U.PORTO
INSTITUTO DE CIÊNCIAS BIOMÉDICAS ABEL SALAZAR
UNIVERSIDADE DO PORTO

PROPOSED MANAGEMENT PLAN FOR RUL DIBBA – AL FAQEET MARINE PROTECTED AREA, FUJAIRAH EMIRATE, UAE

RITA COSTA SAN MIGUEL BENTO

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Dissertação de Candidatura ao grau de Mestre em Ciências do Mar – Recursos Marinhos submetida ao Instituto de Ciências Biomédicas de Abel Salazar da Universidade do Porto.

Orientador – Doutor Christophe Tourenq
Categoria – Manager of Science and Research
Afiliação – Emirates Wildlife Society - WWF.
Co-orientador – Prof. Dra. Maria Armanda Henriques
Categoria – Professor Catedratico
Afiliação – Instituto de Ciências Biomédicas Abel Salazar da Universidade do Porto

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Abstract

In 1995, for the first time in the United Arab Emirates (UAE) three marine protectorates: Rul Dibba Al Faqeet, Dadna and Al Aqa were created in the Emirate of Fujairah, under the instruction of His Highness Sheikh Hamad Bin Mohammed Al Sharqi, Supreme Council Member and Ruler of Fujairah. The lack of a management plan after the legal implementation of these Marine Protected Areas (MPAs) lead to an abandon estate of the areas, where the loss of habitats and species has been gradually noticed, especially in Rul Dibba Al Faqeet MPA, the focus of this present work.

Besides the lack of management, the increase in tourism and coastal development along the Fujairah coast has brought more pressure into Dibba MPA. Preliminary results of the ecological and socio-economic surveys of this present study pointed out the main threats and issues facing Dibba MPA.

From a total of 168 species recorded in Dibba MPA during the present work, 22 were listed on the Red List of endangered species of the international Union for Conservation for Natures (IUCN) and 17 in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The presence of several threatened species in Dibba MPA highlights the importance of the area for the conservation of UAE marine biodiversity and its potential for further studies on the species and habitats. Major ecological issues were identified, such as high temperature and salinity, predation, coral diseases, and natural disasters.

During the socio-economic monitoring, the main stakeholders of Dibba MPA were interviewed, and a tremendous lack of environmental awareness was highlighted. Anthropogenic issues needing an urgent management were identified such as pollution, invasive species, coastal development, commercial and recreational fishing, tourism, and legal and institutional issues.

The categorization according to international standards (*i.e.* IUCN category) as well as the update and institutionalization of the current legal framework will benefit tremendously Dibba MPA. The application of a management plan will help to overcome the principal problems encountered by Dibba MPA, such as the lack of available data on natural resources, the absence of proper fixed and marked boundaries, the lack of patrolling and guarding; the vague legislation and institution mandates, the poor public awareness, and the non-use of a protected area for research purposes.

Keywords: Unites Arab Emirates, Fujairah, Marine Protected Areas, Coral reefs, Management, Biodiversity, Tourism, and Conservation.

Resumo

Em 1995 o Emirato de Fujairah, sobre a instrucção de Sua Alteza Xeique Hamad Bin Mohammed Al Sharqi, Membro do Supremo Conselho dos Emiratos Árabes Unidos (EAU) e Governador de Fujairah, implementou pela primeira vez três protectorados marinhos: Rul Dibba Al Faqeet, Dadna e Al Aqa. A inexistência de um plano de gestão sobre estas Áreas Marinha Protegidas (AMP) conduziu a um abandono destas zonas, onde a perda de habitats e espécies é notável, especialmente na AMP Rul Dibba Al Faqeet, objecto deste estudo.

Além de uma falta de gestão, o incremento do turismo e do desenvolvimento costeiro em Fujairah provoca uma pressão suplementar sobre a AMP Dibba. Os resultados dos estudos ecológico e sócio-económico preliminares deste estudo, identificam as principais ameaças e problemas na AMP Dibba.

Num total de 168 espécies identificadas na AMP Dibba durante o presente estudo, 22 encontram-se registadas na Lista Vermelha da União Internacional para a Conservação da Natureza e dos Recursos Naturais (IUCN) e 17 nos apêndices da Convenção sobre o Comércio Internacional das Espécies da Fauna e da Flora Selvagens Ameaçadas de Extinção (CITES). A presença de várias espécies de elevado valor patrimonial na AMP Dibba demonstra a importância desta zona para a conservação da biodiversidade marinha do país e o potencial para futuros estudos sobre as suas espécies e habitats. Os principais factores de pressão ecológica foram também identificados, como a existência de altas temperaturas e salinidades, predação, doenças de corais, e desastres naturais.

Uma total falta de conhecimento sobre o estatuto da AMP Dibba foi também notada durante o monitoramento sócio-económico, onde os principais intervenientes sociais implicados na utilização da AMP de Dibba foram entrevistados. Ameaças de origem antropogénicas que necessitam uma urgente gestão foram identificadas: poluição, espécies invasoras, desenvolvimento costeiro, pesca comercial e de lazer e turismo.

A categorização de acordo com padrões internacionais (IUCN), bem como o esclarecimento e institucionalização do sistema legislativo existente são necessários à protecção e conservação da AMP de Dibba. A aplicação de um plano de gestão permitirá responder aos principais problemas encontrados na AMP de Dibba, tal como a falta de dados sobre os recursos naturais, a ausência de uma adequada delimitação, a falta de patrulhamento e vigilância, a vaga legislação e mandatos institucionais, a fraca consciência ambiental, e ausência de um acompanhamento científico regular.

Palavras-chave: Emiratos Árabes Unidos, Fujairah, Áreas Marinhas Protegidas, Recifes de corais, Gestão, Biodiversidade, Turismo, Conservação.

1. Introduction

1.1 United Arab Emirates with reference to Fujairah Emirate

The United Arab Emirates (UAE), a federation of seven separates emirates, occupies 83,600 km^2 between the Qatar peninsula, in the Persian/Arabian Gulf (hereafter “Arabian Gulf”), and the Gulf of Oman. From the total area 77,700 km² is mainland and the remaining 5,900 km² is shared amongst over 200 islands. With the exception of the Omani territory in the north-eastern Ru’us al-Jibal (known as Musandam peninsula) and north-central Oman Mountains, the UAE has a total coastline of 1,318 km in length, extending 650 km along the southern shore of the Arabian Gulf and for 90 km in the east along the Gulf of Oman (Figure 1) (Rezai et al. 2004; Brook and Dawoud 2005).

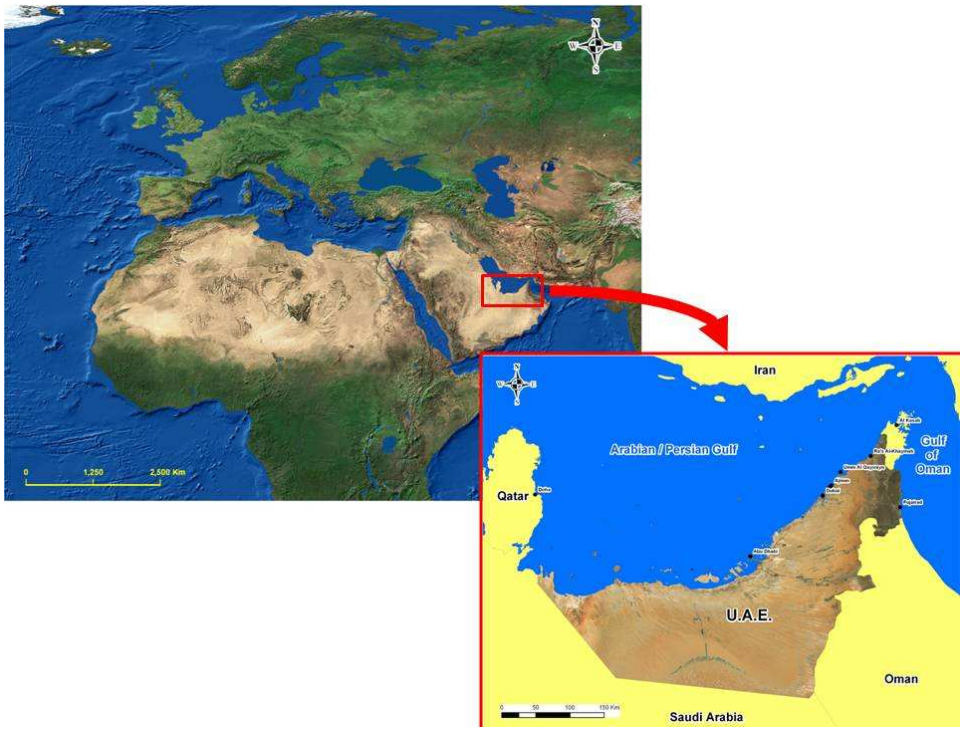


Figure 1 Map of UAE.

According to the last population census by the Ministry of Economy and Planning in 2005, the population of the UAE was estimated to be 4,104,695. From the total population of UAE, around 65% live within 5 km or less of the coastlines of the Arabian Gulf or the Gulf of Oman (Brook and Dawoud 2005; Al-Abed et al. 2008).

UAE comprises the seven emirates of Abu Dhabi (the capital city), Dubai, Sharjah, Ras al-Khaimah, Ajman, Fujairah and Umm al-Qaiwain. Except of some areas belonging to Sharjah, the Fujairah emirate, in which the present work has been conducted, is the only emirate situated on the Gulf of Oman, with the six remaining emirates facing the Arabian

Gulf. Due to its strategic position on the trade routes of the Indian Ocean, just outside the Straits of Hormuz which is the gateway to the Arabian Gulf, the economy of the Fujairah emirate has been based mostly on marine trade, and during the last decades has became one of the world's top oil bunkering port. The Fujairah port is nowadays the third bunkering port in the world after Rotterdam and Singapore, supplying in average more than 1,800,000 million tons of fuel oil per month, having just in 2008 discharged and loaded a total of 24,045,326 tons of oil (Al-Abed and Hellyer 2001; Romano 2004; Government of Fujairah 2008).

While contributing to the cultural heritage of the UAE, the marine environment supports moderate to large local commercial and artisanal fisheries of substantial economic value to the people. Between 2002 and 2006, fish landings along the coast of Abu Dhabi, Ras al Khaimah and Fujairah emirates totaled between 6,658 and 18,764 tons. The Fujairah emirate has the higher values of fish landing for this period, corresponding to values between 21,094,614 and 27,007,720 Euro (Table 1).

Table 1 Fish landing and estimated values in Euro for Abu Dhabi, Ras al Khaimah and Fujairah (Hartmann et al. 2005; Government of Fujairah 2007).

	2002	***2003***	***2004***	***2005***	***2006***
Abu Dhabi					
tons	-	9,042	6,658	-	-
value (Euro)		13,718,319	9,065,167		
Ras al Khaimah					
tons	9,922	10,299	-	-	-
value (Euro)	14,283,199	14,825,537			
Fujairah					
tons	-	14,654	16,567	18,764	17,666
value (Euro)		21,094,614	23,848,163	27,007,720	25,427,328

Besides these major sources of income, the unique surroundings, the Hajar Mountains, and the extended coast line of Fujairah have become popular tourist attractions, and during the last five years a total of eleven resorts and hotels have flourished along the coastline (Government of Fujairah 2008). All along UAE, the rapid and significant urbanization along the coastlines has increased the pressure on the marine and coastal areas, along with other sources such as pollution (from local population, industrial and agricultural sources), coastal erosion, over-exploration of fisheries resources, dredging, and oil spills and pollution due to shipping (Brook and Dawoud 2005).

1.2 Oceanographic and Atmospheric features

The Arabian Gulf is a sedimentary basin, measuring about 1,000 km by 200-300 km. It has an average depth of 35 meters, dipping down towards the north to a maximum of

about 60 meters near Iran, and inclined downwards to about 100 meters deep at its entrance in the Strait of Hormuz (Sheppard et al. 1992; Carpenter et al. 1997; McClanahan et al. 2000; Pilcher et al. 2000). Due to the low depth of the Arabian Gulf the waters of the area lie in the photic zone and sedimentation is mostly a result of foraminiferans and other microfauna. This largely biogenic nature results in a high carbonate concentration and thus the area is predominated by carbonate sand (Carpenter et al. 1997). Coastal waters of the Gulf of Oman stretch from the Strait of Hormuz in the northwest to the eastern tip of the Arabian Peninsula (Ras Al-Hadd) on the Oman side, and to Gwatar near the Pakistani border on the Iranian side (Siddeek 1999). In contrast with the Arabian Gulf, the Gulf of Oman and Arabian Sea are deep seas (more than 2,000 meters deep) with more stable and moderate physical conditions (Figure 2) (Wilson et al. 2002).

Figure 2 Arabian Gulf and Gulf of Oman region (Google Earth 05/08/2009).

The Arabian Peninsula is among the hottest areas in the world, where temperatures above 49℃ have frequently been recorded at some weather stations in the region (SOMER 2003). The extremely arid nature of the Arabian region, the high temperatures and the constant and intensive sunshine, especially along the coastal areas, gives in some areas the usual lack of four seasonal variability. The region lies at the edge of two global weather systems, the Asian and the North Africa weather systems, whose fluctuations cause varied and severe environmental conditions, the summers are hotter and the winters colder than most subtropical zones (Sheppard et al. 1992; Carpenter et al. 1997; McClanahan et al. 2000).

The two different coasts of UAE (Arabian Gulf and Gulf of Oman) are differently characterized. The west coast in the Arabian Gulf is characterized by narrow raised beaches of calcareous sand, with saline flats extending up to 30 km inland. On the other side, the east coast in the Gulf of Oman, where Rul Dibba – Al Faqeet Marine Protected Area (hereafter "Dibba MPA") is located, consists of a narrow gravel plain between the sea and the Hajar Mountains that in some places extend rocky spurs all the way to the sea (Jongbloed et al. 2003).

The majority of rainfall events occur during winter months (October-April) from cloud bands that migrate from the eastern coast of Africa, or from the frontal systems that originate in the Mediterranean when the Siberian high pressure shrinks north-eastwards by late winter, or may be due to the southward advance of active westerly troughs over the south western part of the Arabian Peninsula. Rainfall can also occur during summer months with clouds drifting from the Indian monsoon over the Arabian Sea, afternoon convective clouds due to orographic effects, rare cases of the Inter Tropical Convergence Zone shifting northward over UAE and causing overcast weather and thunderstorm activity. Interestingly, data for the four closest weather stations surrounding Dibba MPA shows that the rainfall in the area might be closely linked with the Pacific Decadal Oscillation, or ENSO El Nino and La Nina events. Overall, precipitation events remain highly variable in the UAE and constantly low (less than 200 mm/year) but they are characterized by the sudden deposition of several centimetres of rain which coupled with the lack of any significant topsoil or vegetation, causes dramatic flash flooding. Flash floods cause in return enormous quantities of terrestrial run-off that can have a locally significant effect on parts of the shallow marine environment (Sheppard et al. 1992).

Tides in the Gulf of Oman and the Arabian Sea are oceanic in type where frictional effects are minimal. Tide heights can range from 1.5 meters, in the Arabian Sea, to 2.5 meters in the Gulf of Oman, being predominantly semi diurnal and correlating closely with that of the Indian Ocean. But generally, tidal height is not very marked anywhere in the region, and ranges of 0.25 to 0.75 meters are most common although it can rises near land, especially in the far north and just outside the Strait of Hormuz (Sheppard et al. 1992).

