEAA); in Jordan, Aqaba Special Economic Zone Authority (ASEZA); in Saudi Arabia, Presidency of Meteorology and Environment (PME); in Sudan, Higher Council for Environment and Natural Resources (HCENR); and in Yemen, Environment Protection Authority (EPA).

The core budget for the logistics of the field-work was raised by PERSGA and complemented with in-kind participation from the national focal authorities in each respective country. In addition, 34 national experts (most of them who had previously gained training through PERSGA) were nominated to cooperate and participate in the field-work in their respective countries with the PERSGA core team (Appendix 1).

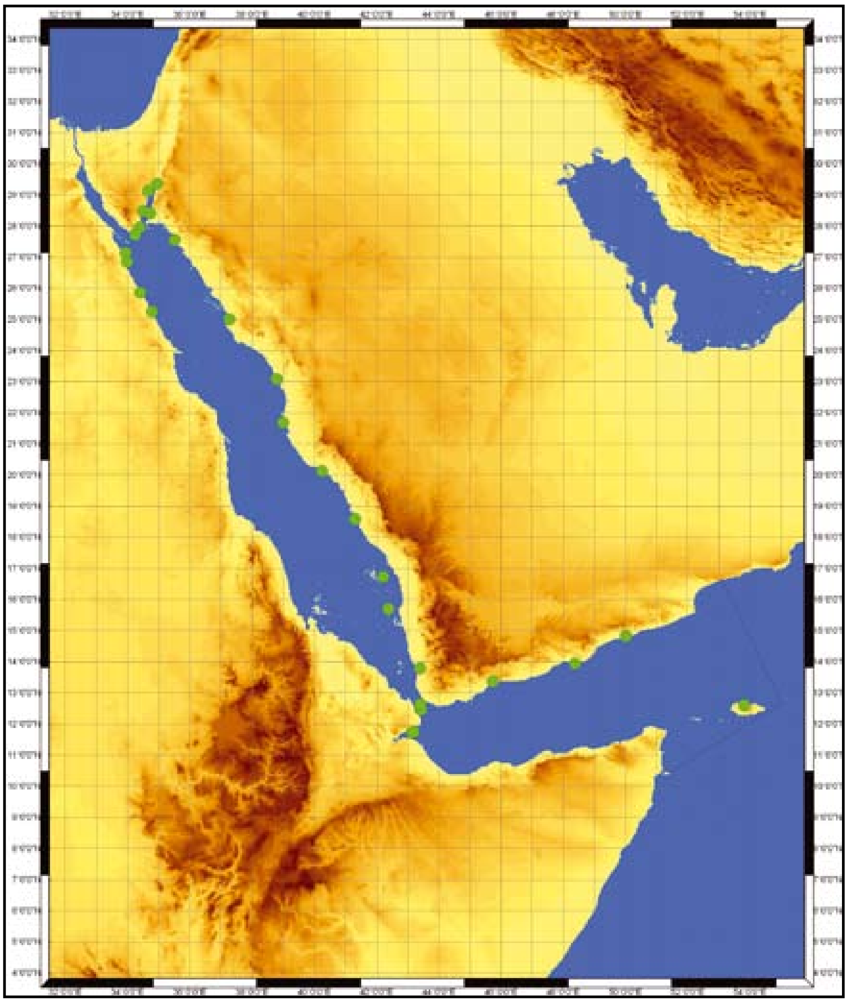
5.3 REGIONAL NETWORK OF CORAL REEF MONITORING SITES

Coral reef monitoring has been taking place within the Region, but it has been limited primarily by the available technical expertise and finance. To ensure appropriate regional coverage and representativeness in the future it was agreed, prior to the 2008 surveys, to establish a set of permanent coral reef survey sites to form a regional network.

In consultation with all the national team members a total of 36 reef sites were chosen to form the permanent regional monitoring network. The sites were chosen using previously discussed criteria such as representativeness, ease of location, logistics for re-surveys, suitability for diving, national team capacities and the necessary site-criteria specified in the SSM (see section on site selection).

The 36 reef sites chosen include: 5 sites in Djibouti, 8 sites in Egypt, 3 sites in Jordan, 9 sites in Saudi Arabia, 4 sites in Sudan, and 7 sites in Yemen. The coordinates and full details of the regional monitoring sites (RMS) are given in Appendix 3 and locations are shown in Map 2. An attempt was made to correlate the length of the coastline in each country with the number of sites chosen (e.g., 3 sites in Jordan which has the shortest coastline and 9 sites in Saudi Arabia which has the longest).

It is important to emphasise that these sites will be the core sites which should be re-surveyed throughout long-term future monitoring. If there is a chance later to increase the number of sites, it should be done logically in accordance with the presented criteria, considering the national capabilities and appropriate regional distribution.



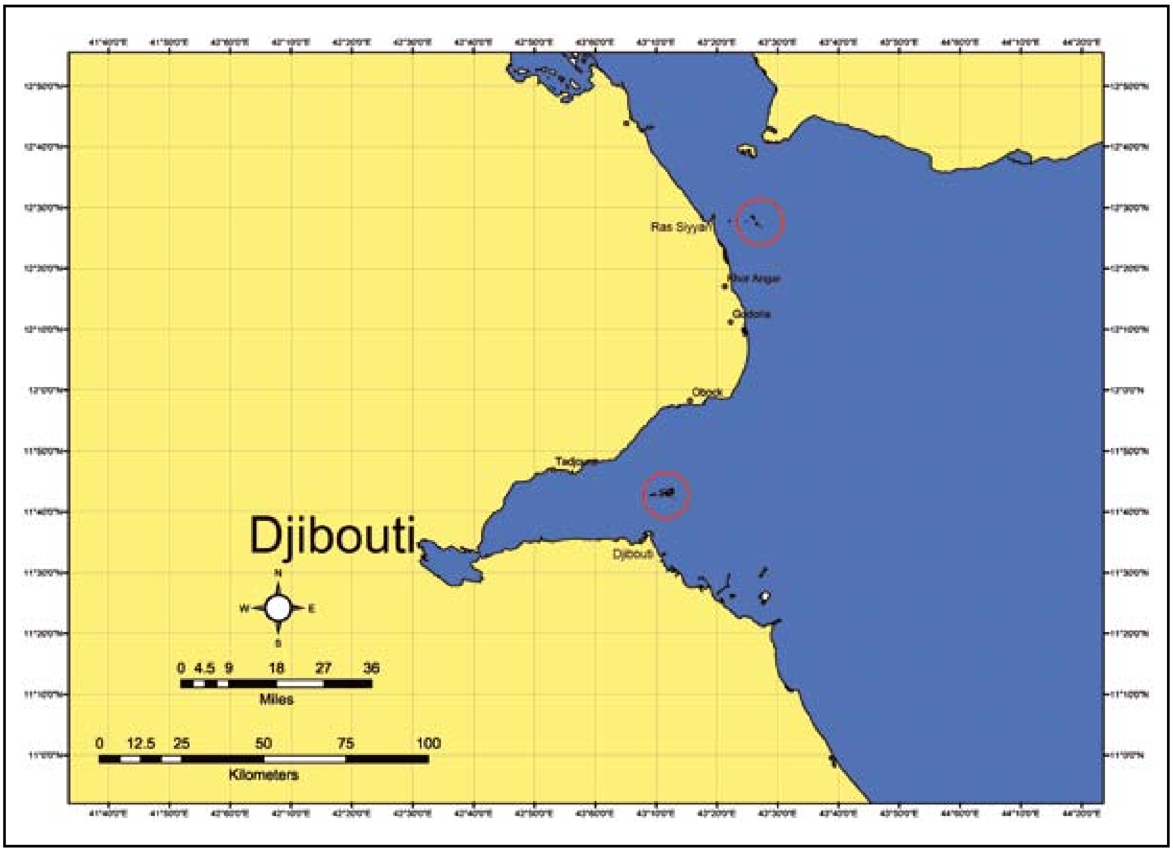
Map 2: Locations of the survey sites for the permanent regional coral reef monitoring network (indicated by green dots). Sites chosen and surveyed during 2008.

5.4 DATA COLLECTED ACCORDING TO COUNTRIES

A) Djibouti

Djibouti has a coastline of 372 km. The north coast is generally shallow and sandy with occasional coral outcrops, with good coral formation around Sept Frères (Seven Brothers Islands). The southern coast is shallow with poorly developed coral reefs, linked to the cold water upwelling from the Indian Ocean. The Gulf of Tadjoura harbours a few coral reef formations but it suffers from many sources of impact such as maritime transport, port related activities, and other anthropogenic coastal pressures that have caused deterioration and difficultly for conservation efforts. At the entrance of the bay, Moucha and Maskali Islands have had relatively good reefs which incorporate many coral and coral reef fish species and there are a few popular diving sites. Hence for long-term monitoring purposes, the reef sites chosen in Djibouti were at Moucha, Maskali, and Seven Brothers Islands.

Five sites were surveyed in 2008. Appendix 3 and Map 3 show the locations of these sites off the coast of Djibouti. Table 2 gives the depths surveyed at each site. Google satellite images for the exact site locations and the reef profile for each survey site are given in Appendix 4.



Map 3: The locations of the reef sites in Djibouti indicated by red circles.

Table 2: The depths surveyed at each reef site in Djibouti.

Country	City / Island	Site Name	5 m Depth	10 m Depth
Djibouti	Maskali Island	Light house	Done	Done
	Maskali Island	Canyon	Done	Done
	Moucha Islands	Grand Recif (Great Reef)	-	Done
	7-Brothers Islands	Grande Ile	Done	-
	7-Brothers Islands	Ile de l'Est	-	Done

Appendix 10 presents the data collected from Djiboutian reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

B) Egypt

Egypt has more than 1,800 km of diverse coral reef habitats along the western Red Sea coast and in the Gulfs of Suez and Aqaba. The Egyptian Red Sea coast harbours many international diving destinations famous for their unique and diverse marine habitats. Therefore, tourist activities have led to very high human pressure on marine life along the Egyptian side of the Red Sea. The reefs are under stress from a number of activities including recreational SCUBA diving, oil spills, land reclamation and sedimentation. Egyptian authorities have enacted a number of laws and presidential decrees through which coral reefs receive direct or indirect protection.

Eight sites were surveyed in 2008 to represent the Egyptian reefs; 3 reef sites in the Gulf of Aqaba and 5 sites on the northern and central Egyptian Red Sea reefs (Appendix 3). Table 3 gives the depths surveyed at each site. Google satellite images show the exact site locations and are given in Appendix 5 together with the reef profile for each site. Map 4 presents the locations of these sites along the Egyptian Red Sea coast.

Table 3: The depths surveyed at each site in Egypt.

Country	City / Island	Site Name	5 m Depth	10 m Depth
Egypt	Nuweiba	Ras Shetan	Done	-
	Dahab	Island	Done	-
	Sharm El-Sheikh	Ras Nosrani	Done	Done
	Sharm El-Sheikh	Ras Mohammed	Done	Done
	Hurghada	Gotta Abu Ramada	Done	Done
	Safaga	Ras Abou Soma	Done	Done
	Qusier	Marsa Wizr	Done	Done
	Marsa Alam	Marsa Shaqraa	Done	Done

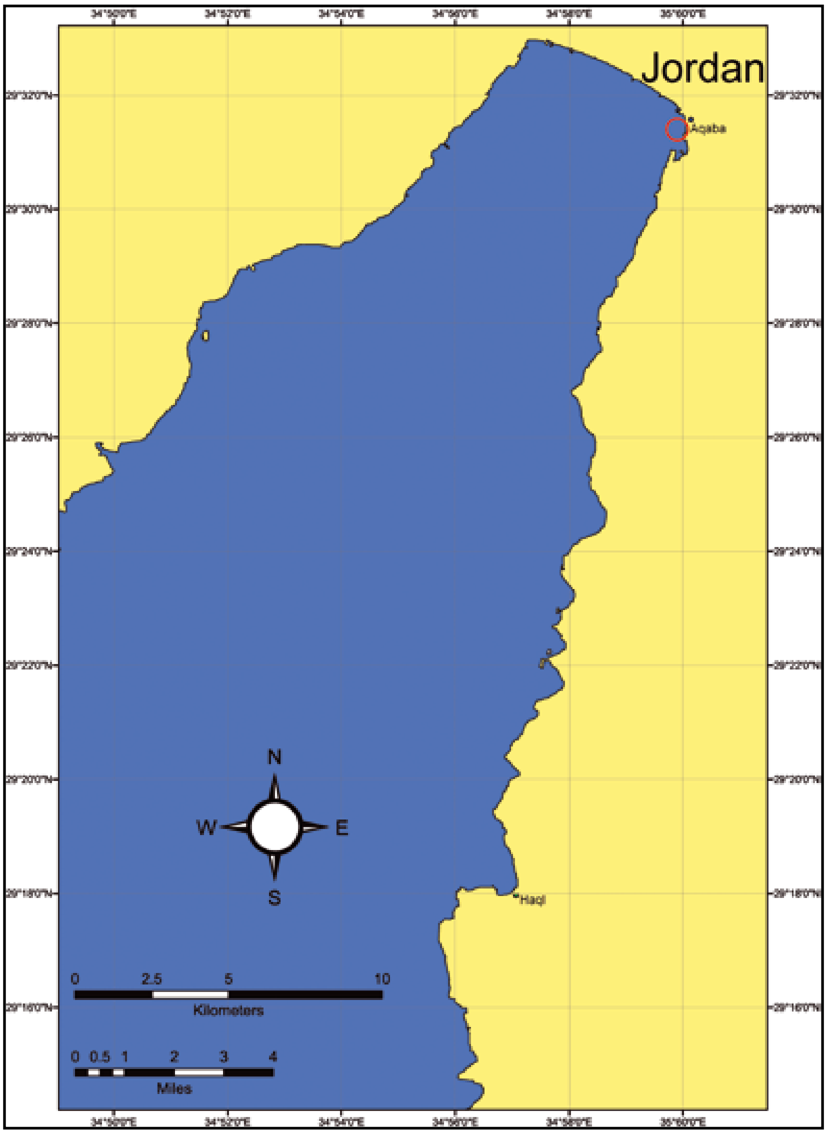
Map 4: The locations of the reef sites in Egypt indicated by red circles.

Appendix 10 presents the data collected from Egyptian reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

C) Jordan

The Jordanian coastline extends approximately 27 km along the north eastern reaches of the Gulf of Aqaba. Approximately 30% of the coast is used for the port. A fringing reef borders up to 50% of the coast and supports a high diversity of coral and associated fauna. The very northern part of the coastline is occupied by tourism development, while the central part is occupied with marina and port activities. The southern part of the coast is the only part protected, through the Aqaba Marine Park where fringing reefs occur and almost 70–80% of Aqaba city recreational activities take place.

Accordingly, it was necessary to allocate the monitoring sites in the vicinity of the Aqaba Marine Park. Three sites were surveyed in 2008 to represent the Jordanian reefs (Appendix 3). Map 5 shows the locations of these sites on the Aqaba coast and Table 4 gives the depths surveyed at each site. Google satellite images for the exact site locations are given in Appendix 6 as well as the reef profile for each site.



Map 5: The locations of the reef sites in Jordan indicated by the red circle.

Table 4: The depths surveyed at each site in Jordan.

Country	City / Island	Site Name	5 m Depth	10 m Depth
Jordan	Aqaba	First Bay	Done	Done
		Japanese Garden	Done	Done
		Aquarium	Done	Done

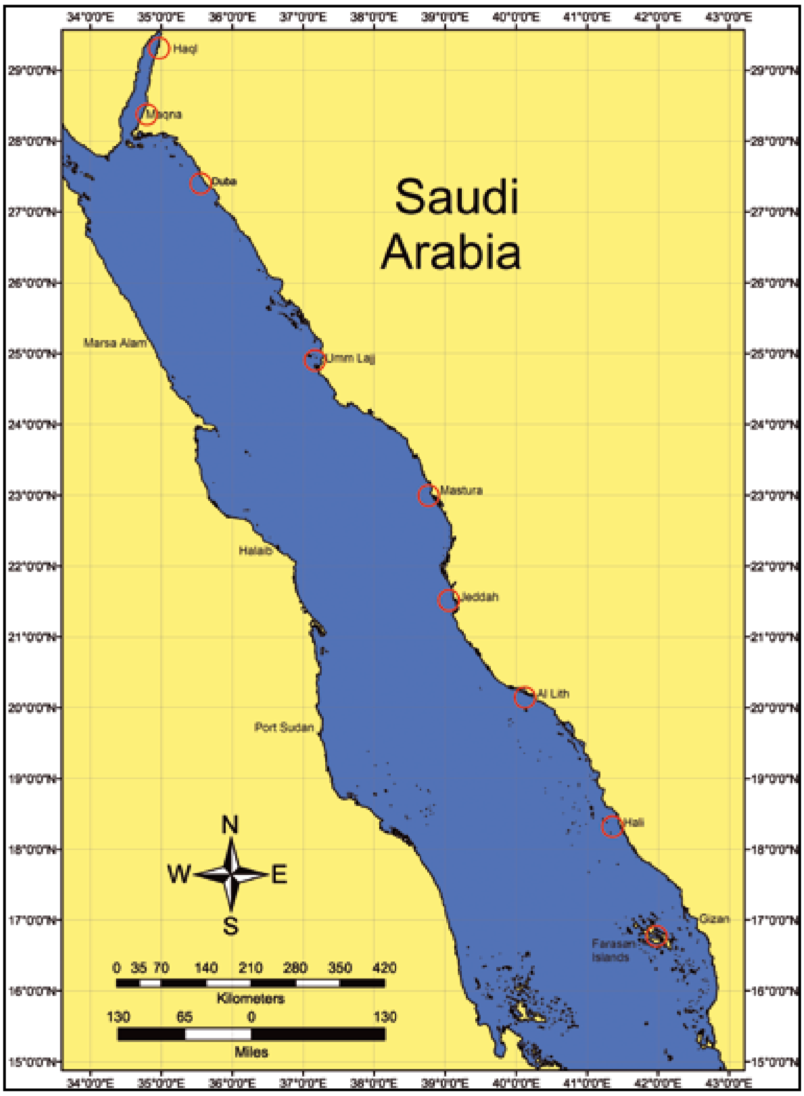
Appendix 10 presents the data collected from Jordanian reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

D) Saudi Arabia

Saudi Arabia's Red Sea coastline extends approximately 1,840 km, with some areas suffering severe impacts from human development. Coral reefs are found fringing most of the Saudi Arabian Red Sea coastline

Table 5: The depths surveyed at each site on the Saudi Arabian Red Sea.

Country	City / Island	Site Name	5 m Depth	10 m Depth
Saudi Arabia	Haql	---------------	Done	Done
	Maqna	---------------	Done	Done
	Duba	---------------	Done	Done
	Umm Lajj	---------------	Done	-
	Mastura	---------------	Done	Done
	Jeddah	Cournish	Done	Done
	Al Lith	---------------	Done	Done
	Assir	Hali	Done	-
	Farasan	Zfaf	Done	Done



Map 6: The locations of the reef sites in Saudi Arabia indicated by red circles.

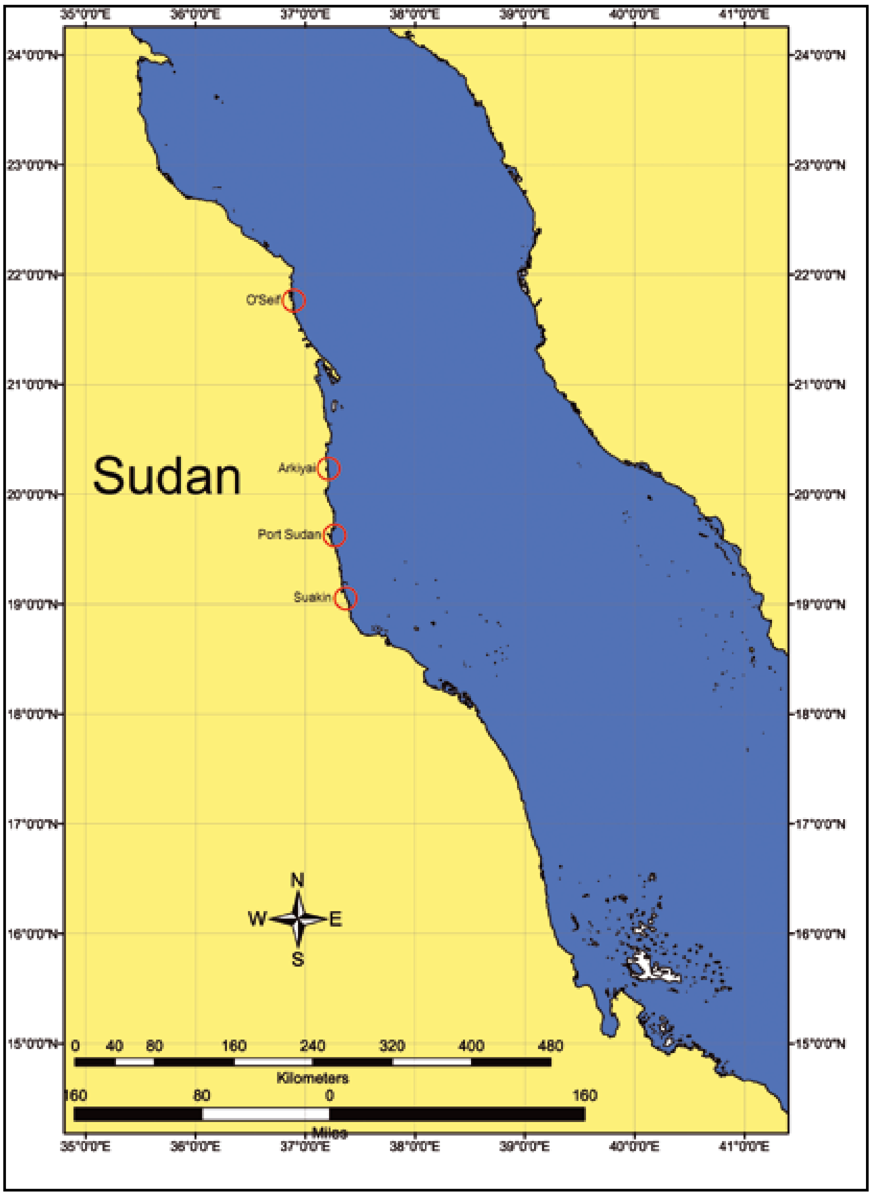
and offshore islands, and are generally in a good condition with the exception of those near the major cities of Jeddah and Yanbu.

