Journal of Arid Environments (2003) **54**: 71–80
doi:10.1006/jare.2001.0889

Integrated Marine and coastal management: a strategy for the conservation and sustainable use of marine biological resources in the Socotra Archipelago, Yemen

R. Klaus*, D. A. Jones†, J. Turner†, N. Simöes† & D. Vousden†

**Department of Biological Sciences, University of Warwick, Coventry, CV4 7AL, U.K.*
†School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Anglesey, North Wales, LL59 5EY, U.K.

Past conservation policies have often foundered due to conflict between those seeking to defend resources and those excluded from their usage. The concept of sustainability was introduced in the 1980s with a world conservation strategy arguing that natural biological populations produce a surplus which can be harvested in a sustainable manner. This policy moved considerably in the 1990s with the recognition that most uses are detrimental and a sustainable harvest is difficult to calculate or achieve. Apart from problems in the determination of environmental and biological factors governing sustainability, it was also recognized that social and economic forces play a major role. Thus, the Convention on Biological Diversity in 1992 was founded upon conservation, sustainable use and an equitable sharing of the benefits from resources. Integrated Marine and Coastal Area Management (IMCAM) also known as Integrated Costal Zone Management has been suggested to be the most suitable strategy to manage human impacts on marine and coastal biodiversity and to promote conservation and sustainable use of biological resources. IMCAM involves all users or stakeholders including decision makers in the public and private sectors, resource owners, managers, users, non governmental organizations and the general public. The use of this approach to conservation is described by reference to the recent UNOPS/GEF/UNDP-sponsored marine zoning plan for the conservation and sustainable use of the biodiversity and natural resources of the Socotra Archipelago, Yemen.

Keywords: convention on Biological Diversity; integrated marine and coastal area management; conservation; sustainable use; marine biodiversity; zoning plan; Socotra

Introduction

Although human population growth rates are slowing and are expected to stabilize during the present century, there is no evidence that the human rate of exploitation of natural resources is following the same trend. With ever more efficient technology, harvesting and consumption of resources is likely to extend beyond present where biodiversity levels can be sustained. The international need for the protection of marine resources was recognized with the First World Conference on National Parks in Seattle in 1962, which called for the creation of marine parks to defend resources from

0140–1963/03/010071 + 09 $30.00/0

human interference (Freestone, 1995). This initiative was further developed at the 1975 International Union for the Conservation of Nature (IUCN) conference in Tokyo, where the concepts of critical habitats and management were introduced. (IUCN, 1976; de Fontaubert, et al. 1996).

Table 1 traces changes in the approach to conservation during the last two decades. It was soon recognized that the simple concept of defending resources from exploitation

Table 1. *Development of approaches to marine conservation and the problems*

	Source	Approach	Problem
1962	First World Conference on National Parks, Seattle	Creation of marine parks to defend marine resources from human interference	Attracts tourism and further degradation
1971	UNESCO Man and Biosphere (MAB) Programme	Aimed to balance conflicts betweeen goals of conservation and development	Requires fulfilment of certain criteria including a management plan.
1975	IUCN Marine Parks Conference, Tokyo	Development of concept of critical marine habitats and need for management of marine parks	Attracts tourism and further degradation
1980	World Conservation Strategy	Recognition that unrestricted use of resources is not sustainable, but surpluses can be harvested sustainably	Simplistic model assumes harvest levels can be accurately measured
1990	Conservation of Wildlife as Renewable Resource by Informed Use IUCN	Recognition that discrimination between sustainable uses and others uses is necessary	Ignores multidimensional nature of problem
1992	1992 United Nations Conference on Environment and Development, Earth Summit, Rio de Janeiro, Brazil	Linkage of conservation and sustainable use with equitable sharing of benefits	Produces difficulty in calculating environmental role in resource fluctuations
1996	1995 Second Conference of the Parties to the Convention on Biological Diversity, Jakarta, Indonesia	Integrated Marine and coastal area management recognized as best strategy as all stakeholders are involved; ecosystem approach	Requires time for participatory consultation with stakeholders from local to government to develop working strategies especially as resources can cross national boundaries

was untenable, particularly where those excluded were from local communities and those depending were from the developed world. In the 1980s and early 1990s it was recognized that while unrestricted exploitation led to collapse, some resources could be exploited sustainably by the removal of natural surpluses. Again, as world fisheries have shown, this was simplistic due to the difficulty in measuring so-called natural surpluses and ensuring that quotas are complied with, especially, for example, in multi-species fisheries with large by-catches (Agardy, 1997).