In the Gulf of Oman water temperatures are moderate when in comparison to the Arabian Gulf. Typical winter surface water temperatures fall to 22-23°C (minimum recorded of 12°C), while summer temperature is characterized by a highly fluctuating regime caused by the rise and fall of a shallow, but strong thermocline. Summer water temperatures range between 23-31°C (maximum recorded of 35°C), and can often cover this range within one day (Figure 3) (Rezai et al. 2004). In the Arabian Sea the seasonally reversing winds induced by the monsoon create a strong upwelling which causes the

remarkable, low sea temperatures off southeast Arabia Peninsula in the hottest summer months (Sheppard et al. 1992; Carpenter et al. 1997). In the Gulf of Oman the cool water influences is less constant, although occasional upwelling occur and can replace surface waters very rapidly such that falls of up to 10°C over one or two days. Such upwelling has a significant impact on the marine ecology, and hereby areas of reef development are few (Randall 1995; Spalding et al. 2001).

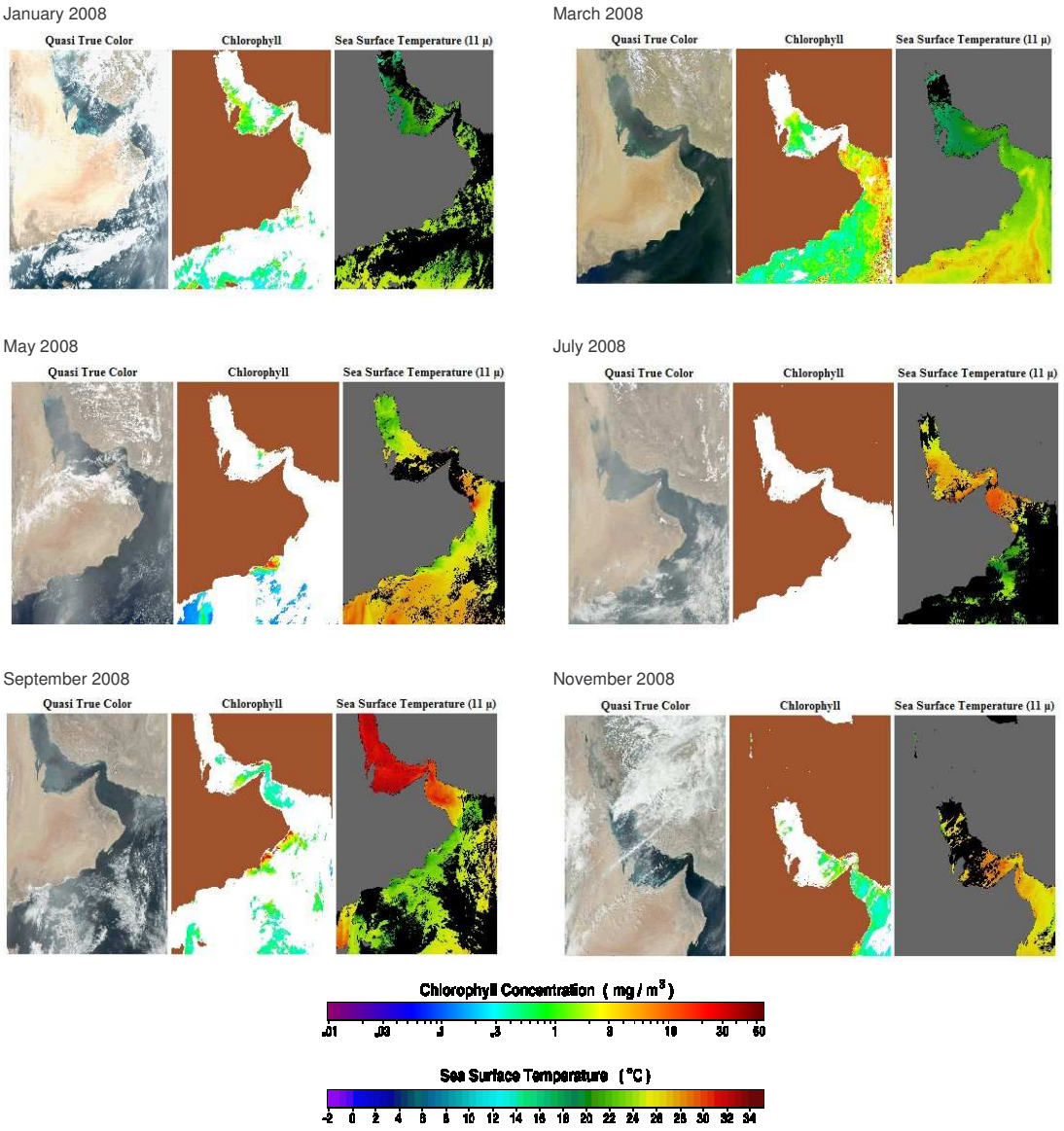


Figure 3 Satellite images of differences in Chlorophyll Concentrations (mg/m^3) and Sea Surface Temperatures (°C) for the Arabian Region during 2008 by Moderate Resolution Imaging Spectroradiometer MODIS (Aqua) < http://oceancolor.gsfc.nasa.gov/ (04/05/2009).

Salinity in the Gulf of Oman is generally at 36.5, but it has been recorded as 38.9 in the surface waters from the Strait of Hormuz in the Musandam peninsula to Ra's Al-Hadd at

the entrance to the Gulf of Oman, from the influence of the Arabian Gulf (Rezai et al. 2004). Evaporation by dry winds is as intense in winter as in the hot summer. Over the whole Arabian Gulf, evaporation averages 144 to 500 $cm.yr^{-1}$, most occurring in the shallow embayments in the south where evaporation locally exceeds 2000 $cm.yr^{-1}$. In these shallow bays salinity exceeds 50 over hundreds of square km, exceeding even 70 in large expanses (McClanahan 2000). These large evaporation rates over the Arabian Gulf lead to the formation of a warm and salty water mass which flows into the Gulf of Oman through the Strait of Hormuz; the mass and salt budget in the Gulf are closed by an inflow of Indian Ocean Surface Water coming from the northern Gulf of Oman (Figure 4) (Pous et al. 2004).

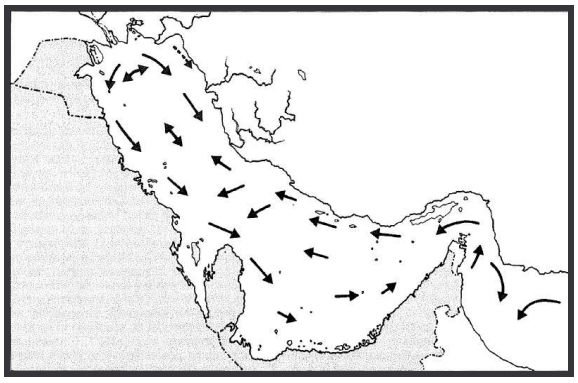


Figure 4 Major current patterns of the Arabian Gulf and northern Arabian Sea (Reynolds 1993).

From principal water sources in the Antarctic region, a northerly stream flows northward into the Arabian Sea. Part of it is deflected backwards, but some is injected well into the Arabian Sea. This stream is a major source of nutrients and hence productivity in the Indian Ocean, being the only significant source of nutrients in the western Arabia Sea. The Indian Ocean generally is one of the most nutrient poor regions of water in the world (average planktonic productivity is less than 54 $gcm^{-2}yr^{-1}$ and not the usual 140 $gcm^{-2}yr^{-1}$) so that this injection is particularly important (Figure 3) (Sheppard et al. 1992).

1.3 UAE coastal ecosystems

The Arabian region comprises a large marine environment which is shallow and, because of the arid climate regime it is exposed to, it undergoes wide fluctuations in different parameters. Strong variations in temperature and salinity influences water density, currents, water mixing, and a host of other environmental parameters that therefore influence species composition. Species that establish populations in the area must be capable of withstanding the stress of osmotic and temperature extremes. Many major shallow water taxonomic groups and species that are prevalent at similar latitudes

elsewhere in the Indo-Pacific, and found in adjacent seas, are completely lacking in the area (Carpenter et al. 1997).

The two different coasts of UAE, featuring numerous islands and lagoons, provide an ideal environment for an abundant growth of living marine resources (Ahmad and Al-Janahi 1999). Plants, birds, reptiles, marine mammals, fishes, echinoderms, polychaetes and corals have been summarised for the Arabian region and UAE in particular (Hellyer and Aspinall 2005). With regard to other taxa, data on diversity and endemic species for the region are either not available or have not yet been summarised (Wehe and Fiege 2002).

1.3.1 *Marine Habitats of the UAE East Coast*

1.3.1.1 Coral Reefs

Although thought not to be present in extreme conditions beyond 23.5° north and south of the equator, the coral reefs found in the Arabian region are a unique example of adaptation by marine organisms (SOMER 2003). The range of environment, latitude and geological formation combine to produce very varied coral habitats within this region. This results in several different coral communities which are distributed according to geographic location and depth (Sheppard et al. 1992).

Some corals have the ability to acclimatise, by phenotypic changes, to more stressful environmental conditions, resulting in the readjustment of the organism's tolerance levels. They have evolved temperature thresholds close to the average upper temperatures of their area, so thermal tolerance varies from region to region. Similar corals in each location live under quite different temperature regimes and thus have different thermal tolerances (Grimsditch and Salm 2006; Marshall and Schuttenberg 2006). The different marine climates, temperature, salinity and turbidity extremes encounter in the Arabian region are reflected in the pattern of coral diversity and reef building. Corals and reef communities in some areas (such as the Arabian Gulf and Gulf of Oman) tolerate salinity and temperature conditions that are lethal when imposed rapidly on the same species in less extreme environments (Baker et al. 2004; Buddemeier et al. 2004; Riegl et al. 2006). In the report of Rezai et al. (2004) coral communities of the Gulf of Oman and Arabian Sea were classified as in good condition, due in part to the mitigating effects of the summer upwelling that cools summer seawater temperatures, possibly protecting the corals from bleaching.

There is a fairly distinct Arabian coral species grouping, and within it, there is a single, principal division into a Red Sea group and a Gulf of Oman/Arabian Sea group, which then fuses with the Arabian Gulf (Sheppard et al. 1992). Although the species composition of Arabian Gulf corals is typically Indo-Pacific, and a few regional endemics, the coral

diversity in the Arabian Gulf and parts of the Gulf of Oman is relatively low compared to most parts of the Indian Ocean where it is up to four times higher (Riegl 1999; Rezai et al. 2004). Of the 656 species among 109 genera of zooxanthellate corals for the Indo-Pacific, only about 10%, or 68 species among 28 genera, occur in the Arabian Gulf and 120 species among 33 genera in the Gulf of Oman (Rezai et al. 2004). Some combination of factors has probably limited the recruitment, settlement, survival and growth of reef corals in the region, eliminating many species and perhaps favoring a few that are adapted to the uniquely harsh condition of the region. Potential limiting factors include extreme temperatures above and/or below usual coral tolerance limits; high salinities; macroalgal competition, oil production and pollution (Coles 2003).

According to the different coast line of the east coast of UAE and Oman, where upwelling effects are attenuated by bays, reef growth continues with typically reef flat and reef slope development. Even where reefs do not develop, prolific coral communities grow on many different types of non-limestone rock. Some coral growths develop into vast monospecific beds to a degree seen only in a few other cases in Arabia seas. Numerous areas of exposed, hard substrate are not dominated or even colonized by hard corals, instead, soft corals and macroalgae generally dominate (McClanahan et al. 2000).

There are three types of reef in the UAE: true coral reefs (fringing reefs around off-shore islands and patches formed in waters deeper than 10 meters); stringer reefs (elongated structures, forming an interconnected maze on banks); and patch reefs (common throughout).

Coral reefs occur in the emirates of Abu Dhabi, Fujairah and Dubai, and probably also in Sharjah, Umm al Qaiwain and Ras al Khaimah, but only Abu Dhabi and Dubai have mapped their coral reefs (Al-Cibahy et al. 2008a; Wilkinson 2008). Throughout Gulf of Oman, *Porites* is the dominant builder of framework reefs. Colonies fuse in shallows to form reef-flats up to tens of meters wide that may be settled by other coral species. On rocky leeward shores, or protected islands, fringing frameworks of fused colonies of *P. lutea* extend from the low water mark to 3 meters depth. Generally, this leads to a zone of mixed corals dominated by abundant *Acropora* with an understory of massive Faviids and smaller *Porites* colonies. In some places, however, large extensive undulating monospecific stands of *Pocillopora damicornis* form reef frameworks 2 to 3 meters thick. Gulf of Oman also supports high diversity of *Goniopora*, Faviid and Mussid coral communities identical in appearance to the deeper communities of the Red Sea (Sheppard et al. 1992; McClanahan et al. 2000; Wilkinson 2008).

At the entrance to the Arabian Gulf, Musandam Peninsula contains reef dominated by *Porites*, and *Acropora.* Rich coral communities such as *P. lutae*, *P. solida*, *Acropora valenciennesi* and *A. valida* are common from Musandam to the capital area of Oman

(Sheppard et al. 1992; McClanahan et al. 2000). In the east coast of UAE the major octocoral communities are dominated by *Sarcophyton*, *Sinularia*, *Dendronephthya*, gorgonians and seawhips (Wilkinson 2008).

Even though the Arabian Gulf's corals are unique and seem to endure extremely harsh conditions when compared to corals in other parts of the world, scientists are increasingly concerned that any additional stress, imposed by global climate change or regional coastal development may accelerate coral die-off (Wilkinson 2004; EWS-WWF 2008). Reefs in the Arabian Gulf have been devastated by major coral bleaching events (in 1990, 1996, 1998 and 2002) and recently by extensive coastal developments along the Arabian Peninsula (Figure 5) (Burt et al. 2008; Wilkinson 2008). The impact extends beyond the shoreline since turbidity and suspended sediments are dispersed from the dredge or reclamation sites. In addition, coastal currents are diverted by coastal engineering, altering the movement of sediments which accumulates (Rezai et al. 2004).

Figure 5 Dead coral (left side) and healthy coral (right side) from Dibba MPA.

Reef building potential remains low also due to high rates of bioerosion fuelled by primary production from the Arabian upwelling system. Some of the principal agents of bioerosion include boring algae and sponges, *Lithophaga*, and the echinoid *Diadema* sp. and *Echinometra mathaei*, both found in Dibba MPA. In the Gulf of Oman and the Arabian Sea, the standing stock of urchins is probably higher than in other reef areas because of the high primary production rates of algal turf. The high incidence of bioerosion weakens corals and makes them more susceptible to physical damage from storms or anchor strikes (Rezai et al. 2004). Coral reefs have also been severely degraded in certain areas of the Arabian region by abandoned fishing nets, especially gillnets, anchors from fishing boats and recreational diving (SOMER 2003).

The coral reef losses from climate related devastation and massive coastal development on the Arabian Peninsula have made this region amongst the most damaged in the world with the lowest predictions for recovery. According to recent estimates, 30 % of the coral reefs are at a threatened-critical stage and up to 65 % of the coral reefs may

have been lost already due to natural causes (fluctuation of temperatures, diseases), and anthropogenic stresses (oil pollution, unmanaged coastal development, unregulated commercial and recreational fishing and diving) (Wilkinson 2004). Unfortunately coral reef research and monitoring continues behind other parts of the world (Wilkinson 2008).