The long Saudi coastline is difficult to survey intensively; therefore a suitable number of reef sites were chosen to become the long-term monitoring sites for Saudi Arabian Red Sea reefs. There are 9 sites: 2 on the Gulf of Aqaba reefs and 7 on the northern and central Red Sea reefs (Appendix 3). Map 6 shows the locations of the sites along the Red Sea coast and Table 5 gives the depths surveyed at each site. Google satellite images for the exact site locations, as well as the reef profile at each site are given in Appendix 7.

Appendix 10 presents the data collected from Saudi Arabian reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

E) Sudan

The Sudanese Red Sea coast is approximately 750 km long inclusive of bays and sharms, and encompasses three primary coral reef formations: barrier reefs, fringing reefs, and an atoll (Sanganeb Atoll).



Map 7: The locations of the reef sites in Sudan indicated by red circles.

Table 6: The depths surveyed at each site in Sudan.

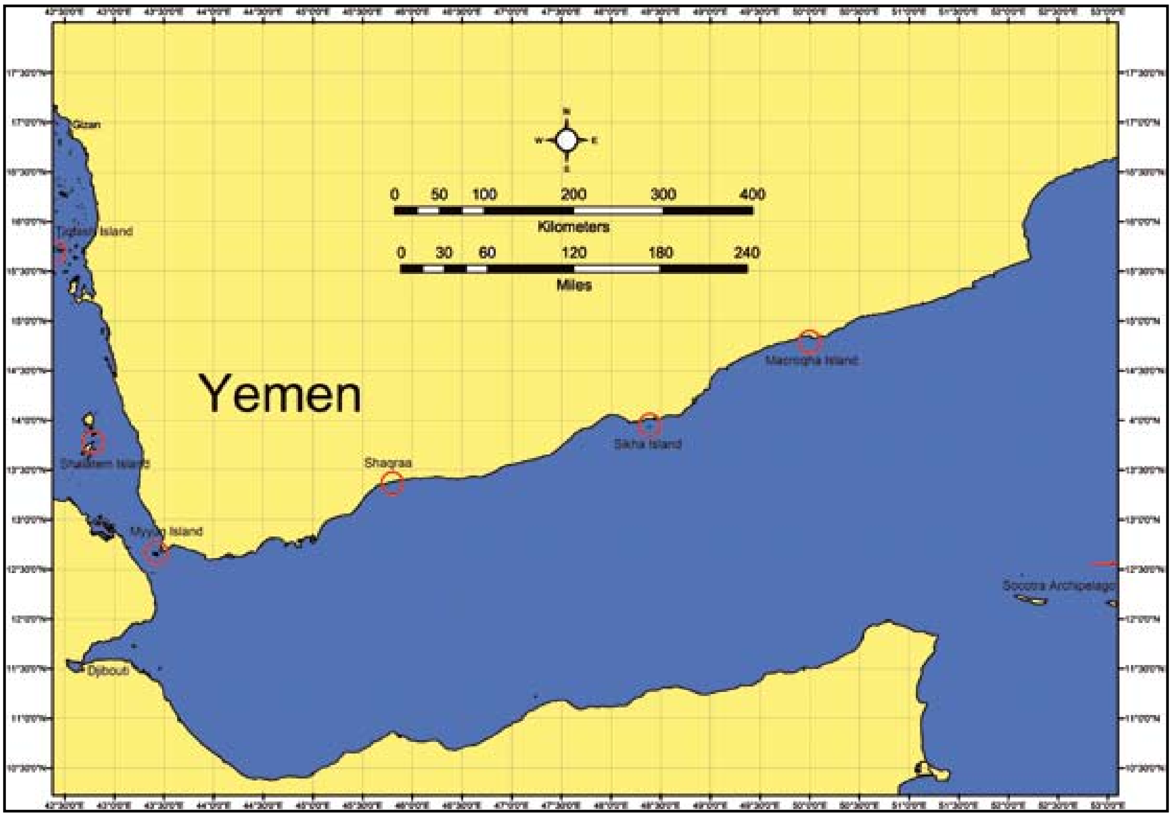
Country	City / Island	Site Name	5 m Depth	10 m Depth
Sudan	O'Seif	---------------	Done	Done
	Arkiyai	---------------	Done	Done
	Port-Sudan	Abou Hashish	Done	Done
	Suakin	---------------	Done	Done

Four sites were surveyed in 2008 to represent the Sudanese reefs (Appendix 3). Map 7 shows the locations of these sites and Table 6 gives the depths surveyed at each site. Google satellite images for the exact site locations are given in Appendix 8 as well as the reef profile at each site.

Appendix 10 presents the data collected from Sudanese reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

F) Yemen

The Republic of Yemen lies in the south-western corner of the Arabian Peninsula, and includes the Socotra Archipelago. The coastline is about 2,200 km long, roughly one third of which is in the Red Sea and the remaining two thirds in the Gulf of Aden. In the Red Sea, Yemeni reefs are found as interrupted fringing reefs along the coast while good healthy reefs surround the many offshore islands. In the Gulf of Aden few reefs are found along the coast except around the islands in the north east in the Belhaf Bir Ali area, and at Makhroqa Island.



Map 8: The locations of the survey sites in Yemen indicated by red circles.

Table 7: The depths surveyed at each site in Yemen.

Country	City / Island	Site Name	5 m Depth	10 m Depth
Yemen	Tiqfash Island	---------------	Done	Done
	Shalatem Island	--------------	Done	Done
	Myyun Island	--------------	Done	Done
	Shaqraa coast	--------------	Done	-
	Sikha Island	--------------	Done	Done
	Macroqha Island	--------------	Done	-
	Socotra Island	Roosh-Halah	Done	Done

The sandy bottom habitats around most of the Yemeni Gulf of Aden coast were investigated and one site is included, i.e. Shaqraa coastal site. Six reef sites were selected to represent Yemeni reefs. One site is on the Socotra Archipelago (Roosh-Halah), two sites in the Gulf of Aden (Macroqha Island and Sikha Island) and three sites in the Red Sea (Tiqfash Island, Shalatem Island and Myyun Island), see Appendix 3. For long-term monitoring purposes all the sites for the survey were chosen at offshore islands because of the intense human pressure, lack of fringing reefs, and the weak protection practices at mainland coastal sites. Map 8 shows the locations of the sites along the Yemeni coast, and Table 7 gives the depths surveyed at each site. Google satellite images showing the exact site locations, and the reef profile at each site, are given in Appendix 9.

Appendix 10 presents the data collected from Yemeni reef sites in more detail. This data includes: substrate percentage cover and averages; invertebrate abundances and averages; fish abundance and averages; and the physical conditions and levels of impact.

5.5 SPATIAL AND TEMPORAL ENVIRONMENTAL CHANGES

In order to detect spatial differences within the RSGA region, the data from the 2008 survey were compiled, analysed and compared between the different countries (Appendix 10). To detect temporal changes, two sets of data were used—the 2002 survey data and the 2008 survey data. The data set gathered during the previous regional survey (2002) was reviewed and standardised to make it comparable with the 2008 data set. This step was essential as the data sheet of Reef Check (as the adopted monitoring methodology by PERSGA) was modified in 2006 with some indicator species changing and methods of data analysis and interpretation modified. The adjusted 2002 survey data which were used for this comparison are given in Appendix 11. Furthermore and for the purpose of

Table 8: The number of sites surveyed in the 2002 and 2008 regional surveys.

Countries	2002 Survey	2008 Survey
Djibouti	7	5
Egypt	13	8
Jordan	3	3
Saudi Arabia	18	9
Sudan	6	4
Yemen	5	7
TOTAL	52	36

comparisons, data from all respective depths and sites in each country were compiled to calculate means and standard deviations (±SD).

There were 52 sites surveyed during 2002, and 36 sites surveyed during 2008. Country sites were grouped together to detect the spatial and temporal changes in the marine environment. Table 8 presents the number of sites surveyed.

There are wide differences in the numbers of sites surveyed in some countries, notably Egypt and Saudi Arabia. The reduction in the number of sites is due to the approach taken for the 2008 survey, where the number and location of sites chosen was based on the sustainability of long-term monitoring logistics. In addition, some of the sites surveyed in 2008 differed from those used during 2002 for the same reason. A list comparing the sites surveyed during 2002 and 2008 is given in Appendix 12. The largest change in the location of the sites surveyed took place in Djibouti, where most of the sites surveyed during 2002 were inside Tadjoura Bay, while the sites surveyed in 2008 were along the reefs off the Djiboutian coast outside the Bay. The decision to avoid surveying sites within Tadjoura Bay was taken in consultation with national team members and is due to the rapid coastal development taking place inside the Bay. Unfortunately, this coastal development accompanied with lack of conservation measures has made rapid changes to the marine environment which will reduce the effectiveness of long-term monitoring in this location.

The Reef Check methodology is designed to provide data that indicates changes taking place on coral reefs that are primarily due to human impacts. Data interpretation will deal with the indicators of: overfishing, curio trade, diving and snorkelling, boat anchoring, nutrient pollution, aquarium fish collecting, as well as evidence of coral bleaching, coral degradation, and crown-of-thorns starfish outbreaks.

A one-way ANOVA test was performed for the abundance/coverage of each indicator using data compiled for the different countries, to detect any regionally significant differences ($p = 0.05$) between the data of 2002 and 2008. Recognizing temporal changes, either in the Region as a whole or for each country individually, can assist PERSGA and the national authorities to evaluate the effectiveness of their environmental protection activities and potentially demonstrate the need for further conservation measures.

However, at this stage, an analysis to detect significant differences over time within each country using a one-way ANOVA test is not possible due to the differences in the number and locations of the surveyed sites during the 2002 and 2008 surveys. This situation will change if all the sites surveyed in 2008 are used for future monitoring—one of the objectives of a permanent regional set of coral reef monitoring sites.

In the next section a rationale is given for the choice of each indicator, followed by a presentation of the results and their interpretation. A comparison with similar data for the Indo-Pacific region is presented whenever available, taken from Reef Check annual reports.

A) Butterflyfish

Butterflyfish of the family Chaetodontidae were selected as indicators of the ornamental fish trade at the global scale, and as indicators of overfishing by local coastal fishermen in the RSGA region. These fish species are caught in the nets of local fishermen not for their value but as by-catch along with

commercial fish species from the reef, and are discarded.

During the two monitoring surveys 2002 and 2008, butterflyfish were recorded at all the reefs surveyed, with a slight increase in the mean abundance for the whole Region during 2008 (average: 6.8 ± 1.5 butterfly fish/100 m^2 reef) over 2002 (average: 6.1 ± 2.0 butterfly fish/100 m^2 reef). Temporal comparison within each country revealed similar patterns of abundance in 2002 and 2008 (Figure 1), except for Saudi Arabia. Data from Jordan was missing for the 2002 survey.

Abundance data recorded in both the 2002 and 2008 surveys were lower for the RSGA region than results recorded for the Indo-Pacific region during 1997-2001 (10.0 ± 10.0 butterflyfish/100 m^2 reef; Hodgson and Liebeler, 2002), and for Indonesian reefs during 1997-2006 (minimum average of 18 butterflyfish/100 m^2 reef; Habibi et al., 2007).

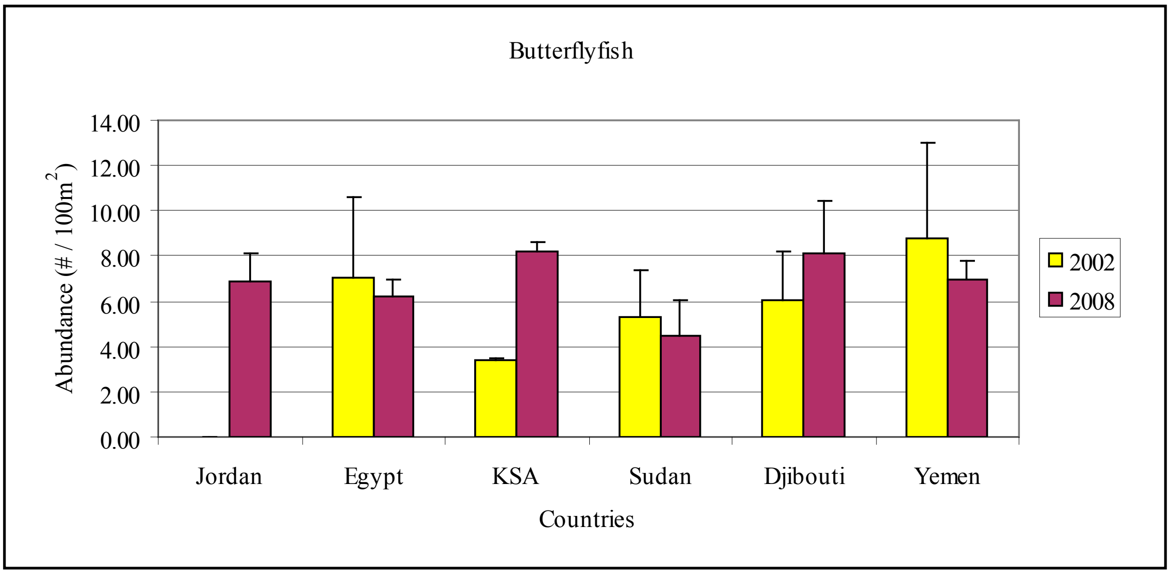


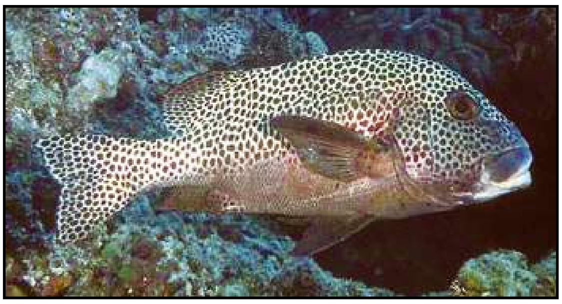
Figure 1: Mean abundance of butterflyfish per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

B) Haemulidae (sweetlips)

This fish species is chosen as an indicator of reef health because it is a popular food fish, targeted by line fishing and spear-fishing.

Similar abundance of sweetlips was recorded for the whole Region in 2002 (2.13 ± 2.95 fish/100 m^2 reef) and in 2008 (2.11 ± 2.01 fish/100 m^2 reef). Temporal changes within each country were low (Figure 2), except data from Djibouti which shows higher abundance in 2008 than in 2002, and Yemen which showed the opposite trend. In Djibouti, this difference might be due to the change in the sites surveyed. At the 2008 survey sites outside Tadjoura Bay the reefs are in a better condition than those inside the Bay.

Abundance levels of sweetlips during 2002 and 2008 were found to be higher in the RSGA region than those recorded by Hodgson and Liebeler (2002) for the Indo-Pacific region during 1997-2001 (average



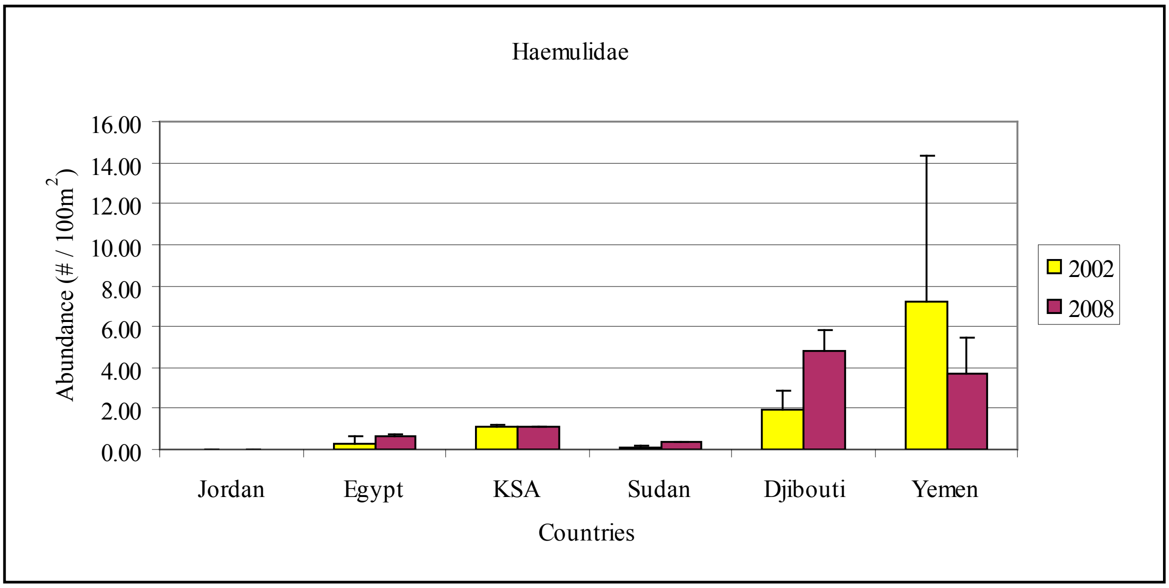


Figure 2: Mean abundance of Haemulidae per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

< 1 fish/100 m^2 reef), but lower than the recorded abundance for Indonesian reefs given by Habibi et al. (2007) for the period 1997-2006 (average of 4 fish/100 m^2 reef).

C) Grouper

Grouper of any species with a length greater than 30 cm were selected to serve as an indicator for overfishing of all types. Grouper are some of the easiest fish for divers to spear because of their size and territorial habits. Grouper also aggregate during spawning, making them vulnerable to many forms of fishing. Grouper are fished using spears, nets, hook and line. The latter is the most popular fishing method used by local and sport fishermen in the RSGA region. Grouper larger than 30 cm are a very useful indicator of fishing pressure

because they are one of the higher priced food fish and most easily fished out due to their reproductive traits. Grouper may take several years to reach sexual maturity and typically change sex. Fisheries that remove large individuals can easily wipe out all sexually mature fish.

Abundance of groupers for the whole Region was slightly higher in 2002 (0.77 ± 0.37 fish/100 m^2 reef) than in 2008 (0.71 ± 0.24 fish/100 m^2 reef). Temporal changes within each country were low (Figure 3), with the highest grouper abundance recorded in Saudi Arabia (KSA). This could be due to the large areas of coastal reefs with low coastal populations. Most fishing effort takes place close to urban areas such as Jeddah and Farasan. This leaves reefs over large areas of Saudi Arabia with low impact from local and sport fishermen, the primary source of pressure on grouper numbers.

Abundances of grouper in the RSGA region recorded during the 2002 and 2008 surveys were higher than those recorded for the Indo-Pacific region NOT including the Red Sea during 1997-2001 (average 0.45 ± 0.98 fish/100 m^2 reef; Hodgson and Liebeler, 2002), but lower than the recorded abundance from Red Sea reefs for the same period (average: 1.15 ± 1.3 fish/100 m^2 reef;

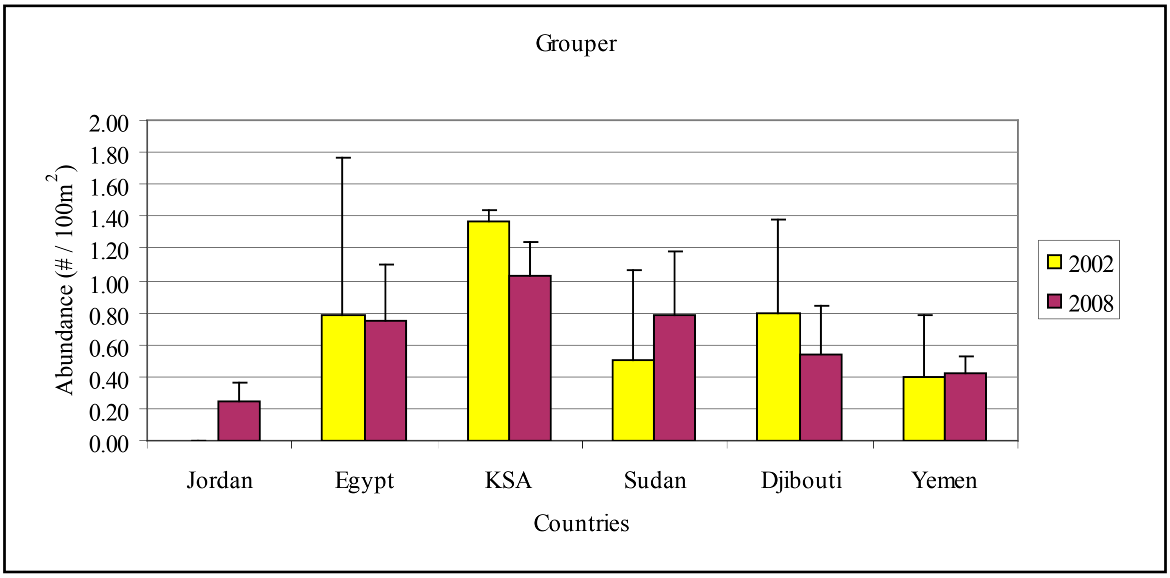


Figure 3: Mean abundance of grouper per 100 m² recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

Hodgson and Liebeler, 2002), and lower than recorded from Indonesian reefs during 1997-2006 (average 2 fish/100 m² reef; Habibi et al., 2007).

D) Snapper

Snapper were selected as a reef health indicator because of their importance as a food fish that is fished by nets from the area close to reefs.

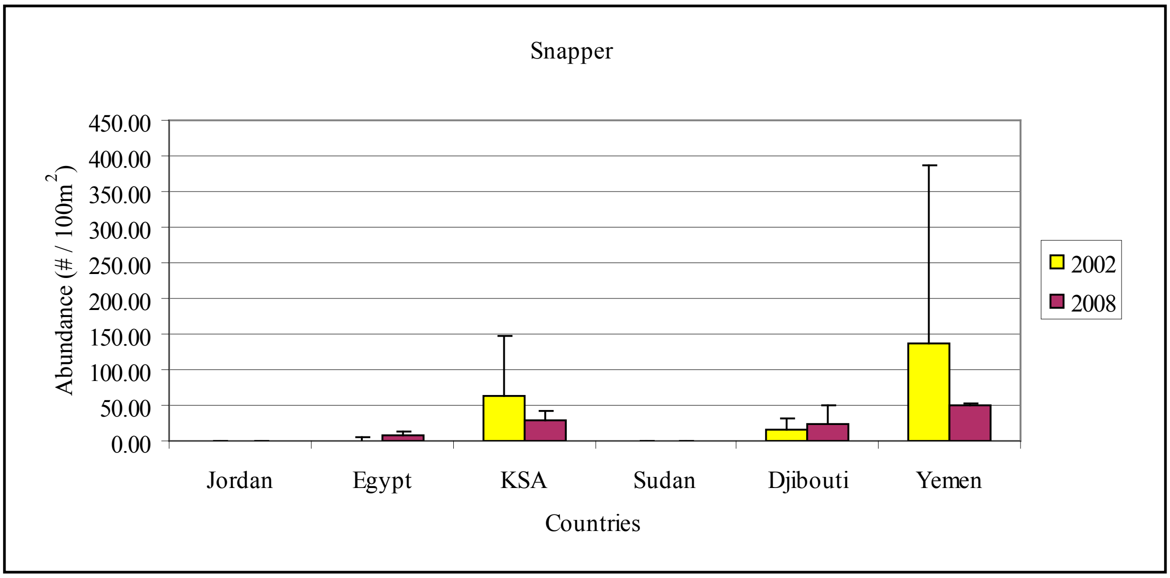


Figure 4: Mean abundance of snappers per 100 m² recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

Average snapper abundance for the whole Region showed a sharp decrease in 2008 (22.4 ± 19.34 fish/100 m^2 reef) from 2002 (43.58 ± 58.02 fish/100 m^2 reef). Comparison of temporal abundances within each country (Figure 4) showed that Yemeni snappers decreased dramatically in the 2008 survey and this might reflect the impact of overfishing on the reefs.

