PERSGA SAP

Component 5:
A Regional Network of Marine Protected Areas

Survey of the proposed Marine Protected Area at
Bir Ali – Belhaf,
Republic of Yemen.

Draft Survey Report

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**Executive Summary**

The Red Sea and Gulf of Aden contain some of the world’s most diverse and varied tropical marine habitats and communities. The combination of high levels of diversity, great biogeographic complexity, and high levels of endemism found in these bodies of water make the Red Sea and Gulf of Aden a region of global importance for marine biodiversity conservation (Chiffings 1995, PERSGA 2001).

The primary goal of the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is the conservation of the environment, and consequently conservation of the biological diversity, of this unique region. The PERSGA Strategic Action Programme (SAP) supports and facilitates that goal. The SAP includes several components (PERSGA 1999), one of which (Component 5) is *Development of a Regional Network of Marine Protected Areas*. Marine Protected Areas (MPAs) act as tools to provide for sustainable use of natural resources, economic development and biodiversity and habitat conservation.

Bir Ali lies on the northern shore of the Gulf of Aden, in Shabwa Province of the Republic of Yemen. Marine and coastal habitats and species of this area were first surveyed in the mid to late 1990s, and were recommended for protection within a Marine Protected Area (to include coastal features) in a survey report of 1998. The Bir Ali – Belhaf proposed MPA is one of four areas proposed under the PERSGA SAP within the Red Sea and Gulf of Aden to complete the regional network of a total of twelve MPAs (PERSGA 2002). The area contains extensive and diverse coral and reef fish communities (including perhaps the most diverse reef fish assemblages of the Arabian mainland), a unique mangrove community, historically and culturally important archaeological remains and spectacular, unspoiled coastal landscapes.

The objective of the PERSGA MPA-SAP field survey of the Bir Ali – Belhaf area was to rapidly identify and map the distribution and diversity of marine and coastal habitats, to establish the current status of resources such fish and benthic communities, and to assess the levels and types of human impacts within the proposed MPA.

The field surveys have been designed on a hierarchical structure, and use a range of different survey methods including Rapid Assessment and detailed methods. Site-specific data on resources including abundance, distribution and diversity of species, and human uses and impacts are key inputs to implementing management plans, and establishing an MPA. Rapid Environmental Assessment is a tool increasingly used to provide this information readily on a broad scale without requiring more time-consuming highly detailed disciplinary research. As such its value has been increasingly recognised, and methods developed to ensure valid comparability between regions (Price *et al.* 1988, De Vantier *et al.* 1998, Price 2001).

During the survey for Bir Ali – Belhaf a total of 136 geo-referenced locations were recorded. These consisted of 23 Rapid Ecological Assessments, 10 Detailed Site Descriptions, 6 each of Substrate and Fish Transects, 69 Quick Site Surveys and 34 miscellaneous terrestrial measurements for use as Ground Control Points (GCP: used to georeference the satellite data). The field survey data have been entered into a GIS database and used to create point maps illustrating the distribution and status of resources at survey sites within the proposed MPA.

The PERSGA MPA-SAP surveys have employed remote sensing data from the Landsat 7 Enhanced Thematic Mapper (ETM+) satellite to map the broad distribution of habitats and biotopes throughout the survey area, beyond the site-specific data of the survey sites. The satellite data was used to identify survey sites prior to the field surveys, and these were then ground-truthed during the survey phase. Preliminary coastal and marine biotope maps have thus been created from the ground truthed field survey data.
It should be noted that the biotope maps have not been fully assessed for accuracy post-classification. This would require another dataset independent from that used to create the initial classification, and fieldwork logistics and other resources available have not enabled such a dataset to be collected.

The proposed MPA at Bir Ali-Belhaf covers a total area of 1184 km², which includes 308 km² of land (including the islands) and 875 km² of sea, over 97% of which is water >15-20m deep. The proposed MPA will include one area of mangrove within an isolated crater lake of. Although of small size (< 0.5 km²) this mangrove is regionally and globally unique, being located inside the volcanic crater at Kharif Sha’ran to the east of Bir Ali.

The findings of the 2002 survey of the proposed Bir Ali – Belhaf MPA can be summarised as:

1. The marine and coastal ecosystems of the entire area remain varied and diverse. Some of the most important areas remain in good or very good condition.

2. Some areas, species and locations within the area are particularly vulnerable to habitat damage or overexploitation.

3. In stark contrast to the situation during the 1998 survey (Kemp 1998a), actually or potentially damaging human impacts and activities are now obvious at many sites visited throughout the survey area. This is a recent development, and the magnitude of the change over this short time of only four years is unexpected. Since 1998 fisheries in the area have become a potentially serious threat to the local environment, and a combination of overfishing and probably unsustainable fishing methods may threaten the medium to long term sustainability of the fishery itself (see also the Fisheries Report annex).

4. Impact of the 1998 coral bleaching event. The impact of the global coral bleaching event of 1998 is evident throughout the Bir Ali – Belhaf area, but levels of impact are highly variable. Sikha, Barakah and Belhaf have escaped almost unaffected, while Hallaniyah has suffered very badly and many areas of coral around that island are now almost 100% dead. Throughout the rest of the area coral mortality is variable, but probably averages 20 – 30%. New recruitment is evident in most locations and with appropriate management the corals of the area should recover over time, so long as further similar events do not recur regularly. The reduced area of healthy coral makes the surviving coral areas all the more important.

5. Some coral mortality is recent or on-going, and appears to be unrelated to the 1998 event, being caused by a white – band type disease instead. This is most apparent in areas with high cover of tabular Acropora, such as the western side of Ras Majdahah, where mortality of the impressive and large Acropora tables found there is very high. Causes of this disease here are unknown.

6. Turtles. The Bir Ali area, both mainland and islands, constitutes a nationally and regionally significant turtle nesting area. All species of marine turtle are globally endangered, and are listed on CITES Appendix 1. Unacceptably high numbers of turtle remains (hundreds of individuals) were found throughout the whole of the survey area. Although some of these casualties may have been killed while coming ashore for nesting, the majority were almost certainly killed by fishing activities including artisanal set-nets, and inshore incursions of industrial trawlers, and subsequently washed up on the shore. Rather than simply being released once caught, a number of very recently dead turtles washed up on the beach had clearly been deliberately killed by fishers before being discarded. It is strongly recommended that detailed surveys of turtle populations throughout the area are carried out as soon as
possible, and an effective monitoring programme introduced. This may be an appropriate role for the Habitats and Biodiversity Component of the PERSGA SAP. A community – based turtle management, protection and monitoring programme is strongly recommended for this entire area.

7. **Cetaceans.** The area is home to large numbers of cetaceans, including at least two species of dolphins. The remains of at least two large whales (one toothed and one baleen), seven small toothed whales and the fresh or skeletal remains of over two hundred dolphins were found along the shore in the survey area. A large proportion of the dolphin mortality is likely to be the result of accidental capture and subsequent discard by commercial trawlers, although it is known that local artisanal fishers occasionally kill dolphins for use as shark bait. Fisheries and particularly the commercial trawl fishery immediately offshore, is a significant threat to turtle and cetacean populations in the area.

8. There is currently no effective fishery management in the Bir Ali – Belhaf area. Fishers throughout the area have noted a rapid decline in abundance of several fisheries species in the past 2 – 4 years, and the disappearance of others. This uncontrolled activity (particularly the large number of seasonal fishermen from other areas who have no knowledge of local fishing traditions that promote sustainability) may, unless addressed, render the proposed MPA unworkable. Without the implementation of strictly enforced management these impacts are likely to continue and to increase, with consequent erosion of the biodiversity, ecological integrity and fisheries wealth of the area.

There is an urgent need for the development of effective MPA – based fisheries management for sustainability, including regulation of fishing effort. In order for the MPA to be effective this will have to include regulating the numbers of fishers, traps, boats and nets (particularly of non-local seasonal migrant fishers), the imposition of limits to the quantity of the catch, the banning of unsustainable methods (including banning the use durable metal fish traps which, when lost, continue to ‘ghost fish’ for many years. To avoid this problem all such traps should be modified to include large biodegradable panels, or replaced with entirely biodegradable traps), banning the use of nets in coral areas, banning trawling and other industrial fishing within the reserve boundaries, and the urgent designation of Fisheries Reserves. None of these measures need cause loss of fisheries productivity to the local fishers (and may significantly increase catch over time), and will ensure the long term sustainability of their fishery resources. Effective enforcement is essential. While enforcement of artisanal fisheries regulations can be at least in part community – based, enforcement of industrial trawling activities will require strong action on the part of the Governorate and possibly national government.

Many or most of the required measures will be effectively met by the relatively simple measure of reintroducing former traditional fisheries management techniques, lost over the past ten to twenty years, and ignored by or unknown to the migrant fishermen.

Of particular concern is the reported intense fishing of spawning and nursery areas.

9. The local community of Bir Ali is, on the whole and with only a few reservations, in favour of MPA status and the implementation of management measures, so long as appropriate consultation and participation processes and mechanisms are in place.

10. Public awareness and education programmes will greatly facilitate both the design and implementation phases of the MPA.
11. The inclusion of a coastal ‘Buffer Zone’ extending inland is essential for the success of any management programme. A failure to include the mainland coast of the area within the management programme will inevitably lead to failure of the MPA in the medium term.

12. Both marine and coastal areas will need to be managed by the use of zoning approaches is success is to be achieved.

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(Name of the co-ordinator???)
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1 INTRODUCTION

1.1 THE GEOGRAPHICAL AND BIOLOGICAL SETTING OF THE BIR ALI – BELHAF AREA.

The Bir Ali – Belhaf area lies on the northern shore of the Gulf of Aden, in Shabwa Province of the Republic of Yemen (Figure 1). This Gulf was created as a result of deep rifting between the African and Arabian plates, and is a north-eastern extension of the African Great Rift valley, separating Africa from the Arabian Peninsula and Asia (Sheppard et al 1992). The Gulf of Aden extends for approximately 1,400km along the southern coast of Yemen, from the Bab al Mandab in the west to the Arabian Sea in the east, and is up to 350km wide, north – south, with maximum depths of up to 3000m (Haddad et al, 1997).

The Gulf of Aden is dominated by the Indian Ocean monsoon system. From January to March the northeast (winter) monsoon forces surface waters to flow westwards towards the Red Sea. During the summer (south-west) monsoon, from May to September, the winds blow offshore and give rise to varying degrees of upwelling within the Gulf of Aden, during which cooler nutrient rich water rises from below to replace surface waters blown offshore. Upwellings in the central and western Gulf of Aden are more geographically restricted than the massive upwelling in the eastern Gulf of Aden and Arabian Sea to the east, and as a result the Gulf of Aden demonstrates a high degree of oceanographic variability, both temporally and spatially. This oceanographic difference, between the relatively oligotrophic waters to the west and the larger and more dominant upwelling to the east, gives rise to biogeographic patterns within the Gulf of Aden which are particularly significant and pronounced in the Hadramaut – Shabwa region. The proposed Bir Ali – Belhaf MPA thus lies in a pronounced biological transition zone, between Red Sea, Arabian Sea and Indian Ocean realms (Kemp 2000a, Kemp & Benzoni 2000).

The marine biology and biodiversity of the inshore areas of the Gulf of Aden were until the mid to late 1990s almost completely undescribed. A few limited studies prior to this time had concentrated on the southern shores of the Gulf, in the area of Djibouti and western Somalia in the west (Pellegrin, 1904; Gravier, 1910a; 1910b; 1911; Randall & Maugé, 1978; Barratt & Medley, 1990) with some very limited work at the Socotra archipelago in the east (Sheeer, 1964; 1971). Virtually no work had been carried out on the northern (Republic of Yemen) shore of the Gulf prior to 1995, except for a brief account of chaetodontid and pomacanthid fishes of Aden by Fraser-Brunner (1950), a study of seagrasses in a small area to the west of Aden (Hirth et al., 1973), and a report on macroalgae of the Hadramaut coast of the eastern Gulf, by Ormond and Banaimoon (1994).

Prior to the surveys of the mid to late 1990s the coasts of this region were believed to be incapable of supporting significant coral growth as a result of the annual Arabian Sea upwelling, which has a profound influence on the ecology and biogeography of the Arabian Sea coast of Oman, to the east of the Gulf of Aden (Currie et al., 1973; Barratt et al., 1984; 1986; Sheppard & Salm, 1988; Sheppard et al., 1992; Glynn 1993). The few areas of rocky shore and shallow hard substrates in the Gulf of Aden were believed to support communities of macroalgae, with only a few scattered corals perhaps surviving among the algae (Sheppard & Sheppard, 1991; Sheppard et al., 1992). Studies carried out in the mid to late 1990s (Anonymous 1995, Watt, 1996, Kemp 1998, 2000a, 2000b, Kemp & Benzoni 2000) revealed that, in common with most of the tropical Indo-west Pacific and against expectations, scleractinian corals are a dominant feature of hard
substrates of the shallow sublittoral throughout much of the northern Gulf of Aden, including the Bir Ali – Belhaf area.