1.3.2 *Marine Species of the UAE East Coast*

The UAE is often regarded as a vast arid land with little or no value from a biodiversity point of view. However, UAE habitats host unique species that show remarkable adjustments to survive harsh environmental conditions with physiological, behavioural and morphological strategies. So far, more than 646 species of marine invertebrates, 724 species of plants (incl. 36 marine algae and seagrasses), 435 species of birds, 540 species of fish (including 3 freshwater species), 67 species of reptiles (incl. 14 marine species) and 64 species of mammals (incl. 17 marine species) have been identified in the country. The apparent lack of bio endemism shall be revised in the near future with numerous species of marine invertebrates found in UAE still unidentified and the recent discovery of ten species of coral new for science in neighbouring Omani waters (Hellyer and Aspinall 2005; Claereboudt 2006; Tourenq and Launay 2008; van Harten 2009).

1.3.2.1 Mammals

The UAE hosts at least 17 different species of whales and dolphins, including the Blue whale (*Balaenoptera musculus*). The deep underwater canyons and cliffs on the edge of the continental shelf off UAE east coast is where most species can be found, but the contrast of the warm, sandy shallows of the Arabian Gulf are favoured by some species adapted for shallow water life, such as the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the rare finless porpoise (*Neophocaena phocaenoides*). Some species are at home in both environments as for example the Bottlenose dolphin (*Tursiops truncatus*) and the Indian Ocean Bottlenose Dolphin (*T. aduncus*) (EAD-AGEDI 2006). The Western Arabian Gulf waters (*i.e.* Qatar and Abu Dhabi emirate) support the second largest known population of Dugong (*Dugong dugong*) in the world (EAD-AGEDI 2006).

1.3.2.2 Seabirds

Due to the strategic location of the UAE in the Center of the Afro-Eurasian flyway, the country receives a significantly large number of Palearctic ecozone birds migrants from their breeding grounds across Europe. Different species winter, or stopover, in the UAE during annual spring and autumn migration (Aspinall 1996; EAD-AGEDI 2006).

Over 400 species of birds have been recorded in the UAE, of which about 100 are breeding (Aspinall 1996). Of the 15 important breeding birds recorded in the UAE, the Socotra Cormorant (*Phalacrocorax nigrogularis*) is considered threatened worldwide and

is listed as "*Vulnerable"* (VU) in the list of globally threatened species (BirdLife International 2000). From the coastal breeding birds known, the Socotra Cormorant, together with five species of Terns (*Sterna* spp.), Sooty Gull (*Larus hemprichii*), Crab Plover (*Dromas ardeola*), Red-billed Tropicbird (*Phaethon aethereus*), Osprey (*Pandion haliaetus*) and Sooty Falcon (*Falco concolor*) are classified as "*important"* and "*regional priority species"* (Evans 1994; Aspinall 1996; Javed and Khan 2003). Of the 19 Important Bird Areas identified in the UAE, 68% are on coastal areas of which 42% of them are on islands (Evans 1994; BirdLife International 2000). Nearly 60% of all the important breeding coastal and marine bird species are also listed in Appendix II of the Convention on the Conservation of the Migratory Species (CMS) and are regarded as important species in the newly proposed Action Plan for the Central Asian Flyway (EAD-AGEDI 2006).

Breeding and wintering coastal and marine birds are protected under Federal Law No. 24, of the year 1999, and Federal Law no. 9, of the year 1983. These two laws prohibit killing, catching or the collection of eggs; however, occasional cases of violations are reported. Although current regulations may provide an adequate framework for conservation of breeding seabirds in the UAE, there is a need for rigorous enforcement and an education programme directed both at the general public and administrators level (EAD-AGEDI 2006).

1.3.2.3 Reptiles

Of the seven species of marine turtles, two species, the Hawksbill turtle (*Eretmochelys imbricata*) and the Green turtle (*Chelonia mydas*), are predominantly occurring in the Arabian Gulf and Gulf of Oman waters. Worldwide, the IUCN Red List (2009) lists the hawksbill turtle as "C*ritically Endangered*" and the green turtle as "*Endangered*". At a local and regional level the stocks of these two species are threatened and the number of foraging habitats and nesting grounds are continually declining. The two species use intensively the Western Gulf region for foraging and nesting. For foraging, the Hawksbill Turtle seems more dependent on coral reef than the Green Turtle that can be found on both seagrass meadows and coral reefs. However, the protection of coral reefs and islands of this region will benefit tremendously to both species. Green Turtles and Hawksbill Turtles are regularly seen feeding on the east coast such as Dibba MPA and in Khor Kalba mangroves. However, nesting has not been recently observed on this coast (EAD-AGEDI 2006).

So far 10 species of sea snakes have been recorded in UAE waters, the three most common being: Arabian Gulf Sea Snake (*Hydrophis lapemoides*), Yellow-bellied Sea Snake (*Pelamis platurus*) and Short Sea Snake (*Lapemis curtus*) (Soorae et al. 2006).

1.3.2.4 Fish

Fishes constitutes a dominant component of the reef fauna and is as varied as the reefs themselves. Reef development clearly has a strong influence on fish diversity, since many studies have shown that species richness increases with factors such as area of habitat and the differentiation of this into zones. Although reefs of the Arabian region support diverse assemblages, they have fewer species than those in much of the Indian Ocean, probably an effect of a scarcity of reef habitat and the rather prevailing extreme environmental conditions. Concurrently they support proportionally higher densities of fishes and are the basis for important artisanal fisheries and recreational activities. Unfortunately reef fishes are coming under increased pressure due to uncontrolled overfishing in many parts of the region (Sheppard et al. 1992; Carpenter et al. 1997).

Overall, the Arabian region harbours about 540 fish species, with about 280-300 species in about 80 families associated more or less closely to the coral reefs, which shows the overriding importance of these habitats for the maintenance of fish biodiversity in the region. Among these fish several are endemic species that only occur only in the Arabian Gulf and several regional endemics that occur in the Arabian Gulf and the Gulf of Oman. Among these are the Persian Dottyback (*Pseudochromis persicus*), the Dark Butterflyfish (*Chaetodon nigropunctatus*) and the Arabian Butterflyfish (*Chaetodon melapterus*). Several commercially important fish are primarily linked to the coral reef habitat, such as the grouper species (Serranidae) locally known as “Hamoor”. The Orange-spotted Grouper (*Epinephelus coioides*) is a very common reef species in the Arabian Gulf, where it is the most important commercially exploited species (Grandcourt et al. 2004).

A recent update on the status of Elasmobranches suggests that there are at least 46 different species of sharks, guitarfish and rays present in the waters of the Arabian Gulf and east coast of UAE (Tourenq et al. 2008).

1.3.2.5 Invertebrates

The coral habitat provides important three dimensional shelters for numerous phyla of invertebrates (*e.g.* Porifera, Cnidaria, Annelida, Crustacea, Mollusca, Bryozoa and Echinodermata). Hellyer and Aspinall (2005) record 646 species of marine invertebrates in UAE waters, a number to revise in the future since some species of marine invertebrates found in UAE are still under the process of identification. Due to the harsh environmental conditions that exist in the shallow waters of the southern Arabian Gulf, the invertebrate fauna tends to be less diverse than that present in the Gulf of Oman and in the Indian Ocean as a whole (EAD-AGEDI 2006). On the UAE east coast, the most obvious marine invertebrates are crabs that can be spotted on the shores, mostly Graspid crabs

(Grapsidae), including the Sesarmine crabs, and Ocypodid crabs (Ocypodidae) with the large Ghost Crab (*Ocypode rotunda*) relatively abundant on sandy beaches. The blue Swimming Crab (*Portunus pellagicus*) is the species most available on the fish markets of the region (Hellyer and Aspinall 2005).

The Mollusca fauna of the UAE is rich and varied and typically Indo-Pacific in character (Al-Cibahy et al. 2008b). The sand habitat is populated by rich and diverse assemblages of different bivalves, such as carditids, cultellids (in particular *Siliqua polita*) and tellinids; being mactrids common in intertidal sands. In muds, which are frequently hypoxic or dysoxic, specialized communities of lucinid bivalves are found. In the region echinoids, asteroids, ophiuroids and holothuroids are common, although limited in species richness. The most common echinoids are *Echinometra mathai* and *Diadema setosum*, which occur mainly in areas with coral growth but also in oyster beds (Al-Cibahy et al. 2008b).

1.3.3 *A region of priority for conservation*

The Arabian Sea is one of the 43 marine priority ecoregions for conservation according to the Global 200 WWF classification. In 2001 WWF has assessed the 1,507 ecoregions and identified the most biologically distinct terrestrial, freshwater, and marine ecoregions of the planet, known as Global 200. This network of ecoregions includes 142 terrestrial, 53 freshwater and 43 marine priority ecoregions for conservation in the world. The Global 200 were selected for their species richness, endemism, higher taxonomic uniqueness, unique ecological or evolutionary phenomena, global rarity of habitats, intactness, and representation. Their conservation status of ecoregions was assessed in the tradition of IUCN Red List categories for threatened and endangered species. With all the threats mentioned above, the Arabian Sea (including Arabian Gulf) ecoregion has been classified as "*Critically Endangered*" and therefore should be the focus of priority conservation actions (Olson and Dinerstein 1998; Olson and Dinerstein 2002).

1.4 Human population and current resources use

1.4.1 *Fisheries*

As coastal populations soar around the world, coastal marine fisheries are under ever-increasing threat of collapse, and marine resources become unsustainable in many places (Hutchings 2000; Pauly et al. 2002). In the east coast of UAE, coastal population is increasing rapidly as well as the demand of marine resources. To support this augment, the number of fishing boats and the number of fishermen in the Fujairah Emirate has been increasing in the last three years (Table 2) (Government of Fujairah 2008).

Around the Gulf of Oman, the continental shelf is narrow, and fisheries concentrate on pelagic species. In deeper waters of the Arabian Sea, and the Gulf of Oman, large trawlers and tuna longliners operate (Everett 1999).

Table 2 No. of fishing boats and fishermen in the Emirate of Fujairah, 2006-2008 (Government of Fujairah 2008).

Year	*Fishing boats*	*Fishermen*
2006	693	1004
2007	818	1060
2008	858	1401

Together with the increase in the number of fishermen, also the total estimate of fish caught in the Fujairah emirate, over the last three years, has increased. Even though the number of boats increased in the same period, the number of fish caught in boats have been relatively constant, the opposite to the catches in coastal nets, that have a higher record in 2008 (Table 3) (Government of Fujairah 2008).

Table 3 Estimate of Fish Caught in Emirate of Fujairah, 2006-2008 (Government of Fujairah 2008).

Year	*Boats*	*Coastal Nets (tons)*	*Total*
2006	872	25551	26423
2007	887	21766	22653
2008	846	29843	30689

Demersal fish species account for approximately 40% of the landings along the east coast of the UAE (Pearson et al. 1998). A review of the demersal fisheries of the Arabian Sea, Gulf of Oman and Arabian Gulf noted the presence of more than 350 commercial fish species in this entire area. Primary families represented were Lethrinidae, Sparidae, Serranidae, Siganidae, Sciaenidae, Stromateidae, Lutjanidae, Trichiuridae and Nemipteridae (Carpenter et al. 1997; Siddeek 1999; EAD-AGEDI 2006). Regarding the fish fauna of the UAE Arabian Gulf coastline little is known and the few publications which exist suggest that the number of species present is also low in number (EAD-AGEDI 2006).

Between 2002 and 2003, the Marine Environment Research Centre, part of Environment Agency of Abu Dhabi (EAD) conducted a Fish Resources Assessment Survey in UAE waters, where a total of 239 commercial fish species were recorded within the area during trawl surveys, representing a total biomass of up to 45.850 tons (Table 4) (Shallard 2003; EAD-AGEDI 2006).

The comparison of the fish resource assessment in UAE waters in 2002-2003 (Shallard 2003) with a similar assessment by the Food and Agriculture Organization of the United Nations (FAO) in 1978, showed that the biomass of demersal fish species declined by 81-93% in 24 years in the east coast and Arabian Gulf coasts of UAE (Figure 6). Recent surveys also showed that the Orange-spotted Grouper had been exploited far beyond sustainable yields (up to 7 times more than the sustainable level) during the last five years (Grandcourt et al. 2005).

Table 4 Comparisons of biomass estimates for demersal species for all areas of UAE waters deeper than 10 meters, based on a combination of trawl and fish trapping data (min and max values in tons) (Shallard 2003).

Type	Biomass (Arabian Gulf area) (ton)	Biomass (East Coast) (ton)
Commercial demersal species	10800 – 26300	140 – 610
Non-commercial demersal species	14100 – 15200	450 – 3740
Total commercial plus non-commercial demersal species	24900 – 41500	590 – 4350

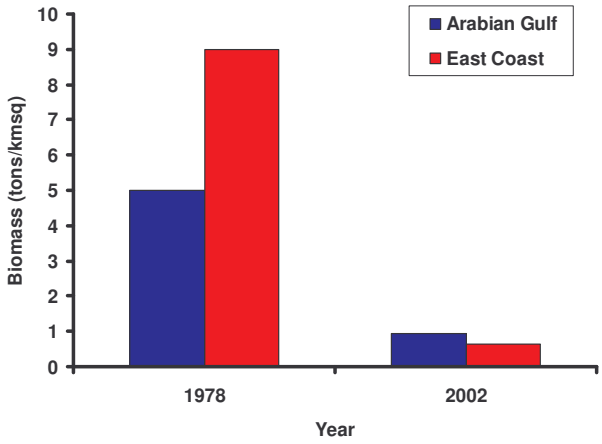


Figure 6 Demersal fish species catches trend in the UAE waters for 1978 and 2002 in tons/km^2 (FAO 1981; Shallard 2003).

To add to this, different species of sharks have been caught in the last years, and an increase in the total tons per year as been noticed, reaching almost the double in 14 years, increasing from 1,600 tons in 1990 to 3,060 tons in 2003 (Lack and Sant 2006).

Fishing in the UAE is carried out mainly by artisanal boats. The fishing vessel more used in the east coast are the traditional dhows and the *tarads,* an open dory usually of fiber-glass construction and powered by outboard motors, fishing trips can be conducted during the day time and at night, depending on the gear type being used and target

species. Due to the small size of the vessels, trip durations do not usually exceed 24 hours (Carpenter et al. 1997; EAD-AGEDI 2006).

The fishing gear utilised in the UAE is more or less the same as the one used decades ago, only the designs and type of materials used to manufacture them have often changed (Table 5) (Carpenter et al. 1997; EAD-AGEDI 2006).

Table 5 Most common traditional fishing gears used in the UAE.