Snappers in the RSGA region showed much higher abundances during 2002 and 2008 surveys than were recorded for the Indo-Pacific region during 1997-2001 (average 1.7 ± 5.2 fish/100 m^2 reef; Hodgson and Liebeler, 2002), as well as for Indonesian reefs during 1997-2006 (average 7 fish/100 m^2 reef; Habibi et al., 2007). The sharp decline in the abundance of snapper in 2008 over levels found in 2002 might reflect an increase in fishing pressure, especially fishing by nets close to the reef areas and could indicate imminent overfishing.

E) Parrotfish

Parrotfish were selected as an indicator of overfishing of various kinds. The different parrotfish species play a critical role in the ecological balance of a coral reef because they are the largest herbivorous reef fish and they scrape large quantities of turf algae

from the reef, ingesting live and dead coral, and creating sand in the process. Without parrotfish, algae would have an advantage in the competition for space with coral. Parrotfish are easily caught using nets, spears, and traps. They form a significant part of the reef fish biomass. When reefs are subject to heavy fishing, the normal pattern is for predators to be fished out first, followed by the herbivores such as the parrotfish (Munro, 1983; Koslow et al., 1988).

For the Region as a whole, parrotfish showed similar average abundances in the 2002 (2.34 ± 0.94 fish/100 m^2 reef) and 2008 surveys (2.32 ± 0.84 fish/100 m^2 reef). Comparing data between the two surveys

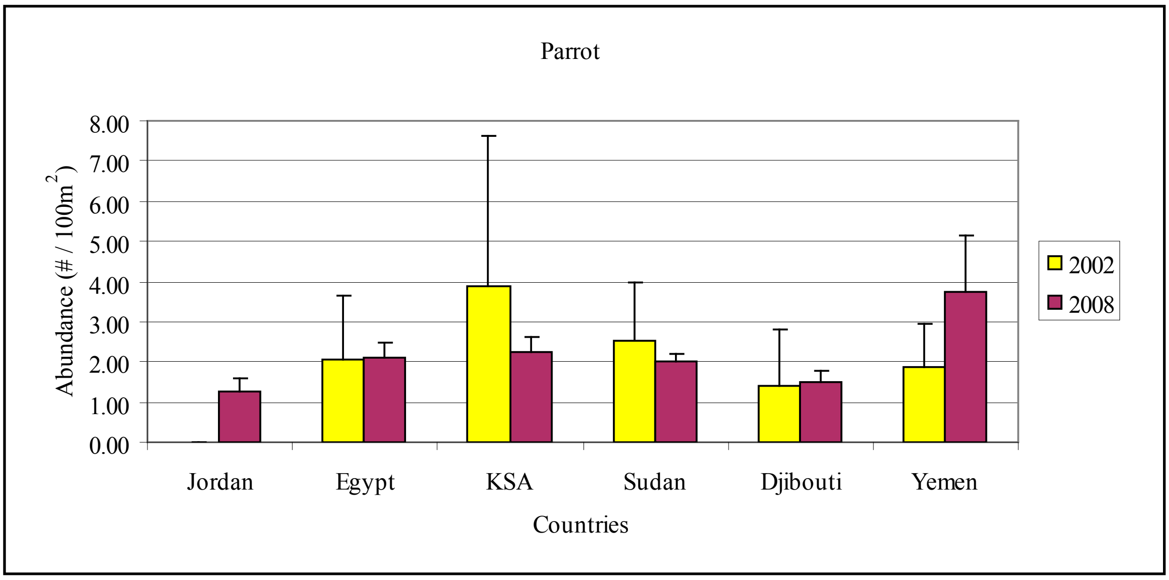


Figure 5: Mean abundance of parrotfish per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

for each country (Figure 5) showed larger parrotfish numbers on Yemeni reefs in 2008. However, this may be a reflection of the different sites used in the two surveys rather than any indication of a change in fishing pressure.

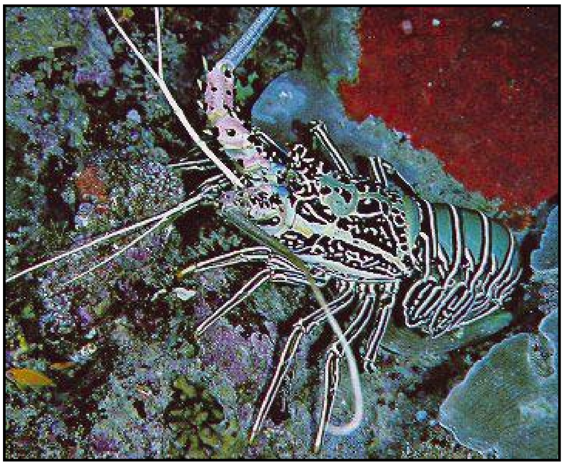
Parrotfish in the RSGA region showed similar abundances during the 2002 and 2008 surveys to those recorded for the Indo-Pacific region during the period 1997-2001 (average 2.0 ± 2.9 fish/100 m^2 reef; Hodgson and Liebeler, 2002), and similar but lower than records from Indonesian reefs in 1997-2006 (average 7 fish/100 m^2 reef; Habibi et al., 2007).

F) Lobster

Spiny lobsters were chosen as an indicator because they are universally prized as a seafood item. Lobsters are harvested commercially in most of the RSGA region. Although lobsters are nocturnal feeders and tend to stay in caves and crevices during the day, they are easily caught using nets and traps. However, the traditional and more popular way of fishing in the Region is by using flames or torches at night and inspecting the shallow reef flat area on foot to capture the lobster. The absence of lobsters on shallow reefs is a good indicator of human predation.

Of the 36 and 52 reefs surveyed for lobster during the 2008 and 2002 surveys, none were recorded on 94.6% and 94.2% of occasions, respectively. Hodgson and Liebeler (2002) recorded the absence of lobster at 90% of the surveyed reefs in the Indo-Pacific, including the Red Sea area, during the period 1997-2001.

Lobster were only recorded during the 2002 survey in Egypt (at two reefs) and Saudi Arabia (at one reef), while during the 2008 survey lobster were only recorded from one reef at each of Djibouti and Yemen (Figure 6). Lobster average abundance for the whole RSGA region was (0.02 ± 0.02 lobster/100 m^2 reef) in 2002 and (0.04 ± 0.06 lobster/100 m^2 reef) in 2008. Hodgson



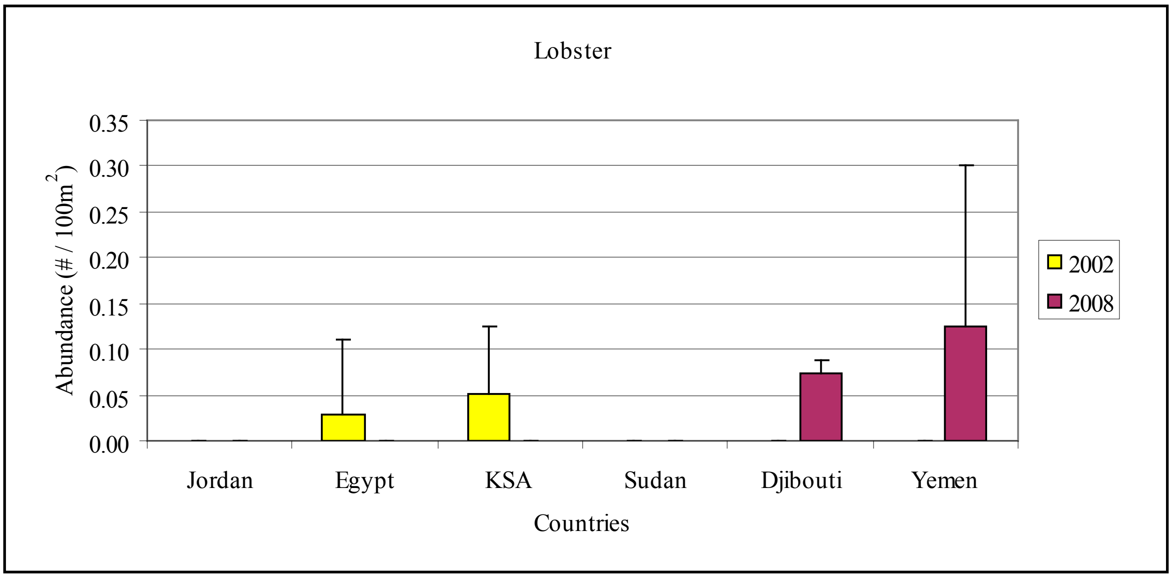


Figure 6: Mean abundance of lobster per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

and Liebeler (2002) estimated the average abundance at 0.05 ± 0.026 lobster/100 m^2 reef for the Indo- Pacific region during the period of 1997-2001. For Indonesian reefs, an average of 0.2–1.5 lobster/100 m^2 reef was estimated during the 1997-2006 period (Habibi et al., 2007).

Lobster fisheries cease, by law, in Egypt during the reproductive season each year for management and stock control purposes. This law was introduced due to overfishing of lobster and declining stocks, a situation which was indicated by stock assessment studies. No other regulations are found in the Region to manage lobster fisheries, and lobsters of very small size are reported in catches from Saudi Arabian reefs.

G) Diadema

Abundance levels of long-spined black sea urchins in the genus *Diadema* serve as global indicators of coral reef health. *Diadema* are nocturnal grazing herbivores that decrease algal cover on reefs through their feeding activities. They feed by scraping algae from the surface of the reef.

Diadema populations contribute to net reef erosion. For example, a normal population of *Diadema* can produce as much as 5 kg of carbonate sediment per square metre per year by scraping the carbonate rock surface. This corresponds to about 1 cm of reef erosion per year (Ogden and Carpenter, 1987). When *Diadema* population densities are high, and the urchins graze around the bases of large colonies, this bio-eroding activity can destabilize coral heads and increase their susceptibility to be knocked over by waves and currents.

On over-fished reefs, where there is a lack of predators on all the life stages of *Diadema*, populations can reach high levels that tip the balance towards bioerosion and make it difficult for new coral recruits to become established. This problem has been observed in the Atlantic and Pacific Oceans (Vo and

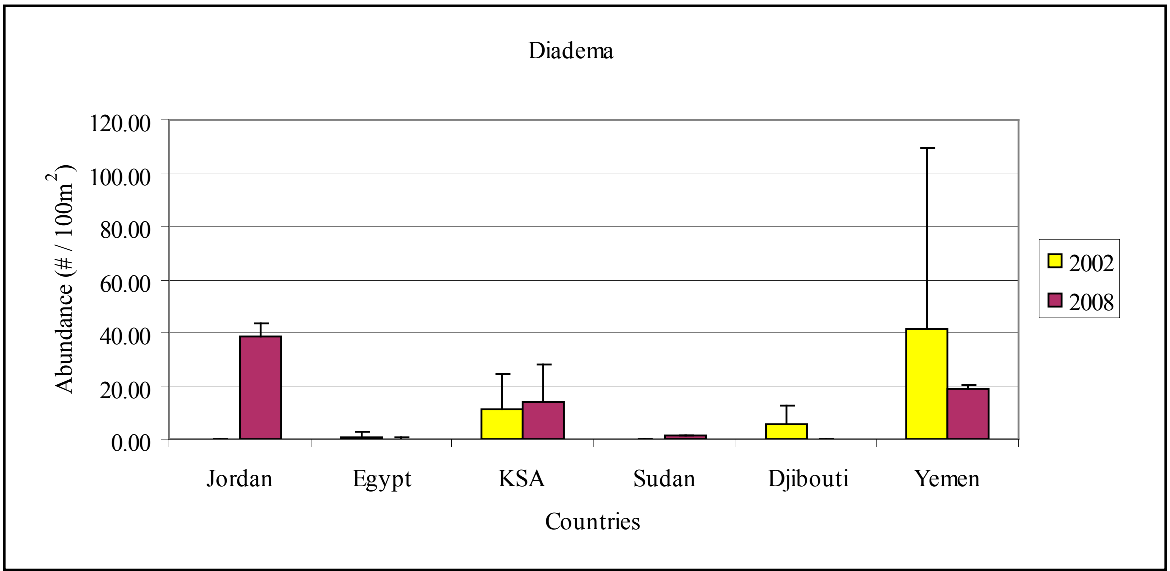


Figure 7: Mean abundance of *Diadema* per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

Hodgson, 1997), and it occurs in the Gulf of Suez (Red Sea) where overfishing is a critical problem (author's observations).

However Hughes (1994) reported that in areas where overfishing had severely reduced both predators and herbivores, such as in Jamaica, the loss of grazers led to an exponential increase in macroalgae. Reef corals, particularly those in shallow water, were overgrown by algae. Living coral cover on these reefs declined from about 30-70% to a mere 1-10%. Lessios (1995) describes a different situation that occurred in 1983 when a species-specific pathogen hit the Caribbean, resulting in a mass die-off of up to 99% of the existing *Diadema* populations in some areas.

While *Diadema* populations are critical to maintaining the natural balance between algae and coral in a healthy reef system, high-density populations are considered a negative indicator in all oceans. In areas where overfishing has reduced herbivore populations, a low population of *Diadema* is also considered to be a negative indicator (Hodgson and Liebeler, 2002).

During the RSGA regional surveys, the mean number of *Diadema* was higher in 2002 (11.73 ± 17.0 *Diadema*/100 m^2 reef) than in 2008 (6.87 ± 8.97 *Diadema*/100 m^2 reef), although this difference was not significant at the 95% confidence level. Figure 7 shows the temporal changes in *Diadema* abundance in each country, with high abundances recorded in Jordan (2008), Saudi Arabia (2002 and 2008) and Yemen (2002 and 2008).

The recorded abundance of *Diadema* in the Indo-Pacific region significantly increased from 17.82 ± 48.9 *Diadema*/100 m^2 reef in 1997 to 36.41 ± 103.1 *Diadema*/100m^2 reef in 1998 and then significantly decreased to 10.9 ± 42.1 *Diadema*/100 m^2 reef in 2000 (Hodgson and Liebeler, 2002). These authors found that the mean number of *Diadema* was higher at sites with high anthropogenic impacts than at sites with no impacts, although these differences were not statistically significant. Habibi et al. (2007) recorded abundance of 24.9 *Diadema*/100 m^2 reef in 2005 on Indonesian reefs.

H) Triton

The triton was chosen as a global reef health indicator because it has a beautiful shell that is very desirable and easy to collect as a curio. The triton is represented in the Pacific region, including the Red Sea area, by the species *Charonia tritonis*. In contrast to smaller molluscs, the triton grows so large (50 cm long) than it cannot hide in small crevices and so is visible to the collector. In the Indo-Pacific, the triton is a predator of the crown-of-thorns starfish that, in turn, preys on corals.

Only 6 sites out of 52 sites in the 2002 survey and 3 sites of 36 in the 2008 survey had at least one triton. The mean abundance of triton recorded in the RSGA region decreased in the 2008 survey (0.02 ± 0.03 triton/100 m^2 reef) from the 2002 survey (0.18 ± 0.31 triton/100 m^2 reef). Figure 8 shows the temporal changes in triton abundance recorded in each country, with no triton found during the 2002 survey in Egypt, Jordan, or Saudi Arabia.

In comparison, the recorded mean abundance of triton in the Indo-Pacific region was 0.03 ± 0.32 triton/100 m^2 reef in the period of 1997-2001 (Hodgson and Liebeler, 2002). Triton was recorded during the period of 1997-2006 on Indonesian reefs in extremely low numbers: 0-1 triton/100 m^2 reef (Habibi et al., 2007). Unfortunately, the triton is now very rare and it is difficult to know what "normal" abundance levels in a natural, undisturbed population would be.

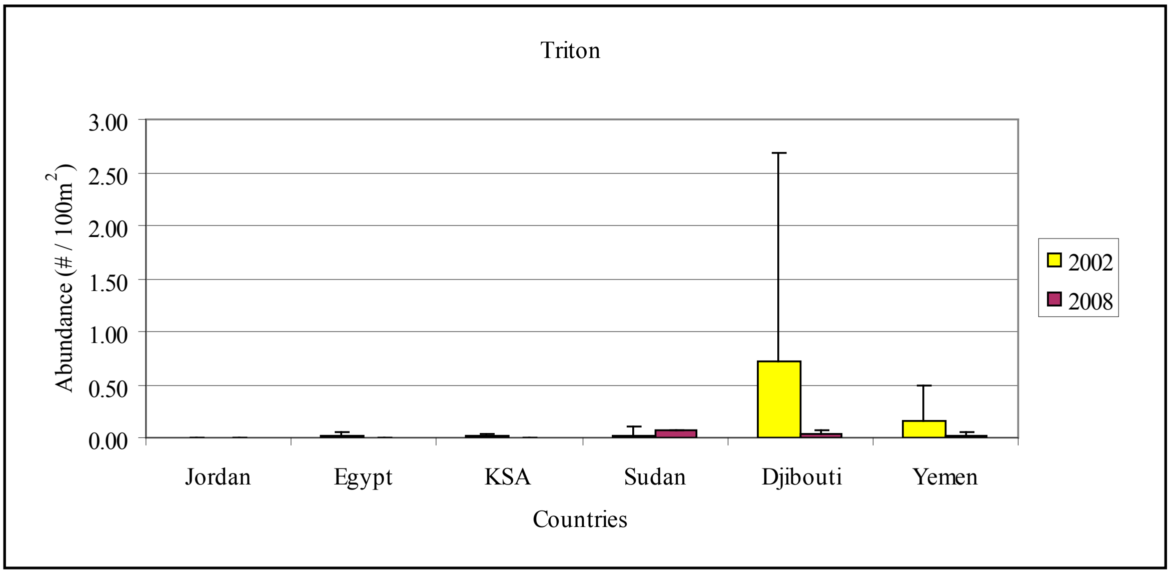


Figure 8: Mean abundance of triton per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

I) Giant Clam

Giant clams of the genus *Tridacna* were selected as indicators because they have long been highly prized both as a food item, as a curio, and more recently as an ornamental shellfish for aquarium keepers. There are two giant clam species in the RSGA region, *T. squamosa* and *T. maxima,* and both species are targets of human predation. The shells of both species may reach more than

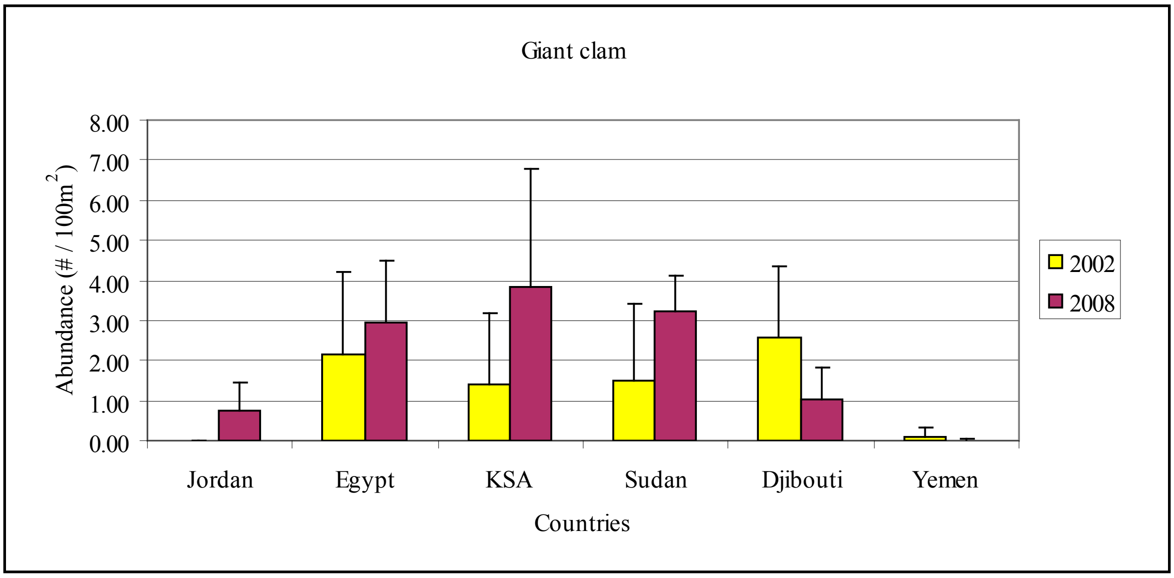


Figure 9: Mean abundance of giant clams per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

30–40 cm, but the occurrence of individuals with these lengths is now very rare in the Region.

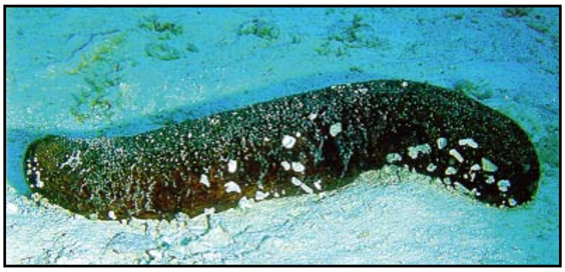
Giant clams were recorded at 69% of the surveyed sites in 2002 with mean abundance of 1.54 ± 0.93 clam/100 m^2 reef, and at 72% of the surveyed sites in 2008 with 2.22. ± 1.62 clam/100 m^2 reef. Most of the clams' size were under 20 cm in length. Clams of this small size live embedded in the reef structure and are difficult to harvest by shell collectors. Figure 9 shows the temporal changes in giant clam abundance recorded in each country during the 2002 and 2008 surveys; the highest recorded abundance was in Saudi Arabia during the 2008 survey.

Giant clam abundance recorded in the Indo-Pacific region was 3.9 ± 19.1 clams/100 m^2 reef during 1997-2001 (Hodgson and Liebeler, 2002); Habibi et al. (2007) recorded a mean abundance of 0.3 clam/100 m^2 reef in Indonesia in 2006.

J) Sea Cucumber

Edible species of sea cucumbers were chosen as Indo-Pacific reef health indicators because they are easily collected from shallow waters and have high economic values. Sea cucumbers perform an important ecological function on the reef, digesting organic matter in the sand and compacting the sediments into pellets that aid in reef formation.