Ecological and biogeographic studies in the northern Gulf of Aden by Kemp (2000a) and Kemp & Benzoni (2000) revealed that the ecological effects of the upwelling are considerably reduced in the Bir Ali – Belhaf area even in comparison to al Mukalla, less than 100km to the east. These studies revealed that the Bir Ali – Belhaf area lies in a biological and biogeographic transition zone between the main upwelling areas in the Arabian Sea and eastern Gulf of Aden to the east, and the more oligotrophic waters of the central and western Gulf of Aden to the west. Reef fish biodiversity at Bir Ali – Belhaf was revealed to be exceptionally high for the Arabian region, with unusual evolutionary and ecological processes also occurring in this area of the Gulf of Aden (Kemp 2000a, 2000b).

One of the most significant features of the Bir Ali – Belhaf area is the presence of the only mangrove stand found on the northern shore of the Gulf of Aden east of Aden. This stand is globally unique, growing in highly saline water isolated from the sea inside a flooded volcanic crater of Kharif Sha’ran.
Figure 1. Map of the Red Sea and Gulf of Aden showing the location of the four MPAs proposed for survey under the PERSGA SAP. Bir Ali – Belhaf is on the northern shore of the Gulf of Aden.
1.2 **The Biogeographic Setting of the Bir Ali – Belhaf Area.**

The Gulf of Aden holds a unique biogeographic position, lying between three biologically very different bodies of water: the Red Sea to the west, the Arabian Sea coast of Oman to the east, and the western margin of the Indian Ocean to the south. Each of these bodies of water is biogeographically quite distinct from, but related to, the others. The Red Sea has the highest levels of endemism of any oceanic body of water in the world, with approximately 5% of molluscs being endemic (Mastaller, 1987) 6% of corals (Sheppard et al., 1992) and 9% of benthic algae (Walker, 1987). At least 17%, of fish species are endemic at the level of recognised species (Ormond & Edwards, 1987), but this proportion is very much greater if subspecies are included as well (see Ormond & Edwards, 1987; Klausewitz, 1989). Most of these Red Sea ‘endemics’ are in fact endemic to the Red Sea and the western and central Gulf of Aden, the Bir Ali area representing the eastern edge of their established ranges. The upwelling area of Oman to the east also has high levels of endemism, particularly in fishes (Salm & Mee 1989, Randall 1996), with Bir Ai being the western edge of these species ranges. The western Indian Ocean has a third distinct fauna, and these three ecologically and biogeographically distinct regions meet in the Gulf of Aden. This overlap is most pronounced in the Bir Ali – Belhaf area, even more than the Socotra islands to the south-east (Kemp 1998a, 1998b, 1999, 2000a).

Where different biological regions meet in this way there is often an overlap of species distributions, which is significant in two ways:

1. Overlap of biological regions frequently gives rise to exceptionally high biodiversity, due to the unusual occurrence of otherwise geographically separated species together in one area.

2. Such overlaps of species ranges are frequently important for the maintenance of diversity (and thus health) within species, by inter-breeding of otherwise isolated populations.

The identification of such areas is important for short and long-term planning for conservation of biodiversity, both at national and regional scales. Surveys at Bir Ali – Belhaf in 1998 (Kemp 2000a, 2000b, Kemp & Benzoni 2000) revealed the presence of both biogeographic overlap and species hybridisation in this area.

1.3 **General Description of the Bir Ali – Belhaf Area**

The coast of the Bir Ali – Belhaf area consists of extensive igneous rocky headlands interspersed with sandy bays (Anonymous 1995, Kemp 1998). The survey area covered in this report extends at the eastern end onto the very extensive sandy beach to the east of Ras Majdahah, and at the western end is bounded by the sandy shore and sea floor to the west of the rocky headland of Belhaf. The seaward edge of the survey area is marked by the southern side of Sikha Island, approximately 9km offshore (Figure 2). The rocky islands at Bir Ali are found between 200 metres and 9 kilometres offshore, and important island sites in addition to Barrakah and Sikha include Ghaddarayn and Hallaniyah. The major embayment of the area is the bay at Bir Ali itself, which serves as an anchorage for the several hundreds of small fishing boats based at Bir Ali, and for visiting small vessels including trading dhows and sailing yachts. Anchorages which are similarly used are found on the western sides of Ras Majdahah and of Belhaf, and to a much lesser extent in the northern and southern bays at Sikha Island.

The coastal landscapes are dominated by volcanic hills and extinct volcanoes, including two large volcanic craters immediately to the east of Bir Ali bay and village. The culturally and historically important hill and promontory of Qana on the western edge of Bir Ali bay, and
extensive areas of volcanic cliffs and hills coming to the waters edge between Bir Ali bay and Belhaf, are all composed of volcanic rock. The geology of the area gives rise to an inshore marine environment which is dominated by shallow rocky slopes. These areas provide hard substrates for the settlement and growth of hard and soft corals and other invertebrate animals, and marine algae (Kemp 1998a, Kemp & Benzoni 2000). At many sites in the Bir Ali area this has allowed the development of diverse and regionally important marine communities, including extensive areas of scleractinian corals. Along the mainland coast these coral-rich rocky areas are almost entirely restricted to depths shallower than 15 metres. At 10 - 15 metres the sea floor generally becomes a flat or very gently sloping sandy plain, frequently with areas of seagrasses and large numbers of fish, but with only scattered corals. The exception to this is the island of Sikha, where the rocky shore extends to as deep as 60 metres. This has important implications for the marine biology and ecology of the area, and makes Sikha one of the most diverse and important small sites of the entire Arabian peninsula (Kemp 1998).

1.4 THE CULTURAL & SOCIO-ECONOMIC ENVIRONMENT

The Republic of Yemen occupies the south-western part of the Arabian peninsula. The population of the country was approximately 15 million in 1994, of which about 7.6 million lived in the eight coastal governorates, with a rapid growth rate of 3.7% (PERSGA 2001). With 620,000 inhabitants Aden, 400km to the west of Bir Ali, is the largest coastal city in the Gulf of Aden. Al Mukalla in Hadramaut Province has over 50,000 inhabitants (PERSGA 2001), and lies approximately 100km to the east of Bir Ali area. Bir Ali – Belhaf lies on the coast of Shabwa province, and only a one hour drive from Al Mukalla. In 1994 the combined populations of these two provinces was almost 1.25 million.

Major economic activities in the coastal zone of Yemen include ports and maritime traffic, fisheries (both artisanal and industrial) and oil and gas exploration (including infrastructure development). Fisheries play a significant role in the national economy of Yemen. Fisheries production expanded from YR 98 million in 1990 to YR 294 million in 1995, and marine products have been estimated to total more than US$40 million per year (PERSGA 2001). Of the total annual catch of 90 – 95,000 tonnes, over 90 percent is landed by artisanal fishermen such as those living and working in the Bir Ali – Belhaf area. In the mid 1990s there was no effective monitoring of catches or fish stocks (PERSGA 2001), although efforts were under way to register boats and fishers.

To date marine and coastal tourism has played a limited role, but the country has very great potential for such development. This factor is likely to be of considerable relevance to the proposed MPA at Bir Ali – Belhaf.

The principal economic activity of Bir Ali – Belhaf is artisanal fisheries, with both resident and seasonal migrant fishermen active throughout the area. In 1992 a total of 280 fishermen were reported to be active in Bir Ali, although this number is now likely to have increased considerably. Target groups include finfish, sharks and invertebrates such as cuttlefish (*Sepia pharaonis*). The main coastal road from Aden to Al-Mukalla and the Hadramaut passes through Bir Ali village and is a focus for some further activity such as shops and other suppliers. This is also the route for export of fisheries catches from the area. Industrial trawlers frequently operate in the Bir Ali - Belhaf area, but no landings from these vessels are made locally.

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Figure 2: Map of survey area, showing the location of the principal features and areas mentioned in the text of this report.
2 OBJECTIVES OF THE SURVEY.

One of six stated objectives of Component 5 of the PERSGA SAP is development of ‘a site-specific master-plan, which is a long-term policy document and includes the management plan [....] for each MPA.” (PERSGA 1999). Development of the site-specific master-plan for the Bir Ali – Belhaf area will be carried out using information provided by biological surveys, as described in this report, and the resource use survey as described in the separate Fisheries Report appended to this report.

Within the constraints imposed by time and other available resources (see Logistical and other factors affecting the field survey, below) information gathered during the field phase and subsequent data analysis included:

- Types and extent of ecosystems and habitats occurring within the MPA, including open water, coral communities, other subtidal habitats, beaches, rocky shores, sabkha, mangrove and seagrasses.
- A broad indicative assessment of the flora and fauna associated with each of these habitats.
- An indicative assessment of the health, structure and extent of coral communities.
- An indicative assessment of the composition of fish assemblages associated with the coral communities and other benthic communities.
- The distribution of sea turtles and marine mammals, and of habitats used by these groups
- Seabirds, and the areas used by them for feeding and nesting.
- An assessment of the impact of the global coral bleaching and mortality event of 1998, by re-surveying a number of sites surveyed in January – March 1998, which formed the basis for the report of Kemp (1998a) on the habitats and species of the area.

Important coral communities identified at Bir Ali in early 1998 (Kemp 1998, Kemp & Benzoni 1999, 2000) were, along with corals in most of the tropical Indo-Pacific and tropical Atlantic oceans, subjected to an unprecedented bleaching event starting in the early summer of 1998, only two or three months after the 1998 surveys of the area were completed (DeVantier & Cheung personal communication, J. Turner personal communication). No assessment of the extent or severity of the bleaching event in the Bir Ali – Belhaf area, or of subsequent recovery, was carried out prior to 2002. The results of the recent survey provide the first description of the impacts of that bleaching event in the area.
3 METHODS

3.1 OVERVIEW OF SURVEY METHODS

Detailed descriptions of survey methods are provided in Kemp & Klaus (2002) and PERSGA (2002). Copies of all survey sheet templates are provided in the Appendices of this report (Appendices 2 – 8).

Prior to the start of 2002 field work the survey area was divided into three sectors (Figure 3) to provide a framework for logistical planning and activities. These sectors were:

Sector 1: The mainland coast and near-shore islands from Belhaf at the western edge of the survey area to Hallaniyah island and Qana hill at Bir Ali bay.

Sector 2: The mainland coast and near-shore islands from Bir Ali bay and village to the eastern edge of the survey area, east of Ras Majdahah

Sector 3: All areas further offshore. Although Sector 3 covers a large area, in practice only Sikha Island within this sector could be surveyed during the field phase, because the rest of the sector is deep water.

The Landsat 7ETM+ satellite image of Bir Ali and Belhaf area of southern Yemen (WRS 163/050, 21st March 2000) (Figure 4) was atmospherically and geometrically corrected in preparation for use in the field, and unsupervised classification of marine (ETM1-3) areas within the proposed MPA were prepared. The map was then subsetted as both true-colour and unsupervised classification images (Figures 5 & 6 provide examples) and laminated for use during the field surveys.

There was considerable spectral confusion between the different biotopes during the subsequent analysis, for two reasons. Firstly, time and other logistical constraints meant that it was not possible to survey a sufficient number of survey sites to create adequate signatures. The second factor was differences in water quality across the area from east to west. Where the signatures for the marine biotopes identified from the cluster multivariate analysis were not separable these were merged (further details of the Landsat satellite image and image processing methods are provided in Appendix 12).

The field survey was carried out between the 23rd of April and 4th of May 2002. Rapid and detailed site surveys were all carried out between the 23rd and 29th of April 2002. Equipment problems earlier in the survey (non-functional depth sounder) meant that the majority of subtidal Quick Look sites for ground truthing were carried out between the 30th April and 2nd May, after the departure of the Team Leader.

Rapid Ecological Assessments (Survey Sheet 1, Appendix 2) were carried out at a total of 20 sites. Detailed surveys of corals (Survey Sheet 3, Appendix 4) and of fishes and substrates (Survey Sheet 4b, Appendix 6), including re-survey of sites surveyed in 1998, were carried out at 5 of those Rapid Assessment Sites. Rapid Intertidal surveys were carried out at 10 sites (Survey Sheet 6, Appendix 8). Quick looks for ground-truthing purposes were carried out at a total of 46 sites, including fixes for Ground Control Points (GCP). An itinerary of survey work is presented in Appendix 9.