Fishing gear	Description
Gargoor	Baited basket traps, often dome-shaped with a cone-like entrance, the whole trap being made from interwoven palm fronds in ancient times, and now a day's steel wired is often used (Figure 7).
Hadrah	Semi-permanent intertidal barrier traps, used especially during the summer months to catch mainly the blackspot snapper (*Lutjanus fulviflamma*), needlefish (Belonidae), jacks (Carangidae), seabream (Sparidae), mullets (Mugilidae), barracuda (Sphyraenidae) and rabbitfish (Siganidae).
Liekh	Gillnets often set on the bottom, used to catch a variety of fish including grunts (Haemulidae), seabream (Sparidae), emperors (Lethrinidae), goatfish (Mullidae), rabbitfish (Siganidae), pomfrets (Stromateidae) and others.
Hayal	Special drifting gill nets which are normally used during the winter to capture in particular the narrow-barred Spanish mackerel (*Scomberomorus commerson*), which is abundant at that time.
Yaroof and Alyakh	Beach seines that can be up to 40 meters or more in length. One end of the seine is moved rapidly from the shore in a wide arc in an effort to surround fishes; both ends of the seine are then pulled to shore by men. This technique is used only at night, normally during the day nets bigger than 500 meters are used in what is locally known as "*alyakh*" (Figure 8).
Salieya	A bell-shaped fine net thrown onto the surface of the water which has small weights around its base to make the net sink and surround the fish. Only used at particular times of year when fish like the Indian oil sardinella (*Sardinella longiceps*) and flathead mullets (*Mugil cephalus*) may be abundant in shallow inshore waters.
Hadaq	Hook and line method particularly used for the capture of groupers (Serranidae), cobias (Rachycentridae), jacks/trevallies (Carangidae), grunts (Haemulidae), emperors (Lethrinidae), seabream (Sparidae), and Spanish mackerel (*Scomberomorus commerson*).
Manshalla	Longlines, which may have 10-20 smaller lines and hooks. These are reputed to be good for catching requiem sharks (Carcharhinidae) and groupers (*Epinephelus* spp.).

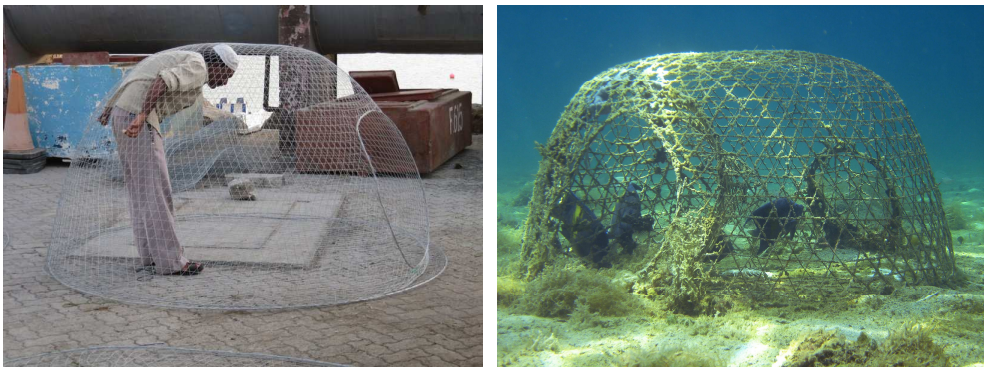


Figure 7 Fishermen in Dibba Port building a *gargoor* (left), and a *gagoor* underwater (right) (last photo by Juma'a Bin Thalet).

The "*alyakh*" technique is especially good at catching mojarra (Gerreidae), flathead mullets (*Mugil cephalus*) and rabbitfish (Siganidae). Many other fishes can also be caught including small needlefish (Belonidae) and jacks (Carangidae) (EAD-AGEDI 2006). In this method, speedboats with outboard motors and even four wheel drive vehicles are used at the present day to pull these seine nets to the shore, but traditionally this was done by a large group of men and it can still be observed in the east coast of UAE, like Dibba (Figure 8).

Figure 8 Fishermen using the "a*lyakh*" technique (photo by Juma'a Bin Thalet).

1.4.2 *Tourism*

Tourism is the fastest growing major industry in the world and ecotourism is growing at 10 to 30 per cent per year and accounts for 20 per cent of worldwide tourism (Wilkinson 2004).

In 2005, a total of 12,310,990 visitors entered UAE according to the Ministry of Interior. Data on tourist figures provided by the Department of Tourism & Commerce Marketing Dubai, Abu Dhabi Tourism Authority and Fujairah Emiri Court Department of Statistics and Planning official publications and websites, show that up to 7,550,325 tourists registered in the hotels, hotel apartments and guest houses of these 3 emirates in 2005. Only in the

Fujairah Emirate in the last three years the average number of bed occupancy by night has double from 717 to 1457. A total of 531,805 nights in 2008 represents a revenue of 97,320,315 Euro (estimation based on residence and hotel room rates at an average of 183 Euro per night) (Tourenq 2007; Government of Fujairah 2008), showing that the tourism represents now a big part of the income of the Fujairah emirate (Table 6).

Table 6 Hotels, Beds and Occupation Average in the Emirate of Fujairah, 2006-2008 (Government of Fujairah 2008).

Year	*No. of Hotels*	*No. of beds*	*No. of occupation average by night (by no. of beds)*
2006	8	1041	717
2007	11	1615	1175
2008	11	2296	1457

Some areas in the Gulf of Oman attract significant numbers of recreational divers, bringing with them the risk of anchor damage, especially in heavily used sites. The diver pressure is being promoted throughout the Arabian region, being important to ensure that protective measures match rising tourist numbers (Rezai et al. 2004).

1.5 Marine Protected Areas

There is a bewildering variety of terms and definitions in use to label marine conservation areas across the world. These include marine reserves, fully marine protected areas, no-take zones, marine or ocean sanctuaries, marine parks, fishery reserve, among others. Many of these have very different levels of protection, and the range of activities allowed or prohibited within their boundaries vary considerably too. They may also vary tremendously at their geographical scale, from 2ha village-level community managed MPAs, to multi-million hectare national parks, like the Great Barrier Reef National Marine Park (WWF 2005; Christie and White 2007; Dunnigan 2008; IUCN-WCPA 2008).

The definition of the terms can vary drastically, depending on national, local or international contexts. But recently, according to Dudley (2008), the most widely accepted definition for an MPA should be the same as the general description used to all protected areas (PA), terrestrial or marine:

> *"A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".*

MPAs are a tool and shouldn't be used as an end for conservation, fisheries, tourism and education. In general, MPAs are essential for various benefits such as (a) conserve biological diversity and associated ecosystems that cannot survive in most intensely managed landscapes and seascapes; (b) promote natural age structures in populations, increasing fish catches locally (by protecting critical spawning and nursery habitats) and in surrounding fishing grounds; (c) provide refuge for species that cannot survive in areas that continue to be fished; (d) provide alternative incomes for local communities and alleviate poverty; (e) protect sensitive habitats from disturbances and damage from fishing gear; (f) eliminate "ghost fishing" by lost or discarded gear; (g) serve as point of reference of undisturbed control reference sites that can be used as baseline for scientific research and also to measure fishery effects in other areas and thereby help to improve fisheries management; and (h) act as focal points for public education and awareness on marine ecosystems and human impacts upon them (IUCN-WCPA 2008).

To achieve these goals and benefits for the community, marine reserves must be successful in maintaining the structure and functioning of the ecosystems they encompass. The true effectiveness of any reserve system should be judged not by what is present now but what will persist there in the future (Game et al. 2008).

In the rush to save fragments of natural land and water from sudden developments, protected areas are often established without careful analysis of the skills and capacity needed to maintain them, resulting in PAs without management or not fully implemented. This sudden need, to implement a PA, many times take place also without considering their representativeness for the conservation of biodiversity: genes, species, and higher taxa, along with the communities, evolutionary patterns, and ecological processes (including migration, recruitment and dispersion patterns) that affect this diversity (Stefansson and Rosenberg 2005; Stefansson and Rosenberg 2006; Christie and White 2007; Dudley 2008). Many receive ineffective enforcement, known usually as 'paper parks', where protection occurs only in theory (Mora et al. 2006). Besides the inadequately management within almost all marine protected areas there is also a lack of MPAs worldwide. To solve this issue, in 2002, at the World Summit for Sustainable Development, the world's leaders agreed to create representative networks of MPAs by 2012 (WWF 2005; Laffoley 2008).

Most of the protected areas worldwide are managed under formal governments' mandates and international institutions such as the Convention on Biological Diversity (CBD), while some protected areas are established by local communities, indigenous people, environment charities, private individuals or companies (IUCN 2004; Dudley 2008).

In general, there are four main protected area governance "types" (Borrini-Feyerabend 2007; Dudley 2008):

1. **Government managed areas**: A government body holds the authority, responsibility and accountability for managing the protected area, determines its conservation objectives, develops and enforces its management plan and often also owns the protected area's land, water and related resources;
2. **Collaboratively managed areas**: Complex institutional mechanisms and processes are employed to share management authority and responsibility among a plurality of entitled governmental and non-governmental doers;
3. **Private protected areas**: Private governance comprises protected areas under individual, cooperative, NGO or corporate control and/or ownership, and managed under not-for-profit or for-profit schemes;
4. **Community based management areas**: Includes indigenous peoples' areas and territories established and run by indigenous peoples, or community conserved areas established and run by local communities.

According to the management objectives of each Protected Area, IUCN classifies them into six different categories, ranging from highly protected reserves, intended only for scientific research or wilderness conservation, to multiple-use areas, created to foster the sustainable use of natural ecosystems and resources (Table 7) (IUCN 1994). This system was established to create a common understanding of protected areas, both within and between countries (Dudley 2008).

Table 7 IUCN protected area management categories (IUCN-WCPA 2008; Laffoley 2008).

IUCN category		Main objective
I a	**Strict Nature Reserve**	Strictly protected areas to protect biodiversity and possibly geological / geomorphological features. Human visitation, use and impacts are strictly controlled and limited to ensure preservation of the conservation values. These areas can serve as indispensable reference areas for scientific research and monitoring. · Managed mainly for science
I b	**Wilderness Area**	Large or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition. · Managed mainly to protect wilderness qualities

II	**National Park**	Large natural or near natural areas set aside to protect large scale ecological processes, along with the complement of species and ecosystems characteristic of the area, to provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities. · Managed mainly for ecosystem protection and recreation
III	**Natural Monument**	Set aside to protect a specific natural monument, which can be a landform, sea mount, submarine caverns, geological feature such as caves or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value. Managed mainly for conservation of specific natural features · Managed mainly for conservation of specific natural features
IV	**Habitat/Species Management Area**	Protect particular species or habitats and management reflects this priority. Regular, active interventions often needed to address the requirements of particular species or to maintain habitats. · Managed mainly for conservation through management interventions
V	**Protected Landscape/ Seascape**	Where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value; and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values. · Managed mainly for landscape/seascape conservation and recreation
VI	**Managed Resource Protected Area**	Large, with much of the area in a natural condition and where a proportion is under sustainable natural resource management. · Managed mainly for exploitation of the area or resources

1.5.1 *Benefits of MPAs*

Marine and coastal ecosystems are highly productive and deliver various goods and services that support communities and economies, including food security, clean water, recreational opportunities and other benefits. Effective area-based protection, through

MPAs, helps maintain ecosystem health and productivity, while safeguarding social and economic development (Agardy and Staub 2006).

Although the existence of various studies regarding MPAs benefits, approximately 2.58 million km^2, just 0.65% of the world's oceans are within Marine Protected Areas (Laffoley 2008).

1.5.1.1 Benefits for Fisheries

Globally, over half of the stocks of fisheries are fully exploited, while more than one quarter are either overexploited, depleted or recovering from depletion (FAO 2007).

By protecting marine populations from fishing, exploited species are allowed to live longer, grow bigger and become more numerous. MPAs especially permit slow-maturing, sedentary and long-lived species to develop natural age structures, thus increasing the number of large fertile animals that can yield more offspring. Since most fish have free-floating larvae or eggs, the offspring of protected animals can drift out of protected areas, re-supplying even far-away fishing grounds. As stocks build up inside, also juvenile and mature fish move out to populate nearby areas open to fishing. This "spillover" can then be harvested by fishermen (Botsford et al. 2001; Hilborn et al. 2004; Kritzer and Sale 2004; Sale et al. 2005; WWF 2005).

In most places where well-managed MPAs exist, fishermen tend to move their activities closer to the boundaries of the protected area. Such fishing in the borders allows fishers to benefit from "spillover". In the case of small MPA, that has already improved fishery species production, fishers have to travel less distance to catch more fishes than before, as they are able to catch in the line of the MPA (WWF 2005).

1.5.1.2 Benefits for conservation

While some MPAs may be set up to protect fish stocks, they also have additional benefits for the wider marine environment. Conserving the diversity of life is an objective of all MPAs, regardless of the specific intent for their creation. Due to worldwide overexploitation and habitat degradation of ocean ecosystems, MPAs have been commonly offered as an important management intervention as a way to protect their habitats (Salm et al. 2000; Wilkinson 2004; WWF 2005; Christie and White 2007).

Biodiversity protection is a primary objective of MPAs and where this includes threatened species, these will need to be made a specific target and focus for management. For a species to benefit fully from protection, it must spend a large proportion of its life inside a protected area. But other species, like pelagic ones, can also benefit from protection, the key is to provide protection principally at vulnerable stages of the life cycle (WWF 2005).

MPAs can conserve entire ecosystems that are unique, particularly rich in species, representative of biogeographic units, or exceptionally productive seafood. Ecosystems that are high in biodiversity, like coral reefs, represent good investments since they yield a high number of options for the conservation effort expended. Although MPAs cover approximately 18.7% of the world's 527,072 km^2 of coral reefs, less than 0.01% of these coral reefs are within no-take MPAs with no poaching and at low risk (Salm et al. 2000; Mora et al. 2006; Laffoley 2008).

1.5.1.3 The economics of MPAs

Studies made by WWF (2005) showed that a global network of MPAs covering 20 to 30 per cent of the seas would cost between 4 and 14 billion euro to run per year. But in the long run, benefits greatly overrule initial costs. Local fishers may start to harvest bigger and more fish closer to home as fish stocks grow and important habitats are restored. Another positive effect is the sustained delivery of marine ecosystem services, worth an estimated by 2005 as 5,000 billion euro each year, also helping coastal communities by generating between 830,000 and 1.1 million full-time jobs in tourism and park monitoring.

Countries with coral reefs attract millions of scuba divers every year, yielding significant economic benefits to the host country. Globally, by the year 2005 it was calculated that almost 7 billion euro was spent on coral reef tourism annually (WWF 2005).

1.5.2 *MPAs of the East Coast of UAE*

Private protected areas in the UAE have been established for a long time by local rulers of the seven emirates mostly for hunting purposes. However, in the early 90's, public protected areas started to show up in the UAE, especially in the marine environment.

Besides the east coast, there are also four MPAs on the Arabian Gulf coast of UAE. In 1995, the Dubai Government declared the Jebel Ali Marine Sanctuary. The Environment Agency of Abu Dhabi Emirate officially designated and declared Marawah Marine Protected Area in 2001, Al Yasat Marine Protected Area in 2005 and Bul Syayeef Marine Protected Area in 2007. Marawah Marine Protected Area was recently declared as a UNESCO Marine Biosphere Reserve on September 2007.