According to the most recent investigations and status reports in the RSGA area, there are five species of sea cucumber that have suffered from overfishing especially since the year 2000: *Holothuria scabra, H. atra, H. leucospilota, Stichopus* spp., and *Actinopyga mauritiana.* For example, these species almost disappeared from 90% of shallow waters down to 30 m depths in the Egyptian Red Sea. Sea cucumbers declined from Yemeni and Saudi Arabia Red Sea areas as well due to overfishing. The abrupt increase in sea cucumber fishing started in the Red Sea region during 2002 due to the high demand for sea cucumbers from South-East Asian markets after the depletion of



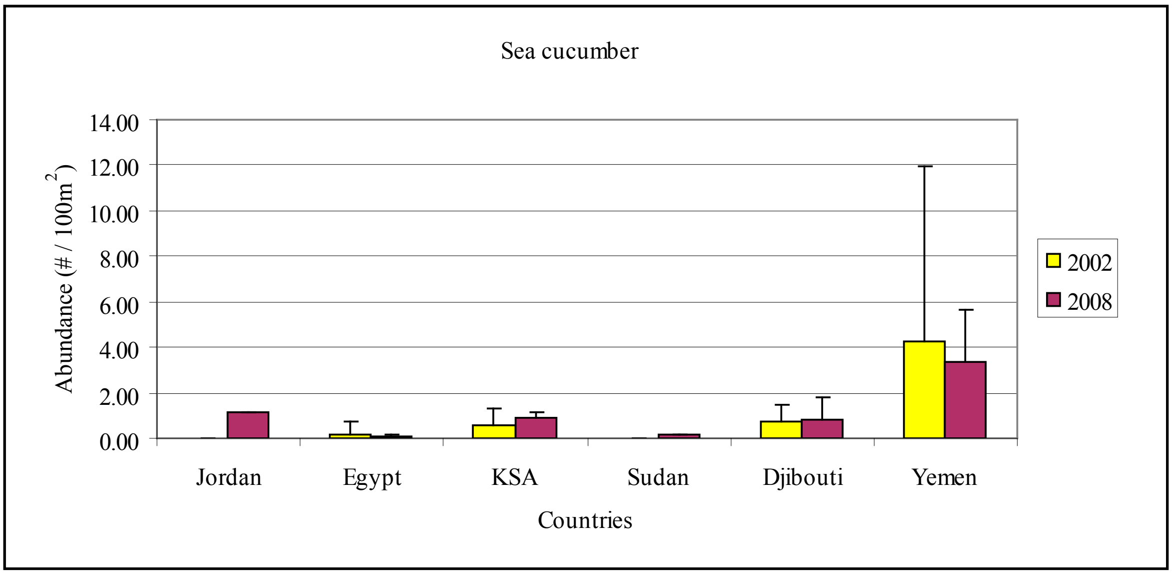


Figure 10: Mean abundance of sea cucumbers per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

most of the world's sea cucumber fisheries. The ease of collecting sea cucumbers from the shallow bottom down to 30 m depths, and the high price of the dry weight unit of these organisms, led vast numbers of fishermen, unemployed youth, and several diving guides and instructors working as sea cucumber collectors. Fishing for sea cucumbers spread all over the RSGA region. When the sea cucumber fishery declined in one area or country, fishermen moved to new areas or neighbouring countries. All the countries in the Region are now suffering from the high pressure of sea cucumber fishing. This has led a few countries to act and ban fishing for sea cucumbers. Egypt and Yemen started prohibiting sea cucumber fishing by law in 2003 and 2007, respectively. PERSGA assisted the Yemeni authorities in preparing management plans to regain healthy stocks of these organisms, but such a serious overfishing problem will take a long time to overcome.

Sea cucumbers were recorded at 48% of the surveyed sites around the Region in 2002 and from 69% of the sites during the 2008 survey. In 2008 most of the sea cucumbers detected were small in size (<10 cm). Fishermen do not collect the small sea cucumbers due to lack of market demand. The mean abundance during 2002 was 1.16 ± 1.76 cucumber/100 m^2 reef, and during 2008 was 1.07 ± 1.35 cucumber per 100 m^2 of reef.

Figure 10 shows the temporal changes in sea cucumber abundance recorded in each country during the 2002 and 2008 surveys. Among all countries, the highest abundances were in Yemen while the lowest were in Egypt.

Hodgson and Liebeler (2002) found that most areas of the Indo-Pacific have already been cleaned out of sea cucumbers, while Habibi et al. (2007) recorded a sharp decrease in sea cucumber abundance on Indonesian reefs from 6.3 to 0.0 sea cucumber/100 m^2 reef between 1997 and 2006.

K) Crown-of-thorns starfish

The crown-of-thorns starfish (COTS) (*Acanthaster planci*) is chosen as an indicator because it can have a major damaging effect on reef corals through predation during periods of population outbreak. The RSGA region has recorded COTS outbreaks since 1997, especially on Egyptian Red Sea reefs where catastrophic events occurred in 2000, 2002 and 2004. Other countries in the region

have also experienced COTS outbreaks at different periods during the last decade. Reports described severe coral bleaching in some reef areas at the time due to these outbreaks. Remedial actions were carried out to save the Egyptian reefs that involved the government, NGOs, and the private sector. The second reason for choosing COTS as an indicator is the controversy regarding the causal factors of COTS population explosions. These have yet to be resolved, though a number of scientists believe these outbreak episodes are linked to human activities. A few hypotheses suggest reasons that could lead to COTS outbreaks, such as: increased runoff due to poor land use leading to eutrophication that facilitates higher survival of COTS larvae and thus outbreaks; or over-harvesting of the triton, a predator of COTS. The evidence to date indicates that COTS outbreaks have occurred sporadically in many areas since the 1970s. However, a confirmed link to human activities has not yet been clearly established.

COTS were recorded at 34% of sites during 2002, and at 36% of sites during 2008 with

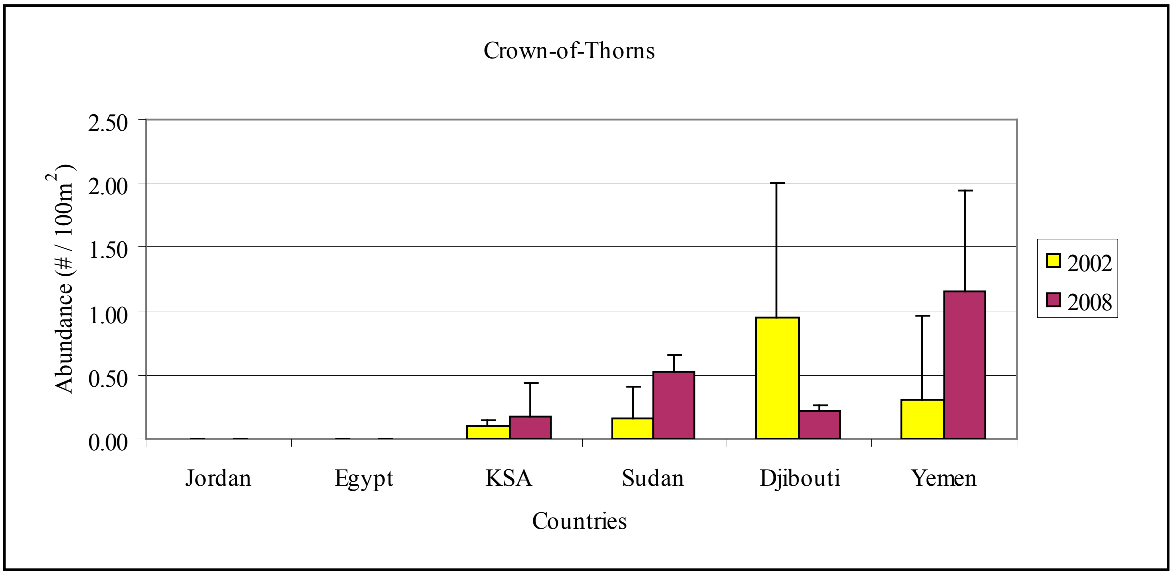


Figure 11: Mean abundance of COTS per 100 m^2 recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

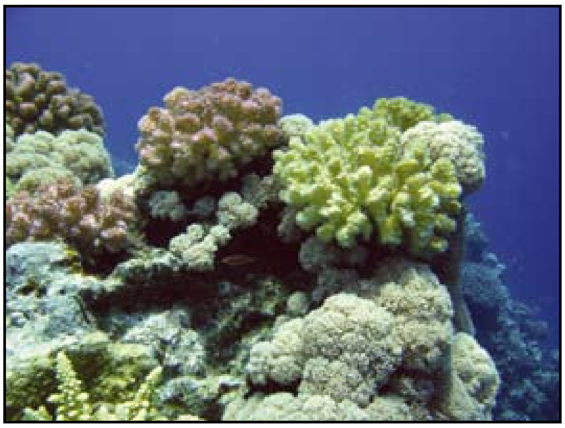
higher abundances towards the southern Red Sea in Yemen and Djibouti (Figure 11).

COTS mean abundance was 0.30 ± 0.38 and 0.42 ± 0.45 COTS/100 m^2 reef in 2002 and 2008, respectively. No evidence of a COTS outbreak was detected during the 2008 survey anywhere in the Region, and the higher abundance towards the south of the Red Sea might be related to the higher level of nutrients in the water of this area, which has been recorded by many authors (e.g., Sheppard et al., 1992).

Hodgson and Liebeler (2002) estimated mean average densities of COTS on Indo-Pacific reefs at 0.23 ± 0.99 COTS/100 m^2 reef during 1997-2001. Habibi et al. (2007) estimated an average of 1.2 ± 0.2 COTS/100 m^2 reef on Indonesian Reefs during the period 1997-2006. These density levels, both in the RSGA region and in the other regions mentioned, are below the numbers which could be considered as a population explosion (outbreak), according to the Australian Institute of Marine Science (1997).

L) Hard coral cover

Coral cover is greatly affected by the distribution of hard substratum on a reef as well as by the health of the corals living there. Out of the 52 and 36 sites surveyed during 2002 and 2008 respectively, most of the sites had a hard coral coverage of 10-50% (44 and 30 sites in 2002 and 2008, respectively). Only 7 sites in 2002 and 4 sites in 2008 showed hard coral coverage higher than 50% but less than 70%. Similar mean percentage cover of hard corals was recorded in 2002 at 33.69 ± 8.37 and in 2008 at 34.08 ± 5.85. Figure 12 shows the temporal changes in the percentage hard coral cover recorded in each country during the 2002 and 2008 surveys.



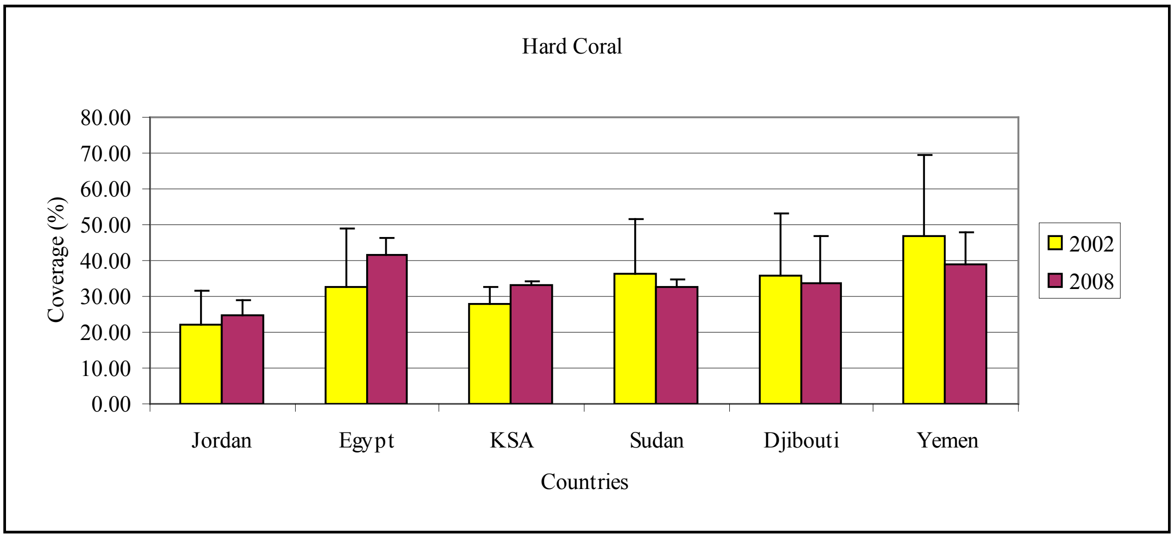


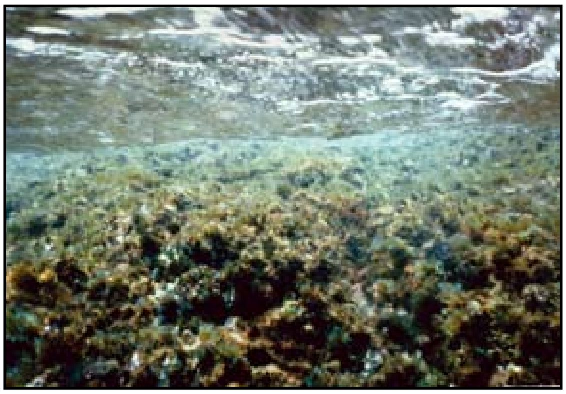
Figure 12: Mean percentage hard coral cover recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

Hodgson and Liebeler (2002) stated that many of the healthiest reefs in the world have probably never had more than about 30% coral cover, and they found the mean coverage in the Indo-Pacific reefs around 35% during the period 1997-2001. Habibi et al. (2007) estimated hard coral cover in the range of 26-50% for Indonesian reefs during the period 1997-2006.

However, coral cover by itself may not be a very useful indicator of reef health unless permanent transects are re-sampled over time, or unless very large sample sizes are available (Hodgson and Liebeler, 2002). Without permanent transects it is possible that a subsequent sample of the reef will hit a large patch of sand or rubble, biasing the results.

M) Nutrient indicator algae

Nutrient indicator algae (NIA) is the fleshy seaweed which is a substratum category that was introduced to the survey protocol of Reef Check in 1999 as a way to measure impacts of high nutrient inputs from land-based sources such as fertilizer and sewage pollution.



The recorded mean percentage cover of NIA was 2.44 ± 2.02 in 2002 and 1.24 ± 3.03 in 2008. Spatial and temporal comparison showed highest NIA mean coverage on Saudi Arabian reefs with 4.8% and 7.4%, in 2002 and 2008 respectively (Figure 13).

Hodgson and Liebeler (2002) found, from global monitoring data during the period 1997-2001, that reefs with no perceived level of sewage pollution had 3.8 ± 8.1 percent cover of fleshy seaweeds, whereas reefs with a perceived heavy level of sewage pollution had a mean 13.1 ± 12.7 percent cover of fleshy seaweed. The RSGA reefs suffer in some areas from sewage pollution due to the practice of sewage discharge directly into the sea. Generally, and according to Hodgson and Liebeler (2002), reefs of the

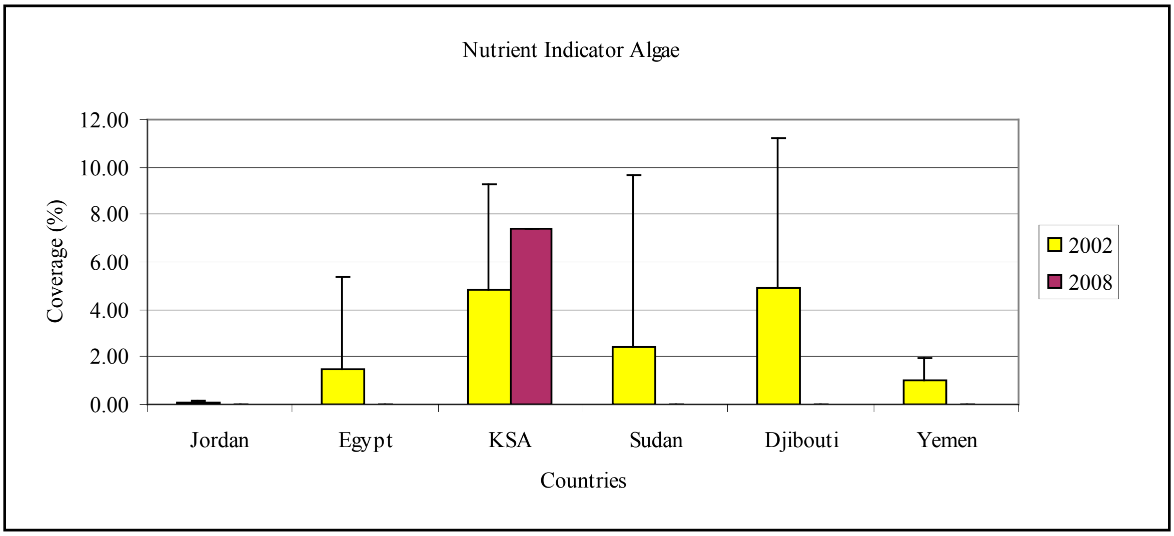


Figure 13: Mean percentage cover of NIA recorded at each country during the 2002 and 2008 surveys; bars represent standard deviations.

RSGA region might not be receiving sewage pollution at high levels, and the only clear result is that the reefs off the Saudi Arabian coast indicate higher levels of nutrient pollution.

N) Impacts

Overall, indicators for coral damage due to anchors, coral bleaching and trash did not show significant changes over time and place. Coral damage by anchors was 0.68% in 2002 and 0.53% in 2008. It is important that this kind of damage is monitored because of the wide use of anchors in the RSGA region due to the lack mooring buoys and lack of awareness of the value of coral reefs.

In spite of the considerable use of anchors in the Region by local fishermen, a low percentage of coral damage by anchoring was recorded. This might be due to the local anchoring method preferred by fishermen in the Region. The local fishermen who are travelling over the reef areas for fishing use small pieces of rock tied to the boat by a long rope and use it to anchor over the reef for fishing. This does not destroy as large an area as any metal anchor. They consider that the option of leaving the rocks underwater to free their boats is safer, as well as being cheaper than losing a metal anchor.

Diving and pleasure boats are not common all over the Region; they occur in the tourist destinations of Egypt, Jordan, Saudi Arabia, and on a small scale in other countries. The major tourist destinations are monitored by the concerned government authorities. A mooring system was implemented at all the

key dive sites in Egypt. Over 1000 moorings were created with the aid of NGOs. PERSGA carried out a project in Saudi Arabia during 2007 to introduce the mooring technology to the diving industry and installed mooring buoys at 40 Jeddah reef sites. Also, a joint project between PERSGA and ASEZA in Jordan implemented in August 2009, installed 26 mooring buoys at diving sites along the Aqaba coast.

The percentage of bleached corals detected was 0.36% in 2002 and 1.27% in 2008. The 2002 survey followed the 1998 global coral bleaching event, but it seems that the detected bleaching level was not related to either the global warming or the COTS outbreaks. Such bleaching might be due to localized effects of COTS, molluscs, or other causes.

The amount of trash estimated was 0.37% in 2002 and 0.18% in 2008. Most of the sites visited had the usual types and amounts of solid waste carried by wind and currents but the sites monitored which are close to large cities or urban aggregations received different kinds and quantities of solid waste including plastic bags, cans and plastic bottles.

6. RECOMMENDATIONS

Significant progress in conservation of the marine environment of the RSGA has been made in a relatively short time. However, further actions are needed to ensure continued progress. These include full implementation of the recent regional protocol on biodiversity, the regional MPAs network, the RAPs, and the NAPs. Below are some key recommendations that need to be carried out to ensure improved monitoring of the coral reef environment. This will help in the evaluation of the conservation measures currently taken at national and regional levels. Such evaluation will lead to continued progress in marine environmental conservation and the sustainability of marine resources.

1. To be useful, monitoring using PERSGA-SSMs methodology (Reef Check) should be carried out every year with sufficient replication (number of sites) to provide a comprehensive view of the reefs of interest. The present 36 regional monitoring sites should be included in all future monitoring programmes. There are tradeoffs between investing in more replication at different geographic and temporal scales. For example, quarterly surveys at one location will provide a more accurate picture of local reef health—particularly with respect to highly mobile fish, but this may limit the number of locations that can be surveyed and thus give a biased picture of the overall health in the region. *Ideally, long-term coral reef environmental monitoring programmes should be developed at the national level in each country with monitoring resources allocated in a logical design that best supports management goals.*

2. Standard Reef Check methodology alone is not sufficient to provide a complete picture of coral reef health. Ideally, a long-term monitoring plan should include both Reef Check and some more taxonomically detailed surveys. The PERSGA-SSMs include GCRMN Lifeform and English et al. (1997) survey methodologies as more detailed techniques which include fish families, fish size estimates, coral genera, and coral colony sizes. Unfortunately, such detailed surveys require teams of highly trained scientists and are more time consuming and costly than Reef Check. In most countries, an initial goal of establishing a network of Reef Check sites alone is already a serious challenge. Currently, PERSGA plans to participate with the countries in regional monitoring surveys using SSMs–Reef Check methodology every two years. *PERSGA recommends that each country set up a national network of monitoring sites using Reef Check methodology as a first step towards a "regionally and globally comparable" monitoring programme. When this network can be successfully funded and maintained, then sites where more detailed monitoring is carried out can be added as financial and scientific personnel become available.*

3. A number of issues must be considered when using the SSMs–Reef Check protocol for long-term monitoring. The most important are taxonomic specificity, temporal and spatial replication. Each of the RSGA countries has specific needs, capabilities, and resources that will require a custom design. *An "ideal" two-level monitoring programme would have a few high-resolution sites using more detailed methods such as English et al. (1997), and a larger number of lower-resolution Reef Check sites.* The Reef Check methodology has key characteristics that ensure it plays an important role in a two-level monitoring programme. First it is a relatively fast method that allows a team to gather a snapshot of the health of reef corals, other invertebrates and fish at up to two sites per day. As more sites are surveyed in a particular area, the resolution of the snapshot is increased.

4. Second, because Reef Check can be based on major inputs from volunteers it can be built and extended through community participation. *PERSGA and the official environmental authorities in each country can use NGO support to engage volunteers in the regular monitoring survey. Then Reef Check teams can be mobilized to survey many more sites than is currently possible. The national teams can focus on more intensive methods which are much more costly in time, staff and funding. Each country can define the number of high-resolution sites to be monitored according to its capabilities and needs.* In addition, the Reef Check sites can be resurveyed by volunteers more frequently than the high-resolution sites. If Reef Check surveys are repeated at quarterly intervals, they can then act as an early warning system for major anthropogenic changes such as bleaching, overfishing, eutrophication and sedimentation.