The results of the field survey from 136 georeferenced locations around the proposed MPA were entered into Geographical Information System (MapInfo™ Professional v6.0). A list of the GIS...
data layers created is included in Appendix 14. Data from these surveys were used to identify the main coastal and marine habitats and biotopes. The biotopes were identified using multivariate analysis of the detailed and quick site data, using hierarchical agglomerative clustering (Wards Method) and SIMPER analysis (see Appendix 12.2.2). These data were used to perform a supervised classification of the Landsat 7ETM+ satellite data to identify and map the extent of the coastal and marine biotopes (details of which are included in Appendix 12).

A biotope is defined as *the physical habitat together with its associated assemblage of species*. As relatively little species information were collected during these surveys the use of the term biotope in this context is fairly loose and for subtidal areas refers to the benthic structure and dominant cover types.

### 3.2 Assessment of Coral Mortality and Fish Community Changes Subsequent to the 1998 Bleaching Event.

A total of eight fish community Underwater Visual Census (UVC) belt transects that were first surveyed in 1998 were resurveyed during the survey of 2002. These eight transects were located within a total of four rapid Assessment Sites. The 1998 transects incorporated rapid substrate / habitat assessment that estimated coral and other benthic substrates along the course of the transect. The survey methods used for the UVC transects in 2002 were identical to those of the 1998 survey (Kemp 1998, 2000a, Kemp & Benzoni 2000).

The 1998 transect locations were not permanently marked and so, although the transect sites were relocated to within a few metres in 2002, there is likely to be an error in their relocation of up to 5 metres in any direction. This possible error means that the substrate quadrats located at 50m intervals along the UVC transects are not paired between years. This weakens statistical analyses of the survey results for significant difference (makes it less likely, for purely statistical reasons, that differences that may in fact be genuine will be detected or supported statistically), but does not invalidate the results obtained (see Results, below).

Constraints upon survey effort (see section 5, below) meant that taxonomically wider assessments of the fish communities in the area were not carried out in 2002. If the diving equipment and personnel had been available these would have been included within the ReefCheck survey methodology (survey sheet 4a, Appendix 5). The ReefCheck survey is particularly important within the array of survey methods (Kemp & Klaus 2002) for assessment of fisheries groups, both of fishes and invertebrates. Time and other constraints detailed below meant that the decision was made to concentrate on the use of survey form 4b (Fish community structure, Appendix 6) at the expense of the Reef Check method. The fish community structure survey (with associated habitat / substrate assessment) was necessary for an assessment of changes between 1998 and 2002, so enabling an update of the data upon which the conclusions of Kemp (1998) were based.

### 3.3 Survey Sites.

Rapid and Detailed surveys (excluding ground-truthing ‘Quick Looks’ and georeferencing) were carried out at a total of 21 sites (one of which was only an intertidal survey site), as listed in Appendix 10. The locations of survey sites are illustrated in Figures 7 & 8, below.
Figure 3: The three survey sectors in the Bir Ali – Belhaf survey area. Survey site numbers include reference to the sector within which each site is located. For example site number 01/03 refers to Sector 1, Site 3.
Figure 4: True colour composite of Landsat 7ETM satellite image of Bir Ali-Belhaf, Yemen (WRS 163/050 21st March 2000).
Figure 5: A subsection of the true colour composite of the Landsat 7ETM+ satellite image of Bir Ali-Belhaf, Yemen (WRS 163/050 21st March 2000) prepared for use during the field surveys.

Figure 6: The same subsection, as an unsupervised classification (before ground-truthing) of marine areas in the Landsat 7ETM+ satellite image of Bir Ali-Belhaf, Yemen (WRS 163/050 21st March 2000) prepared for use during the field surveys.
Figure 7: Locations of Rapid Assessment sites within the survey area at Bir Ali – Belhaf.
Figure 8: Locations of Quick Look ground truthing sites within the survey area at Bir Ali – Belhaf.
4 Results

The detailed results of analysis of field survey substrate transect data are illustrated in Appendix 13 (figures A13.1 – A13.20).

Section 4.1 presents an overview of the results of the supervised classification of marine and coastal biotopes created using the Landsat 7ETM+ satellite image.

In Section 4.2 the results from the site specific field surveys (Rapid, Detailed and Quick Site surveys) and the marine and coastal biotope classification are combined and discussed by major habitat types namely corals, seagrass, mangroves, then fish and other communities. These results are followed by results of Rapid Assessment surveys on the socioeconomic environment and human impacts. Detailed analysis and results of surveys of the fisheries of the study area are reported separately in Annex II.

4.1 Marine and Coastal Habitats and Biotopes of Bir Ali - Belhaf.

The proposed MPA at Bir Ali – Belhaf covers an area of 1184.33 km². This includes 308.4 km² of land and 875.93 km² of sea. The Landsat 7ETM+ satellite data has been analysed, and used to map the distribution, and create preliminary area estimates, of the extents of different marine and coastal habitats and biotopes within this area. These are described in more detail below.

Table 1. Land area within the proposed MPA at Bir Ali-Belhaf, Yemen (from Landsat 7ETM satellite data).

<table>
<thead>
<tr>
<th>Name</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yemen mainland coast</td>
<td>305.725</td>
</tr>
<tr>
<td>Mangrove Crater</td>
<td>0.49</td>
</tr>
<tr>
<td>Barakah</td>
<td>0.025</td>
</tr>
<tr>
<td>Gaddaharyan Isl.</td>
<td>0.117</td>
</tr>
<tr>
<td>Halanniyah</td>
<td>0.72</td>
</tr>
<tr>
<td>Sikkha</td>
<td>0.543</td>
</tr>
<tr>
<td><strong>Total Area Land</strong></td>
<td><strong>307.62</strong></td>
</tr>
<tr>
<td><strong>Total Area Marine</strong></td>
<td><strong>873.81</strong></td>
</tr>
<tr>
<td><strong>Total Area</strong></td>
<td><strong>1181.5</strong></td>
</tr>
</tbody>
</table>

4.1.1 Coastal Habitats and Biotopes

The coastal biotope map of Bir Ali Belhaf was created using the site descriptions from the Rapid Assessment surveys. An overview of the coastal classification for the area around Bir Ali Belhaf is shown in Figure 9. Detailed subsections of the coastal biotope map are included in the Appendix 13 (A13. 7 – A13. 12).

The dominance of consolidated basaltic and other volcanic rocks throughout the western part of coastal areas of the proposed MPA is well illustrated by Figure 9. This landscape effectively limits access to large sections of the western coast from the landward side. Vegetation on these basaltic areas is extremely sparse, being limited to scattered grasses and occasional bushes.
inland, although along the shore there are areas of sparse halophytes, particularly in areas where beaches occur.

East of Bir Ali exposed volcanic rock dominates only around the two craters immediately to the east of Bir Ali village and at the major headlands. Elsewhere the substrate is sand or gravel with areas of sedimentary rock or fossil reef. Access to the shore is easy in many locations along this part of the coast. The main Aden – al-Mukalla coast road runs behind the headlands and hills, seldom being more than two or three kilometres from the shore, and numerous well-worn tracks depart southwards from this road, leading to beaches and to occasional seasonal fishing camps. Vegetation is less sparse along the shore throughout this western part of the survey area, with some areas of scrub and halophyte vegetation behind the beaches and along the various wadis and other low-lying areas between the hills.

4.1.2 Overview of Marine Habitats and Biotopes

The results of the cluster analysis and SIMPER (Appendix 12) of the field data revealed 20 broad marine biotopes (Table 2, below). The categories of marine biotope identified from the cluster analysis of the ground truth data, together with additional descriptive data from the Rapid Assessment surveys, were used to develop of a set of 48 spectral signatures to enable a supervised classification of the image. The signature set was then used to conduct a supervised classification of the Landsat 7ETM satellite data.

The 20 marine biotopes identified included 3 sand and sediment classes and 17 coral biotopes (including both live and dead corals, and coral rubble). The remaining classes were deep or turbid water. The supervised classification of marine habitats and biotopes of Bir Ali - Belhaf from the Landsat 7ETM+ satellite image is presented in Figure 10. Detailed subsections of the marine biotope maps are included in the Appendix 13 (Figures A13.13 – A13.19), and this Appendix should be referred to when considering details of the identified biotope distributions.

The proposed MPA covers an area of 875.93 km² of marine habitats, and more than 72 % of this area is in deep water. Sand habitats are the most widespread throughout the area, covering more than 15.5 km², or 70% of the total area of marine biotopes mapped. Table 3 (below) lists biotope areas in detail. Coral and other biotope groups are discussed in more detail in Section 4.1.3 – 4.1.5.

The 2002 survey was designed to provide a preliminary overview of the area and, due to the limited field survey time available (see section 3.4 above), only a subset of the biotopes within the area could be surveyed, and some are known to have been omitted. For instance, sparse but widespread areas of seagrass (Halophila ovalis) are known to occur in the bay at Bir Ali (Kemp, 1998). No site specific data was acquired during this survey on seagrasses and hence this biotope could not be mapped. It was also not possible to separate out the macroalgae class from the coral signatures.
Figure 9: The coastal habitats and biotopes of Bir Ali – Belhaf, Yemen (Landsat 7ETM+ 166/051 13th May 2000). A larger copy of this map is provided in Appendix 13 (figure A 13.7)
Figure 10: The marine habitats and biotopes of Bir Ali to Belhaf, Yemen (Landsat 7ETM+ 166/051 13th May 2000). A larger copy of this map is provided in Appendix 13 (figure A 13.13). The west-east variation in water quality described in Section 3.1 is clearly illustrated by the changing colour of the deeper water, from darker to lighter blue, from left to right in the image.
Table 2. Marine biotopes identified within the Bir Ali – Belhaf area by the cluster and SIMPER analysis.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Marine Biotope</th>
<th>GPS/Waypoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dead coral community on rock (<em>Pocillopora damicornis</em>)</td>
<td>1/1</td>
</tr>
<tr>
<td>2</td>
<td>Sand</td>
<td>1/4, 1/8, 1/15, 1/20, 1/26, 1/35,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/41, 3/21, 3/22, 3/23, 3/24, 3/25,</td>
</tr>
<tr>
<td>3</td>
<td>Rubble (<em>Stylphora / Acropora</em>)</td>
<td>1/7, 1/36, 1/50</td>
</tr>
<tr>
<td>4</td>
<td>Cobbles</td>
<td>1/10</td>
</tr>
<tr>
<td>5</td>
<td>Massive coral community (~15%) on sand and rubble</td>
<td>1/11, 1/12, 1/15, 1/22</td>
</tr>
<tr>
<td>6</td>
<td>Massive coral community (~20%) on sand, rubble and rock</td>
<td>1/16, 1/24, 3/27, 3/28, 3/29,</td>
</tr>
<tr>
<td>7</td>
<td>Massive coral community (~30%) on sand</td>
<td>1/17</td>
</tr>
<tr>
<td>8</td>
<td>Dead coral community on rock (<em>Stylphora</em>)</td>
<td>1/18</td>
</tr>
<tr>
<td>9</td>
<td>Dead coral community on rock (<em>Acropora Tabular</em>)</td>
<td>1/19</td>
</tr>
<tr>
<td>10</td>
<td>Sparse coral community (~2.5%) on rock</td>
<td>1/21, 3/30</td>
</tr>
<tr>
<td>11</td>
<td>Massive coral community on rock (<em>Goniastrea</em>)</td>
<td>1/23</td>
</tr>
<tr>
<td>12</td>
<td>Mixed coral community (~30%) on rock (<em>Porites/ Pocillopora/ Acropora</em>)</td>
<td>1/30, 1/46</td>
</tr>
<tr>
<td>13</td>
<td>Mixed coral community (~50%) on rock (<em>Porites/ Pocillopora/ Acropora</em>)</td>
<td>1/31</td>
</tr>
<tr>
<td>15</td>
<td>Sparse coral community (~10%) (<em>Millepora / Stylphora</em>) on rock</td>
<td>1/33, 1/42, 3/38, 3/40</td>
</tr>
<tr>
<td>16</td>
<td>Macroalgae (50%) and sparse coral community (2.5%) and on rock</td>
<td>1/44, 1/45</td>
</tr>
<tr>
<td>17</td>
<td>Dead massive coral community on rock (<em>Porites / Goniastrea</em>)</td>
<td>1/49</td>
</tr>
<tr>
<td>18</td>
<td>Volcanic rock and sand</td>
<td>3/1, 3/48</td>
</tr>
<tr>
<td>19</td>
<td>Sparse mixed coral community (~5%) on rock</td>
<td>3/31</td>
</tr>
<tr>
<td>20</td>
<td>Sparse coral community (~10%) (*Porites/Stylphora) and turf algae (30%) on sand and rock</td>
<td>3/55</td>
</tr>
<tr>
<td>Marine Biotope Classification</td>
<td>Area (km²)</td>
<td>% of Total Area Mapped</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Land</td>
<td>307.71</td>
<td>26.04</td>
</tr>
<tr>
<td>Deep water (6 classes)</td>
<td>850.88</td>
<td>72.02</td>
</tr>
<tr>
<td>Mangrove crater</td>
<td>0.49</td>
<td>0.04</td>
</tr>
<tr>
<td>Sabkha</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sand (&lt;1m), Sand (1-2m), Sand (2-5m), Sand (5-10m)</td>
<td>15.37</td>
<td>1.30</td>
</tr>
<tr>
<td>Cobbles</td>
<td>0.44</td>
<td>0.04</td>
</tr>
<tr>
<td>Rubble</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Dead coral</td>
<td>0.58</td>
<td>0.05</td>
</tr>
<tr>
<td>Sparse corals (&lt;10%) on sand</td>
<td>1.40</td>
<td>0.12</td>
</tr>
<tr>
<td>Massive corals on sand (Porites / Goniastrea)</td>
<td>0.10</td>
<td>0.01</td>
</tr>
<tr>
<td>Sparse corals (&lt;10%) on rock</td>
<td>1.66</td>
<td>0.14</td>
</tr>
<tr>
<td>Mixed corals on rock (Porites/Pocillopora/ Acropora)</td>
<td>0.52</td>
<td>0.04</td>
</tr>
<tr>
<td>Massive corals on rock (Porites / Goniastrea) 01</td>
<td>2.35</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Total Area Mapped</strong></td>
<td><strong>1181.52</strong></td>
<td><strong>1.90</strong></td>
</tr>
<tr>
<td><strong>Total Area of Marine Biotopes (excluding deep water)</strong></td>
<td><strong>22.44</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3:** The area of each marine biotope mapped, and the % of each marine biotope mapped as a proportion of the total area mapped (293.78 km²), and the total area mapped excluding deep water classes (40.5 km²). The cluster groupings identified from cluster and SIMPER analyses are also included.
4.1.3 CORAL COMMUNITIES