Under the instruction of His Highness Sheikh Hamad Bin Mohammed Al Sharqi, Supreme Council Member and Ruler of Fujairah, the Emirate of Fujairah implemented a number of projects aiming to prevent the collection of coral reefs, rocks, fishes or sea shells by visitors and at the same time to promote tourism to the area. In June 1995, the Emiri Decree No. 1 demarcated for the first time in the UAE, and in the Fujairah Emirate, three marine protectorates (Figure 9) (Fujairah Municipality 2001):

- **Rul Dibba** (approximately 1,100 x 1810 x 760 meters)

- **Dadna** (approximately 350 x 190 x 240 meters)
- **Al Aqa** (approximately 1,535 X 480 x 300 meters)

After the implementation of these 3 MPAs, one more was proposed, but istill waiting for approval:

- **Al Bidiyah** (approximately 1,000 x 580 meters)

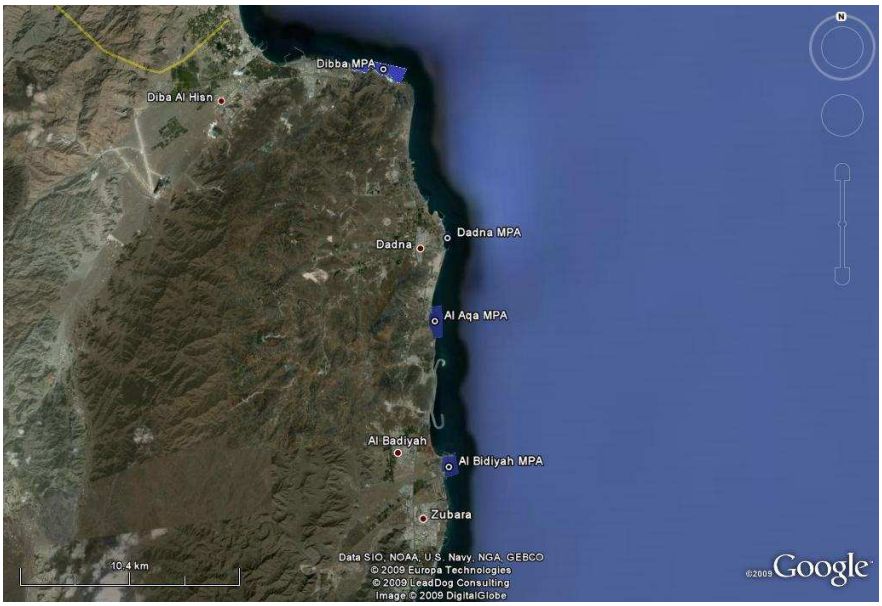


Figure 9 Location of the three MPA in the UAE East Coast (Rul Dibba, Dadna and Al Aqa) and the proposed MPA (Al Bidiyah).

The Emiri decree No.1 of the year 1995 defines the three natural marine protected areas in the Fujairah emirate, building upon the importance of benefiting the general public, and the protection of the rich marine life. According to the Articles within the decree (Fujairah Municipality 2001):

- **Article 2:**
  Throwing anchors by any fishing, leisure or sea transportation in the MPAs is prohibited, with the exception of diving for scientific studies and research. The rule to follow in all fields is to refrain from touching the marine life *i.e.* corals, rocks and marine life.
- **Article 3:**
  Anyone who disobeys the mentioned rules above will be punished accordingly.
- **Article 4:**
  This decree is valid from the date of issue and each municipality official has to take the necessary actions to implement this decree.

In 2005, a local temporary ban from catching six species of fish to preserve local fish stock in Dibba-Fujairah was issued; five of the banned species being Common silver-biddy (*Gerres oyena*), Streaked spinefoot (*Siganus javus*), Flathead mullet (*Mugil cephalus*), Spangled emperor (*Lethrinus nebulosus*) and Spinycheek grouper (*Epinephelus diacanthus*).

Dibba MPA is secured by the Environment Protection and Development Department of Fujairah Municipality (EPDD), with the Dibba branch of Fujairah Municipality and the Dibba Marine Environment Research Centre (DERC) of the Ministry of Environment and Water. The EPDD is responsible for the management and conservation of natural resources in the whole Fujairah Emirate. However, the Dibba branch of Fujairah Municipality is responsible for the implementation of the law at the local level, including the patrolling and guarding of the Dibba MPA.

Dibba Municipality raised signs in Arabic and in English at all MPAs, on shore and offshore, showing clearly the area and warning people that these are marine protectorates and that there is strictly prohibited fishing by any means (Figure 10) (Fujairah Municipality 2001).

Figure 10 Buoy used to delimitate Dibba MPA.

1.5.2.1 Rul Dibba – Al Faqueet Marine Protected Area

The Dibba Marine Protected Area is located south of the border of UAE with Mussandam Peninsula, a spur of mountainous limestone cliffs of 90 km belonging to Oman (Figure 9 and Figure 11).

Little is known about the marine environment of Dibba MPA, and since the implementation of the Emiri Decree No.1 of 1995, limited scientific study was conducted in the area. Information gathered to classify Dibba MPA relies only upon the general description existent for the area and adjacent areas (Table 8).

In Dibba MPA, several short-term research projects were carried out in the last years, supervised by different departments and organizations. In 2003, the Ministry of Environment and Water established the Dibba Marine Environment Research Centre to

develop the MPA and to educate the community in Fujairah coast. In the last years the research centre has been conducting different research studies as the implementation of artificial reefs close to Dibba MPA.

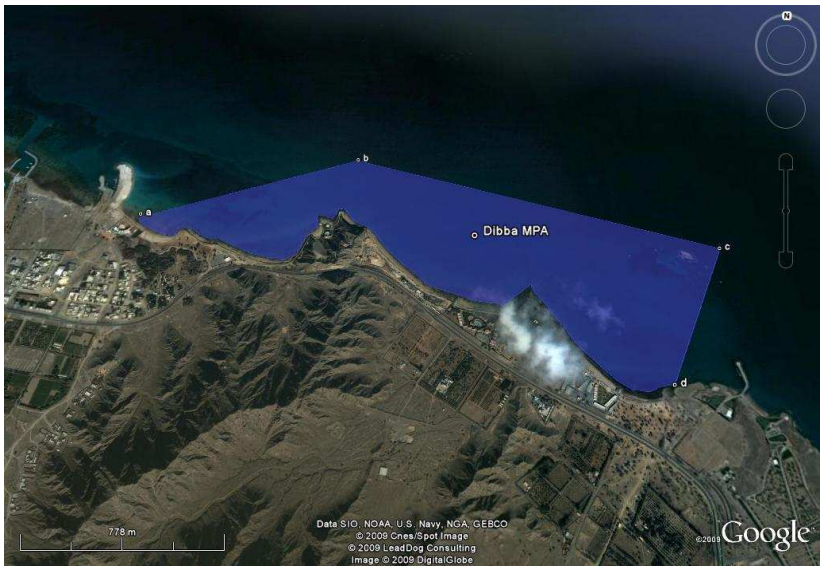


Figure 11 Map of the Dibba MPA

Table 8 Summary of Dibba MPA features

Feature	Description
Region	Arabian Peninsula / Gulf of Oman
Country	UAE
Municipality / City	Fujairah / Dibba
MAP size (sq km)	2.2
Governance type	Government-managed area
Year legally established as MAP	1995
Assign patrolling	Yes
Habitat / ecosystem (s) within the MPA	Not known
Type of coral reef	Not known
Assisting organization(s) on-site	Dibba Environment Research Centre
Year field management began	Never
Boundary coordinates (Lat/Long)	N 25º36. / E 056º20.
Mooring / Marker buoys	8
Anchor buoys	Yes, 2
Signs posted	Yes
Management plan approved and implemented	No
Management plan zones	No
Enforcement (1-none, 2-some, 3-active)	2
Biophysical monitoring (years conducted)	0

A coral reef monitoring station was also implemented in Dibba MPA. This operation was initiated in 2007 by the Department of Environment of Fujairah Municipality, National

Coral Reef Institute (NCRI, Florida, USA) and the Emirates Wildlife Society in association with the World Wide Fund for Nature (EWS - WWF). Four monitoring stations were positioned on the seabed between Fujairah city and Dibba, being one of the stations inside Dibba MPA. The purpose of monitoring stations was to study the re-growth and re-colonisation of corals that were damaged during Cyclone Gonu of 2007.

The shallow near shore of the Fujairah area contains mixed substrates, where rocky reefs and coral reefs are common throughout the area. Reef development is controlled largely by the physical environment, and extremes of temperature and salinity, that coupled with turbidity water makes Dibba MPA a generally harsh setting for reef growths (Pearson et al. 1998).

Coral diversity throughout the Arabian region follows a clearly established pattern, being the Gulf of Oman and the Arabian Sea fuse together closely. According to Sheppard et al. (1992), the coral colonies found in the area of Dibba MPA are more closely identical to the colonies of the Arabian Sea than to the ones found in the Arabian Gulf, as shown in Figure 12. In a study conducted by Rezai (2004) the coral cover in the area was around 30-40% at depths of 4-12 meters, decreasing very rapidly in deeper water.

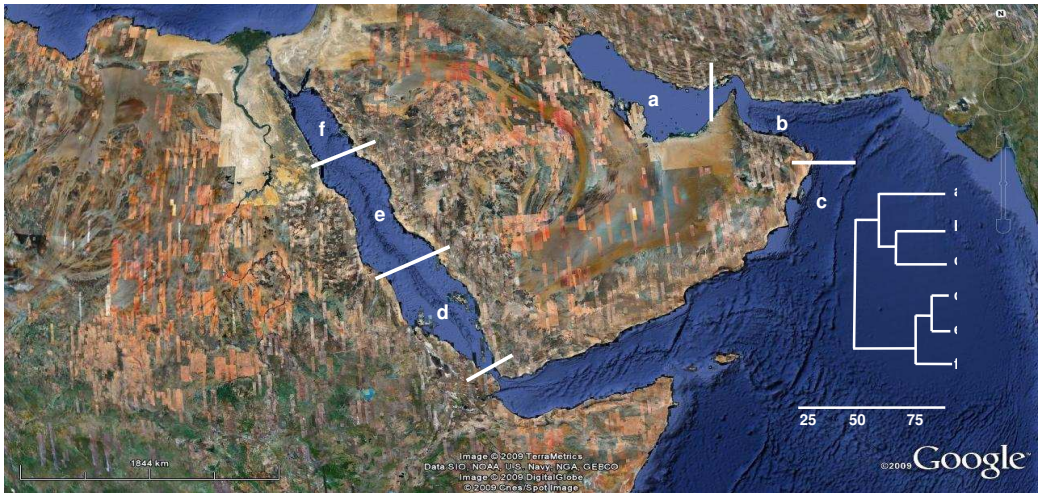


Figure 12 Cluster analysis of corals of Arabian region divided into six major areas. The dendrogram shown is based on an index of commonality which takes into account the inequality of diversity between areas (Sheppard et al. 1992).

1.6 UAE Marine Environment Legal framework

1.6.1 *National Level*

In UAE all seven emirates are governed by a double legal system. Secular (nonreligious) courts try criminal and commercial cases; Sharia (Muslim religious) courts try cases relating to family and personal behavior and offenses against Muslim religious

law. According to Sharia courts, rights of animals formulated over seven centuries ago on the basis of the Prophetic traditions is still taking in consideration (Bagader et al. 1994):

> "*The rights of livestock and animals with regard to their treatment by man: These are that he spend on them the provision that their kind require, even if they have aged or sickened such that no benefit comes from them; that he not burden them beyond what they can bear; that he not put them together with anything by which they would be injured, whether of their own kind or other species, and whether by breaking their bones or butting or wounding; that he slaughter them with kindness if he slaughter them, and neither flay their skins nor break their bones until their bodies have become cold and their lives have passed away; that he not slaughter their young within their sight; that he set them apart individually; that he make comfortable their resting places and watering places; that he put their males and females together during their mating seasons; that he not discard those which he takes in hunting; and neither shoot them with anything that breaks their bones nor bring about their destruction by any means that renders their meat unlawful to eat*"

1.6.1.1 Institutions

UAE as several administrative units and government departments related to the environment, as the Ministry of Environment and Water (Table 9).

Table 9 Present responsibilities and activities of various Government Agencies and federal levels with regards to the marine and coastal environment (EAD-AGEDI 2006)

Government Agency	Level	Activity / Responsibility
Ministry of Environment and Water	Federal	Fisheries management
Ministry of Communication	Federal	Roads, ports, shipping, maritime affairs, marine pollution
Ministry of Defence	Federal	Hydrographic surveys, EEZ security, bathymetric charts and mapping
Ministry of Justice	Federal	Legislation
Ministry of Planning	Federal	Coastal planning
The Coast Guard Group	Federal	Enforcement of regulations, offshore operations
Municipalities in Ras Al Khaimah, Ajman, Um Al Quwain and Fujairah	Emirate	Lead agency on environmental protection and development in Ras Al Khaimah, Ajman, Umm Al Qaiwain and Fujairah

In September 2000, a “National Environmental Strategy and Work Plan of the United Arab Emirates” was published by the Federal Environment Agency (established in 1993, not in operation presently) with the financial and technical support of the United Nations Development Programme (UNDP). The plans and priority projects of the marine sector of this UAE national strategy included (EAD-AGEDI 2006):

1. Survey of marine biodiversity;
2. Conservation of endangered species;
3. Public awareness and environmental education;
4. Protection of marine water quality;
5. Environment Impact Assessment (EIA) legislation;
6. Sustainable commercial fishing;
7. Marine pollution.

In 2005, the creation of the first Ministry of Environment and Water of the UAE was a highlight in the country’s history, showing the growing concern of authorities towards the environment. In the same year, after the dramatic results of the fish resource assessment in UAE waters, trawling was outlawed in UAE waters until 2020 (Raouf 2007). The Ministry of Environment and Water has jurisdiction over matters relating to wildlife conservation and the marine environment and is also involved in the monitoring, assessment and management of living marine resources. The Fisheries Department, from the Ministry of Environment and Water, undertakes applied coastal and marine research relating to commercial activities (EAD-AGEDI 2006).

1.6.1.2 Federal Laws

More than 10 federal laws and 20 emir decrees related to the marine and coastal environment have been produced by the UAE since 1971. However, none of these provide a comprehensive framework for integrated planning and management of the coastal zone. The existing legislation relating to the marine and coastal environment features some major omissions and requires a comprehensive review (EAD-AGEDI 2006). Re-evaluation is needed on:

1. mandating and definition of executive authority;
2. penalties are not always clearly stated;
3. liability and security against environmental damage are not emphasized;
4. monitoring, control and surveillance schemes, and mechanisms of enforcement are not explained;
5. specific regulations for the coastal zone are not present .

However, so far, these laws and decrees are considered the main support and set a legal precedence for the establishment of any new legislation related to the conservation of marine habitats, including coral reefs.

Regarding the UAE Federal Laws, the most significant for the protection of local Marine Protected Areas are:

1. **Federal Law number (9)** of the year 1983 on Regulating the hunting of birds and animals;
2. **Federal Law number (11)** of the year 2002 on Regulating and Controlling the International Trade in Endangered Species of Wild Fauna & Flora;
3. **Federal Law number (19)** of the year 1993 concerning the Delineation of the Maritime Zones of the UAE;
4. **Federal law number (21)** of the year 1981 on the Establishment of the General Authority of Water Recourses Management in the UAE;
5. **Federal Law number (23)** of the year 1999 on Exploitation, Protection, and Development of the Living Aquatics in the UAE; Ministerial Decree No. 302/2001 of the executive order of this law deal with fisheries legalization, registration, and control. They include articles for the protection and development of fishing grounds. In addition to the restriction of specific areas, fishing gear, seasons, and activities, they also ban destructive gear, hunting any endangered species or affecting their feeding/breeding areas. A ministerial decree on bye-laws of Federal Law no. 23 of 1999 was issued in 2008, banning hunting of sharks from January 1 to the end of April of every year, and limiting the area of hunting and banning the hunting of whale sharks and finning;
6. **Federal Law number (24)** of the year 1999 for the Protection and Development of the Environment. The articles cover aspects related to the EIA of all development projects, permitting of activities according to environmental standards, environmental monitoring and contingency plans. It also provide a platform of regulations dealing with hazardous and medical wastes, establishment of natural protected areas and liability and indemnity against environmental damages;
7. **Federal Law number (81)** of the year 1974 on the admission of the UAE to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The UAE signed in 1990, the CITES ensuring the survival of wild animal and plant species threatened by international trade. There are currently 32 species of Scleractiniae (living true corals) listed in the Appendix II of the CITES for UAE. Therefore, their trade is subject to strict regulation in order to avoid utilization incompatible with their survival;

8. **Resolution No. 5** of the year 1998 prohibiting the use of ships, tankers and barges as floating containers for transportation or storage of petroleum or its derivatives. This Resolution aims at the protection of marine environment against pollution caused by petroleum.