5. *PERSGA should also facilitate the cooperation of regional scientists with international networks of scientists engaged in monitoring global sea temperatures for early warning signs of coral bleaching.* In particular, coral research into the sensitivity and resilience of RSGA coral reefs to bleaching events should be actively supported and encouraged (especially those reefs that form part of the Regional Network of Marine Protected Areas).

6. There is a need to integrate current and future research and monitoring into global initiatives, and the ongoing research and monitoring taking place in the PERSGA member states. *PERSGA maintains such integration with global initiatives but further advances should be made at the national level. National monitoring programmes need to be designed and implemented with the results integrated into the PERSGA database at headquarters to facilitate the preparation of regular regional status reports. This would assist decision makers in their conservation efforts.*

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APPENDICES

APPENDIX 1

Members of the national fieldwork teams that participated in the 2008 regional monitoring survey, their official authorities and level of experience.

#	Country	Name	Authority	State
	PERSGA	Dr. Mohammed Kotb	PERSGA – Biodiversity & MPAs Programme	Scientific & Diving Leader
1	Egypt	Essam S. Khalil	Sharm El-Sheikh Protectorates (EEAA)	Experienced
2		Mohamed A. Abdou	Sharm El-Sheikh Protectorates (EEAA)	New participant
3		Said B. Al-Housiny	Sharm El-Sheikh Protectorates (EEAA)	New participant
4		Aly A. Badawy	Nuweiba (EEAA)	New participant
5		Emad H. Mohamed	Dahab (EEAA)	New participant
6		Tamer M. Attalla	Hurghada Protectorates (EEAA)	Experienced
7		Tamer K. Farghal	Hurghada Protectorates (EEAA)	Experienced
8		Beshoy M. Fahmy	Hurghada Protectorates (EEAA)	New participant
9		Wael A. Hefny	Hurghada Protectorates (EEAA)	Experienced
10	Jordan	Salim Y.S. Al-Nawaiseh	Aqaba Marine Park (ASEZA)	Experienced
11		Abdullah M.A. Al-Momani	Aqaba Marine Science Station	Experienced
12		Omer A.A. Al-Momani	Aqaba Marine Science Station	Experienced
13		Atieh A.A. Al-Tarabeen	Aqaba Marine Park (ASEZA)	New participant
14		Rakad B.M. Al-Hweeti	Aqaba Marine Park (ASEZA)	New participant
15		Nasser H. Al-Shamailah	Aqaba Marine Park (ASEZA)	New participant
16	Saudi Arabia	Dr. Abdel-Mohsen A. Al-Sofiany	King Abdul-Aziz University-Jeddah	Experienced
17		Rabiea M. Khayat	King Abdul-Aziz University-Jeddah	New participant
18		Kamal K. Al-Dahory	King Abdul-Aziz University-Jeddah	Experienced
19		Yehia A. Falous	King Abdul-Aziz University-Jeddah	New participant

20	Yemen	Aref A. Hamoud	General Authority of the Marine Science Research	Experienced
21		Maeen L. Al-Swari	General Authority of the Environment Protection	New participant
22		Hesham S. Awadh	General Authority of the Marine Science Research	New participant
23		Zaher A. Al-Agwan	PERSGA	Experienced
24	Djibouti	Houssein Rirache	Environment and Land Planning Department (MHUEAT)	Experienced
25		Sayaka Matsumura	Japan International Cooperation Agency (JICA)	New participant
26		Saied	Djibouti Marine Force	New participant
27		Mohamed	Djibouti Marine Force	New participant
28	Sudan	Moamer E. Aly	Marine Science Faculty–Port Sudan University	New participant
29		Khalid A. Shakour	Implementing Science Faculty–Port Sudan	New participant
30		Khassan M. Ahmed	Nile Oil Company	Experienced
31		Abdullah N. Al-Awad	Red Sea Fish Research Center	New participant
32		Ehab O. Abdulla	Marine Science Faculty–Port Sudan University	Experienced
33		Al-Amin M. Al-Amin	Red Sea Fish Research Center	Experienced
34		Yasser H. Ebrahim	Marine Science Faculty–Port Sudan University	New participant

APPENDIX 2

The data sheets for the different categories and indicator species used during the current survey (after Reef Check, 2006).

Site Name: ____________ Country/Island: ____________

Depth: ____________ Team Leader: ____________

Date: ____________ Time: ____________

Fish

Data recorded by: ____________

	0-20m	25-45m	50-70m	75-95m
Butterflyfish (Chaetodontidae)				
Sweetlipis (Haemulidae)				
Broomtail wrasse (*Cheilinus lunalatus*)				
Humphead wrasse (*Cheilinus undulatus*)				
Bumphead parrotfish (*Bolbometopon muricatum*)				
Other parrotfish (Scaridae) only >20 cm				
Snapper (Lutjanidae)				
Moray eel (Muraenidae)				

Grouper (Serranidae) sizes (cm) (count ONLY >30cm):	0-20m	25-45m	50-70m	75-95m
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total # grouper				

Rare animals sighted (type/#)				

Comments:

Site Name:	______	Country/Island:	______
Depth:	______	Team Leader:	______
Date:	______	Time:	______
Data recorded by:			

Invertebrates	0-20m	25-45m	50-70m	75-95m
Banded coral shrimp (*Stenopus hispidus*)				
Diadema urchins (including *Echinothrix* spp.)				
Pencil urchin (*H. mammilatus*)				
Collector urchin (*Tripneustes* spp.)				
Sea cucumber (Holothuridae)				
Crown of thorns (*Acanthaster plancii*)				
Triton (*Charonia tritonis*)				
Lobster (Palinuridae)				

Giant clam (*Tridacna* sp.) sizes	0-20m	25-45m	50-70m	75-95m
<10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
>50 cm				
Total # giant clams observed				

Impacts: Coral Disease/ Bleaching/Trash/Other	*0 = none, 1 = low, 2 = medium and 3 = high*			
	0-20m	25-45m	50-70m	75-95m
Coral damage: Boat/Anchor				
Coral damage: Dynamite				
Coral damage: Other				
Trash: Fish nets				
Trash: General				
Bleaching (% of coral population)				
Bleaching (% of colony)				
Coral Disease (% of coral affected if yes)				
Rare animals sighted (type/#)				

Comments:

Site name	Country/Island:
Depth:	Date:
TS/TL:	Data recorded by:
Time:	

Substrate Code

HC hard coral	SC soft coral	RKC recently killed coral
NIA nutrient indicator algae	SP sponge	RC rock
RB rubble	SD sand	SI silt/clay
OT other		

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1				SEGMENT 2				SEGMENT 3				SEGMENT 4			
0 - 19.5 m				25 - 44.5 m				50 - 69.5 m				75 - 94.5 m			
0		10		25		35		50		60		75		85	
0.5		10.5		25.5		35.5		50.5		60.5		75.5		85.5	
1		11		26		36		51		61		76		86	
1.5		11.5		26.5		36.5		51.5		61.5		76.5		86.5	
2		12		27		37		52		62		77		87	
2.5		12.5		27.5		37.5		52.5		62.5		77.5		87.5	
3		13		28		38		53		63		78		88	
3.5		13.5		28.5		38.5		53.5		63.5		78.5		88.5	
4		14		29		39		54		64		79		89	
4.5		14.5		29.5		39.5		54.5		64.5		79.5		89.5	
5		15		30		40		55		65		80		90	
5.5		15.5		30.5		40.5		55.5		65.5		80.5		90.5	
6		16		31		41		56		66		81		91	
6.5		16.5		31.5		41.5		56.5		66.5		81.5		91.5	
7		17		32		42		57		67		82		92	
7.5		17.5		32.5		42.5		57.5		67.5		82.5		92.5	
8		18		33		43		58		68		83		93	
8.5		18.5		33.5		43.5		58.5		68.5		83.5		93.5	

APPENDIX 3

Coordinates and names of the reefs and the sites surveyed.

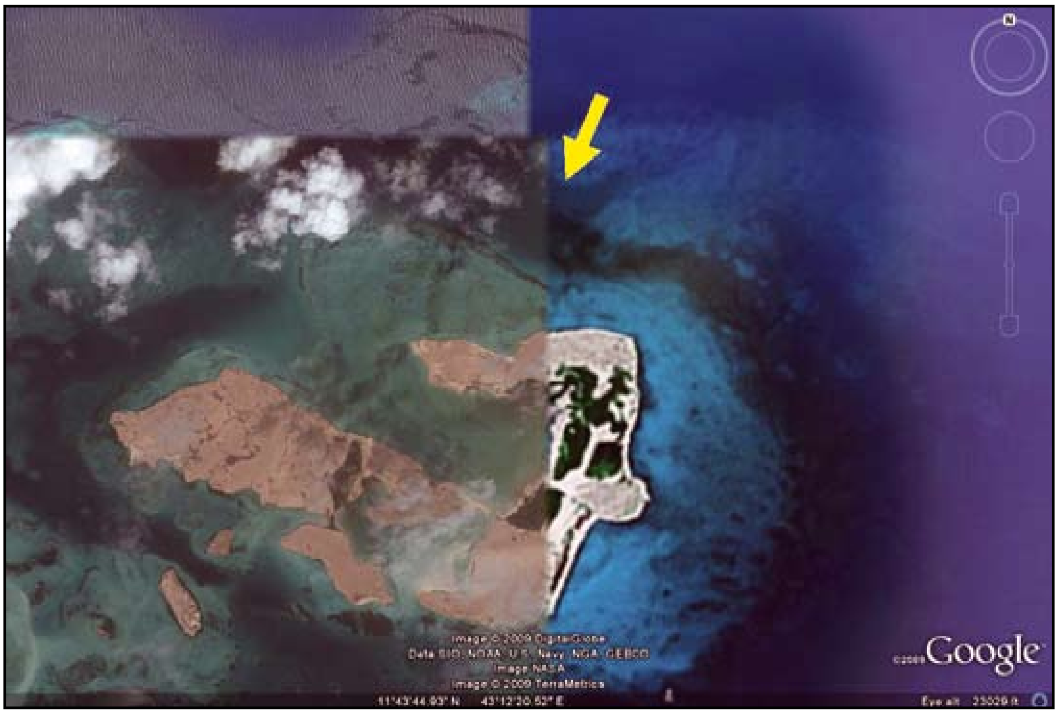
Country	City / Island	Site Name	Beach/Reef Name	Lat. (D-M-S)	Long. (D-M-S)	#
Egypt	Nuweiba	Ras Shetan	Castle Beach	29°07'39.89"N	34°41'04.97"E	1
	Dahab	Island	Dive Inn Beach	28°28'42.63"N	34°30'49.81"E	2
	Sharm El-Sheikh	Ras Nosrani	Melina Sinai	27°57'49.98"N	34°24'50.75"E	3
	Sharm El-Sheikh	Ras Mohamed	Anemone City Reef	27°43'39.37"N	34°15'27.90"E	4
	Hurghada	Gotta Abu Ramada	Gotta Abu Ramada	27°08'21.61"N	33°57'16.58"E	5
	Safaga	Ras Abou Soma	Ras Abou Soma Reef	26°50'35.15"N	34°00'11.46"E	6
	Qusier	Marsa Wizr	Mangrove Bay Beach	25°52'14.62"N	34°25'25.37"E	7
	Marsa Alam	Marsa Shaqraa	Marsa Shaqraa Reef	25°14'44.48"N	34°47'53.80"E	8
Sudan	O'Seif	------------	East of O'Seif Prot jetty	21°45'56.01"N	36°53'11.59"E	9
	Arkiyai	------------	Reef off Arkyai fishing village	20°13'39.67"N	37°12'33.36"E	10
	Port-Sudan	Abou Hashish	Reef off Port-Sudan fish market	19°37'40.13"N	37°14'44.81"E	11
	Suakin	------------	Reef off Suakin Port	19°8'4.90"N	37°22'9.30"E	12
Djibouti	Maskali Island	Light house	Light house western reef	11°42'47.28"N	43°08'54.73"E	13
	Maskali Island	Canyon	Light house northern reef	11°42'56.10"N	43°09'14.55"E	14
	Moucha Islands	Grand Recif (Great Reef)	Tombant Nord (northern slope)	11°44'26.99"N	43°12'30.06"E	15
	Seven Brothers Islands	Grande Ile	Japanese Garden	12°28'00.32"N	43°25'56.90"E	16
	Seven Brothers Islands	Ile de l'Est	Chinese Garden	12°27'16.00"N	43°26'34.00"E	17

Country	City / Island	Site Name	Beach/Reef Name	Lat. (D-M-S)	Long. (D-M-S)	#
Somalia	No survey	------------	---------------	---------------	---------------	---
Yemen	Tiqfash Island	------------	--------------	15°42'05.82"N	42°23'30.53"E	18
	Shalatem Island	------------	--------------	13°47'18.99"N	42°48'22.61"E	19
	Myyun Island	------------	--------------	12°38'11.79"N	43°25'08.97"E	20
	Shaqraa coast	------------	--------------	13°21'49.70"N	45°44'49.09" E	21
	Sikha Island	------------	--------------	13°56'09.18"N	48°23'11.08"E	22
	Macroqha Island	------------	--------------	14°49'11.74"N	50°00'55.95"E	23
	Socotra Island	Roosh-Halah	--------------	12°36'10.40"N	53°49'00.38"E	24
KSA	Haql	------------	Dora	29°21'14.50"N	34°57'20.99"E	25
	Maqna	------------	---------------	28°24'53.27"N	34°44'43.94"E	26
	Duba	------------	Cement Tabouk	27°32'43.24"N	35°31'53.97"E	27
	Umm Lajj	------------	---------------	24°59'50.21"N	37°16'45.61"E	28
	Mastura	------------	---------------	23°03'04.68"N	38°46'47.85"E	29
	Jeddah	Corniche	---------------	21°38'40.0"N	39°06'01.56"E	30
	Al Lith	------------	---------------	20°08'56.01"N	40°14'00.60"E	31
	Assir	Hali	---------------	18°22'35.98"N	41°26'52.34"E	32
	Farasan	Zfaf	---------------	16°43'26.77"N	41°48'03.41"E	33
Jordan	Aqaba	------------	First Bay	29°27'01.00"N	34°58'10.90"E	34
		------------	Japanese Garden	29°25'42.63"N	34°58'22.88"E	35
		------------	Aquarium	29°24'03.70"N	34°58'00.44"E	36

APPENDIX 4

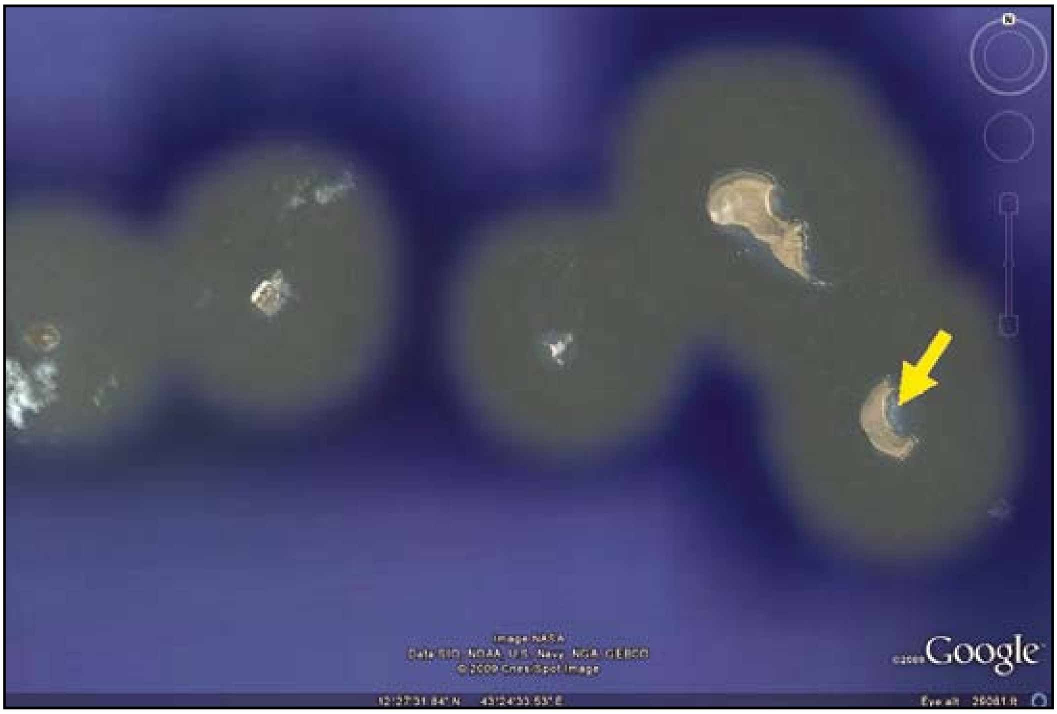
Data collected from Djiboutian reef sites
Google images showing the locations of the sites surveyed on Djiboutian reefs

Google image of Maskali Island showing sites of Light House (above) and Canyon (below); the yellow arrows indicate the exact locations of the transects surveyed.



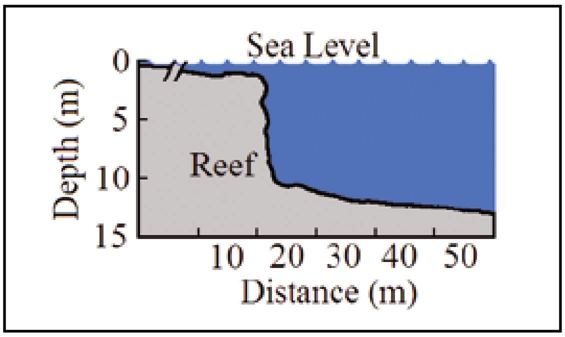
Google image of Moucha Island showing the location of northern slope/great reef (Grand Recif–Tombant Nord); the yellow arrow indicates the exact location of the transects surveyed.

Google image of the Seven Brothers Islands; the yellow arrow indicates the exact location of the transects surveyed at the Japanese Garden Reef on the Great Island (Grande Ile).

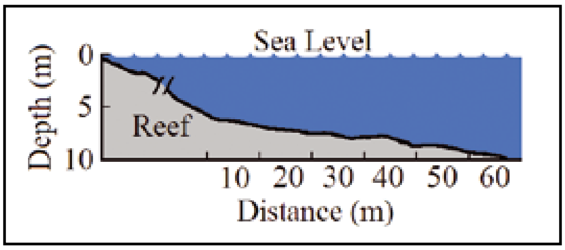


Google image of the Seven Brothers Islands; the yellow arrow indicates the exact location of the transects surveyed at the Chinese Garden Reef on the Eastern Island (Ile de l'Est).

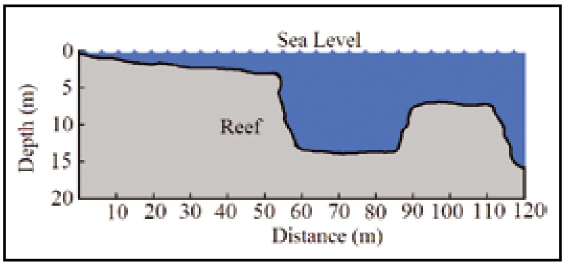
Reef Profiles for the Sites Surveyed in Djibouti



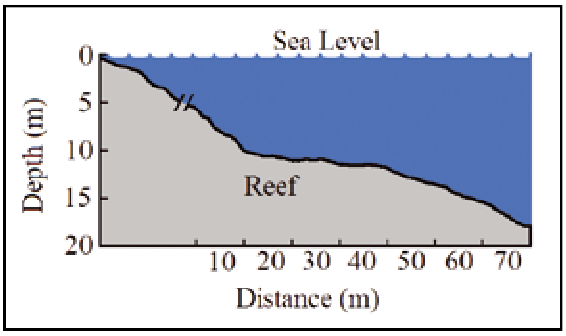
Maskali Island—Light House



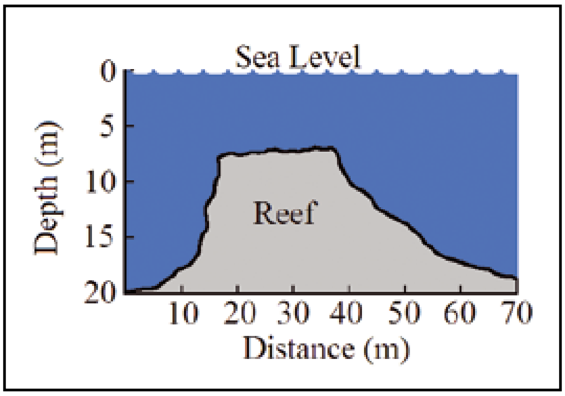
Seven Brothers
Grand Ile–Japanese Garden



Maskali Island—Canyon



Seven Brothers
Ile de l'Est–Chinese Garden



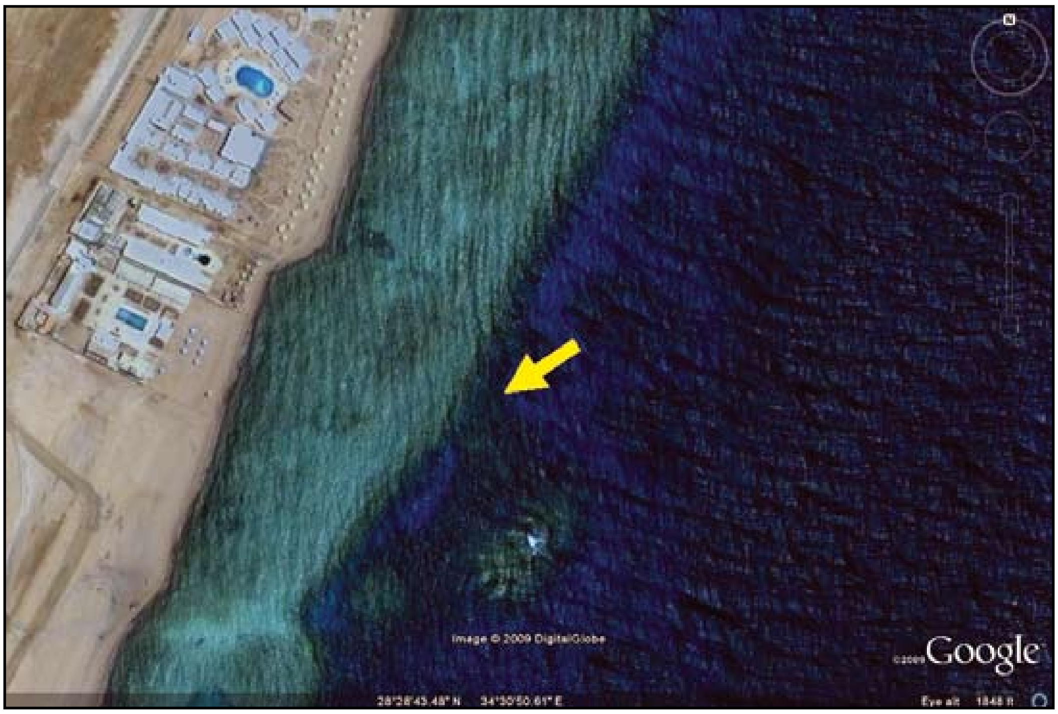
Moucha Island
Grand Recif–Tombant Nord

APPENDIX 5

Data collected from Egyptian reef sites

Google images showing the locations of the sites surveyed on Egyptian reefs

Google image of Nuweiba-Egypt; the yellow arrow indicates the exact location of the transects surveyed in front of Castle Resort beach, Ras Shitan reef site.