In spite of the global coral bleaching event of 1998, which severely affected the western Indian Ocean and much of the Arabian region, a number of important areas of the corals in the Bir Ali - Belhaf area are still in good condition, although others have suffered severely. All or most surviving areas of corals are particularly vulnerable to destruction or damage through inappropriate or uncontrolled development or other activities, and the reduced area of very healthy coral makes these surviving areas all the more important. Extensive reference to the impacts of the bleaching event are made throughout this section, with more detailed analysis presented in section 4.1.7, below.

A total of 5 broad coral biotopes were identified and mapped in the satellite image (Figure 10, above). Figures 11 shows the distribution of corals/ coral reef habitats at Rapid Assessment sites. Figure 12 provides a breakdown of different substrates in the detailed substrate transects.

Figure 13 and Figure A.13.14 illustrate the total area of coral habitats (6.03 km²) with ‘sparse’ coral habitats on either sand or rock (where cover is <10%) in pink, and ‘dense’ coral habitats, consisting of the combined area of massive and mixed coral communities on coral or rock, indicated in red.

Figure 11. The distribution of corals and coral reefs at Rapid Sites. True coral reefs (large structures of coral rock) are absent from the Bir Ali – Belhaf area. This figure primarily illustrates the distribution of living and dead coral in the area, rather than of well developed reef structures. Well developed coral reef structures are rare throughout the Gulf of Aden, while high cover, high diversity coral communities are much more common (Kemp & Benzoni 2000). Very high levels of biodiversity usually associated with coral reefs elsewhere in the world are found in the Gulf of Aden in association with coral communities that do not form reefs.
Figure 12. Substrate transect data from detailed substrate transect sites. This illustrates the exceptional coral communities found at the Barrakah site. The Sikha site with very high cover of rubble is the location of the extremely shallow 100% cover *Acropora* communities of 1998. These communities suffered very badly in the bleaching event of that year. These substrate results should be consulted alongside the substrate assessment data for the fish community survey, which provides further information about the substrates within each site.

N.B. These detailed substrate transects were *not* carried out along the same line as the detailed fish transects. Fish transects, which included the habitat assessment used to assess the 1998 coral bleaching event were 200m long, and at several sites more than one was completed. The detailed substrate (point intercept) transects shown here were carried out over a total of 100m (see Kemp & Klaus 2000).
**The Mainland Shore.**

Along the mainland coast ‘dense’ or ‘sparse’ coral communities are almost ubiquitous as a more or less narrow fringe broken only by the principal sandy bays. The majority of the dense coral communities are dominated by massive or sub-massive corals (principally *Porites*, *Goniastrea*, *Galaxea*) or large monospecific areas of *Pocillopora*, with a variable scattering of diverse other corals on biogenic or non-biogenic rock, or scattered over areas of rubble and gravel, between and around them. The majority of *Pocillopora* and *Galaxea* colonies fringing the mainland shore are dead as a result of the 1998 bleaching, but at the majority of mainland sites *Porites* and *Goniastrea* have survived to varying extents, ranging from no visible mortality to, in a few cases, almost no visible survival. The monospecific areas of *Montipora* recorded by Kemp (1998a, 1998b) and Kemp & Benzoni (2000) could not be relocated in 2002 and have probably suffered almost complete mortality throughout the survey area.

The corals of the rocky reef across the western part of the mouth of Bir Ali bay have suffered badly as a result of the 1998 bleaching, but some areas on the western and northern sides of the reef appear to have survived well. Very poor in-water visibility combined with time constraints meant that this reef could not be surveyed effectively enough in 2002 to provide a detailed assessment of this reef.

There has been very little visible recruitment of *Pocillopora* since 1998, but recruits of *Acropora*, *Stylophora* and massive and encrusting corals are extremely abundant at many of these mainland sites (e.g. YEM/02/03), and recovery of coral cover (although with attendant shifts in community structure) at many of these sites may be rapid with effective management to mitigate localised human impacts. Coral recruitment is most obvious on non-biogenic rock surfaces, with some on dead massive or branching corals, but the extensive areas of dead *Pocillopora* showed absolutely no recruitment on their surfaces in 2002. These dead *Pocillopora* were in remarkably good structural condition, often having only a very fine film of filamentous algae over their surfaces, and appearing to be alive until the surveyor was within a few metres of them.

In practice many of the ‘sparse’ coral areas are dominated by rock or sandy rubble and boulders with coral cover well under 10%. For example, the fringe of low cover coral around the northern side of Bir Ali bay is largely composed of patchy algal-turf covered rock (<2%) with extremely low cover (<5% of the rocky surface) of scattered small encrusting, massive and branching corals (J. Kemp unpublished data, 1998) typical of a relatively turbid shallow inshore environment in the northern Gulf of Aden.

**The near-shore Islands.**

The coral communities of the near shore islands (Hallaniyah, Ghaddarayn islands, Barrakah) show very variable degrees of survival. The corals of Hallaniyah identified by Kemp (1998a) as being of a quality justifying designation as a core zone within any MPA have suffered very extensive mortality and are now a shadow of their former selves.

The corals of the channel on the western side of Hallaniyah are largely dead in both shallow and deeper areas, although there is patchy survival of *Goniastrea* and other massive or encrusting corals. Huge monospecific areas of *Pocillopora damicornis* here (see photograph presented in Kemp and Benzoni 1999) have suffered >98% mortality, and even the extremely large *Porites* colonies that were a dominant feature are now mostly dead. Very little new recruitment was
observed herein 2002. On the eastern side of Hallaniyah extensive areas of branching and tabular Acropora have apparently suffered almost 100% mortality, but extensive and unusual areas of Stylophora have survived largely intact between 4 and 10 metres depth, and new recruits of massive, encrusting and branching corals were abundant on the extensive non-biogenic rock surfaces of this site at the time of the 2002 survey.

The Gheddarayn islands have lost the extensive shallow areas (<2m) of branching Acropora and Stylophora recorded by Kemp (1998a) but around the northern, eastern and western sides of Gheddarayn Sarir slightly deeper (2m – 8m) communities of massive and branching corals, including monospecific Pocillopora, have survived with no apparent damage.

Corals at Barakah Island, which was not surveyed in 1998, were in excellent condition in 2002 and provide very good examples of monospecific areas of Pocillopora, Acropora, Montipora and Stylophora of the types that suffered so badly along the mainland shore and at Hallaniyah. The very limited extent of these corals at Barrakah, forming a narrow band between 5 and 15 metres wide around the foot of the cliffs, means that they are vulnerable to anchor damage and other impacts. Severe anchor damage was apparent in one or two areas here, and management to avoid this occurring in future is essential in order to protect these corals. Exclusion of boats is unlikely to be an option due to the traditional collection of guano from the island, during which these areas serve as the only available anchorages, so the installation of mooring buoys to provide an alternative to anchoring should be carried out as a matter of priority. This area is deserving of a high level of protection, and the use of nets for fishing here should be restricted or banned in order to protect the corals.

The isolated emergent reef just offshore at 14°0.7’N 48°25.02E is probably dominated by algal turf covered dead coral and non-biogenic rock on top with a fringe of live coral around the sides. This reef is approximately circular in shape and parts are emergent by up to 1m at spring low tides, but is entirely covered at high tides. Water here was too turbid, and wave action too strong, to allow any effective survey during the 2002 fieldwork, and this description needs to be confirmed.

Sikha Island.

Sikha island was identified by Kemp (1998, 2000) and Kemp & Benzoni (2000) as a site of particular significance. The very extensive, high cover and communities of branching corals exist in the very shallow waters of the northern bay have suffered approximately 100% mortality and now exist only as extensive areas of dead Stylophora and Montipora, and Acropora rubble and eroded coral stumps. However, this appears to be the only significant impact suffered by corals at this island over the four intervening years since 1998.

In both the northern and southern bays of the island the corals are unchanged, and the description of Kemp (1998) is still applicable. Even extensive areas of unusual Millepora, often highly vulnerable to bleaching events, show no signs of any recent mortality.

The description of Kemp (1998) is reproduced here, excluding only reference to the areas of very shallow corals described above, which suffered high mortality:

[In the northern bay of Sikha] … as the depth increases [beyond 2m] the coral community becomes dominated by ancient and very large Porites, although there are high levels of generic diversity. Large corals extend as deep as 25 metres within the bay. At this depth they are replaced by a sandy gravel slope rich in fish and small invertebrate life.
[In the bay on the southern side of Sikha] the corals [...] are very different from those of the northern bay. It does not possess the very shallow corals characteristic of the northern bay [but now, in 2002, dead], but has exceptional corals between the depths of 3m and 18m. A monospecific area of *Millepora*, of a highly unusual and possibly unique growth form, occurs along the western edge of this bay. The rest of the bay is dominated by very large *Porites* colonies (many larger than 3 metres high, and 5 metres in diameter), with very diverse corals growing between them. Corals at a depth of 3 to 15 metres extend throughout the bay, growing on a sandy gravel sea floor which is itself covered in soft corals and other invertebrates, and is home to an abundant and diverse fish community.

Coral growth is very extensive at all sites visited at Sikha, including exposed sites. Outside the bays the rocky shores between 0m and 5m depth are densely covered in algae, scattered small corals and other invertebrates, and support large populations of herbivorous fish such as surgeonfish and parrotfish, and both planktivores and large carnivores such as jacks (family Carangidae) are abundant and diverse. Major coral growth is limited to depths deeper than 5 metres; between 5 and 8 metres a very high cover *Porites* community is characteristic in many places, and this community extends to between 14 and 30 metres depth. In some areas where *Porites* growth is limited or absent encrusting corals, and smaller corals such as *Dendrophyllia*, are common. Black coral (*Antipathes* sp.), highly vulnerable to diver damage or unsustainable exploitation, is common below 30m in some areas [N.B. no deep diving was carried out at Sikha in 2002 so the continued existence of *Antipathes* here is an assumption, albeit a fairly safe one].

A more detailed comparison of 1998 and 2002 coral community changes at a sample of four sites (8 transects) is provided below (Section 4.1.7).

*Crown of Thorns starfish.*

Kemp (1998) reported the presence of a small outbreak of Crown of Thorns starfish (*Acanthaster plancii*) at one site at Sikha island, and suggested that monitoring of the abundance and distribution of this coral-eating species be monitored throughout the Bir Ali area. The site of the 1998 Crown of thorns (CoT) outbreak was not revisited during the 2002 survey due to limitations on time, but CoT were rare throughout the survey area and no signs of a current or impending outbreak were observed.