1.6.2 *Regional level*

In addition to the existing national legislation and conventions, a number of environmental strategies and action plans have been developed in the region, such as, the “Regional Action Plan for the Conservation of Coral Reefs in the Arabian Seas Region” and the “Kuwait Action Plan” developed by the Regional Organization for the Protection of the Marine Environment (ROPME). The “Convention on Conservation of Wildlife and its Natural Habitats” in the GCC countries (Gulf Cooperation Council Countries) was signed in 2003 (EAD-AGEDI 2006).

The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (1978) has four related protocols that were developed in accordance with the recommendations of the Legal Component of the “Kuwait Action Plan” (SOMER 2003). These protocols are (EAD-AGEDI 2006):

1. **Protocol Concerning Regional Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency**, 1978. Date of ratification 1979, in force 1980;
2. **Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf**, 1989, in force 1990;
3. **Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and Other Wastes**, 1998. Date of ratification 2005, in force 2006;
4. **Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources**, 1990. Not ratified.

Memorandums and agreements have been regional ratified, some are extracted from international conventions:

1. **Memorandum of Understanding concerning Conservation and Management of marine turtles and their habitats of the Indian Ocean and South East Asia**, 2001(from CMS Convention). In force 2007;
2. **Memorandum of Understanding concerning the Conservation of Migratory Birds of Prey in Africa and Eurasia**, 2008 (from CMS Convention). In force 2008;
3. **Agreement for the Establishment of the Regional Commission for Fisheries (RECOFI)**, 1999. In force 2001.

1.6.3 *International conventions and agreements*

The UAE ratified and accessed numerous international conventions and protocols on environment protection:

1. **Convention on the International Maritime Organization**, 1848. In force 1980;
2. **International Convention for the Prevention of Pollution of the Sea by Oil,** 1954, as amended in 1962 and 1969. In force 1984;
3. **International Convention on Civil Liability for Oil Pollution Damage**, 1969, as amended by Protocols 1976 and 1992 (CLC Convention).In force 1984;
4. **Protocol to amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage**, 1992. Date of ratification 1998;
5. **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter**, 1972 with Amendment to Annex I and II. In force 1994;
6. **Convention Concerning the Protection of the World Cultural and Natural Heritage (WHC),** 1972; In force 2001;
7. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** 1973 with the Amendments 1979. In force 1990;
8. **Convention for the Safety of Life at Sea (SOLAS),** 1974. In force 1984;
9. **Convention on Limitation of Liability for Maritime Claims**, 1976. Date of ratification1997, in force 1998;
10. **International Convention for the Prevention of Pollution from Ships (MARPOL) as modified by the Protocol of** 1978. In force 2007;
11. **Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal**, 1989. Date of ratification 1992, in force 1993;
12. **United Nations Framework Convention on Climate Change**, 1992. In force 1996;
13. **Convention on Biological Diversity (CBD)**, 1992. Date of ratification 2000; in force 2000;
14. **Kyoto Protocol to the United Nations Framework Convention on Climate Change**, 1997. Date of ratification 2005, in force 2005;
15. **The International "Convention on Wetlands" or RAMSAR Convention**, 1971. Date of ratification 2007; in force 2007.

The UAE is currently examining the possibility to ratify the following international conventions and protocols:

1. **Convention on the Conservation of Migratory Species of Wild Animals (CMS)**, 1979.

2. **United Nations Convention on the Law of the Sea (UNCLOS)**, 1982.
3. **Annex III (Optional): Hazardous substances carried in packaged form from International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL)**.
4. **International Convention on Pollution Preparedness, Response and Co-operation, 1990.**

2. Methods

According to Kelleher (1999), in practice, most decisions in a management or zoning plan have to be taken with incomplete data knowledge. Not only can the search for great detail delay decisions, but excessive detail can hinder decision-making by obscuring the major factors. A competent plan can be developed from relatively simple descriptions of the physical, biological and socioeconomic characteristics of an area. The absence of site-specific information is not normally a good reason for postponing management in favour of more research. Having this in mind, in the present study, several scientific articles, guidelines and management plans were consulted; having as primary result the necessary data for the implementation of a management plan.

Considering the lack of information and studies for Dibba MPA and adjacent areas, as well as the lack of funding and support for this study (except logistics by the Fujairah Municipality and UAE Ministry of Environment and Water), the main focus was the collection of general and basic ecological and socio-economical information. At the current stage of Dibba MPA, it was more relevant to collect all the existing information as well as generate data in order to point out the existing gaps and propose future studies needed to reach main objectives and management plan goals on international criteria. In paradox with its ancient seafaring and pearl diving cultural heritage, being a recent country, UAE marine research is in its early years and data in UAE are scarce and/or not often promptly available (*i. e.* grey literature or confidential consultancy reports).

Ideally a coral reef site manager perform a baseline survey that includes many measures or parameters that may or may not change over time. These include (Hill and Wilkinson 2004):

1. Mapping the extent and location of major habitats, particularly coral reefs;
2. Understanding the status of coral communities, fish populations and fishing practices;
3. Measuring the size and structure of the human population using these resources;
4. Understanding government rules and regulations on coral reefs and conservation;
5. Determining the decision making process in local communities and major stakeholders.

Due to the lack of information of Dibba MPA, all the data had to be collected from scratch. Because of limited time and amount of resources, the focus was mainly on the following:

1. Mapping the extent and location of major habitats, particularly coral reefs (resource assessment and mapping) ;
2. Understanding government rules and regulations on coral reefs and conservation;
3. Mapping and understanding the main users and stakeholders of Dibba MPA.

According to Dudley (2008), management options should be determined primarily by the ecological characteristics and life history of the species and ecosystems, therefore ecological monitoring is needed. This monitoring includes the data collection of biological and physical parameters in the natural environment (Hill and Wilkinson 2004). A total of 28 dives in Dibba MPA were realized to collect ecological data. In the absence of proper habitat map, initial dives were conducted to identify and describe the different habitats followed by a sequence of dives to collect local biodiversity data. CTD (Conductivity-Temperature-Depth) readings were also collected to gather information regarding physical parameters.

Management options should also consider the needs, capacities and desires of local communities and should generally be selected after discussion with stakeholders. According to Hill and Wilkinson (2004), management objectives that are supported by local communities are more likely to succeed than those that are unpopular or opposed. For this study proper questionnaires were written to collect data regarding the socio-economic component, involving stakeholders, namely hotels, dive centres and fishermen.

2.1 Ecological monitoring

2.1.1 *Biological parameters*

For the ecological monitoring, Dibba MPA was divided in three areas (A, B and C), and reconnaissance surveys, which are a brief survey of the study area, were conducted to assess the size and location of major habitats types within the protected area (Figure 13). Due to limited resources, habitat maps were created using maps of the area, local knowledge and dive checks to confirm the location of major habitat types. In order to choose the place of the replicates (additional samples), the sites were selected as representatives of the habitats inside Dibba MPA.

According to Hill and Wilkinson (2004), stratified haphazard selection is the best method of choosing where to place the transects. This means that first the habitat necessary to monitor is selected (for instance, a reef), and then, haphazardly suitable sample sites are select within this area. For repeated surveys, the same sites are chosen and haphazardly re-laid transects in approximately the same area as on the previous visit.

The replicates are carefully selected in a way that they do not overlap, so statistically each replicate sample could be looked as independent.

Figure 13 Dibba MPA divided in 3 areas for random dives.

After the reconnaissance dives, and according to the findings, six different locations were then chosen to place transects for future data collection. The locations were selected regarding the different habitats encountered as well as known dive sites (Figure 14). Permanent transects were placed in dive site 1, 2, 4 and 5, but their use was challenging, the marker buoys disappeared at several occasions during the study period.

Figure 14 Location of the dive sites in Dibba MPA for transect data collection.

The method chosen for the data collection was an adaptation of the “Reef Check” method (Hodgson et al. 2006) and broad scale surveys (Wilkinson et al. 2003). The conduction of the surveys and data collection was the same as Reef Check except the species identified were not only indicator species but general broad scale identification, since the aim of this study was to identify marine life of Dibba MPA, and not the health status of the reef.

In each dive site chosen transects of 20 meters minimum were deployed; variations in length depended on sea conditions and visibility, being 100 meters (20 meters x 5) the maximum length deployed.

The depth contour chosen for transects was within the following ranges: shallow, between 2 to 6 meters, and mid-range in some areas from 6 to 12 meters. The depths contours were chosen for security reasons as well as habitat reasons, since most marine life was encounter within this range. Along the transect fish, invertebrates, coral and substrate diversity data was collected in a data sheet or using underwater camera, in order to gather for the first time a biodiversity list for Dibba MPA. Any impact encounter during the dive was also collected in the Note section of the data sheet.

Fish surveys were the first surveys to complete, since fish can easily be disturbed by divers. After the deployment of the transect line, a waiting period of 10 minutes was done in order to the fish return to their normal behaviour after the disturbance created by the deployment of the transect line. Fish species were recorded, along the transect line within a “tunnel” of 5 meters high and 5 meters width around the diver – observer.

Invertebrate surveys were done in an S-shaped pattern along the transect line, in a face down feet up position, to ensure all parts of the transect were explored, and cracks or crevices could be searched.

The transect line was then surveyed for a third time to collect substrate data, as coral identification, additional organisms (sponges and algae), coral damage and trash.

2.1.2 *Physical parameters*

Physical parameters provide a physical description of the environment surrounding reefs which assists in creating maps, as well as measuring the change in the environment. Physical parameters, such as dissolved oxygen, temperature, pH, turbidity and salinity, were collected with the help of Dr. Elise Marquis from United Nations University - International Network on Water, Environment and Health (UNU-INWEH). A CTD profiler was deployed, until 10 meters deep, when possible.

Two random locations inside Dibba MPA (P1 and P2) were chosen to collect the physical data (Figure 15) at three different months, November and December 2008 and February 2009.

Figure 15 Location of the two sites P1 and P2 for physical parameters data collection.

2.2 Socio-economic monitoring

The socio-economic monitoring aims to understand the perceptions of community members with respect to the impact of a marine protected area on the many dimensions of their daily lives and on the management of the natural resources. It is impossible to separate human activities and ecosystem health, especially when the marine habitat is important to the livelihoods of the local community. Socio-economic monitoring can measure the needs of resource from the community as well as the social, cultural, and economic conditions in communities near MPAs. Socio-economic data can help determining which stakeholder and community attributes provide the basis for successful management.

Questionnaires were personally done to the General Managers, or representatives, of the three hotels located in the Dibba MPA: JAL Hotel (250 rooms), Holiday Beach Motel (60 rooms) and Royal Beach Hotel (41 rooms) (Figure 16). In what is left of Dibba MPA coast, two more resorts are under construction.

Figure 16 Location of the three hotels in Dibba MPA.

Knowing that Dibba MPA is one of the places more renowned for diving in the UAE, questionnaires were personally made to the managers of three dive centres located in Dibba MPA. For the remaining eleven dive centres across the UAE the questionnaires were sent by e-mail.

Due to the serious difficulties in language, different nationalities, and unwilling desire to help, it was only possible to interview 22 fishermen in Dibba port. Both fishermen working in dhows (launchs) and *tarads* (fiber-glass dory) were interviewed at the time catches were being unloaded at the port. In all the fishermen interviews an Emirati volunteer helped in the translation of information.

Questionnaires conducted to dive centres, hotels and fishermen can be found in Annex B.

3. Findings

3.1 Ecological monitoring

3.1.1 *Biological monitoring*

During the first reconnaissance surveys in Dibba MPA, the locations of the delimitating buoys were taken with GPS. The data showed that part of the area of Dibba MPA was outside the official line of protection (Figure 17). During the period of surveillance for several times the location of the buoys were recorded again and it was noticed, more than once, that they were moved from the correct place. Even though the all area of Dibba MPA wasn't under proper protection, the rest of the surveys were done taking in consideration the total area of Dibba MPA.

Figure 17 Location of the buoys delimitating Dibba MPA (from A to H) compared to the offical locations. In red the area that is not being protected; in blue the area that is being protected but doesn't belong to Dibba MPA.

During the reconnaissance surveys, three main habitats were identified, two types of coral habitat and one sand habitat. In some areas prolific reef growth was ascertained while in other areas a rubble substrate with sporadic corals was observed (hereafter "coral patches"; Figure 18).General coral formation in Dibba MPA can be categorized as coral reefs that grow in shallow waters and closely border the coastline or are separated from it by a narrow stretch of water, known as fringing coral reef (Veron 2000; Miththapala 2008).

Dibba MPA has an islet, known as "Dibba rock", which markedly separates two different areas of coral formation. In the underwater area of the islet facing the coastline, shallow water and coral formation was constant. In the exposed area of the islet, facing

the outside of the MPA, the bathymetry was sharp, increasing rapidly in depth from the surface to 16 meters. Due to the sharp slope, the number of coral communities' formation was much less than the ones found in the inner side of the islet.

Figure 18 Location of the three main habitats found in Dibba MPA: prolific reef growth in purple; coral patches in green; sand in transparent.

The major habitat found at Dibba MPA is sand habitat, followed by coral patches and prolific coral growth habitat, both covering mainly the east and west sides of the protected area. The areas with corals were mainly coral patches, being the more dense coral formation found in the surroundings of Dibba rock and in a small area in the west corner of the MPA.

From the transect surveys, a total of 168 species were identified from 31 different orders included in the Phylum Annelida, Arthropoda, Chordata, Cnidaria, Equinodermata, Mollusca, Porifera, Rhodophyta and Hetrerokontonphyta (Table 10 and Table 11). Species identification was done visually during the dive or after through underwater photographs taken during the dive. Since no specimen was collected, some species identifications weren't possible, and identification was done until genus or family. For a detailed list of the species identified in the surveys see Annex A.

Table 10 Total of species / genus counted in each transect in Dibba MPA

Transect	**Species/Genus count**
Fish transect (Chordata)	94
Invertebrates transect (Annelida, Arthropoda, Equinodermata and Mollusca)	37

Substrate transect (Cnidaria, Porifera, Rhodophyta and Hetrerokontonphyta)	37

Table 11 Number of classes, orders and families for each phylum observed in Dibba MPA.

Phylum	Classes	Orders	Families
Annelida	1	2	3
Arthropoda	2	2	8
Chordata	5	6	44
Cnidaria	2	5	16
Equinodermata	4	5	6
Mollusca	2	7	16
Porifera	1	2	2
Rhodophyta	1	1	1
Hetrerokontonphyta	1	1	1

From the total 168 species, 22 are listed on the IUCN Red List (2009) and 17 included in CITES appendices (2009) (Table 12).

Table 12 Status of species observed in Dibba MPA according to IUCN Red List (2009) and CITES (2009).