Google image of Dahab-Egypt; the yellow arrow indicates the exact location of the transects surveyed in front of Dive Inn beach, the island reef site.

Google image of Ras Nosrani, Sharm El-Sheikh, Egypt; the yellow arrow indicates the exact location of the transects surveyed in front of Melina Sinai Resort beach.

Google image of Ras Mohamed, Sharm El-Sheikh, Egypt; the yellow arrow indicates the exact location of the transects surveyed at the Anemone City reef site.

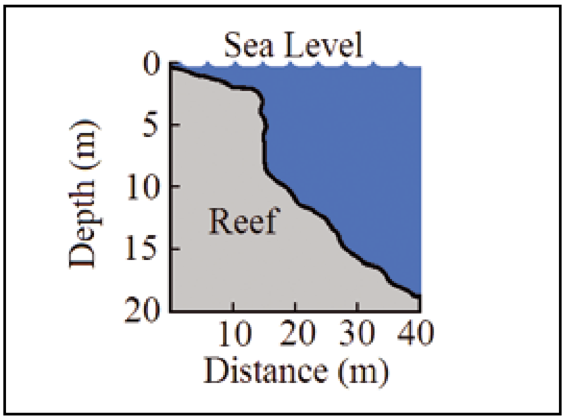
Google image of Gotta Abu-Ramada submerged reef, Hurghada, Egypt; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Ras Abu Soma, Safaga, Egypt; the yellow arrow indicates the exact location of the transects surveyed.

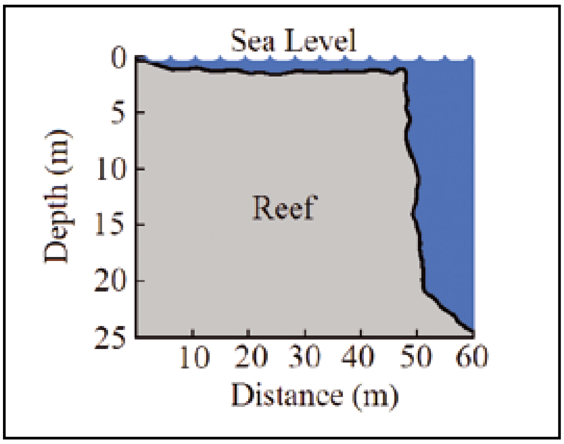
Google image of Marsa Wizr, Qusier, Egypt; the yellow arrow indicates the exact location of the transects surveyed in front of the Mangrove Bay Resort reef.

Google image of Marsa Alam, Egypt; the yellow arrow indicates the exact location of the transects surveyed at Marsa Shaqraa reefs.

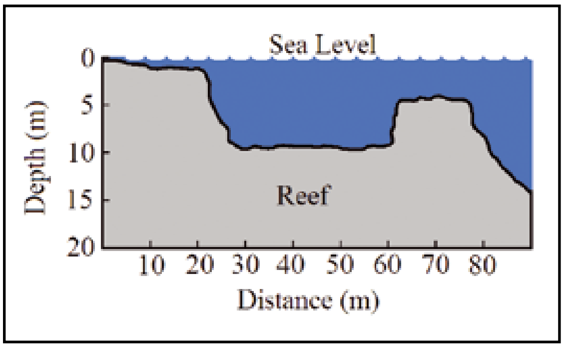
Reef Profiles for the Sites Surveyed in Egypt



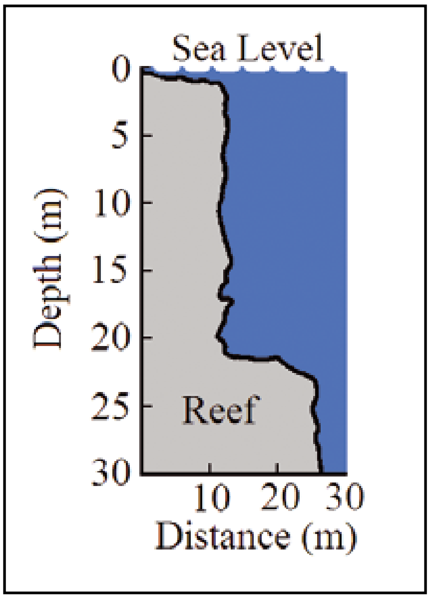
Nuweiba–Ras Shetan



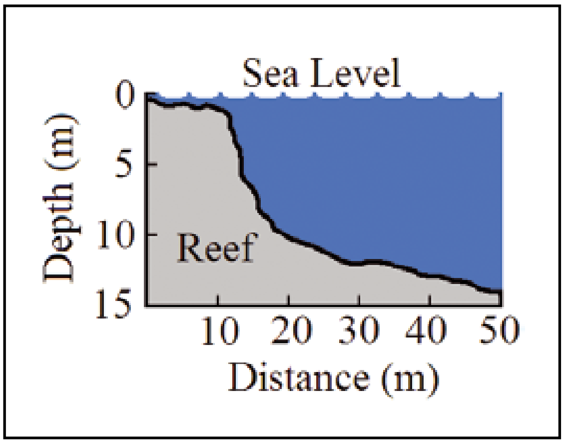
Sharm El-Sheikh–Ras Nosrani



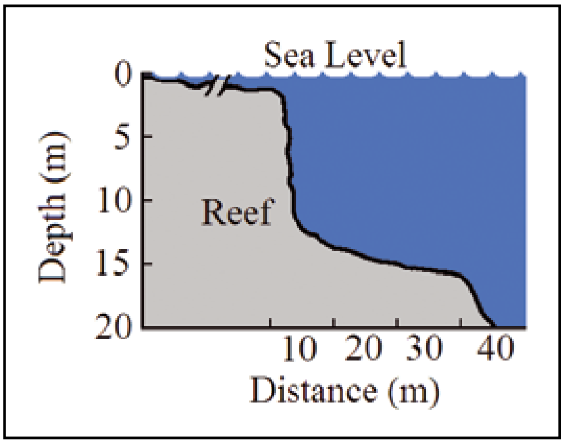
Dahab–the island



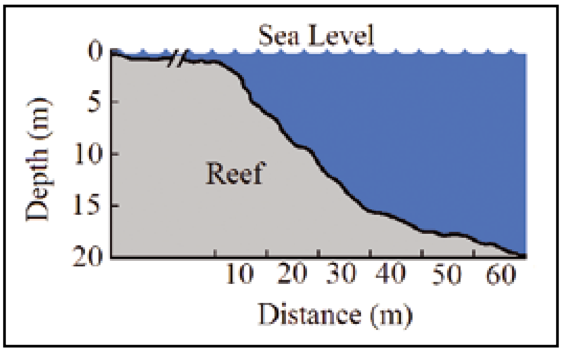
Sharm El-Sheikh–Ras Mohamed



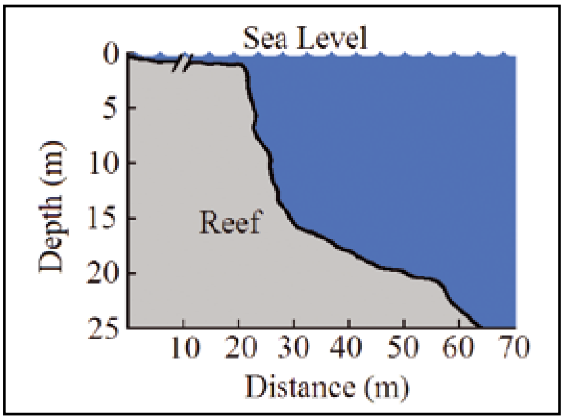
Hurghada–Gotta Abu Ramada



Qusier–Marsa Wizr



Safaga–Ras Abu Soma



Marsa Alam–Marsa Shaqraa

APPENDIX 6

Data collected from Jordanian reef sites

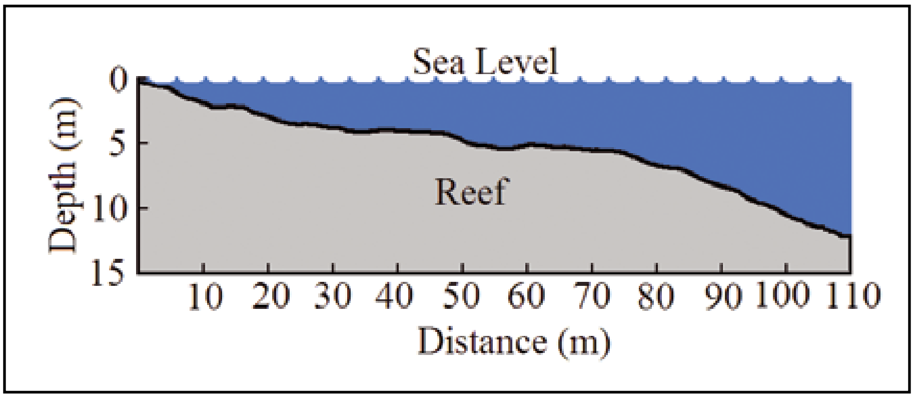
Google images showing the locations of the sites surveyed on Jordanian reefs

Google image of the First Bay reef site on the Aqaba coast; the yellow arrow indicates the exact location of the transects surveyed.

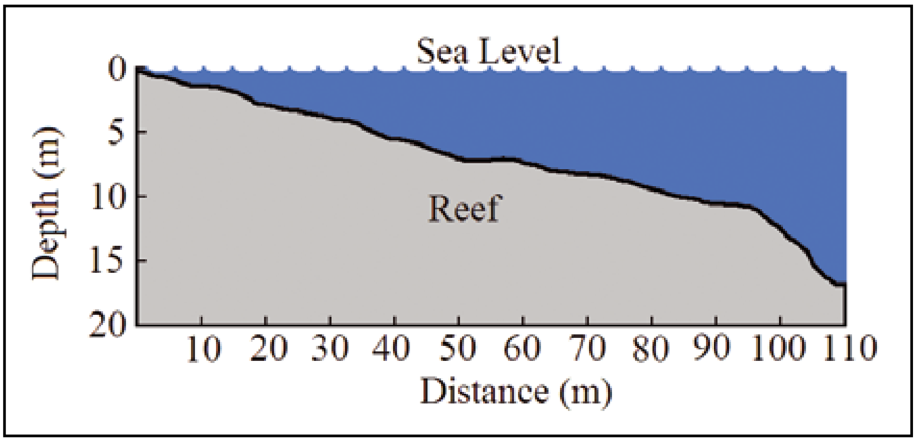
Google image of the Japanese Garden reef site on the Aqaba coast; the yellow arrow indicates the exact location of the transects surveyed.

Google image of the Aquarium reef site on the Aqaba coast; the yellow arrow indicates the exact location of the transects surveyed.

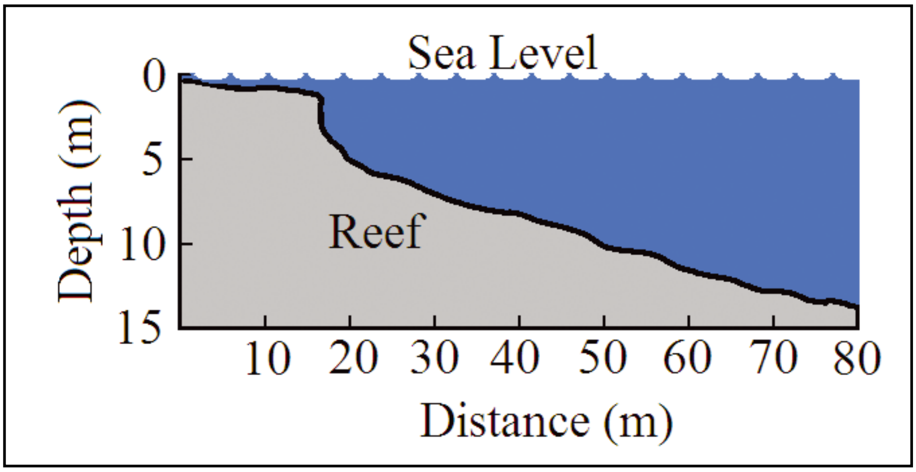
Reef Profiles for the Sites Surveyed in Jordan



First Bay Reef



Japanese Garden Reef



Aquarium Reef

APPENDIX 7

Data collected from Saudi Arabian Red Sea reef sites

Google images showing the locations of the sites surveyed on Saudi Arabian Red Sea reefs

Google image of Haql-Dora site on the KSA Gulf of Aqaba reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Maqna surveyed site at the KSA Gulf of Aqaba reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Duba site, KSA northern Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Umm Lajj site, KSA northern Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Mastura site, KSA northern Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

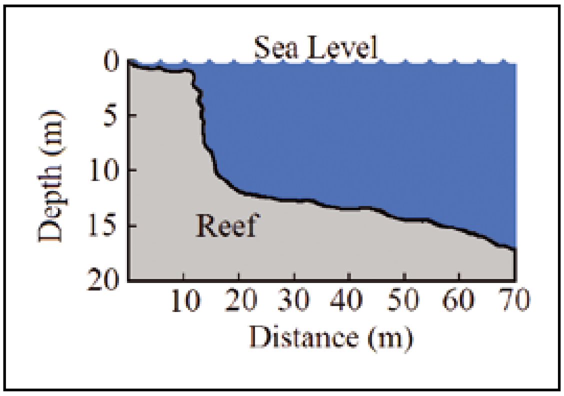
Google image of Jeddah Corniche site, KSA central Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Al Lith site, KSA central Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

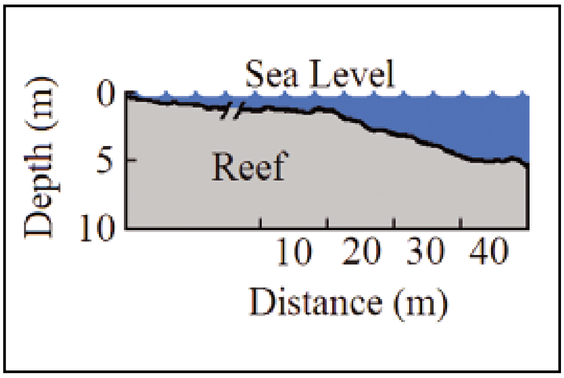
Google image of Hali site, KSA central Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Farasan-Zfaf site, KSA southern Red Sea reefs; the yellow arrow indicates the exact location of the transects surveyed.

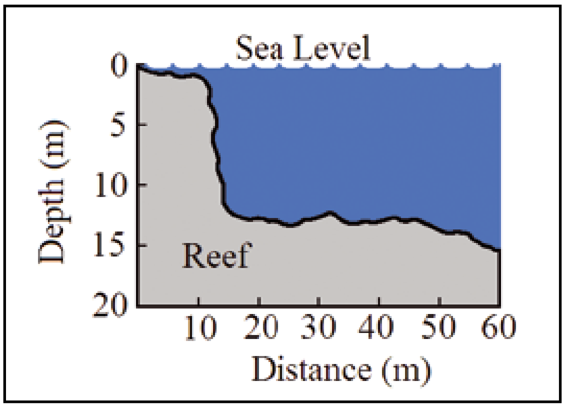
Reef Profiles for the Sites Surveyed in Saudi Arabia



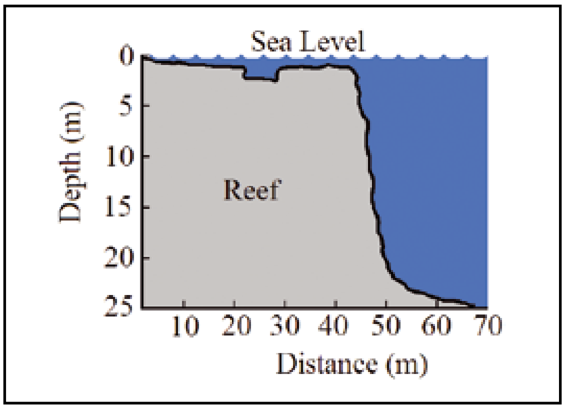
Haql Reef



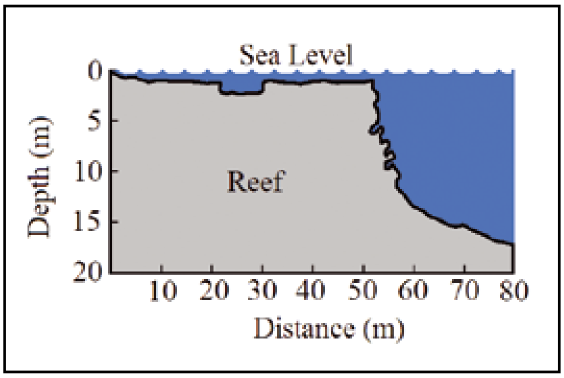
Umm Lajj Reef



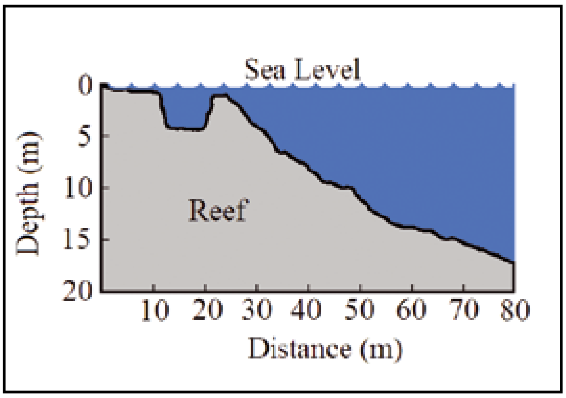
Maqna Reef



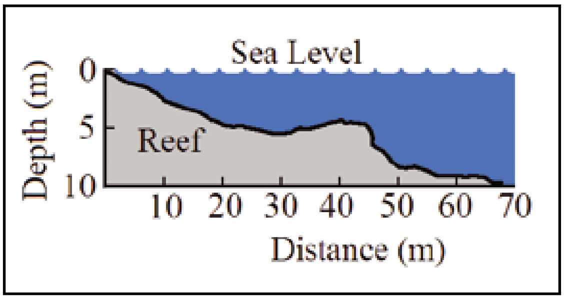
Jeddah Corniche Reef



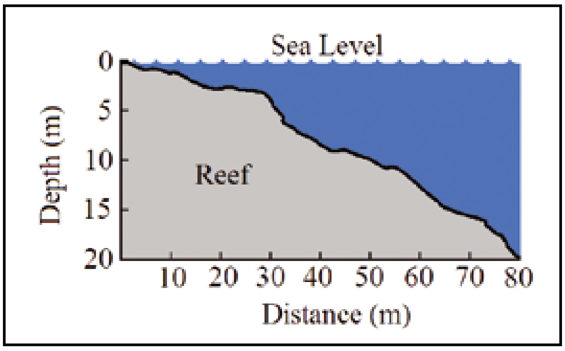
Duba Reef



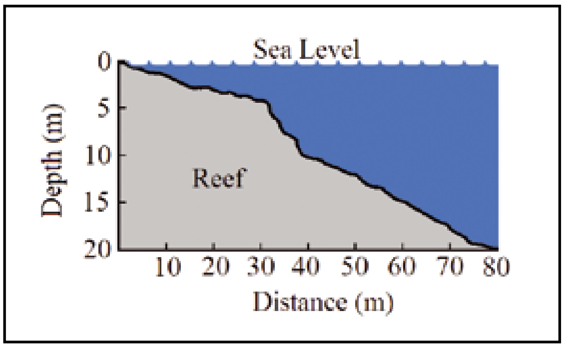
Mastura Reef



Al Lith Reef



Hali Reef



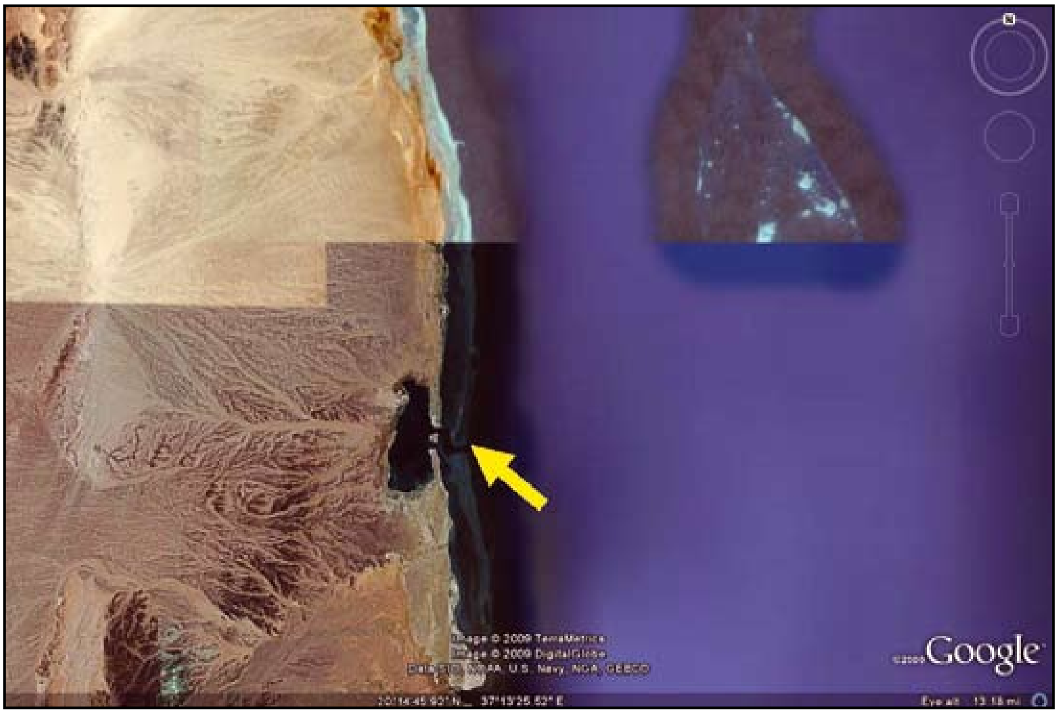
Farasan-Zfaf Reef

APPENDIX 8

Data collected from Sudanese reef sites

Google images showing the locations of the sites surveyed on Sudanese reefs

Google image of the O'Seif reef site; the yellow arrow indicates the exact location of the transects surveyed.