Monitoring of CoT, which have been and still are a major management issue in many area of the world including the Red Sea (Egypt, Saudi Arabia, Sudan, Yemen) and Gulf of Aden (Djibouti) will be a management requirement within the Site Specific Management Plan.

*Limitations of the images.* [N.B. Mohammed – this section requires technical ‘clearance’ and comments from Rebecca before incorporation into the final version of the report!]. JK]

For management and planning purposes the limitations of the remotely sensed images must be recognised.

The wide survey experience of the Survey Team Leader in the Bir Ali area confirms that these images provide an accurate broad indicative assessment of the distribution of principal biotope types throughout the area. The limitations of the fieldwork, already described, combined with some technical limitations of the Landsat images (for example the 30m pixel size) mean that the images have limitations when examined in close detail. For example, the analysis does not
differentiate between dead coral and live coral with a high degree of accuracy. Areas of high percentage cover of dead coral at Hallaniyah (YEM 01/01 dp – 70% dead coral and rubble) and at Sikha (YEM/03/01 sh1 – 80% dead coral and rubble) are classified as areas of sparse coral cover on sand, and cobbles respectively. In both cases these areas of dead coral are in close association with the biotopes identified. The dead corals at site YEM/01/01 are largely on sand, with very low cover of live coral, so the analysis is half – correct. The dead corals at site YEM/03/01 are sandwiched between extensive areas of inshore cobbles to the south and extensive areas of live corals in deeper water to the north, both of which are identified in the images.

Conversely, at site YEM/01/04 there is a long narrow north-south oriented band of high cover live *Stylophora* corals, sandwiched between sandy gravel to the east and rocky substrates with dead *Acropora* and very low cover of live encrusting and massive corals to the west. This coral area was recorded by Kemp (1998, 2000) as being the only extensive monospecific *Stylophora* community identified in the area, and as having a very unusual fish community, but it was not identified by the image analysis. This coral and fish community survived the 1998 bleaching but the maximum width of the coral band, of approximately 20m, is below the level of effective resolution of the satellite image in this case.

A degree of caution should be exercised by management of the proposed MPA when making management decisions solely on the basis of these images. Decisions about activities that may adversely impact coral communities should only be made on a case-by-case basis, and further site-specific subtidal assessments should be made by experienced observers where necessary to complement these maps. Total reliance on the maps is not recommended for detailed information. Use of the maps to guide larger scale planning of zoning for the MPA is appropriate. Further guidance for such issues should be provided in the Site Specific Master Plan.

<table>
<thead>
<tr>
<th></th>
<th>Total Area of coral habitats (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Sparse’ coral habitats</td>
<td>3.06</td>
</tr>
<tr>
<td>‘Dense’ coral habitats</td>
<td>2.97</td>
</tr>
<tr>
<td>Total Coral Habitats</td>
<td>6.03</td>
</tr>
</tbody>
</table>

**Table 5:** The total area of coral habitats within the proposed MPA at Bir Ali-Belhaf (estimated from the marine biotope classification of Landsat 7ETM+ data).
Figure 13: Map illustrating the distribution of coral habitats in the Bir Ali – Belhaf area. Red indicates dominance by higher cover coral communities. Pink indicate where corals were found in sparse communities, associated with other more dominant groups such as macroalgae or turf algae. A larger version of this map is provided in Appendix 13 (figure A13.14).
4.1.4 **SEAGRASSES**

Seagrasses were only recorded, as extremely sparse *Halophila ovalis* of very limited extent, at one site in the Bir Ali – Belhaf area during the survey of 2002 (YEM/02/05). Kemp (1998a) recorded the presence of scattered but extensive patches of sparse *H. ovalis* on sand inside Bir Ali bay. Although these seagrass patches were most widespread in the eastern part of the bay they were recorded throughout the bay at depths ranging from 2m to 8m. No other seagrasses have been recorded within the survey area to date. Significant areas of seagrasses are only recorded at only a few locations in the northern Gulf of Aden to date, at Khor Umeriah and at Ras Imran (Hirth et al., 1973).

It is unlikely that extensive areas of seagrass exist within the survey area outside Bir Ali bay.

4.1.5 **MANGROVES**

There are no known mangrove areas along the mainland coast of the Gulf of Aden anywhere east of Aden, but a globally unique sand of mangroves (*Avicennia marina*) fringes the interior of the easternmost of the two large volcanic craters (Kharif Sha’ran) to the east of Bir Ali village. The crater is filled with highly saline water of unknown depth, and is isolated from the sea by a ridge approximately 100m high 800m in width. The crater lake is 750m in diameter east to west and 920m in diameter north to south, covering a total area of 0.49km². The mangroves within the crater form a narrow fringe with a maximum width of less than 15m, around almost the whole of the inside margin of the crater. The greatest concentration of trees is on the southern edge of the crater lake.

There is no other known occurrence globally of mangroves growing in a similarly isolated position. This crater lake and its mangrove trees are thus of global importance, and are perhaps the most significant single natural feature of the Bir Ali – Belhaf area.

Time and other logistical constraints meant that it was not possible to re-visit the crater to update the observations of Kemp (1998) although the people of Bir Ali village said that there had been no discernible change to the mangroves in recent years. The survey team was informed, while at Bir Ali, that a research group from an American University has recently spent some time studying these mangroves, although it was not possible to find out which university they came from. The information those researchers gathered has the potential to constitute a very important set of baseline data, and efforts should be made to track the information down and repatriate it to Yemen.

The extent of mangroves was mapped using the Landsat 7ETM+ satellite data (Figure 14).
Figure 14: The mangrove crater at Bir Ali-Belhaf, Yemen.
4.1.6 Fish Communities

Fish communities were surveyed using two different methods. The Rapid Assessment provided a simple combined measure of fish abundance and diversity at each site (Figure 15). More detailed information about abundance and diversity of selected families of fishes is provided by the Reef Fish Community Structure survey.

Note that logistical problems prevented the inclusion of the ReefCheck survey that was planned to include the main fisheries groups.

Figure 15: Relative fish abundance at Rapid Sites. The relatively high abundance of fishes at island sites is clear from this figure, although it should be stressed that this does not refer specifically to fisheries groups, but to all fish within the site, including non-commercial species.

As described by Kemp (2000a) from the 1998 survey, sites at Sikha Island still have the greatest abundance of fishes in 2002. Lowest abundance of fishes occurs at relatively turbid inshore sites with low-relief substrates (sand or coral-free rock). The Rapid Assessment survey does not include collection of numerical data on diversity, but rapid observations of the levels of diversity within the observed fish communities at Rapid Sites confirmed that low abundance tends to correspond to low diversity across the range of Rapid Sites surveyed.

The greatest diversity of fishes was observed at four Rapid Assessment sites: both of those at sikha (YEM/03/01; YEM/03/02), the site at Barrakah (YEM/02/04) and the Stylophora / rocky reef site at eastern Hallaniyah. The two Sikha sites and the Hallaniyah site were all identified by Kemp (1998) as having diverse reef fish communities important within the area. The Barrakah site was not surveyed in 1998.

Abundance of butterflyfishes, a useful general indicator group, is very variable between sites (Figure 16) as is the structure of those same butterflyfish communities (detailed comments will be made in the management plan about how and why to use butterflyfish surveys for monitoring in the Bir Ali area). Figure 14b shows the abundances of obligate corallivore species (species
that only feed on living corals) and of generalists at quantitative survey sites in 2002. The five sites with the highest abundance of corallivores are the five with the highest cover of live hard coral [N.B. still have to test this for significance – Spearmans rank].

**Figure 16.1.** Abundance of butterflyfishes at detailed survey sites, 1998 and 2002. The between-year differences are discussed in section 4.1.7 below.

**Figure 16.2.** Abundance of obligate corallivorous butterflyfishes at detailed survey sites, 1998 and 2002. The very obvious between-year differences are discussed in section 4.1.7 below.
Table 6 Zoogeographic affinities of fishes from selected families in the Bir Ali area (adapted from Kemp 1998), showing both 1998 and 2002 values for two of the five families.

The 2002 figures are in brackets.

IO = Indian Ocean species; I-WP = Indo-west Pacific species.

The changed species richness between surveys for the Chaetodontidae (butterflyfishes) is largely a sampling effect. The 2002 survey did not include as many sites as the 1998 survey. The total species list for 1998 (used for the other three families in this table) included a species list developed during over 100 hours of diving, and many more hours of snorkelling. The 2002 survey included less than 30 hours in the water in total for the fish surveyor, both for transects and for other assessments. For this reason the figures for the total species richness of other families are non-comparable between years (unlike the transect totals, which are used in other between-year comparisons, below) and are not included here.

The proportion of ‘Red Sea’ endemic species is very high at Bir Ali, with 12% of 1998 survey species of these five families being ‘Red Sea’. Within the Red Sea itself the overall level among all families of fishes is approximately 17 – 18% (Edwards & Ormond 1987).
4.1.7 Changes in Coral and Fish Communities 1998 – 2002.

The Bir Ali – Belhaf area was extensively impacted by the global coral bleaching event of 1998, and the recent survey provided an opportunity to assess the impact of that event by repeating surveys carried out in the area immediately prior to that bleaching event (Kemp & Benzoni 2000). Transects at four different sites within the survey area were resurveyed for both fishes and corals, using methods identical to those of 1998, and the results of that re-survey provide information of direct relevance to the management of the area within an MPA and ICZM framework. In particular, areas where high cover coral communities did exist but which were heavily impacted, are likely to benefit from management, with consequent faster recovery and recolonisation of corals.

Coral Mortality.

The impact of the global coral bleaching event of 1998 is evident throughout the Bir Ali – Belhaf area, but levels of impact on corals are highly variable. Sikha, Barakah and Belhaf have escaped almost unaffected, while Hallaniyah has suffered very badly, and many areas of coral there are now almost 100% dead. These dead corals include some of the most impressive monospecific areas recorded in 1998 (Kemp & Benzoni 1999). Throughout most of the rest of the area coral mortality is variable, but probably averages 20 – 30%. New recruitment is evident in most locations and with appropriate management the corals of the area should recover over time (a time scale of decades for similarly huge monospecific areas at these sites, but probably very much faster for extensive growth of other corals), so long as further mortality events do not recur regularly, and so long as the area is protected from direct deleterious human impacts such as anchoring, nutrient (sewage) pollution, landfill, etc.

Figures 17.1 – 17.3 illustrate the differences between 1998 and 2002 graphically, based upon the results of the UVC substrate assessment carried out along UVC transects at four Rapid Sites. These figures illustrate the high degree of variability in coral mortality within and between sites.

Most notable is the good condition of corals in Sector 3 (Sikha Island). Hard coral cover here decreased at only one transect (03/01/sh1). This was in 1998 a very shallow (0.5 – 2m) area of extremely high cover branching Acropora and Stylophora corals, with some foliose Montipora. This community suffered approximately 100% mortality, with recent recruitment of small Acropora and Pocillopora corals accounting for virtually all of the live coral still present along this transect. This mortality is likely to have been due to the combination of sheltered location and extreme shallowness. Other transects within the same Rapid Assessment site showed no change from 1998 due to greater exposure (03/01/sh2) or greater depth (03/01/dp). This was supported by the subjective impression of the surveyor that this exceptional site was largely unchanged since 1998, and is still very much worthy of inclusion within a core conservation area.

The other sites shown in these figures were all mainland or near-shore island sites in shallow water and sheltered locations, and so were vulnerable to the high water temperatures that are one of the principal causes of bleaching events, and which were the main cause of the 1998 mortality. All suffered extensively, both in terms of total reduction in live coral cover, and taxonomically in that virtually all coral taxa including those usually relatively resistant to coral bleaching were killed. This was most striking along transect YEM/01/01dp, which had previously been dominated by a mixture of very large Porites colonies and monospecific areas of Pocillopora.
and *Pavona*. Virtually all corals at this site had been killed, although some new recruitment was evident in some places.

The community of massive corals at Belhaf is still in excellent condition (site YEM/01/05), and the area of monospecific *Stylphora* recorded by Kemp (1998) and Kemp & Benzoni (1999, 2000) to the east of Hallaniyah island (site YEM/01/04) is still in good condition, but the *Acropora* corals at the same site have suffered 100% mortality, accounting for the differences shown in figures 17.1 – 17.3. The community of almost 100% cover *Goniastrea* corals, fringing the mainland shore immediately to the east of Hallaniyah (Quick Look site at waypoint 1/35), is in excellent condition with no visible bleaching impact apparent.