The political influence of economics over conservation was fully recognized at the Earth Summit in Rio de Janeiro in 1992 one of the key agreements to emerge from the Earth Summit was the convention of Biological Diversity, in which the conservation of biodiversity was linked to sustainable use and the equitable sharing of the benefits. Although the convention did not resolve the problems in calculating environmental effects on the variability of a resource, it recognized that unless all those involved in conserving a resource (i.e. the stakeholders) benefit, successful conservation is unlikely. The importance of marine and coastal biological diversity was recognized at the Second Conference of the Parties to the Convention on Biological Diversity (November 1995, Jakarta, Indonesia). The resulting agreement, the Jakarta Mandate on Marine and Coastal Biological Diversity, realised the need for a broad based management framework. Follow up discussions identified the principles of Integrated Marine and Coastal Area Management (IMCAM) as the best strategy for the conservation and sustainable use of biological diversity (Table 2).

The principles of IMCAM amalgamate scientific, social, political and economic factors into a comprehensive management strategy, which can be applied to the entire ecosystem. The participation of all the stakeholders, from the local community to the government, from the outset, during development, through to the implementation phase of the management plan is of prime importance. Although at the outset, it is necessary to have a clear base for prioritization of threats to biodiversity, over time, priorities may change and regular review is necessary. Finally, there will be a need for national and local

Table 2. *Principles of integrated marine coastal area management*

Principle	Activity
Integrate methods and approaches	Integrate a top-down and bottom-up approach; Integrate science, social, political and economical factors; Integrate sectors and disciplines.
Integrate across scales	Ecosystems approach; considers the importance of the region to the individual species and vice versa.
Strategic Focus	Provide an action plan for identifying the critical habitats/species within the ecosystem in need of protection and prioritizing threats.
Participation	Broad stakeholder participation, from local resource users to government with ongoing consultations throughout the process.
Long term perspective	Review and evaluate long term project strategy. Recognition that all problems cannot be tackled at the same time.
Adaptive/Flexible	Sensitive to resource user needs and historical rights. Recognition that threats and user needs may change with time.
Capacity Building & Training	Build capacity at local, national and regional levels through training to ensure long term viability.