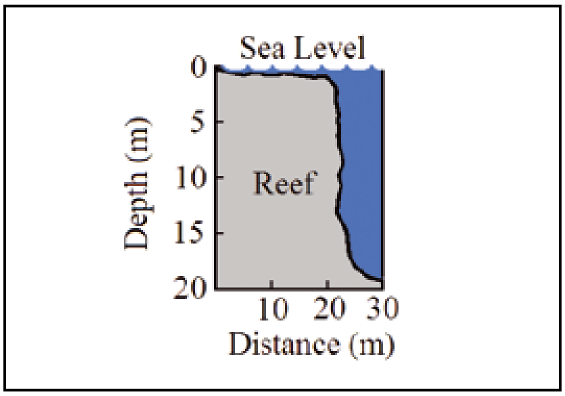


Google image of the Arkiyai reef site; the yellow arrow indicates the exact location of the transects surveyed.

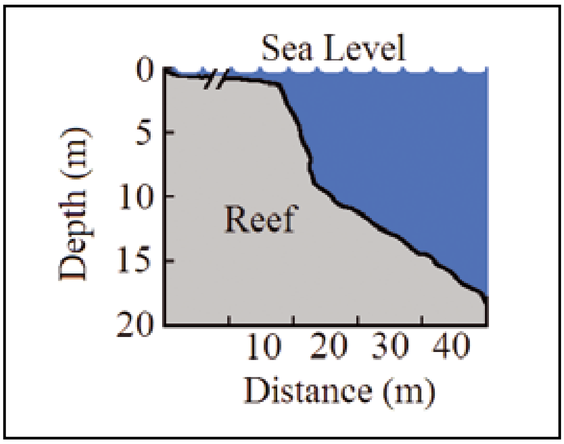
Google image of the Port Sudan–Abu Hashish reef site; the yellow arrow indicates the exact location of the transects surveyed.

Google image of the Suakin reef site; the yellow arrow indicates the exact location of the transects surveyed.

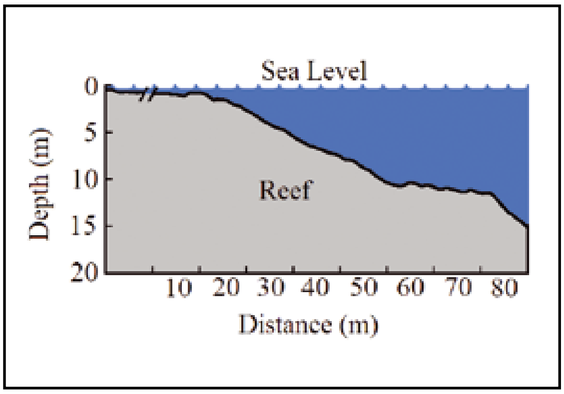
Reef Profiles for the Sites Surveyed in Sudan



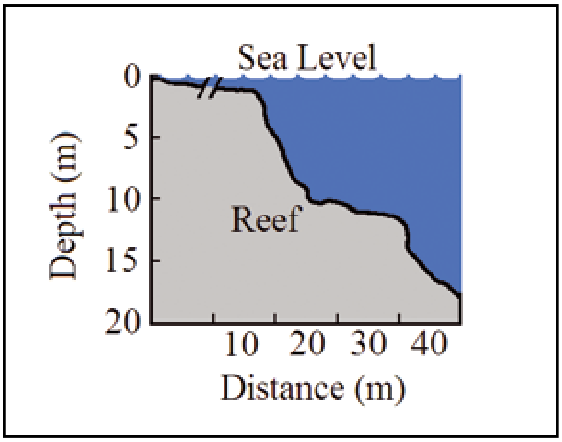
O'Seif Reef



Port Sudan–Abu Hashish Reef



Arkiyai Reef



Suakin Reef

APPENDIX 9

Data collected from Yemeni reef sites

Google images showing the locations of the sites surveyed on Yemeni reefs

Google image of Tiqfash Island; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Shalatem Island; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Myyun Island; the yellow arrow indicates the exact location of the transects surveyed.

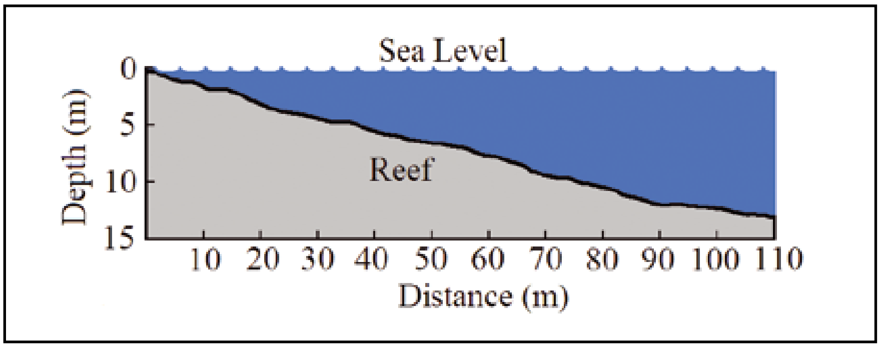
Google image of the Shaqraa coast; the yellow arrow indicates the exact location of the transects surveyed.

Google image of Sikha Island; the yellow arrow indicates the exact location of the transects surveyed.

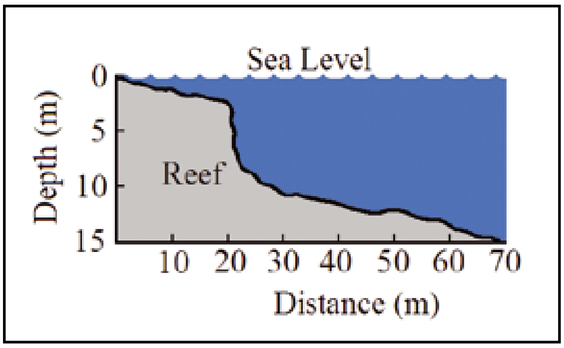
Google image of Macroqha Island; the yellow arrow indicates the exact location of the transects surveyed.

Google image of the Socotra Archipelago; the yellow arrow indicates the exact location of the transects surveyed.

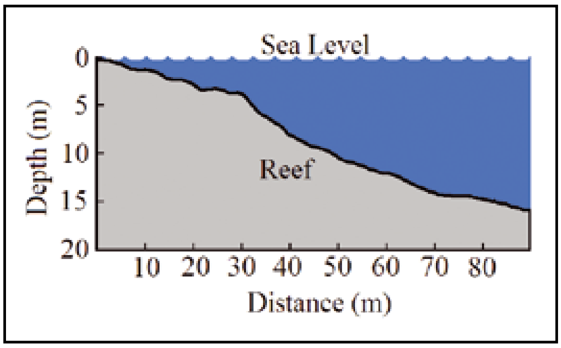
Reef Profiles for the Sites Surveyed in Yemen



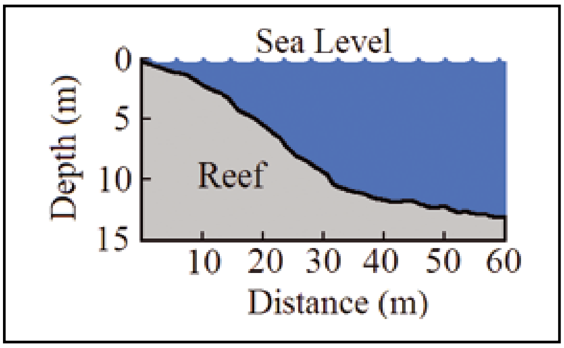
Tiqfash Island Reef



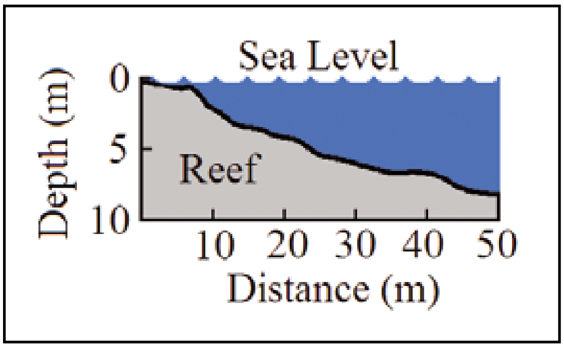
Shalatem Island Reef



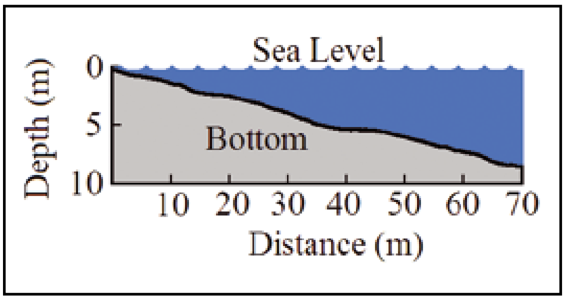
Sikha Island Reef



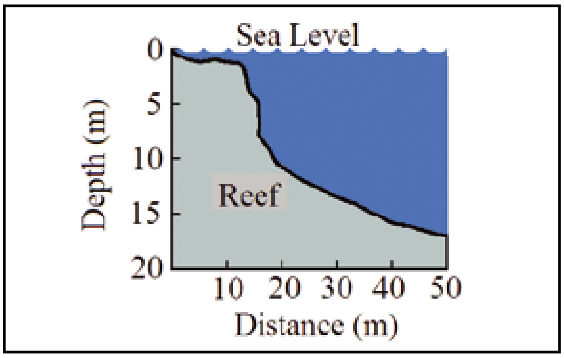
Myyun Island



Macroqha Island Reef



Shaqraa Coast



Socotra, Roosh–Halal Reef

APPENDIX 10

The data collected from the different countries of the RSGA region—2008

The mean abundances (±SD) of fish and invertebrate indicator species

Fish (abundance)	Djibouti		Egypt		Jordan		KSA		Sudan		Yemen	
	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Butterflyfish	8.08	2.36	6.23	0.69	6.88	1.24	8.22	0.36	4.47	1.55	6.94	0.86
Haemulidae	4.81	0.97	0.64	0.07	0.00	0.00	1.09	0.03	0.34	0.04	3.68	1.79
Broomtail wrasse	0.16	0.22	0.84	0.18	0.38	0.29	0.59	0.08	0.94	0.27	0.31	0.09
Grouper	0.54	0.29	0.75	0.35	0.25	0.12	1.03	0.20	0.78	0.40	0.43	0.11
Humphead wrasse	0.15	0.03	0.24	0.07	0.00	0.00	0.00	0.00	0.16	0.04	0.10	0.15
Bumphead parrotfish	0.04	0.06	0.10	0.03	0.75	0.24	0.10	0.02	0.00	0.00	0.00	0.00
Parrotfish	1.51	0.25	2.13	0.35	1.25	0.35	2.24	0.37	2.00	0.18	3.75	1.41
Snapper	24.64	24.47	8.01	4.54	0.00	0.00	28.02	13.81	0.88	0.00	50.49	2.32
Moray eel	0.10	0.03	0.10	0.03	0.08	0.00	0.00	0.00	0.06	0.00	0.21	0.29

Grouper – size class (cm)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
30-40 cm	0.26	0.25	0.55	0.16	0.25	0.12	0.84	0.13	0.44	0.35	0.30	0.22
40-50 cm	0.17	0.12	0.12	0.13	0.00	0.00	0.14	0.05	0.16	0.04	0.13	0.05
50-60 cm	0.07	0.01	0.08	0.07	0.00	0.00	0.05	0.03	0.00	0.00	0.03	0.04
>60 cm	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.09	0.07	0.02

Invertebrates (abundance)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Banded coral shrimp	0.10	0.03	0.02	0.02	0.71	0.41	0.00	0.00	0.06	0.00	0.10	0.15
Diadema	0.04	0.06	0.20	0.16	38.33	5.30	14.12	13.70	1.09	0.22	18.89	1.50
Pencil urchin	0.07	0.01	1.16	1.41	0.21	0.18	0.00	0.00	1.03	0.66	0.00	0.00
Collector urchin	0.24	0.10	0.54	0.70	0.25	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Sea cucumber	0.84	0.93	0.08	0.06	1.17	0.00	0.92	0.24	0.13	0.00	3.38	2.30
Crown-of-thorns	0.22	0.04	0.00	0.00	0.00	0.00	0.18	0.26	0.53	0.13	1.15	0.78
Giant clam	1.04	0.77	2.93	1.55	0.75	0.71	3.85	2.92	3.25	0.88	0.02	0.03
Triton	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.04
Lobster	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.18

Giant clam – size class (cm)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
<10 cm	0.06	0.09	1.36	0.81	0.33	0.35	1.89	1.21	2.00	0.71	0.00	0.00
10-20 cm	0.78	0.66	1.13	0.30	0.29	0.29	1.31	1.05	0.81	0.35	0.02	0.03
20-30 cm	0.20	0.19	0.27	0.38	0.04	0.06	0.51	0.57	0.19	0.27	0.00	0.00
30-40 cm	0.00	0.00	0.00	0.00	0.04	0.06	0.09	0.03	0.00	0.00	0.00	0.00
40-50 cm	0.00	0.00	0.03	0.04	0.04	0.06	0.04	0.06	0.22	0.22	0.00	0.00
>50 cm	0.00	0.00	0.14	0.02	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.00

Averages (±SD) of impact levels and substrate cover

Impacts (%)	Djibouti		Egypt		Jordan		KSA		Sudan		Yemen	
	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Coral damage: Boat/Anchor	0.31	0.09	0.33	0.12	0.29	0.29	0.15	0.02	1.41	0.40	0.44	0.20
Coral damage: Dynamite	0.08	0.12	0.00	0.00	0.04	0.06	0.07	0.10	0.00	0.00	0.00	0.00
Coral damage: Other	0.29	0.06	0.67	0.11	0.92	0.24	0.82	0.25	0.38	0.00	0.25	0.29
Trash: Fish nets	0.00	0.00	0.05	0.07	0.00	0.00	0.01	0.02	0.31	0.35	0.23	0.03
Trash: General	0.04	0.06	0.00	0.00	0.08	0.00	0.40	0.02	0.44	0.00	0.00	0.00
Bleach – Disease	**mean**		**mean**		**mean**		**mean**		**mean**		**mean**	
Bleaching (% of coral population)	0.09		0.00		0.46		0.04		4.78		1.44	
Bleaching (% of colony)	0.13		0.00		0.17		1.32		10.47		0.16	
Coral disease (% of coral affected)	0.00		0.24		0.08		0.46		0.00		0.00	
Living Substrate Cover (%)	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**
Hard coral	33.70	12.89	41.47	4.88	24.58	4.42	33.14	1.16	32.66	2.21	38.92	8.78
Soft coral	9.79	3.24	9.73	7.02	2.60	1.03	29.16	6.37	13.52	2.32	15.57	1.69
Nutrient indicator algae	0.00	0.00	0.00	0.00	0.00	0.00	7.42	0.01	0.00	0.00	0.00	0.00
Sponge	1.74	1.36	0.05	0.07	0.73	0.74	0.86	0.84	0.00	0.00	0.70	0.63
Other	12.99	11.97	1.37	1.60	0.00	0.00	0.00	0.00	0.23	0.11	2.50	0.88
Non-living Substrate Cover (%)	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**	**mean**	**SD±**
Recently killed coral	0.10	0.15	0.00	0.00	3.65	1.33	0.00	0.00	1.17	0.33	0.16	0.22
Rock	26.22	4.16	36.99	7.68	36.15	5.75	10.49	2.46	27.81	4.86	23.15	4.10
Rubble	8.33	0.29	3.61	1.86	5.63	2.06	0.00	0.00	12.66	3.31	10.56	1.86
Sand	6.88	7.95	6.78	5.73	26.67	15.32	18.93	1.90	11.95	3.43	8.45	0.60
Silt/Clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX 11

The data collected from the different countries of the RSGA region—2002

The mean abundances (±SD) of fish and invertebrate indicator species

[(-) means no data collected]

Fish (abundance)	Djibouti		Egypt		Jordan		KSA		Sudan		Yemen	
	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Butterflyfish	6.05	2.15	7.04	3.58	-	-	3.39	0.05	5.32	2.09	8.75	4.24
Haemulidae	1.90	3.91	0.32	1.52	-	-	1.11	0.08	0.09	0.17	7.25	9.61
Broomtail wrasse	0.00	0.00	0.36	0.61	-	-	0.57	0.42	0.02	0.08	0.15	0.22
Grouper	0.80	0.57	0.79	0.98	-	-	1.36	0.08	0.50	0.56	0.40	0.38
Humphead wrasse	0.53	0.57	0.06	0.18	-	-	0.13	0.18	0.05	0.10	0.00	0.00
Bumphead parrotfish	-	-	-	-	-	-	-	-	-	-	-	-
Parrotfish	1.40	1.42	2.07	1.58	-	-	3.87	3.74	2.52	1.46	1.85	1.11
Snapper	16.55	15.95	1.20	3.70	-	-	62.79	84.12	0.45	0.53	136.90	250.44
Moray eel	0.25	0.35	0.32	0.99	-	-	0.11	0.03	0.05	0.10	0.00	0.00

Grouper – size class (cm)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
30-40 cm	-	-	-	-	-	-	-	-	-	-	-	-
40-50 cm	-	-	-	-	-	-	-	-	-	-	-	-
50-60 cm	-	-	-	-	-	-	-	-	-	-	-	-
>60 cm	-	-	-	-	-	-	-	-	-	-	-	-

Invertebrates (abundance)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Banded coral shrimp	0.53	1.03	0.00	0.00	-	-	0.13	0.05	0.14	0.38	0.00	0.00
Diadema	5.53	7.01	0.95	1.71	-	-	10.95	13.70	0.09	0.23	41.15	68.20
Pencil urchin	9.48	20.08	0.08	0.18	-	-	0.20	0.19	0.00	0.00	0.20	0.45
Collector urchin	-	-	-	-	-	-	-	-	-	-	-	-
Sea cucumber	0.75	0.74	0.18	0.55	-	-	0.60	0.72	0.00	0.00	4.25	7.71
Crown-of-thorns	0.95	1.06	0.00	0.00	-	-	0.11	0.04	0.16	0.26	0.30	0.67
Giant clam	2.55	1.79	2.15	2.07	-	-	1.41	1.79	1.48	1.93	0.10	0.22
Triton	0.73	1.97	0.01	0.05	-	-	0.01	0.02	0.02	0.08	0.15	0.34
Lobster	0.00	0.00	0.03	0.08	-	-	0.05	0.07	0.00	0.00	0.00	0.00

Giant clam – size class (cm)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
<10 cm	-	-	-	-	-	-	-	-	-	-	-	-
10-20 cm	-	-	-	-	-	-	-	-	-	-	-	-
20-30 cm	-	-	-	-	-	-	-	-	-	-	-	-
30-40 cm	-	-	-	-	-	-	-	-	-	-	-	-
40-50 cm	-	-	-	-	-	-	-	-	-	-	-	-
>50 cm	-	-	-	-	-	-	-	-	-	-	-	-

Averages (±SD) of impact levels and substrate cover

[(-) means no data collected]

Impacts (%)	Djibouti		Egypt		Jordan		KSA		Sudan		Yemen	
	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Coral damage: Boat/Anchor	0.80	0.42	0.00	0.00	-	-	1.12	0.14	0.64	0.67	0.83	0.53
Coral damage: Dynamite	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00	0.00	0.00	0.00
Coral damage: Other	0.90	0.32	0.17	0.32	-	-	0.67	0.15	0.84	0.67	0.70	0.80
Trash: Fish nets	0.00	0.00	0.00	0.00	-	-	0.30	0.39	0.00	0.00	0.00	0.00
Trash: General	0.35	0.46	0.59	0.76	-	-	0.63	0.42	0.23	0.33	0.05	0.11

Bleach – Disease	mean		mean		mean		mean		mean		mean	
Bleaching (% of coral population)	0.00		0.12		-		0.00		0.00		1.70	
Bleaching (% of colony)	0.00		0.05		-		0.02		0.00		8.80	
Coral disease (% of coral affected)	0.00		0.00		-		0.00		0.14		0.00	

Living Substrate Cover (%)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Hard coral	35.83	17.32	32.88	15.90	22.28	9.56	28.06	4.51	36.08	15.40	47.01	22.64
Soft coral	0.87	1.75	12.50	8.87	17.11	18.70	8.06	8.05	10.69	8.33	0.00	0.00
Nutrient indicator algae	4.93	6.32	1.49	3.87	0.06	0.14	4.80	4.50	2.39	7.31	1.00	0.95
Sponge	1.28	2.27	0.10	0.38	0.11	0.17	1.55	0.92	1.87	3.55	0.25	0.56
Other	4.79	4.12	0.31	0.59	0.78	0.58	3.63	5.08	1.31	2.23	5.00	5.45

Non-living Substrate Cover (%)	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±	mean	SD±
Recently killed coral	1.88	1.87	2.60	4.02	0.56	0.17	0.09	0.03	0.70	1.49	0.63	1.40
Rock	29.69	11.87	36.42	11.41	24.11	5.49	33.40	4.61	34.41	8.70	24.13	9.87
Rubble	13.96	11.75	4.78	6.30	5.28	1.96	10.79	2.32	6.83	5.17	13.25	9.68
Sand	5.52	6.16	8.92	11.15	29.61	11.48	7.68	7.22	4.15	5.89	8.75	8.42
Silt/Clay	1.25	1.71	0.00	0.00	0.11	0.17	1.93	0.96	0.00	0.00	0.00	0.00

APPENDIX 12

The sites surveyed during the 2002 and 2008 regional surveys

Country	City / Island / Shore	2002 Survey	2008 Survey
Egypt	Nuweiba (Ras Shetan – Castle Beach)	----------	Done
	Dahab (Island – Dive Inn Beach)	Done	Done
	Nabq (Ghargana)	Done	----------
	Ras Nosrani (Melina Sinai)	----------	Done
	Ras Nosrani (Ras Gamila)	Done	----------
	Ras Nosrani (Ras Bob)	Done	----------
	Ras Mohamed (Visitor Centre)	Done	----------
	Ras Mohamed (Marsa Berika)	Done	----------
	Ras Mohamed (Anemone City)	Done	Done
	Hurghada (Fanader)	Done	----------
	Hurghada (Gotta Abu Ramada)	Done	Done
	Safaga (Ras Abou Soma)	Done	Done
	Hamrawin	Done	---------
	Qusier (Marsa Wizr – Mangrove Bay Beach)	Done	Done
	Marsa Alam (Marsa Shaqraa)	Done	Done
Sudan	O'Seif (Eastern of O'Seif Prot jetty)	----------	Done
	Arkiyai (Reef off Arkyai fishing village)	----------	Done
	Wingate SSE	Done	----------
	Sanganeb SSW	Done	----------
	Sanganeb NNE	Done	----------
	Port-Sudan (Abou Hashish – Reef off Port-Sudan fish market)	----------	Done
	Tawartit (Nemrose wreck)	Done	----------
	Suakin (Reef off Suakin Port)	Done	Done
	Tala Tala Saghir (South)	Done	----------
Djibouti	Maskali Island (Light House western reef)	Done	Done
	Maskali Island (Canyon)	----------	Done
	Moucha Islands (Grand Recif – Tombant Nord)	Done	Done
	Moucha Island (South)	Done	----------
	Tadjoura Bay (Sable Blanc – Adali west)	Done	----------
	Tadjoura Bay (Sable Blanc – Ras Ali east)	Done	----------
	Tadjoura Bay (Trois Plages east)	Done	----------
	Tadjoura Bay (Trois Plages west)	Done	----------
	Seven Brothers Islands (Grande Ile – Japanese Garden)	----------	Done
	Seven Brothers Islands (Ile de l'Est – Chinese Garden)	----------	Done
Somalia	No survey was conducted	----------	----------