Scientific name	Vernacular name	IUCN Red List category	CITES
Acanthastrea echinata	Starry cup coral	Least Concern	Appendix II
Acropora arabensis		Near Threatened	Appendix II
Acropora downingi		Least Concern	Appendix II
Acropora valida		Least Concern	Appendix II
Favia matthaii		Near Threatened	Appendix II
Favites pentagona		Least Concern	Appendix II
Galaxea fascicularis		Near Threatened	Appendix II
Goniopora albiconus		Vulnerable	Appendix II
Goniopora ciliatus		Least Concern	Appendix II
Hydnophora microconos		Near Threatened	Appendix II

Montipora danae		Least Concern	Appendix II
Platygyra daedalea	Brain coral	Least Concern	Appendix II
Pocillopora damicornis	Cauliflower coral	Least Concern	Appendix II
Pseudosiderastrea tayami		Near Threatened	Appendix II
Aetobatus narinari	Spotted eagle ray	Near Threatened	
Carcharhinus melanopterus	Blacktip Reef Shark	Lower risk/ Near Threatened	
Rhincodon typus	Whale shark	Vulnerable	Appendix II
Cephalopholis hemistiktos	Yellowfin Hind	Near Threatened	
Epinephelus multinotatus	White-blotched Grouper	Least Concern	
Epinephelus stoliczkae	Epaulet Grouper	Data deficient	
Eretmochelys imbricata	Hawksbill turtle	Critically Endangered	Appendix I
Chelonia mydas	Green turtle	Endangered	Appendix I

Unfortunately, during the data collection period, the whole east coast of UAE experienced an unprecedented long lasting Harmful Algal Bloom (HAB) from August 2008 to May 2009, with a peak from September 2008 to January 2009 (Richlen et al. in press). During this period most of the dives were cancelled due to the high concentrations of algae in the water. After the HAB the coral cover of Dibba MPA changed from large areas to small patch reefs, and some areas appeared completely without coral cover, so long transects were no longer suitable in most of the areas.

3.1.2 *Physical parameters*

The physical parameters collected showed a wide range of values but most of these values were influenced by the presence of an HAB in the area, especially in November 2008. The data to be more affected due to the high concentration of algae in the water was oxygen and turbidity (for more information on major threats from HAB see section 3.3.2.2 below).

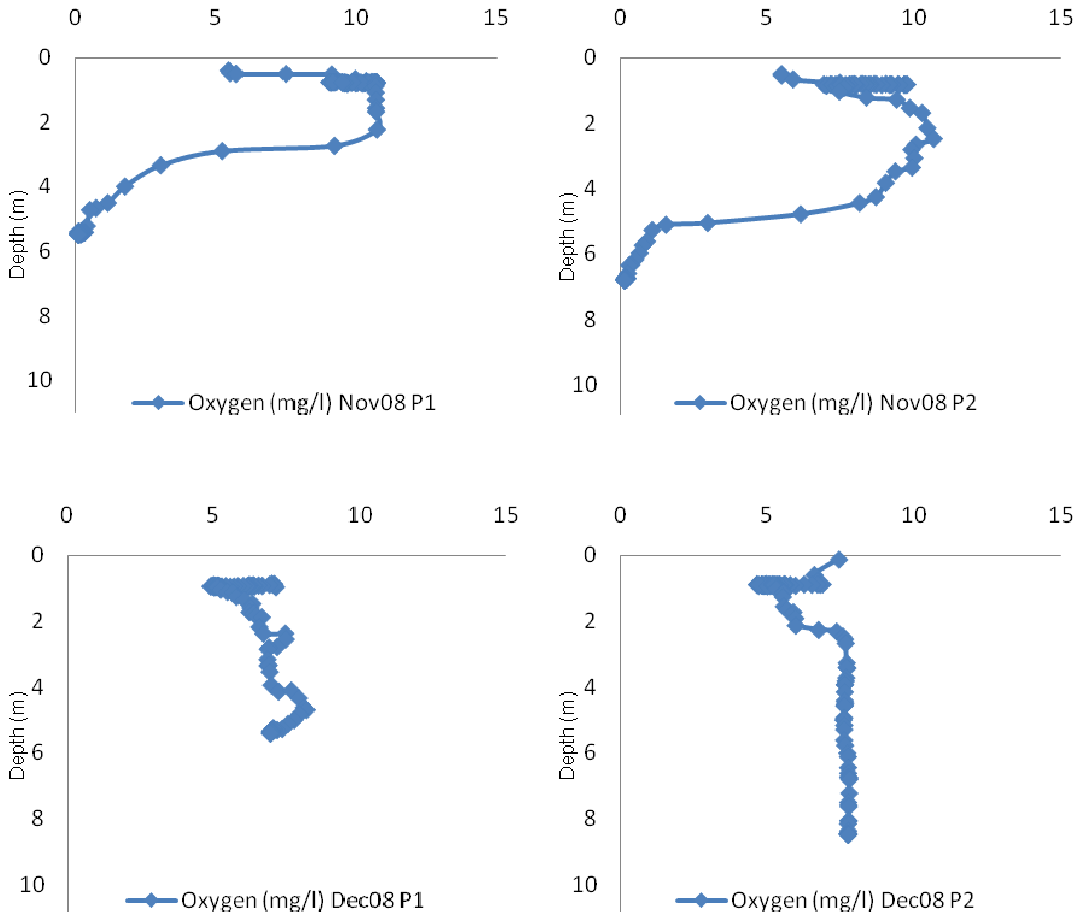
Values regarding pH weren't possible to collect due to a malfunction of the equipment.

Average values collected with CTD in the three months of November and December 2008 and February 2009 are in Table 13.

Table 13 Physical parameters average values for P1 and P2 during the three data collection months.

Parameters	P1			P2		
	Nov08	Dec08	Feb09	Nov08	Dec08	Feb09
Oxygen (mg/l)	6.25	6.32	8.41	5.62	6.40	5.38
Salinity	37.12	36.88	36.75	37.13	36.75	36.79
Temperature (℃)	28.84	24.11	23.23	28.61	24.11	23.05
Turbidity	10.70	1.11	2.26	11.80	2.32	0.87

Oxygen values ranged from a minimum of 0.11 mg/l and a maximum value of 10.73 mg/l both in November 2008 in P1. In February 2009 values in P1 were higher than P2 (Figure 19).



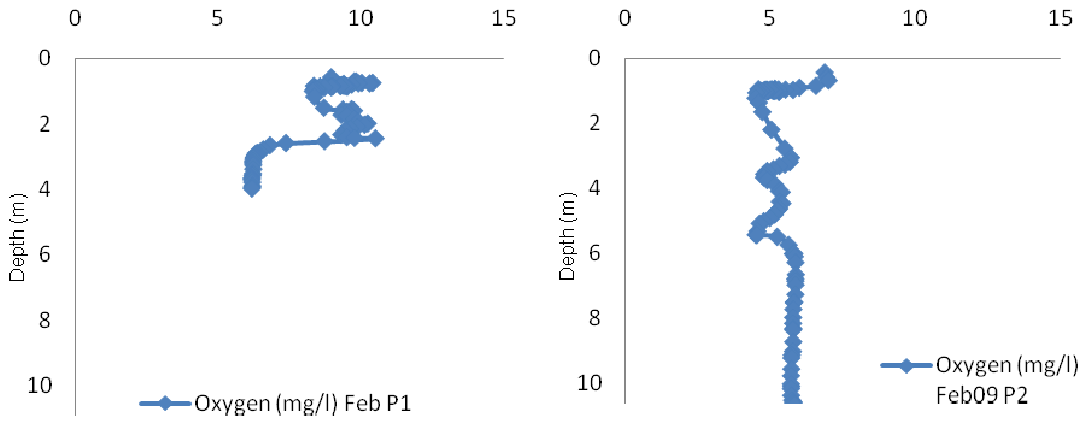
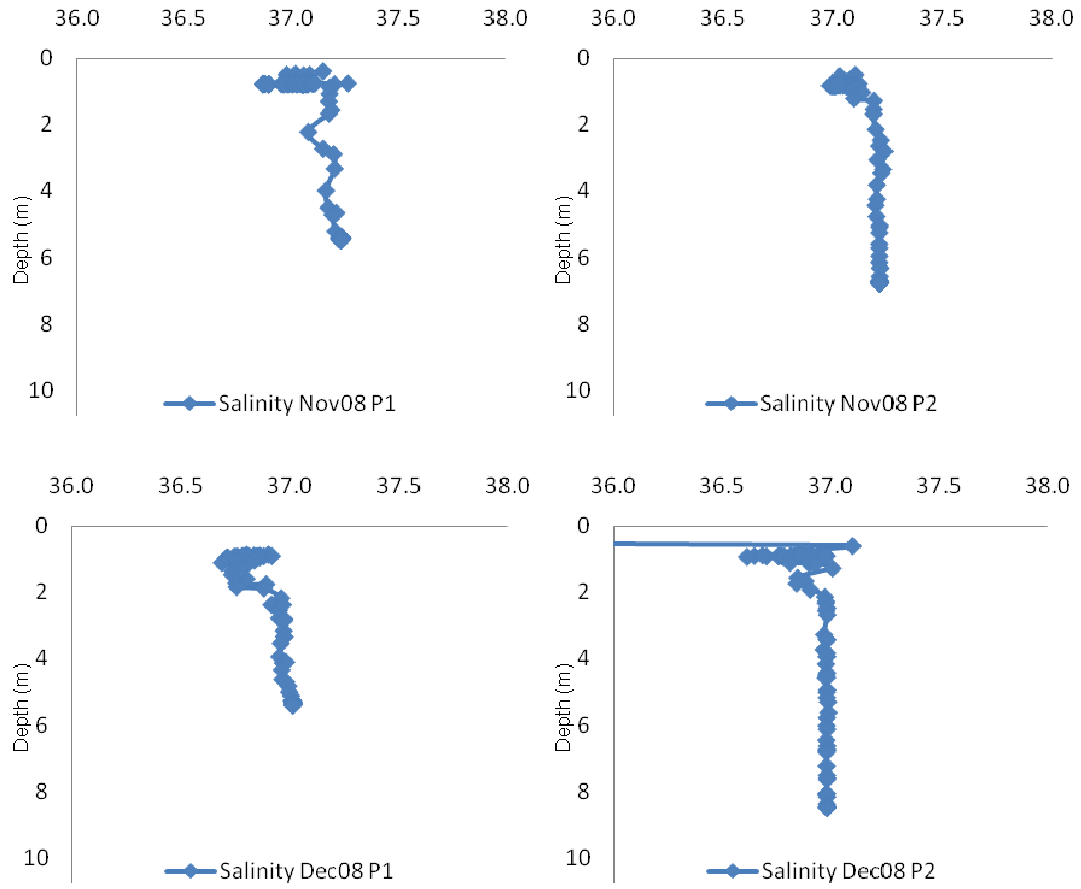


Figure 19 Oxygen (mg/l) data for P1 and P2 in November 2008, December 2008 and February 2009, from 0 to 11 meters depth.

Salinity values varied always between 37.27 maximum at P1 in November 2008 and 26.51 minimum, except for a value of 18.79 at 0.12 meters in P2 December 2008 (Figure 20).



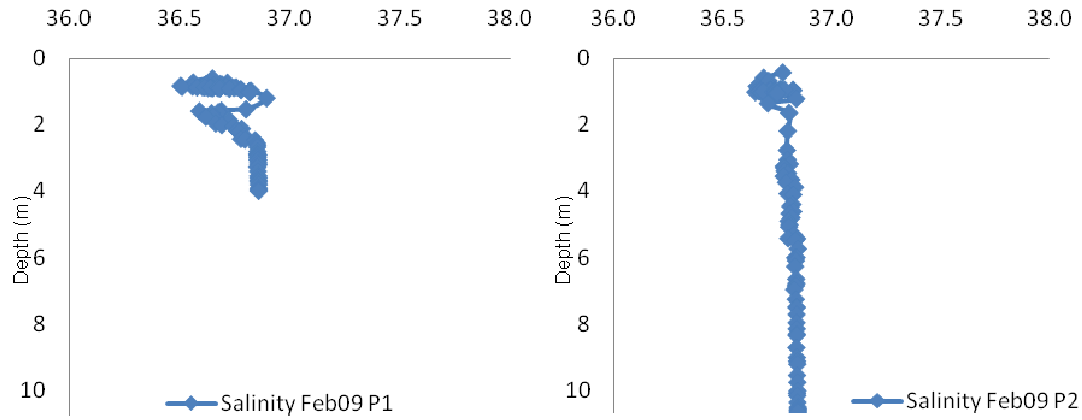
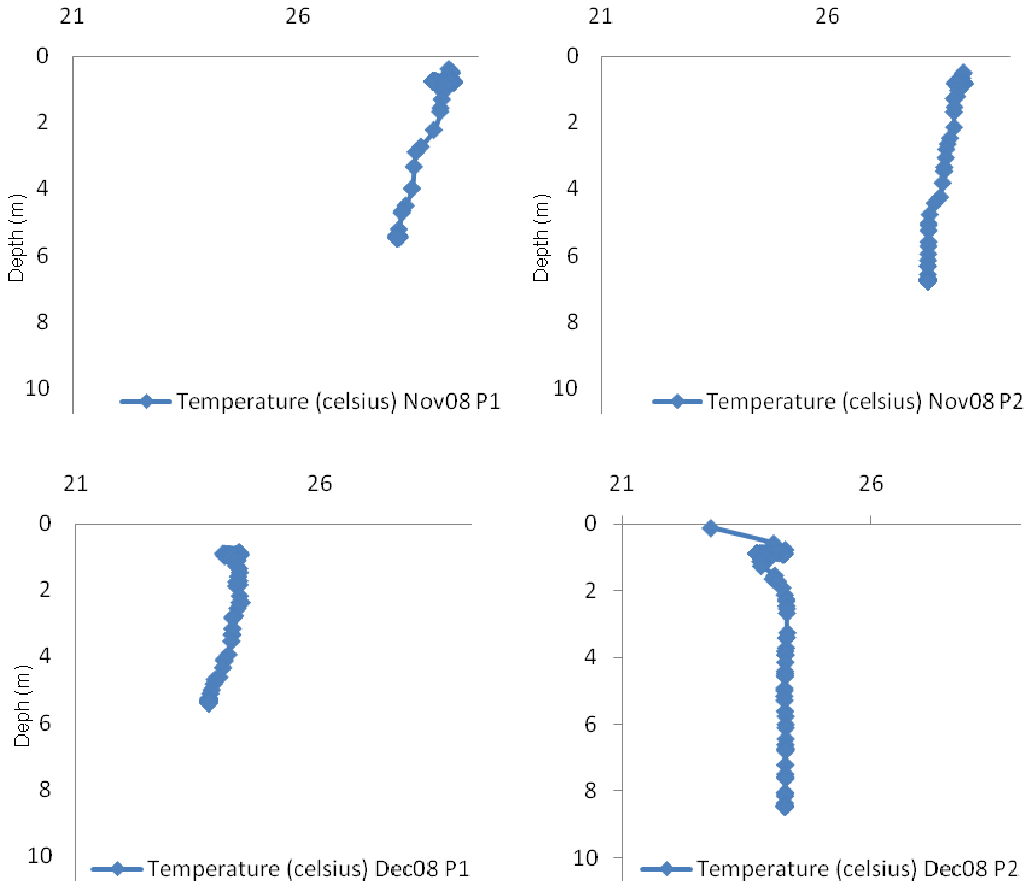


Figure 20 Salinity data for P1 and P2 in November 2008, December 2008 and February 2009, from 0 to 11 meters depth

Temperatures were recorded with minimum range values in February 2009, and maximum values in November 2008 with maximum record of 29.48℃ at P1 in November 2008 and a minimum of 22.78℃ at P2 in December 2008 (Figure 21).