More widely, mortality was patchy, and it is likely that there are numerous but relatively small areas of good condition corals along the mainland coast and near-shore islands, in locations that were not surveyed during 2002. However, the general impression gained from the 2002 survey is one of an area where virtually all of the shallow coral communities of the mainland and near-shore islands, and some of the deeper ones, have suffered severely as a result of the 1998 event, although with some recovery apparent.

![Figure 17.1. Percentage cover of live coral along eight transects at four Rapid Assessment Sites, 1998 vs 2002. Sites where the difference is statistically significant (Wilcoxon unmatched pairs or t-test) are marked with a star. Small sample size within sites (5 replicates) means that this may have failed to detect real differences at some sites which were not found to be significantly different according to these tests.](image)

Significance levels:

* P = 0.05 – 0.01
** P = 0.01 – 0.001
*** P = <0.001
Figure 17.2. Percentage cover of dead hard coral and rubble along nine transects at four Rapid Assessment Sites, 1998 vs 2002. Sites where the difference is statistically significant (Wilcoxon unmatched pairs or t-test) are marked with a star. Small sample size within sites (5 replicates) means that this may have failed to detect real differences at some transects (such as YEM/01/01 sh).

Significance levels:

* P = 0.05 – 0.01
** P = 0.01 – 0.001
*** P = <0.001
Figure 17.3. Percentage cover of soft coral along nine transects at four Rapid Assessment Sites, 1998 vs 2002. Small sample sizes and low percent cover at all sites in both survey years mean that none of the sites show a statistically significant difference, but a clear trend mirroring that apparent in hard coral cover at the same locations is nevertheless apparent.
Changes in fish communities.

1. Butterflyfishes

Butterflyfish communities were surveyed in detail at all UVC transect sites in 1998 and 2002. Between-year differences in those butterflyfish communities over that time period are very pronounced at a number of sites.

Butterflyfishes have been proposed by several authors as indicator groups (i.e. they respond to changes in environmental conditions by changes in their own community structure or abundance - e.g. Crosby and Reese 1996), although other authors have questioned their suitability for detailed monitoring studies (e.g. Roberts et al 1988). In the Bir Ali area the very detailed methods proposed by Crosby & Reese (1996) are invalidated by the observed occurrence of previously unrecorded feeding behaviour in some key species of butterflyfishes (Kemp in review). However, there is no doubt that reef fish communities in general and butterflyfish communities in particular do respond to habitat degradation or alteration, and that those responses are very clear at a number of sites in the Bir Ali – Belhaf area.

![Butterflyfish abundance](image)

**Figure 18.1. Changes in total abundance of butterflyfishes between 1998 and 2002.** The greatest decline in total butterflyfish abundance is at the three transects that suffered the worst impacts of the 1998 bleaching. This pattern, although less pronounced, closely follows that of the corallivorous specialists.

Significance levels:  
* $P = 0.05 – 0.01$  
** $P = 0.01 – 0.001$  
*** $P = <0.001$
Figure 18.2. Changes in abundance of corallivorous butterflyfishes between 1998 and 2002. The decline among the areas of formerly very high cover shallow branching corals at Sikha (Site YEM/03/01) is particularly dramatic in terms of absolute numbers, but the decline at site YEM/01/01 deep is similarly large in percentage terms.

Significance levels:

* $P = 0.05 – 0.01$

** $P = 0.01 – 0.001$

*** $P = <0.001$
Figure 18.3. Changes in abundance of generalist butterflyfishes between 1998 and 2002. This presents a less clear-cut picture than either of the previous two graphs, with a marked increase in abundance of generalist butterflyfishes at a number of sites. In some cases this is most probably due to the marked change in habitat / substrate, from a very high cover coral substrate suiting coral specialists, to a rocky or rubble substrate providing more food for generalist species (for example, this will be the case at site YEM/03/01 sh1 and sh2). At other sites such as YEM/03/01dp the reason is less clear, but this large increase in abundance, which is not matched by substrate changes within the transect area, may still be a result of generally increased abundance of these species at this site due to the nearby change in habitat at the other transects. It is significant that at sites such as YEM/01/01, at both shallow and deep transects, the abundance of generalists has decreased markedly. This site had mixed hard coral and other substrates in 1998, with a very mixed butterflyfish community. This decline suggests that, at sites with mixed coral communities and mixed fish communities, loss of corals impacts both specialists and generalists alike.

Significance levels:  
* $P = 0.05 - 0.01$  
** $P = 0.01 - 0.001$  
*** $P = <0.001$
2. *Species richness of five families of fishes.*

In addition to butterflyfishes, four other families of fish were surveyed at UVC sites. Angelfishes (Pomacanthidae) were counted, and damselfishes (Pomacentridae), triggerfishes (Balistidae) and surgeonfishes (Acanthuridae) were recorded as present or absent. These five families totalled 56 species throughout the survey transects over the two separate years. Across all sites the between years difference in species richness is small (average of 28.3 in 1998 and 23.8 in 2002), and statistically the difference is not significant. Figure 18.4 below illustrates the differences. In spite of the lack of statistical significance, the trend for reduced species richness in these five families is clear at all sites in 2002. If real (small sample size limits the effectiveness of statistical tests for significance) this difference is likely to be for two different reasons: Firstly, many of the species recorded are more or less closely associated with the benthic habitat and topographic structure, and so are likely to have suffered some impact as a result of the 1998 bleaching event and subsequent coral mortality. Secondly, the apparent absence of these species from the area, if figures from the UVC transects alone are consulted, is misleading. Fourteen species recorded in these transects in 1998 were not recorded in 2002. However, of those fourteen, only seven were not recorded at any time during the 2002 survey in other areas or sites. Two of those species are obligate corallivore butterflyfishes only recorded as rare individuals (1 and 4 respectively) in 1998, at Sikha island (*C. trifasciatus* and *C. zanzibarensis*). Furthermore, one species not recorded in 1998 (*Epinephelus flavocaeruleus*) was found to be both widespread and common in 2002.

It seems that, while there may have been a slight decrease of diversity at the scale of individual transects (*alpha* diversity) within the Bir Ali area, there is unlikely to have been any overall loss of fish diversity throughout the area as a whole unless some of the disappearances of fisheries species reported by Bir Ali fishermen are complete (but these fish species were not assessed in any systematic manner in 1998, so their loss will not be apparent from the 2002 ecological fieldwork).
Figure 18.4. Species richness of five families of fishes along UVC transects at four Rapid Assessment Sites, 1998 vs 2002. The difference between years is not statistically significant.
4.1.8 **TURTLES**

The Bir Ali area, both mainland and islands, constitutes a nationally and regionally significant turtle nesting area. As Figure 19 shows, turtle nests were observed at almost all sandy beach sites throughout the area. Although no nests were seen at the very large beach to the east of Ras Majdahah (and so no turtle nesting is shown at this location on the map) this beach is, according to local fishers, of very great importance for turtle nesting. Mortality at this beach is apparently high during nesting due to proximity to the road, which enables people to easily access the nesting area while the turtles come ashore. Huge numbers of dead turtles were recorded throughout the survey area.

All species of marine turtle are globally endangered, and are listed on CITES Appendix 1. Unacceptably high numbers of turtle remains (hundreds of individuals) were found throughout the whole of the survey area. Although some of these casualties may have been killed while coming ashore for nesting, the majority were almost certainly killed by inshore incursions of industrial trawlers, and subsequently washed up on the shore. Rather than simply being released once caught, a number of very recently dead turtles had clearly been deliberately killed by fishers before being discarded. *It is strongly recommended that detailed surveys of turtle populations throughout the area are carried out as soon as possible, and an effective monitoring programme introduced. This will be an appropriate role for the Habitats and Biodiversity Component of the PERSGA SAP, and should be linked with turtle conservation efforts elsewhere in the Gulf of Aden.*

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**Figure 19:** Distribution and abundance of turtle pits at Rapid Sites, Bir Ali - Belhaf 2002. N.B. the very long curving beach at the eastern end of the survey area, east of Ras Majdahah, is reported to be a significant turtle nesting site. No turtle nesting activity is shown there on this map because no nests were apparent to the survey team in 2002. This should be further investigated and incorporated into a local turtle conservation and monitoring programme.
4.1.9 **BIRDS**

Birds were observed at almost all sites, and were commonly seen throughout the area, often in large numbers. Large areas of guano are obvious on the cliff faces of all the higher islands and headlands (particularly at Sikha, Barrakah and Qana), indicating important roosting and/or nesting areas. Gulls (*Larus* sp.) and boobies (*Sula* sp.) were observed nesting on the cliff ledges around Sikha and Barakah. Hallaniyah island has in the past been recorded as a summer (July - August) breeding area for *Larus hemprichii*, with *Phalacrocorax nigrogularis*, breeding on Barakah and Sikha over the same period. (Evans, 1994). Kemp (1998) recorded huge number of *P. nigrogularis* feeding in Bir Ali bay and around Hallaniyah. The guano of these and other birds provides an important source of income for the area, with approximately 365-730 tones of collected from these islands (particularly from Barrakah) every year, and sold. From the brief field survey it appears that Barrakah island is the most important single site for birds in the area.

It is likely that the entire Bir Ali – Belhaf area is of at least national, if not regional, significance for birds, for feeding, roosting and breeding. A dedicated bird survey of the area is recommended, with subsequent modification of the Site-Specific Master Plan to protect nesting, feeding and roosting areas if necessary. In the interim, the offshore islands and all areas of steep rocky headland and cliff should be protected from activities that may be damaging to the bird populations of the area. An assessment of the impact of guano-collection activities should be undertaken for precautionary reasons as a matter of priority. However, it is likely that this activity, which has apparently been carried out for many years, is sustainable and not damaging to the bird populations of the area. Any alterations in the guano collecting methods or intensity should be carefully monitored, and any damaging changes should be ruled out. Enlisting of the cooperation of the local guano collectors with any bird monitoring programme may be advantageous. [Mohammed: do you have access to the IBAs of the Middle east book? If so, please fax or post a copy of the relevant pages to me in Massawa so that I can write a paragraph based on that for insertion here]
Figure 20: Bird density and distribution from Rapid Site surveys, Bir Ali - Belhaf 2002.

4.1.10 CETACEANS

The area is home to large numbers of cetaceans, including at least two species of dolphins (the common dolphin *Delphinus capensis*, and the bottlenose dolphin *Tursiops truncator*). Bottlenose dolphins in particular are abundant and the area appears to be home to at least one, and perhaps two, large groups of these animals. Bottlenose dolphins were observed at various locations along the whole coast of the area.

The remains of at least two large whales (one toothed and one baleen), seven small toothed whales and the fresh or skeletal remains of over two hundred dolphins were found along the shore in the survey area. A large proportion of the dolphin mortality is likely to be the result of accidental capture and subsequent discard by industrial trawlers. Commercial trawling immediately offshore from Bir Ali – Belhaf is a significant threat to turtles and cetacean populations in the area.

4.1.11 INTERTIDAL HABITATS

The rapid intertidal survey carried out at most of the Rapid Assessment sites provides a brief description of the dominant intertidal habitats and species of the area. These are here summarised by type (sandy beaches and rocky shores), with some more detail then provided for specific sites within the area.

**Sandy beaches**

A lack of time, of sampling instruments, and of sample containers limited the scope of the intertidal surveys within the Bir Ali – Belhaf area. However, earlier studies, notably the beach pollution study 1996 (MSRRC, 1996), revealed that polychaetes and amphipods, with other undefined species are common on the sandy shores of this area, and provide a baseline for the recent PERSGA survey.

The ghost crab *Ocypode saratan* is common on all sandy beaches of the area, distributed from the high tide line up to the upper supralittoral, being found in large number even in areas with a high level of human impact such as the beach at Bir Ali village. Burrows of adults of this species form a conspicuous band of small pyramids in the supralittoral, with those of juveniles abundant further down on the upper eulittoral. Other unidentified *Ocypode* species are also present throughout the area.

The hermit crab *Coenobita scaevola* is very commonly found on the supralittoral, and is particularly abundant on sand beaches near to areas of fossil reef and rocky platforms. Numerous other hermit crabs are common on these beaches, and in areas of mixed rock and sand a diverse array of species occurs.

**Rocky shores**

The rocky shore communities of the area are home to a relatively diverse and frequently very abundant array of species. Filter feeders (oysters, barnacles and mussels) dominate much of the intertidal, numerically followed by grazers such as chitons, limpets and crabs. Predators such as
Drupa, Vasum, Coronia, and crabs are also abundant. Mats of algal turf or mixed small macroalgae are extensive throughout the eulittoral in rocky areas.