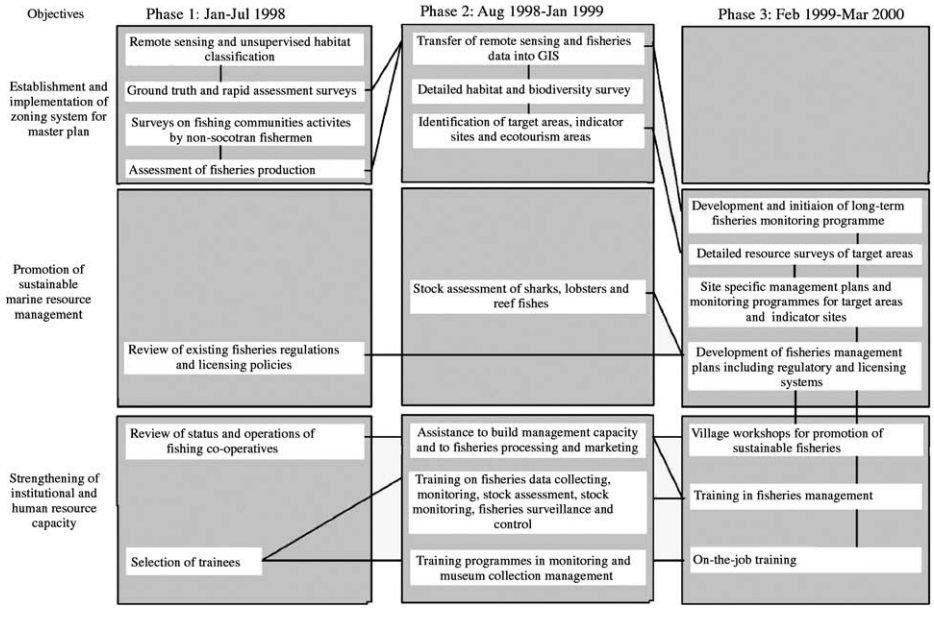

Figure 1. Task flow chart for the UNDP-GEF project 'Conservation and Sustainable Use of the Biodiversity of the Socotra Archipelago'.

training in aspects of environmental awareness and technology so that, for example, monitoring programs and less invasive fishing methods can be initiated and become self-sustaining at the local level.

The present work aims to examine the application of some of the principles of IMCAM in the development of a marine zoning plan for the conservation and sustainable use of the biodiversity of the Socotra Archipelago, Yemen (UNOPS/UNDP/GEF project Yem/96/G32). The Socotra island group lies some 400 km south of the Arabian Peninsula and 95 km east of Somalia and consists of the main island of Socotra and three small islands, Abdel-Kuri, Samha and Darsa and two rock outerops subyona and Kal Farun, all under the administration of the Republic of Yemen (Fig. 1). The total population is estimated at 50,000–80,000, mostly living on Socotra, and is mostly dependent upon livestock and fishing for livelihood. The islands are subject to the northern Indian Ocean monsoon climate, with cold water upwelling and strong winds associated with the South West monsoon in the northern boreal summer and calmer weather during the weaker North East monsoon in the northern boreal winter.

From the terrestrial perspective the islands of Socotra are remote and isolated, but from the marine perspective the islands are located at the coincidence of three marine biogeographical areas; the Red Sea, Arabian Sea and Indian Ocean. The location is reflected in the unique and diverse combination of marine and terrestrial flora and fauna for instance, of the 850 plant species present, at least 277 are endemic. As a result, the World Wide Fund for Nature has designated the archipelago as a priority area with exceptional biodiversity under threat. It has been nominated as a UNESCO Man and Biosphere (MAB) Reserve. And in 1996 Yemen ratified the Convention on Biodiversity in 1996, and recognized Socotra as a Special Protected Area in urgent need of protection. The UNOPS/UNDP/GEF Socotra project is part of an overall five-year Global Environment Facility (GEF) plan for Yemen, and was initiated in 1997, with the aim of developing a zoning plan for the islands to ensure conservation and sustainable use of the biodiversity. The development of a zoning plan is one of the basic qualifying

Table 3. *Conservation and sustainable use of the biodiversity of the Socotra Archipelago, Yemen: objectives and participants*

a Objectives

1. Strengthen institutional and human resource capacity
2. Establish and implement a zoning system for the development plan
3. Promote sustainable land and marine resource management
4. Promote environmental education and awareness
5. Develop and implement an ecotourism management strategy

b Organisations and roles

Organisation	Role
International	
Global Environmental Facility (GEF)	Funding
United Nations Office for Project Services (UNOPS)	Management contracts
United Nations Development Programme (UNDP)	Environmental management
National	
Environmental Protection Council (EPC) UNDP Sustainable Environmental Management Program for Yemen	Implementing agency Coordination of project from mainland
Project Management Unit (PMU)	Project implementation base on Socotra
Socotra authorities, village leaders, public	biodiversity users
Marine scientific collaborators	
Senckenberg Institute and Natural History Musium	Contractors and execution of tasks
Hariri & Associates, Yemen	Marine habitat
University of Jordan, and Yarmouk University Marine Science Station	Biodiversity and fisheries surveys,
Red Sea University, Faculty of Marine Science & Fisheries	local training and provision of a marine
University of Wales Bangor, School of Ocean Sciences	zoning plan
University of Warwick, Department of Biological Sciences	

requirements for MAB Reserve designation. Table 3 lists the objectives of this project, and the international, national and local groups participating in the execution of the marine part of the project.