Country	City / Island / Shore	2002 Survey	2008 Survey
Yemen	Tiqfash Island	Done	Done
	Jabal Makasar (Six Foot Rocks)	Done	----------
	Kamaran Island	Done	----------
	Zuqar Island-NW (Al-Sheikh Faian)	Done	----------
	Zuqar Island-SW	Done	----------
	Shalatem Island	----------	Done
	Myyun Island	----------	Done
	Shaqraa coast	----------	Done
	Sikha Island	----------	Done
	Macroqha Island	----------	Done
	Socotra Island (Roosh Halah)	----------	Done
KSA	Haql (Dora)	----------	Done
	Maqna	----------	Done
	Duba (Cement Tabouk)	----------	Done
	Al-Wajh (Marsa Zaam)	Done	----------
	Al-Wajh (Raikha Island)	Done	----------
	Al-Wajh (Marduna Island)	Done	----------
	Al-Wajh (Sheikh Mirbat Island)	Done	----------
	Al-Wajh (Umm Rumda Island)	Done	----------
	Umm Lajj	----------	Done
	Mastura	----------	Done
	Jeddah (Gruglg Tower)	Done	----------
	Jeddah (Al-Kharq)	Done	----------
	Jeddah (Bayatha)	Done	----------
	Jeddah (Big Patch Reef)	Done	----------
	Jeddah (Corniche)	Done	Done
	Al Lith	----------	Done
	Assir (Hali)	----------	Done
	Farasan Islands (Oshka Island)	Done	----------
	Farasan Islands (Al-Baqla Patch Reef)	Done	----------
	Farasan Islands (Mashkoor Island)	Done	----------
	Farasan Islands (Duraka Island)	Done	----------
	Farasan Islands (Rakda Island)	Done	----------
	Farasan Islands (Murba Island)	Done	----------
	Farasan Islands (Zfaf)	----------	Done
	Farasan Islands (Sumeer Island)	Done	----------
	Farasan Islands (Ramin Island)	Done	----------
Jordan	Aqaba (First Bay)	Done	Done
	Aqaba (Japanese Garden)	Done	Done
	Aqaba (Aquarium)	Done	Done

1. يجب على المستوى الوطنى (فى كل دولة لم تبدأ بعد) وضع وتنفيذ برنامج طويل الأمد لمتابعة ومراقبة الشعاب المرجانية، مما سيوجد الفرصة لتحديد الموارد وحشد الإمكانات المطلوبة لتنفيذ هذا البرنامج من خلال الهيئات والموازنة الوطنية لكل دولة، وهو ما سيعضد تحقيق أهداف وإستمرارية أنشطة المراقبة البيئية والحماية.
2. تقترح الهيئة على كل الدول الأعضاء تحديد شبكة مكثفة من مواقع رصد الشعاب المرجانية على المستوى الوطنى من خلال برنامج الرصد الخاص بها وإستخدام طريقة ريف تشيك (Reef-Check) كخطوة أولى بهدف الحصول على نتائج بشكل يتيح إمكانية مقارنتها على المستوى الإقليمى والدولى، وهو ما سيعطى الفرصة لتقييم الوضع وحالة الشعاب فى كل دولة ومدى كفاءة أنشطة وإجراءات الحماية الوطنية. وعند نجاح تمويل وإستمرارية تلك البرامج الوطنية، يمكن إدماج عدد أكبر من مواقع الرصد وإستخدام طرق أكثر تفصيلا وذلك طبقا للخبرة والإمكانات المتاحة حينئذ.
3. البرنامج الأمثل لمراقبة ومتابعة حالة الشعاب المرجانية يمكن أن يحتوى على مستويين من الرصد: فى المستوى الأول عدد قليل من مواقع "الرصد التفصيلى" يستخدم فيها طرق عالية الجودة للرصد (يتم فيها تجميع كم ونوع نتائج تفصيلية أكثر تعقيدا) مثال تلك الطرق الموجودة فى دليل طرق الرصد ل English et al. (1997)، وفى المستوى الثانى عدد أكبر من مواقع "الرصد السريع" يستخدم فيها طرق رصد أقل تعقيدا مثل طريقة ريف تشيك (Reef-Check). ويحتوى دليل الهيئة "الدليل الإسترشادى لمسح الموائل والأنواع الرئيسية فى البيئة البحرية" على كل تلك الطرق والتى تحتوى على طرق سريعة وطرق أكثر تعقيدا بحيث يمكن أن يستخدمها فريق العمل الوطنى طبقا للإمكانيات والخبرة المتاحة وتطورهما المستقبلى.
4. نظرا لحقيقة أن طريقة الرصد "ريف تشيك" قد أعدت وصممت خصيصا لمشاركة المجتمع فى أعمال رصد الشعاب المرجانية، لهذا يمكن للهيئة والوزارات المعنية فى دول الإقليم الإستفادة من دعم الجمعيات الأهلية لإشراك الفئات المختلفة من المجتمع فى العمل التطوعى للأنشطة الدورية لمتابعة ومراقبة الشعاب المرجانية. وبذلك يمكن زيادة عدد مواقع "الرصد السريع" بصورة كبيرة دون تحمل ميزانيات إضافية، وكذلك يمكن توزيع فرق العمل التطوعى طبقا لإحتياجات برنامج المراقبة الوطنى. وعليه فإن فرق العمل الوطنية (التابعة للجهات الرسمية) يمكنها بذلك تركيز أنشطة الرصد فى مواقع "الرصد التفصيلى" والتى تحدها الإمكانيات والخبرة الوطنية المتاحة، وبذلك سيتاح كم أكبر من النتائج على المستويين.
5. يجب أن تدعم الهيئة مشاركة باحثين من الإقليم فى المبادرات والبرامج الدولية للباحثين المعنيين بمتابعة ظاهرة إرتفاع درجة حرارة مياه البحار كمؤشر تحذيرى لتفشى ظاهرة إبيضاض الشعاب المرجانية.
6. تهتم وتعمل الهيئة على التواصل مع المبادرات الدولية المعنية بالمحافظة على البيئة البحرية ولكن يجب كذلك البدأ وتطوير المشاركات على المستوى الوطنى. وهنا تبرز أهمية تصميم وإعداد وتطبيق برامج مراقبة وطنية للبيئة البحرية. بالإضافة إلى ذلك يجب إدماج برامج المراقبة الوطنية فى شبكة إقليمية واحدة وإدماج كل النتائج فى مركز المعلومات الإقليمية للهيئة والذى سيتيح فرصة إعداد تقارير موحدة على المستويين الوطنى والإقليمى وبصورة دورية عن حالة البيئة البحرية، ويعطى فرصة تقييم حالة البيئة البحرية على المستوى الإقليمى والدولى، مما سيؤدى إلى تطوير وكفاءة إتخاذ القرارات وإجراءات الصون فى دول الإقليم.

94% من مواقع الرصد سواء خلال المسح في عام 2008 أو فى عام 2002، مما يدل على وجود كثافة شديدة لأنشطة صيده وتجميعه. هذا وقد تم تسجيل إختفاء الإستاكوزا من 90% من مواقع الرصد فى منطقة المحيط الهندى-الهادى خلال 1997-2001.

- قنفذ البحر ذو الأشواك الطويلة السوداء (*Diadema*)، والذى تعتبر وفرة أعداده مؤشر يرتبط بوجود مشاكل بيئية فى منطقة الشعاب المرجانية، أظهرت النتائج إنخفاض فى أعداد ذلك الحيوان فى 2008 عما كانت عليه فى 2002. ولكن تلك الأعداد أقل مما تم تسجيله فى منطقة المحيط الهندى-الهادى خلال عام 2000.
- محار التريتون (Triton)، والذى تعتبر وفرة أعداده مؤشر يرتبط بكثافة تواجد لأنشطة صيد وتجميع المحار من على الشعاب المرجانية لإستخدامه كتحف بحرية، وقد أظهرت النتائج إختفاء ذلك المحار من 90% من مواقع الرصد سواء خلال عام 2008 أو عام 2002، مما يدل على وجود صيد وتجميع كثيف لذلك المحار. وقد تم تسجيل نفس النتائج فى مواقع الرصد فى منطقة المحيط الهندى-الهادى خلال 1997-2001.
- محار البصر (Tridacna)، والذى تعتبر وفرة أعداده مؤشر يرتبط بكثافة تواجد لأنشطة صيد وتجميع المحار من على الشعاب المرجانية لإستخدامه كغذاء أو لأحواض أسماك الزينة أو كتحف بحرية، وقد أظهرت النتائج تواجد ذلك المحار فى 70% من مواقع الرصد سواء خلال عام 2008 أو عام 2002. وكان المحار المرصود أقل من 20سم طولا وهى الأطوال التى يصعب على الصيادين تجميعها. هذا وقد تم تسجيل كثافة أعداد أعلى فى مواقع الرصد بمنطقة المحيط الهندى-الهادى خلال 1997-2001.
- خيار البحر (Sea-cucumber)، والذى تعتبر وفرة أعداده مؤشر يرتبط بكثافة تواجد لأنشطة صيد وتجميع لتصديره كغذاء بحرى، تم تسجيل إعداد أكثر خلال 2008 عما سجلت خلال 2002، ولكن بأحجام أصغر (أقل من 10سم)، وهو ما يمكن أن يعكس إندثار الأحجام الكبيرة من ذلك الحيوان نتيجة الصيد الجائر له. وكانت معظم مواقع الرصد فى منطقة المحيط الهندى-الهادى خالية تماما من خيار البحر خلال عام 2001.
- نجم البحر ذو التاج الشوكى (Crown-of-Thorns)، وهو يؤدى إلى تدمير شامل للشعاب المرجانية فى حالة تفاقم أعداده من خلال ظاهرة الإنفجار التكاثرى له (outbreak)، تم تسجيل ذلك الحيوان فى 35% من مواقع الرصد خلال عام 2008 وعام 2002 ولكن بأعداد متزايدة كلما إتجهنا لجنوب البحر الأحمر. تم تسجيل أعداد أقل فى منطقة المحيط الهندى-الهادى خلال 1997-2001.
- لم يختلف معدل الغطاء الحى للمرجان الصلب فى 2008 عما كان عليه فى 2002، وقدر الغطاء بنحو 10%-50% فى معظم مواقع الرصد. ولكن أظهرت بعض المواقع كثافة غطاء قدرت بنحو 50%-70% فى 4 مواقع من أصل 36 خلال 2008، و 7 مواقع من أصل 52 خلال 2002. وقد تم تسجيل معدلات مماثلة من الغطاء الحى للمرجان الصلب فى مواقع الرصد بمنطقة المحيط الهندى-الهادى خلال 1997-2001.
- الطحالب الدالة على الأملاح المغذية، والتى يعتبر معدل تواجدها مؤشر يرتبط بوجود مصادر صرف للأملاح المغذية إلى مياه البحر، أظهرت النتائج إنخفاضا حادا فى الغطاء الحى لتلك الطحالب خلال عام 2008 عما تم تسجيله خلال عام 2002. وطبقا للنتائج المرصودة لمعدلات تواجد تلك الطحالب فى مناطق أخرى من العالم، فإن منطقة البحر الأحمر وخليج عدن تعتبر من أقل البحار فى إحتوائها على تركيزات أملاح مغذية يمكن أن تكون ناتجة من مصادر صرف للأملاح المغذية إلى مياه البحر، كالتلوث بالصرف الصحى مثلا.

هناك بعض التوصيات التى يقترحها التقرير كإجراءات يجب تنفيذها لضمان تطوير إجراءات المتابعة والمراقبة لبيئة الشعاب المرجانية والتى ستساهم فى تقييم معايير وإجراءات الصون والحماية التى يتم تنفيذها على المستويين الوطنى والإقليمى. وتتلخص تلك التوصيات فى الآتى:

تقييم كمى عن الغطاء الحى لبعض الكائنات القاعية ومنها المرجانيات. بالإضافة إلى ذلك، يمكن من خلال طريقة المسح تجميع معلومات مختلفة عن أنواع المؤثرات السلبية ومدى تأثر الشعاب بها، مثل كمية المخلفات الصلبة، وكمية المرجان الميت، وكمية المرجان المعرض للإبيضاض.

وبهدف إستمرارية أعمال المراقبة والمتابعة البيئية للشعاب المرجانية على طول الإقليم فى خطة طويلة الأجل ولدقة مقارنة النتائج المستقبلية، تم إعداد خريطة تفصيلية لكل موقع من مواقع الرصد التى حددت وبإستخدام: صور جوجل – إيرث (Google-earth)، وجهاز تحديد الموقع الجغرافى (GPS)، وصور أرضية، وخرائط الملاحة البحرية الإنجليزية. وقد تم إختبار مدى دقة وصحة تحديد كل موقع على تلك الخرائط أثناء العمل الميدانى وتعديلها فى حينها وبالتشاور مع أعضاء فريق العمل الوطنى.

تم مراجعة وتعديل نتائج المسح الإقليمى لعام 2002 (52 موقع) وذلك بهدف وضعها فى صورة قابلة لمقارنتها بنتائج المسح الميدانى لعام 2008 (36 موقع). ترجع أهمية تلك الخطوة إلى محاولة تحييد التعديل الدولى الذى حدث خلال عام 2006 فى تطبيق طريقة المسح "ريف تشيك" بتعديل أنواع بعض الكائنات وكذا طريقة تحليل النتائج. وعليه أمكن مقارنة نتائج عامى 2002 و 2008 وإبراز وجود أى إختلافات بيئية طبقا للتوزيع الجغرافى أو الزمنى. كذلك تم إجراء إختبار المتغيرات الملحوظة (One-way ANOVA) بإستخدام أعداد وكثافة الكائنات المرصودة بعد تجميع النتائج لرصد أى إختلاف على مستوى الإقليم ($p=0.05$). هذا وقد تم حساب وإدماج نتائج كل دولة على حدة وإرفاقها فى ملحق التقرير للمرجعية. بالإضافة إلى ذلك فقد تم إرفاق الخرائط التفصيلية لكل موقع رصد والشكل التوضيحى لتضاريس ومدى إنحدار الشعاب المرجانية.

كذلك فقد تم مقارنة نتائج مسح شعاب إقليم البحر الأحمر وخليج عدن مع النتائج المتاحة والمماثلة من مناطق أخرى من العالم. وقد تلخصت نتائج المسح فى الآتى:

- أسماك الفراشة (Butterflyfish)، والتى تعتبر وفرة أعدادها مؤشر يرتبط بكثافة تواجد أنشطة صيد لأسماك الزينة، أظهرت أعدادها زيادة طفيفة فى 2008 عنها فى 2002. ولكن هذه الأعداد كانت أقل من مثيلتها التى سجلت فى منطقة المحيط الهندى-الهادى خلال الفترة 1997-2001.
- أسماك المحسنى (Haemulidae-sweetlips)، والتى تعتبر وفرة أعدادها مؤشر يرتبط بكثافة تواجد لأنشطة الصيد بإستخدام خيوط الصيد أو بالحراب، كانت أعدادها متشابهة فى كلا من مسوحات 2008 و 2002. ولكن تلك الأعداد كانت أعلى بكثير من مثيلتها المرصودة فى منطقة المحيط الهندى-الهادى خلال 1997-2001.
- أسماك الوقار (Grouper) الأكبر من 30سم طولا، والتى تعتبر وفرة أعدادها مؤشر يرتبط بكثافة تواجد لأنشطة الصيد بالقرب من مناطق الشعاب بإستخدام خيوط الصيد أو الحراب، أظهرت أعدادها إنخفاضا طفيفا فى 2008 عنه فى 2002. ولكن تلك الأعداد كانت أعلى مما تم رصده فى منطقة المحيط الهندى-الهادى خلال 1997-2001، وأقل مما تم رصده فى البحر الأحمر فقط فى نفس الفترة.
- أسماك فارس - مرجان (Snapper)، والتى تعتبر وفرة أعدادها مؤشر يرتبط بكثافة تواجد لأنشطة الصيد بالشباك بالقرب من مناطق الشعاب، أظهرت أعدادها إنخفاضا حادا خلال المسح الميدانى فى 2008 عما تم رصده فى 2002. وتعد تلك الأعداد عالية جدا عما تم رصده فى منطقة المحيط الهندى-الهادى خلال 1997-2001.
- أسماك الببغاء - الحريد (Parrotfish)، والتى تعتبر وفرة أعدادها مؤشر يرتبط بكثافة تواجد لأنشطة الصيد ومدى نمو الطحالب البحرية على الشعاب المرجانية، كانت أعدادها متشابهة فى كلا من مسوحات 2008 و2002. وتشابهت تلك الأعداد مع مثيلتها المرصودة فى منطقة المحيط الهندى-الهادى خلال 1997-2001.
- كركند-إستاكوزا (Lobster)، والذى تعتبر وفرة أعداده مؤشر يرتبط بكثافة تواجد لصيد وتجميع للإستاكوزا من على منطقة الشعاب، لم يتم تسجيل أى أعداد من الإستاكوزا فى

الملخص التنفيذى:

يتميز إقليم البحر الأحمر وخليج عدن بالتنوع الكبير فى البيئات البحرية، وإحتوائه على كائنات بحرية فريدة، والأهمية الإجتماعية والإقتصادية لموارده البحرية فى تنمية الإقليم. وقد شهد الإقليم نهضة تنموية ساحلية سريعة ومضطردة على مدار الأربع عقود الماضية. وفى بعض المناطق صاحبت تلك النهضة تدهور للبيئات البحرية والساحلية وإنخفاض قدرة تلك البيئات على إستدامة مواردها لتوفير سبل المعيشة للمجتمعات الساحلية. لذلك سعت دول الإقليم لتوفير الحماية والحفاظ على هذه البيئات وقامت بإنشاء الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن "برسجا". تتمركز مهمة الهيئة فى تنسيق الجهود الوطنية، والمبادرات، والأنشطة فى إطار إقليمى للمحافظة على الموارد الطبيعية وإستدامة إستخدامها.

وخلال العقدين الماضيين تم تحقيق تطور كبير فى معرفة وإدارة الكثير من الموارد البحرية والساحلية فى الإقليم. فهناك الكثير من النتائج قد تم تجميعها ساهمت فى إعداد مراجع علمية وتقارير فنية لمساعدة متخذى القرار فى إتخاذ التدابير اللازمة للحفاظ على البيئة البحرية والساحلية.

تم إعداد برامج مراقبة للبيئات الحساسة، أثناء فترة عمل البرنامج الإستراتيجى (SAP)، وذلك لتوحيد طرق القياس والمسح البيئى أثناء تجميع النتائج المطلوبة، ولمقارنة الحالة الراهنة لتلك البيئات فى الإقليم مع قريناتها فى مناطق أخرى من العالم. لهذا تم صياغة وإعداد دليل لطرق موحدة للمسح البيئى فى الإقليم، وتدريب المتخصصين الوطنيين على تلك الطرق لضمان دقة وإمكانية مقارنة النتائج التى يتم تجميعها فى المسوحات المستقبلية. وقد نجحت الهيئة فى التعاون مع الدول الأعضاء وتنفيذ مسوحات حقلية لبيئات الشعاب المرجانية على طول سواحل الإقليم وذلك خلال عامى 2002 و2008. وقد إستخدمت طرق المسح الموحدة عند إجراء تلك المسوحات، وخلال المسح الأخير (2008) تم تحديد عدد من مواقع الشعاب المرجانية على طول الإقليم لتكون الشبكة الإقليمية لمواقع رصد ومراقبة الشعاب المرجانية.

يستعرض التقرير نتائج المسح الإقليمى لعام 2008. حيث تم تحديد وإختيار 36 موقع شعاب مرجانية على طول الإقليم بواسطة فريق العمل المكون من خبراء الهيئة والخبراء الوطنيين. وتتوزع تلك المواقع فى دول الإقليم كالآتى: 5 فى جيبوتى؛ 8 فى مصر؛ 3 فى الأردن؛ 9 فى السعودية؛ 4 فى السودان؛ 7 فى اليمن. وقد تم الأخذ بعدة إعتبارات أساسية عند إختيار تلك المواقع لضمان إمكانية إستدامة أعمال المراقبة فى المستقبل. وتضمنت هذه الإعتبارات: سهولة الوصول إلى تلك المواقع خلال المسوحات القادمة، إعتبارات تتعلق بأمن وأمان أعضاء الفريق أثناء العمل الميدانى، وبالطبع تم الأخذ فى الإعتبار الإستعدادات اللوجستية والإمكانيات المتاحة فى كل دولة.

خلال المسح الإقليمى فى 2008 تم إستخدام طريقة المسح البيئى للشعاب وفقا لطريقة "ريف تشيك"، وهى إحدى طرق المسح المتعارف عليها دوليا والمحددة من الهيئة فى "الدليل الإسترشادى لمسح الموائل والأنواع الرئيسية فى البيئة البحرية لإقليم البحر الأحمر وخليج عدن". وصممت تلك الطريقة بحيث تعطى تقييم سريع وشامل عن مدى تواجد وكثافة عدد من أنواع الأسماك واللافقاريات المعروف بأن تواجدها وأعدادها يمكن أن يستخدم كمؤشر يدل على صحة الشعاب أو على مدى كثافة الصيد فى المناطق المتواجدة بها. وتعطى تلك الطريقة أيضا

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تستمد الهيئة قاعدتها القانونية من الإتفاقية الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن (١٩٨٢م). وقد تم إعلان إنشائها فى القاهرة فى سبتمبر ١٩٩٥م، حيث تتخذ من مدينة جدة مقرا لها. تضم الهيئة فى عضويتها كل من الأردن، جيبوتى، السعودية، السودان، الصومال، مصر، واليمن.

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بريد إليكترونى: persga@persga.org
موقع إليكترونى: http://www.persga.org

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الوضع الراهن للشعاب المرجانية
في البحر الأحمر وخليج عدن

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