Barnacles are abundant on rocky shores throughout the area. Large barnacles including Tetraclita squamosa, Chthamalus Euraphia and Balanus reach 100% cover on some rocky areas, with the chthamalid barnacles forming a distinct zone, mixed with a few of the “giant” Tetraclita squamosa rafotincta and the smaller Tetrachthamus sp. Tetrachthamus is more tolerant to heat and desiccation and therefore tends to live higher up the shore than Tetraclita squamosa, which extends into the lower eulittoral and sublittoral fringe, together with S. cuculata. The eulittoral zone is in many places marked by an abundant and often extensive oyster band (Saccostra cucullata), normally exceeding 1.0 m in vertical width, particularly on steeper cliffs around the islands of Barakah, Ghadharin and Sikha. This species also found heavily encrusting many of the more exposed areas of isolated intertidal rocks on sandy beaches. The barnacle T. squamosa tends to be more abundant in sheltered areas, while the S. cuculata tends to favor the more exposed surfaces with up to 100% substrate over large areas of the rocky shore especially at the islands with steeper cliffs. The chiton Acanthopleura haddoni is always found together with other Acanthopleura sp. distributed to the upper limit of the eulittoral.

The limpet Patelloida profunda together with the gastropod Nerita textiles has a wide vertical distribution, ranging from the upper eulittoral to the sublittoral. Another limpet, Cellana radiata has a more limited range of vertical distribution, overlapping only with the lower distribution range of Patella profunda. The gastropod Nirita plicata and the periwinkle Littoraria undulata are both present in the upper eulittoral, with a vertical distribution extending into the supralittoral zone. The vertical distribution limit of Nodilittorina natalensis, together with Planaxis sulcatus, extends to the end of the supralittoral. Cerithium caeruleum were present on the mid eulittoral but very rare.

The gastropods Vasum sp. and Cornia sp. are found throughout the lower eulittoral, their vertical distribution normally overlapping with that of barnacles and oyster bands. Monodonta sp. is occasionally found from the upper to the lower eulittoral zones. Various grapsid crabs including Metopograpsus messor, Grapsus albolineatus and Eriphia smithi are commonly distributed from the upper eulittoral into the supralittoral.

Belhaf- Qana:

Along the coast between Balhaf and Qana terrestrial and supralittoral slopes are steep, with little accumulated sand, and often with substantial boulder fields. Intertidal slopes here tend to consist of an intertidal lava plateau with occasional strips of sand, and small areas of cobbles.

This western area of coast can be divided into two on the basis of degree of dominance by basaltic lava (clearly shown in the coastal and true-colour satellite images). From Belhaf to about 7 km west of Qana volcanic rock slopes and cliffs up to 15-20m in height fall directly into the sea in many areas, although small patches of accumulated sand and rubble in some places form small beaches backed by lava headlands. Ocypoda sp. burrows are abundant at these beaches, and other crabs such as Metopograpsus messor and Grapsus albolineatus are abundant on rocky platforms close to the sea. Tar balls are occasionally abundant here, with driftwood and other litter also present in abundance.

The rest of the coast to Qana is dominated by sandy beaches with occasional lava outcrops, backed with a band of halophytes and arid shrubs, of about 30-35% cover, on sand. Much of the area immediately west of Qana is dominated by rocky platform and boulders.
Ghost crabs burrows are abundant in the bay adjacent to Qana, and other crabs such as *Metopograpsus messor* and *Eriphia smithi* were frequent on the rocky margins here.

**Qana- Bir Ali bay:**
Bir Ali bay is a large sandy bay, interrupted by some small rocky lava intrusions, reef rock platforms (on the western and eastern sides of the bay), and small patches of pebbles and cobbles in the wadi outfall to the west of Bir Ali village. Numerous of crab burrows of least two species of *Ocypod* were recorded here.

**Mainland coast to the east of Bir Ali.**
The shore to the east of Bir Ali consists largely of volcanic rocky bays and headlands, interspersed with several sandy bays.

Al-Baidha beach, approximately 3km to the west of Ras Madrakah, is typical of the smaller bays along this coast. It is a semi circular bay backed by a large rocky hill and with headlands at either end, making it largely inaccessible from the shore. The intertidal zone here consists largely of low-lying undercut rocky platforms, interspersed with small sandy beaches. Algal mats are widespread on the rocky reefs throughout the eulittoral zone (and a feature common to all the low-lying rock shores of the Bir Ali – Belhaf area). Several crab species, including ghost crabs and hermit crabs are abundant here.

To the east of Ras Madrakah a small sandy beach extends for about 2.0 km, ending at a rocky outcrop/headland, with scattered boulders in the intertidal zone. This beach is backed by a narrow low-lying coastal plain covered with small shrubs at 10-15% cover. Several turtle nests were recorded here, and ghost crabs burrows were abundant.

Finally, approximately 4km east of Ras Madrakah is a long sandy beach (Ammbah Beach) extending many kilometers, and marking the eastern edge of the survey area.

**The Islands:**
The islands of the area are all of volcanic origin, often with steep sides rising directly from the sea, and limiting areas where access can be made to the land. Ghost crab burrows are very abundant at the few beaches found on the islands (beaches were only recorded at Sikha, Ghaddarayn Sarir, and Hallaniyah). Those rocky shores that could be accessed at the islands were dominated by barnacles, chitons and very extensive areas of algal turf, particularly in the lower eulittoral.
4.2 **HUMAN IMPACTS**

In stark contrast to the situation in 1998, actually or potentially damaging human impacts and activities are now obvious at many sites visited throughout the survey area. Without the implementation of adequate management these impacts are likely to continue and to increase, with consequent erosion of the beauty, biodiversity and fisheries wealth of the area.

4.2.1 **CONSTRUCTION**

New construction is not currently apparent anywhere in the survey area apart from small and temporary or at most semi-permanent fishing camps, which are found throughout the whole of the survey area, including Sikha Island. There are two principal built areas within the survey area, at Bir Ali village and at Belhaf.

*Bir Ali village.*

(This section includes some basic socio-economic information about the village, collected largely by the two national surveyors from MSRRC).

The village of Bir Ali extends along approximately 1km of the north-western shore of Bir Ali bay. Buildings in the village extend from just above the high tide line to the road, although there are few buildings except for the ice factory on the landward side of the road. The majority of buildings in the village are well-built stone structures. The only stone jetty in the village is in disrepair and is used very little, boat launching, loading and unloading taking place directly from the beach.

The current permanent population of Bir Ali village is approximately 3,800 people, of which 2000 are male and 1,800 female (these figures need verification). Approximately 70 people in total are employed in state and private sector enterprises in the village. Attempts by the Ministry of Fish wealth to provide women of Bir Ali with employment making fishing nets ultimately failed, in spite of the provision of training courses completed by 14 women. A small number of people have an income from shops, mostly associated with the main Aden – Mukalla road. Families in the village not employed by state organisations (school, health, and fish marketing), the private sector (ice factory) or with an income from shops are dependent upon the fishery. During the survey a total of 218 full time fishers were estimated to be permanent inhabitants of Bir Ali, with a further 100 taking part in fishing part – time.

During the summer season this number increases to approximately 3000 due to the influx of migrant fishers from throughout the Yemen Gulf of Aden including Socotra, and from as far away as the Yemen red Sea coast. At this time the number of boats operating throughout the Bir Ali area increases from 120 fibreglass, to approximately 620 fibreglass and wood, including a number of large sanbouk.

Fish receiving facilities in Bir Ali including a cold storage unit (unknown capacity), a freezer (3 – 4 tonnes capacity) and two ice –making plants (see fisheries report for details).

During the survey it was estimated that the average income per family in Bir Ali was in the region of 12,000 – 15,000 YR per year, with approximately 70 families in receipt of financial help (approximately 1,000 – 2,000 YR each) from the Governmental Social Care box in order to meet their basic needs. Fishing income is unpredictable from year to year, and is highly variable over the course of a year due to the seasonality of fishing.
<table>
<thead>
<tr>
<th>Employer</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>School (State)</td>
<td>23</td>
</tr>
<tr>
<td>Health (State)</td>
<td>3</td>
</tr>
<tr>
<td>Fish marketing corporation (State)</td>
<td>42</td>
</tr>
<tr>
<td>Ice factory (Private)</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 6.**  Number of employees of State and private organisations in Bir Ali village (N.B. These figures need to be verified).

Education in Bir Ali is provided at primary school level, with approximately 120 boys attending school in 2002, and 70 girls. Girls tend to leave school after year four, while boys tend to stay on until year 7. Literacy within the village is approximately 75% among males and 50% among females (the lower level among women probably being because of their lower school leaving age). There is currently one school in the village, with a new one under construction.

The village clinic has no doctor and is administered by three nurses / medical technicians. Basic laboratory facilities are available here. The main medical problems are malaria and anaemia, with fungal infections being common.

Waste disposal is the principal environmental issue in the near proximity of this village, with large amounts of fishing and domestic refuse in the water and on the beach, leading on at least one day of the survey to development of an extensive area of very black anoxic water close to the shore. Raw sewage was commonly observed in the water here. These are important public health issues that any future MPA management should, in cooperation with all relevant authorities, strive to address with and on behalf of the villagers.

**Belhaf.**

There are approximately 10 moderately substantial stone buildings in Belhaf, the rest being predominantly small wooden structures. The population of this village was not accurately determined during the survey but was very low (less than 100). During the summer monsoon the population grows substantially due to migrant fishermen (see fisheries report).

**Temporary and semi-permanent camps.**

Temporary and semi-permanent fishing camps are described in some detail in the Fisheries Report, appended to this Ecological report.

The most significant of these camps in terms of size is at the eastern end of the bay on the western side of Ras Majdahah. During the survey this camp was almost empty, with probably less than two dozen fishers and half a dozen boats present. This camp grows very considerably during the summer fishing season. This camp was in 1998 very small, consisting of probably less than one dozen temporary shelters, and has grown to perhaps ten times that size in the past four years.

A temporary camp on the only beach at Sikha island is seasonally inhabited by migrant fishers from Socotra. This camp is apparently a relatively new feature, having only come into existence in the past eight to ten years (it was already present in 1998), and was empty during the survey period, only being occupied during the summer monsoon season. Kemp (1998) reported damage
from passage of boats over shallow corals at this important site, and some significant anchor damage. This location of this particular camp will be a management issue for the MPA, and the impacts occurring as a result of the camp should be assessed in detail, and mitigation measures taken to protect the very important corals and fish of the two Sikha bays taken. This may require the relocation of the camp to a mainland site, although with the cooperation of the fishers and with careful mitigation relocation may not be necessary while the camp remains small. The lagoon behind the beach showed some signs of eutrophication in 2002, which may be a result of sewage from this camp. Crucially, Sikha beach is a turtle nesting site, and disturbance of the nesting will be a key issue if the camp is to remain.

The possible familiarity of the Socotra fishers with the management of the marine and coastal habitats and species of Socotra, developed with GEF funding over the past several years, should be investigated exploited to the full (Development of links with the Socotra Project should be developed within the wider context of the Bir Ali programme will be a major recommendation of the forth-coming Site Specific Management Plan).

The recent growth of the mainland and island seasonal fishing camps appears to reflect the situation generally in the area, with a much greater influx of seasonal fishers in recent years than was previously the case. These fishers apparently have little of no knowledge of the traditional local management methods, and represent the most significant immediate management issue for the proposed MPA.

A Tourist Camp now exists on the mainland coast at the foot of Qana hill. This camp was apparently built for use of hotel guests from an establishment in Mukalla, and is an indication of the potential of the area for local, national and international tourism activities. The sustainable development of tourism is one of the most widely used ways to both economically justify and sustainably finance marine and coastal management and conservation. Integration of potential future tourism development as part of the Bir Ali MPA will be a feature of the Site Specific Management Plan for the area.

Inappropriate tourism development, unintegrated with environmental management plans and considerations, will be rapidly damaging to the area, and will be self-defeating in that it will erode or destroy the features that currently make the area so attractive.

4.2.2 **DIRECT EFFECTS OF FISHING / COLLECTING.**

Since 1998 fisheries (both industrial and artisanal) in the area have become a much more immediate and potentially serious threat to the local environment. In addition, a combination of overfishing and unsustainable fishing methods may threaten the medium to long term sustainability of the local fishery, as well as the objectives of any MPA for the area.

Direct effects of fishing and collecting that could be observed as a result of the survey were restricted to:

- Direct damage to corals and other benthic habitats by nets, including lost nets continuing to ghost fish. Kemp (1998) reported lost nets causing turtle mortality and damage to corals at Sikha, and damage to corals from lost nets was observed at the important coral site at Barrakah during the 2002 survey.
- Direct damage to corals due to anchoring in coral rich areas. Again this was observed as being moderately serious at Barrakah, and was also observed at Sikha and in other coral rich areas along the mainland.
The lack of baseline data on fisheries species abundance in the area precluded any quantitative assessment of recent changes to target species abundance. However, local fishers throughout the area have noted a rapid decline in abundance of several important fisheries species in the past several years, and the complete disappearance of others.