Materials and Methods

Figure 1 shows a flow chart outlining the sequencing of the tasks performed to complete the IMCAM objectives. During Phase I, a Landsat 5 Thematic Mapper (TM) satellite image (Plate 1) was acquired and processed prior to the first rapid assessment surveys in 1998 to facilitate the selection of survey sites. The construction of a geographical

information system (GIS) was also initiated to collate data from all project components. Details of this system are given elsewhere (Turner, 1997; Klaus, 1999), as are methods used for intertidal and subtidal ground-truthing surveys (Krupp & Hariri, 1999; Turner *et al.*, 1999a–c). During Phase I, surveys of fishing communities and fisheries production were completed and added to the GIS data-base. During Phase I, surveys of fishing communities, fish production and stock assessment of key fish and lobster resources were commenced. Collections of marine biota were made, duplicates of which were stored on the island, and sent to experts to ensure that accurate biodiversity and habitat identification was possible.

Socotran and mainland Yemeni counterparts participated in all surveys, and training was provided both during the surveys and at specific formal training workshops held on Socotra. These activities included; position fixing using global positioning systems (GPS); map interpretation; snorkelling and sub-tidal surveys; shore profiling and zonation mapping; species identification; sample collection, preservation and labelling; data recording; and the use of computer databases. A full training course and manual was produced in Arabic and English for use of Socotra.

During phase II biodiversity surveys were also completed by teams concerned with land and sea birds, marine turtles, terrestrial biodiversity and fisheries (Fig. 4). Traditional resource uses together with development requirements were also documented in consultation with Socotrans. Potential impacts on biodiversity, such as port developments and future tourism, were also estimated. Each of these specialist teams also contained local and national counterparts, and participated in workshops to obtain local views, and to provide environmental education and awareness campaigns.

Phases I-II were completed mostly on schedule despite the severe logistic problems posed by the monsoon from April to September which prevented access for visiting groups during this period each year. In the autumn of 1999, representatives of all groups met at a workshop held by the Senckenberg Institute in Germany to draft a marine zoning plan (an MZP). For details see Krupp & Klaus (2000). This was then taken to Yemen for discussion with the local community on Socotra, who drew up their own zoning plan. This was integrated with the experts' draft plan at meetings at Sana'a. In Phase III during 2000, the main goals will be to; use recent Landsat 7 Enhanced Thematic Mapper (ETM) satellite data the results of Phase II survey and further ground truth surveys to produce accurate marine and coastal biotope maps; conduct bioinventories of the proposed core sanctuaries areas; implement a monitoring

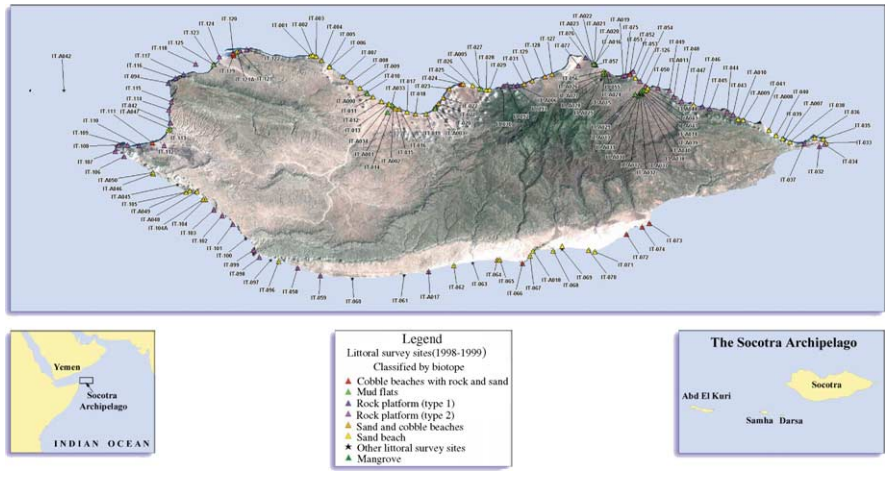

Figure 2. Littoral biotopes of the Socotra Archipelago.

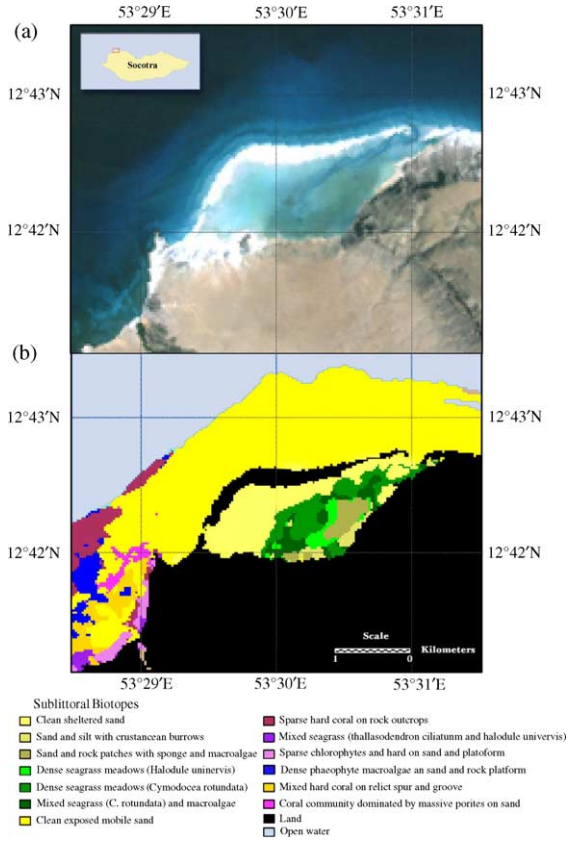

Figure 3. An example of the Sublittoral Biotope Classification for Diduah lagoon, NW Socotra island, (a) Landsat 5TM true colour composite; (b) Sublittoral Biotope Classification (Klaus *et al* 2000).

program; identify site specific protection requirements and develop the management plans.

Results

Plate 1 is Landsat 5 TM image of the Socotra island, which together with other GIS data such as bathymetry formed the basis for the intertidal and subtidal survey plans (Klaus, 1999). Results of these rapid assessment surveys which covered some 180 intertidal and subtidal sites (Turner et al., 1999; Simões & Jones, 2000) allowed supervised classification and production of habitat and resource maps using the satellite imagery which were imported into the GIS.

A preliminary classification of the seven littoral biotope complexes is shown in Fig. 2, and Fig. 3 shows the distribution of the 15 subtidal biotopes recognized during the study. In 1999, further studies concentrated upon the ecology and biodiversity of these biotopes allowing prioritization of target conservation areas such as the Diduah Lagoon, Khor Kari and Net Mangrove (Turner et al., 1999a, b; Simões & Jones, 2000). Monitoring or indicator sites were also identified as representative areas of the major biotopes. Similar studies were conducted subtidally with special attention given to the 1998 coral bleaching event which has severely reduced the density of live coral around the islands (Turner, 1999).

As illustrated in Fig. 4, the information gathered was used to focus discussion on a draft marine zoning plan MZP at the local level on Socotra; then a workshop was held in Sana'a to integrate local views with proposals from scientific groups. The draft MZP was returned to Socotra for public consultation by local authorities and NGOs, and was reviewed by local villagers and community leaders. At this stage particular attention was paid to the exact positioning of the boundaries of the core nature sanctuary areas (NS). Each of the proposed NS was visited by the author, the local project team members, together with at least one community leader present. Any potential conflicts of the NS with local resource use (e.g. fishing areas and gear types) were discussed. Only once conflicts were resolved and agreement had been reached were the boundaries of the proposed NS were then mapped using a GPS and included in the MZP. The draft zoning plan was created and submitted to the government of Yemen for approval.