There is currently no effective fishery management in the Bir Ali – Belhaf area. There is an urgent need for the development of effective management of the fishery for sustainability. This should include regulation of fishing effort. This should include:

- Regulating the numbers of fishers, traps, boats and nets.
- The imposition of limits to the size of the catch
- The banning of unsustainable methods (including banning industrial trawling in the area of the proposed MPA, replacing durable metal fish traps which, when lost, continue to ‘ghost fish’ for many years, with biodegradable traps, and banning the use of nets in coral areas)
- The designation of Fisheries Reserves.

4.2.3 POLLUTION

Pollution within the survey area currently falls into three categories: litter; sewage; oil.

Litter. The distribution of litter at Rapid Assessment Sites within the survey area is illustrated in Figure 21. Litter was present to some extent at every Rapid Assessment Site with a beach or otherwise more or less gently sloping (rather than vertical) shore throughout the area, although at very variable levels. The very high density of litter at Bir Ali village is a reflection of the presence of the village, and the apparently complete lack of organised waste disposal there. Large amounts of domestic refuse at Bir Ali ends up on the beach or in the water. This is both a public health and a conservation issue. At all other sites with the possible exception of Belhaf all or most litter has probably come from the sea. The very heavily littered site approximately half way between Bir Ali and Belhaf (YEM/01/07) is a beach at the end of a bay that will tend to trap drifting or floating litter. All types of plastic, glass, wood and any kind of metal container that will float is abundant on many beaches throughout the area. Removal of potentially damaging litter from important sites such as turtle nesting beaches will be an issue for MPA management.

Sewage. Sewage is a significant issue at Bir Ali village, and possibly at any other sites throughout the area with substantial permanent or seasonal populations. At Bir Ali this issue will need to be addressed early in any MPA programme for both public health and environmental conservation reasons. In combination with domestic refuse this pollution occasionally leads to very obvious localised eutrophication in the waters near to the village.

Oil. Oil pollution of the shores within the survey area was not severe (Figure 22), and appears to originate entirely from ships rather than from local sources. All observed oil pollution was in the form of weathered tar balls on beaches, or weathered patches of oil on rocky shores. The lack of observed oil pollution within Bir Ali bay is probably a reflection of the fact that this site is relatively sheltered from the open sea by two headlands, and a rocky reef across part of the entrance to the bay.
Figure 21: Distribution and abundance of litter at Rapid Sites, Bir Ali – Belhaf 2002.

Figure 22: The distribution of oil pollution, including tar balls, at Br Ali – Belhaf.
5 LOGISTICAL AND OTHER CONSTRAINTS UPON THE CONDUCT OF THE SURVEY OF THE BIR ALI – BELHAF AREA.

Kemp (1998) provided a number of recommendations for both management and further survey work in the Bir Ali – Belhaf area. The management recommendations will be addressed in the forthcoming Site Specific Management Plan (Kemp et al, in prep). The recommendations for survey work (quoted verbatim) included:

- “Surveys of the terrestrial species and habitats throughout the entire Belhaf - Bir Ali - Burum area.

Inclusion of terrestrial habitats within the protected areas scheme is strongly recommended for two reasons:

1. Protection of subtidal areas is likely to be wholly or partly ineffective if activities on the adjacent shores are not carefully controlled. Direct and indirect impacts on marine communities by shore-based activities are a common reason for failure of both short and long term protection programmes aimed at [protection of] coastal and marine communities.

2. The impressions of the author of this report, and of his colleagues on the Arabian Seas Expedition [the vehicle for the 1998 surveys], were that the terrestrial ecosystems and landscapes of the Bir Ali area are highly varied and important in their own right, regardless of the undoubted importance of the marine species and habitats present. Terrestrial areas should be included in future surveys to determine how far this is an accurate impression. Integration of marine and terrestrial planning and survey work, and implementation of protected areas schemes, is essential for the success of any protected areas which may be designated in the Bir Ali area.

- Surveys of the coastline between Ras Majdahah and Burum. Inclusion of the Burum area in any Protected areas scheme may be important, if anecdotal accounts of the marine habitats there are accurate.

- Surveys to characterise the marine habitats between Hallaniyah Island and Belhaf, which were excluded from the survey reported here.

- Surveys to assess the locations and nature of important macroalgal communities, which are a seasonal result of the south-west monsoon, and are important habitats in eastern Arabia.

- Surveys of resource use within the entire Bir Ali area. In particular a detailed study of the extent and nature of the local fishery should be carried out.

- Surveys of megafauna, in particular to determine the presence and extent of turtle nesting sites.”

Practicalities of the field conditions and resources available to the 2002 survey, as described above, meant that not all of these recommended activities were carried out. The short duration of the 2002 survey precluded the inclusion of the seasonal (summer) maroalgal communities that
may occur in the area. The boundaries of the MPA proposed within the PERSGA SAP do not include areas to the east of Bir Ali – Belhaf, such as Burum.

The survey design for the MPAs proposed under the PERSGA SAP (PERSGA 2002) was adhered to as far as possible throughout the implementation of the Bir Ali – Belhaf survey, but a number of logistical problems significantly reduced the effectiveness of the field survey. These can be summarised under the broad headings of (1) reduced duration of the survey and (2) equipment and personnel issues.

5.1 Duration

The survey, as originally planned, was to take place over a 4-week period. The survey as carried out was approximately 10 days in duration, during which only eight or nine effective survey days were possible. The Team Leader was present for only 6 effective survey days.

5.2 Other constraints.

Further logistical and personnel issues had an impact on the effectiveness of the survey. These issues included:

- *The fisheries boat*, which through the considerable efforts of the MPA Lead Specialist had been promised for the use of the survey team throughout the survey, was not made available. Although the boat was ready for use and the skipper was prepared to help the survey team, no permission was forthcoming from higher authorities. The survey team instead used a small (6m) fishing boat with an outboard motor, hired specifically for the purpose. This allowed the survey to take place, but was less than ideal.

- *Diving equipment.* The diving equipment, imported to Yemen by PERSGA specifically for the MPA project, and vitally important for the survey, was not made available for *any* part of the survey. *This situation was completely unacceptable.* The diving equipment was, throughout the time that the survey team was in the field, held up in customs, and no news was received *at any time* as to progress being made to secure its release. Fortunately the survey team was able to acquire some SCUBA tanks from al Mukalla, and the Survey Team Leader and Co-Leader had provided some of their own equipment. Only eight SCUBA tanks, without the possibility of refills, could be obtained from Mukalla. Without these two unplanned and fortuitous factors the entire survey would have failed. Even with the fortunate but unplanned presence of this SCUBA equipment the survey was severely compromised, and had to be considerably altered. Consequently:

  - The two survey team members from MSRRC in Aden were unable to take an effective part in subtidal surveys. This meant that some survey methods that should have been included were not (for example the Reef-Check fish and invertebrate surveys, which should have been core methods, were not carried out at any sites). The MSRRRC team members were as a result unable to benefit fully from the training opportunity presented by the PERSGA survey.

  - The four trainees could not be given *any* adequate experience of subtidal surveys, although they did take part extensively in coastal and intertidal surveys.

- *Underwater video housing.* The lack of an underwater video housing (lost from inside a vehicle in Sana’a) meant that habitat and ground-truthing surveys were severely compromised.
• *Diving equipment and Video housing problems together* meant that only limited ecological data could be collected during the survey.

**The socio-economic survey.**

The gathering of Socio-economic information was severely constrained by the fact that no socio-economist took part in the survey at any time, although this had been repeatedly identified by the Lead Specialist and the Team Leader as being an important component of the survey.

The survey team, particularly the Fisheries Surveyor and the Intertidal Surveyor (both from MSRRC, Aden), gathered what information they could within the time available and without compromising their other work. The survey team as a whole carried out some very limited but essential public awareness work in Bir Ali, as far as possible under these circumstances. The lack of a dedicated socio-economic survey and subsequent report will have important repercussions for the development of the Site Specific Management Plan which will follow the production of this survey report.

**5.3 Satellite Image Processing**

The lack of underwater photography or underwater video, and the problems of survey duration discussed above, had implications for the effectiveness of image processing. As is true for all areas within the PERSGA MPA-SAP the marine and coastal habitat maps have not been assessed for accuracy. It is recommended that the accuracy of the biotope maps be determined at a later date to check whether the categories mapped agree with those found in the field.
CONCLUSIONS

Kemp (1998) indicated that protection of the marine and coastal environment of the Bir Ali – Belhaf area has the potential to provide a strong foundation for marine conservation throughout the mainland coast of the Gulf of Aden. Features of the Bir Ali area which led to this conclusion are still largely unaltered, and include:

- **Exceptional coral communities.** The coral communities present in the Bir Ali area were at that time healthy and diverse, representing many of the community types typical of the Gulf of Aden and Arabian Sea coasts of Arabia. Such communities are not found anywhere else in the Indo-west Pacific region. Protection of this area will include an exceptionally wide range of representative coral communities, and their associated fish and invertebrate species, within one management programme.

- **A diverse and highly unusual coral reef fish community.** The fishes associated with the marine habitats of the Bir Ali area are unique in Arabia, both in terms of species composition, and levels of diversity. The zoogeography of marine species at Bir Ali is unique, differing substantially from the species assemblages at Mukalla 100km to the east, from the Aden area to the west, and from Socotra to the south. Bir Ali is the eastern-most location for a number of Red Sea species, the western-most for several Arabian Sea species and the only Arabian location for some very striking east African fish. Recent work in Oman has revealed a significant number of marine species believed to be endemic to that country. As a result of the recent survey several of these are now known from Yemen.

- **Rare and exceptional coastal landscapes.** The flooded volcanic crater to the east of Bir Ali village, which has a highly unusual isolated population of mangrove trees (*Avicennia marina*), and which is presently almost pristine (little or no litter, minimal man-made erosion or damage) should be afforded protection. The entire volcano should be included in any protected area. The area of coast between Qana and Belhaf is also exceptional, and should be included in any Protected Area scheme. Detailed surveys of terrestrial habitats and species should be carried out throughout the Bir Ali area.

- **Internationally important archaeological remains at the ancient port of Qana.** The archaeological remains, both terrestrial and underwater (inside Bir Ali bay) should be included in the Protected Areas, and stringently protected. The submerged areas of the ancient anchorage, in which large quantities of ancient pottery are easily found, are particularly vulnerable to damage and plunder by SCUBA divers in search of artefacts or souvenirs (map 3). It is recommended that a thorough marine archaeological survey of the Bir Ali area be carried out as part of the management plan, and that any significant areas of archaeological remains identified be protected from interference under the CZM plan. In particular, sport diving activity should be disallowed at all such sites.

- **Cultural, educational and scientific significance of the Bir Ali area.** The diversity of biological, historical and landscape features of Bir Ali mean the entire area has great potential for environmental, natural history, and cultural education for schools, Universities and the general public. Designation of a marine and coastal protected area at Bir Ali could be a conspicuous flagship project for conservation in Yemen and the Gulf of Aden area. Any Protected Area scheme should take these factors into account. It is recommended that a protected areas scheme include educational and scientific elements. The recent surveys in the Gulf of Aden have shown that the marine habitats of the region are very different from what had been believed. This gives added scientific significance to the coral habitats which have been discovered at Bir Ali, and
promotion of the study of these communities by both Yemeni national and visiting foreign scientists should be promoted, within a protected areas scheme.

To this list now has to be added the need for effective fisheries management for long term sustainability within the entire area of the proposed MPA. This is perhaps the single most important issue facing the management of the MPA in the short to medium term (as well as any other authority with an interest in maintaining the long term productivity of the fisheries of this important and resource-rich area of the Yemeni Gulf of Aden). Failure to implement such management will certainly compromise the biodiversity conservation objectives of the MPA. Given the increasingly extensive evidence for extremely slow recovery (or often complete non-recovery) of heavily overexploited tropical coastal fisheries (see, for examples, Birkeland 1997, Bohnsack 1997, Birkeland & Friedlander 2001) a failure in this respect may result in permanent loss of some or most of the fishery resources of the area. This is of particularly critical relevance to the apparently increasing fishing of spawning aggregations / nursery sites in the waters of the Bir Ali – Belhaf area.
7 References.


Richmond, M.D. 1997. *A Guide to the Sea Shores of Eastern Africa and the Western Indian Ocean Islands.* SIDA, Department of Research Cooperation, SAREC.