In the plan, four zones are proposed for the coastal region: Resource Use Reserve, General Use Zone, National Park and Natural Sanctuary. The marine General Use Zone covers approximately 1 km^2 and is designated mainly for port infrastructure development and commercial development within the much larger (16,498 km^2) Resource Use Zone. The latter which extends out to the 12 nautical mile limit, will be managed to ensure long-term protection of the unique biological diversity of Socotra, but allow sustainable use of natural products to meet the needs of the community.

The National Park (1514 km^2) contains areas of land and sea where the unique coastal ecosystems of Socotra will be protected by excluding exploitation or occupation which is incompatible with conservation. However, these areas may be used by the local community for subsistence resource uses which do not conflict with biodiversity conservation objectives, and provide sites for recreation, scientific research and ecotourism. Within the National Park a total of 152 km^2 has been designated as a network of Nature Sanctuaries around the islands, consisting of natural unmodified or only slightly modified areas where risk of irreversible environmental damage is high so that protection and management is essential to protect biodiversity. These areas have been selected to allow recruitment of biota into other areas and to act as breeding areas. A total of five of these NS were already either traditionally managed by the Socotri or were proposed by them, the rest have all been agreed with the local community. Specific support is envisaged to allow existing low-density communities within or close to Natural Sanctuary zones to maintain their lifestyle while remaining in balance with the natural resources.

The MZP was provisionally accepted in 1999/2000. In Phase III (2000) the main goals will be to; provide accurate subtidal and intertidal habitat maps; in-depth bioinventories of core NS; implement monitoring programs; and site specific protection requirements and management plans. Development of fishery management plans will take place in village workshops to establish regulatory and licensing systems with further training provided in fisheries management and monitoring (Fig. 1).

Discussion

While it is recognized that the MZP is only part of the overall strategic plan for the conservation of the biodiversity of Socotra, and outcomes have yet to be evaluated, it illustrates many of the principles of Integrated Marine and Coastal Area Management (Table 2). The MZP was agreed upon through lengthy consultation, the integration of international, national and local opinion, together with the Socotri predisposed understanding of protected area management.

The remote situation of the archipelago, poor infrastructure, and severe climatic conditions combined to make initial classification and distribution of the biodiversity difficult to evaluate within the short time frame available. However, the selection of national and international scientists with regional expertise for rapid assessment surveys

combined with the use of satellite data and GIS has helped to surmount these obstacles. Data from the Phase I surveys was analyzed to produce littoral and sublittoral biotope maps (Figs 2 and 3), which allowed identification of target areas and indicator sites during Phase II. At the same time, other teams reviewed existing fishery regulations and traditional operations and conducted stock surveys to provide a base for the development of sustainable resource management. The approach was participatory (Fig. 4) involving local communities not only in the documentation of traditional fishing methods, but also in the provision of input into their development requirements and improvements, such as water supply and fish processing technology.

The MZP was designed using the ecosystems approach and incorporates the entire island groupout to 12 nm. The formulation of the MZP itself is an excellent example of strategic program focus providing a clear goal to which all stakeholders can relate. The proposal of zones and their functions provided stimuli for discussion by potential users at all levels from the government down to local village communities. This, in turn, has stimulated a demand for education in environmental awareness and triggered the training programs in monitoring, and stock assessment and other conservation-related employment. This commitment to building the human capacity for IMCAM (Table 2) also reinforces stakeholder participation, especially when it is perceived as delivering benefits such as employment.

It is important to emphasize that IMCAM is a long-term strategy and that designing a MZP is only the beginning. However, already a start has been made in the building of a local and national infrastructure capable of sustaining management of the issues arising from the MZP once this is in place. Many previous attempts at marine conservation have focussed upon individual species or the protection of small areas of biodiversity (marine parks) and failed, as these are part of and reliant upon a larger ecosystem (Agardy, 1997). Hence, management, as in the Socotra plan, must be extended to cover the whole island ecosystem and ultimately further extend into the region.

This requires links to be forged not only nationally but internationally with exchange of information between countries within a region. As evidenced by the recent coral bleaching phenomena (Turner, 1999), such links may be required to be made throughout the Indian Ocean or even globally. Above all, history teaches that unless all involved in the use of a national resource can see a beneficial return, a basic premise of IMCAM, conservation of biodiversity is unlikely to succeed.

The Socotra project is funded by the GEF under UNOPS YEM/96/G32, Contract No. C-972248. We are grateful to all those listed in Table 2 for their cooperation from 'top to bottom' and 'bottom to top' throughout this project.

References

Agardy, T.S. (1997) *Marine Protected Areas and Ocean Conservation*. Academic Press, Texas, USA. 248p.

de Fontaubert, A.C., Downes, D.R., and Agardy, T.S. (1996) Biodiversity in the Seas, Implementation of the Convention on Biological Diversity in Marine and Coastal Habitats IUCN Gland and Cambridge, in collaboration with Center for International Environmental Law, Washington DC and, World Wildlife Fund, Washington DC.

Freestone, D. (1995). The Conservation of Marine Ecosystems under International Law in Redgwell, C. and Bowman, W. (eds) International Law and the Conservation of Biological Diversity London, Kluwer Law International, pp. 97–107.

IUCN (1976) Proceedings of an International Conference on Marine Parks and Reserves held at Tokyo, Japan 12–14 May 1975. IUCN Publications new series No. 37. Switzerland: IUCN

Krupp, F. & Klaus, R. (1999) Contributions to a zoning plan for coastal and marine areas of Socotra. In Marine Habitat and Biodiversity and Fisheries Surveys and Management. Progress Report of Phase II. UNOPS YEM/96/G32 Contract No. C-972248.

Klaus, R. (1999) Summary of marine satellite image processing and geographical information systems. In: *Report of Phase I*, *Marine Habitat*, *Biodiversity*, *and Fisheries Surveys and Management*, pp. 9–32. Frankfurt: UNOPS YEM/96/G32 Contract No. C-972248.

Krupp, F. & Hariri, K.I. (1999). Conservation and sustainable use of biodiversity of Socotra Archipelago. *Marine Habitat, Biodiversity and Fisheries Surveys and Management. Report of Phase I*: Frankfurt: UNOPS YEM/96/G32, Contract No. C-972248. Pp. 1–212.

Simões, N. & Jones, D.A. (2000) Intertidal and coastal lagoons ecology survey of Socotra. In *Report of Phase II. Marine Habitat and Biodiveristy and Fishereis Surveys and Management*. UNOPS YEM/96/G32 Contract No. C-972248.

Turner, J.R. (1997). Habitat classification by remote sensing and ground truth surveys. In: Krupp, F. (Ed.), *Marine Habitat*, *Biodiversity and Fisheries Surveys and Management*: *proposal to UNOPS*. Frankfurt: Senckenberg Institute. pp 1–87.

Turner, J.R. (1999). A status report Socotra Archipelago. In: Linden, O. & Sporrona, N. (Eds). *Coral reef degradation in the Indian Ocean*, pp. 3–64. Stockholm, Sweden: CORDIO/SAREC. pp 1–108.

Turner, J.R., Klaus, R., Simöes, N. & Jones, D.A. (1999*a*). Ground truthing survey of the Socotra Archipelago: Abstract Reef Conservation UK 1999. London, UK Institute of Zoology.

Turner, J.R., Klaus, R., Simöes, N. & Jones, D.A. (1999*b*). Littoral and sublittoral ground truthing survey of the Socotra Archipelago. In: Krupp, F. & Hariri, K.I. (Eds). *Report of Phase I*, *Marine Habitat*, *Biodiversity and Fisheries Surveys and Management*: Frankfurt: UNOPS YEM/96/G32 Contract No. C-972248.

Turner, J.R., Klaus, R., Simöes, N. & Jones D.A. (1999*c*). Intertidal and subtidal survey training manual: Project Report. Frankfurt: UNDP/GEF UNOPS/YEM/96/G32.