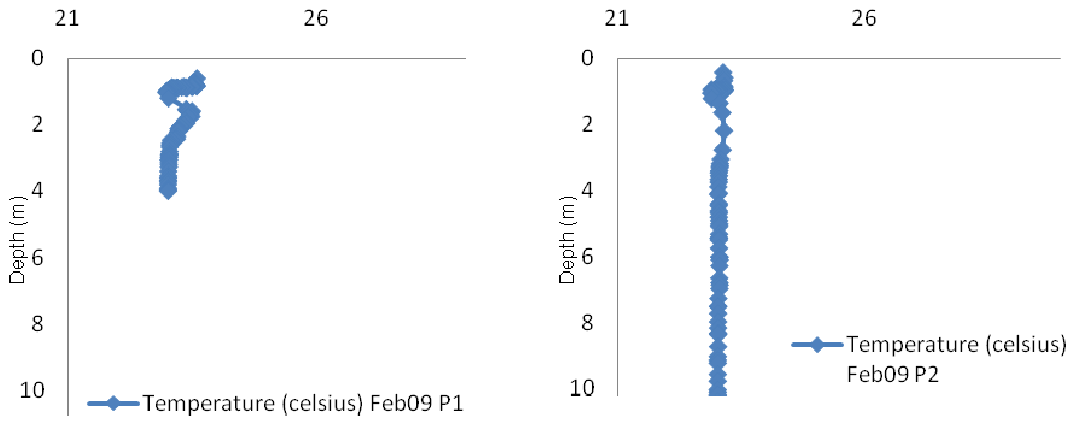
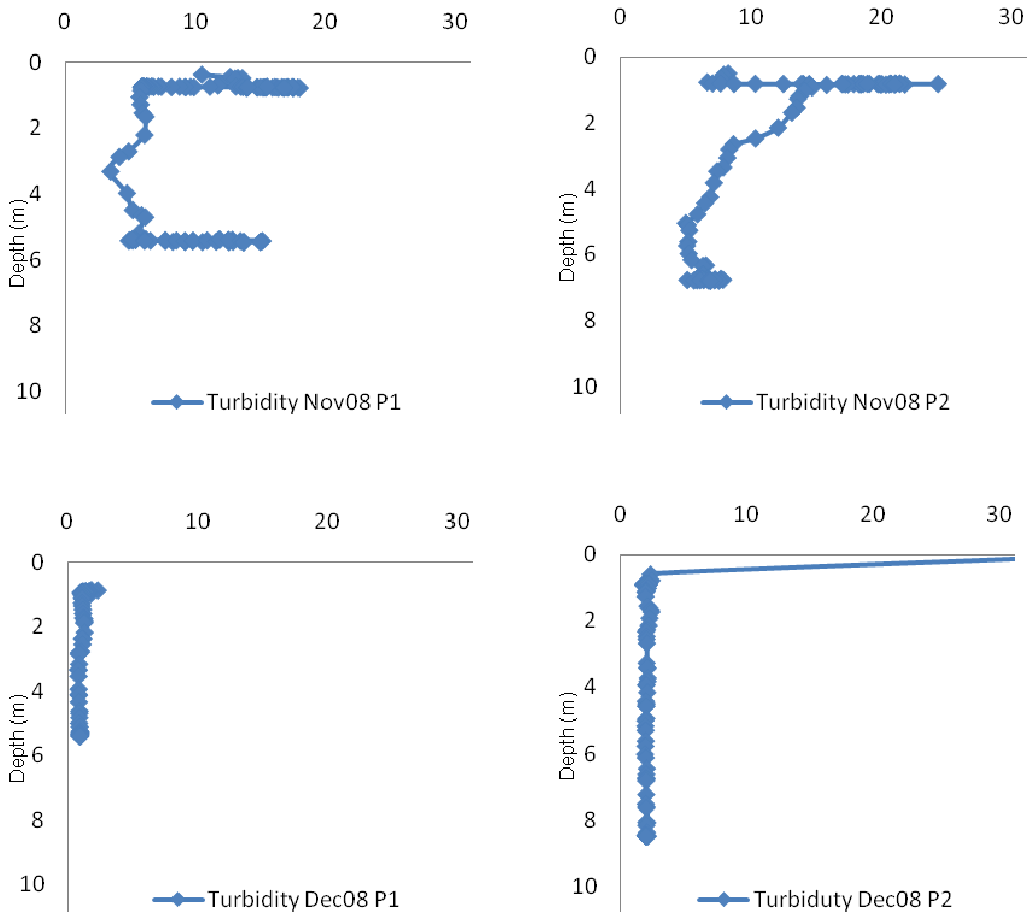


Figure 21 Temperature (℃) data for P1 and P2 in November 2008, December 2008 and February 2009, from 0 to 11 meters depth.

Maximum range in values for turbidity was found in November 2008, although the maximum value register was 33.24 on P2 December 2008 at 0.12 meters. Minimum values were recorded in February 2009. In general turbidity levels were always higher in P2 during the three months with data collection (Figure 22).



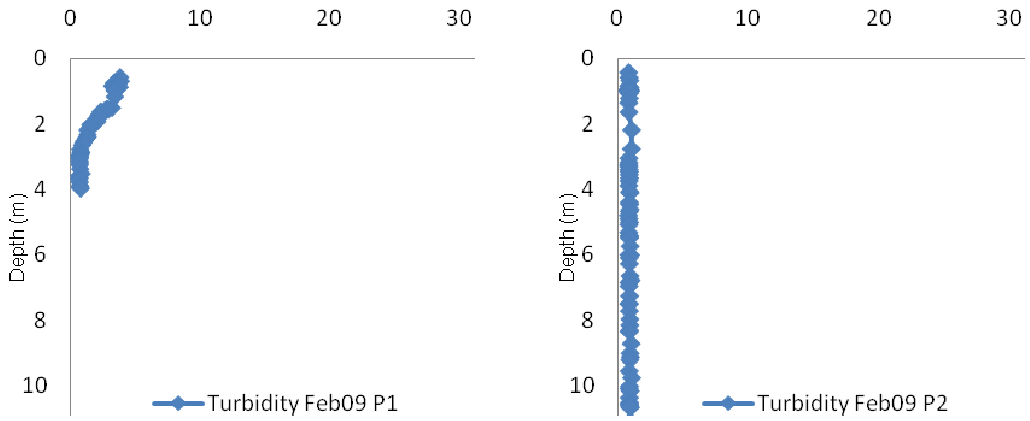


Figure 22 Turbidity data for P1 and P2 in November 2008, December 2008 and February 2009, from 0 to 11 meters depth.

3.2 Socio-economic monitoring

Anonymity was promised to the stakeholders regarding the analyses of data shared, so the tables showed here refer to the values given by dive centres, hotels and fishermen without mention the respective names.

3.2.1 *Diving Centres*

From the total of 14 dive centres contacted to answer the questionnaire, only four replied positively. Three of them are located inside Dibba MPA, and one outside that has three branches located in Jebel Ali, Dubai and Al Aqa.

All the dive centres interviewed said to have dive guides and always do a briefing before each dive. Even though the awareness and responsiveness are present before the dives, only half of the dive centres take their dive guides in every dive (Figure 23).

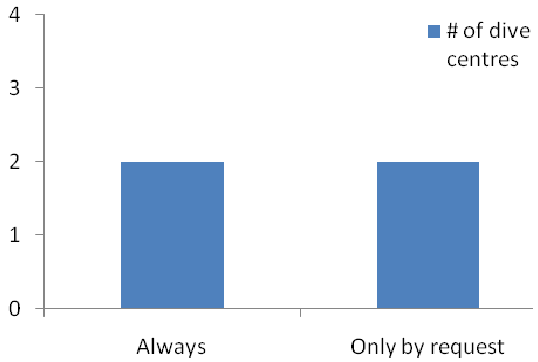


Figure 23 Number of dive centres that always dive, or only by request, with costumers.

All the dive centres frequently dive in Dibba MPA, and in general three dive centres dive every day and only one dive three to four times a week over the protected area

(Figure 24). The number of divers per dive vary in each dive centre, being the majority observed between 5 to 10 divers per dive. One of the dive centres afirmed taking around 25 divers per dive to Dibba MPA (Figure 25).

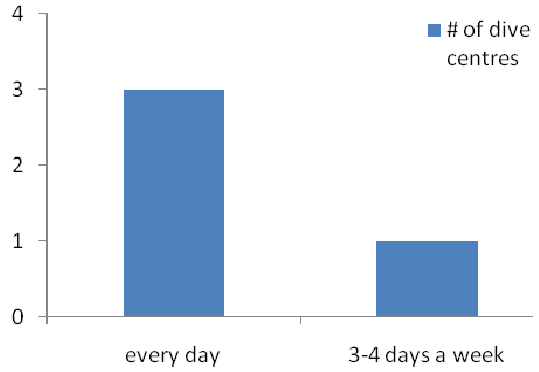


Figure 24 Number of dive centres that dive every day and 3-4 times a week in Dibba MPA.

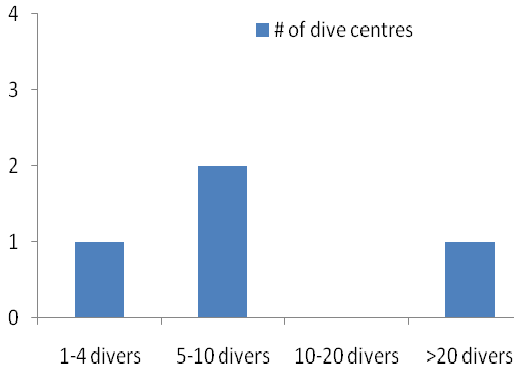


Figure 25 Average number of divers per dive in Dibba MPA, in each dive centre.

Regarding the awareness and knowledge about MPAs, half of the dive centres didn't know the right location and names of the MPAs of the east coast. Only one dive center knew exactly the name and location of the 3 MPAs, and one just knew correctly Dibba MPA (Figure 26).

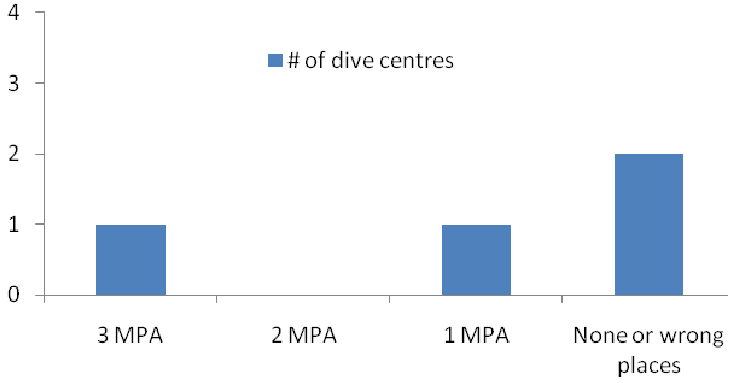


Figure 26 Number of dive centres that knew 3, 2, 1 or none MPAs in the East Coast.

Regarding the management of Dibba MPA, the four dive centers pointed out that there is no actual management and that the lack of authority and public awareness is enormous. Nevertheless all agree that they have been beneficiated by the presence of Dibba MPA as they represent ideal dive sites, an increased marine life in the area, less danger from passing boats and jet skis and the fact that sometimes is patrolled.

All dive centres managers suggested for Dibba MPA an increase in environment monitoring, more public awareness, stricter policing (especially for anchoring and fishing),

a limit number of boats and boats speed limits, more mooring buoys and marker buoys and the implementation of new artificial reefs.

3.2.2 *Hotels*

In the coast of Dibba MPA three hotels already exist and two more are under construction. According to the questionnaire done to the three existing hotels, all of them promote aquatic activities inside Dibba MPA, but none is responsible for the information given to the clients or the action exercised by them, these activities are run by an external operator.

Some of the information regarding the number of guest by year and room occupancy along the year was difficult to get, since most of the information is confidential. Nevertheless one hotel had an average occupancy of 10,000 to 12,000 guests a year while another had an average of 30,000 guests a year. In two of the hotels, from the total guests, more than 50% take part in the maritime activities offered by the tourist operator, which include in all the hotels, diving, snorkelling, paddle boat, kayak and banana boat (Figure 27). All the three hotels pointed out as the low season the months between June and October, being the months with higher number of guest for the three hotels, January, March and April.

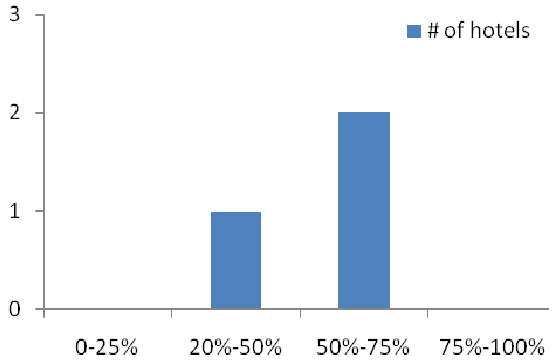


Figure 27 Percentage of guests who participate in water activities offered by the tourist operators in the hotels.

Regarding the awareness and knowledge about MPAs, all of the hotel managers were aware of Dibba MPA, but none knew about the correct existence of three MPAs in the east coast (Figure 28). Even though all the three hotels are located inside Dibba MPA, only one manager said to benefit from the existence of a MPA in the area of the hotel (Figure 29). The main reason for the other two hotel managers state that the hotel does not benefit from the existence of a MPA is the lack of awareness and information given to the hotel guests.

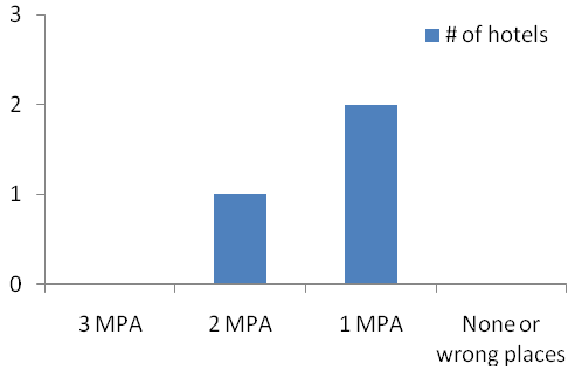


Figure 28 Number of hotels that know 3, 2, 1 or none MPAs in the East Coast.

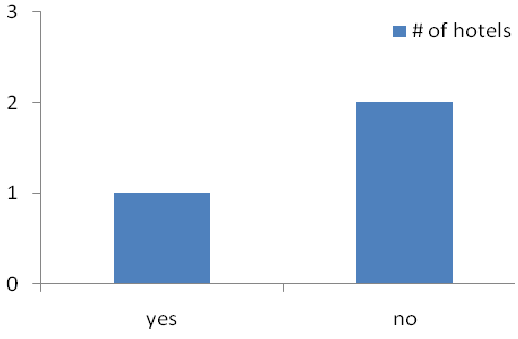


Figure 29 Number of hotels that benefit, or not, from Dibba MPA.

The three hotel managers were not aware of any kind of management in action in Dibba MPA, and all complained about the lack of information shared with them by authorities. Nevertheless, all were interested in more involvement in the management of Dibba MPA and all gave diferent suggestions to apply in the area, such as coral monitoring, the implementation of more signs and information available for the hotel guests, training for the hotel staff regarding MPAs, more policing and boats speed limit.

3.2.3 *Fishermen*

Interviewing the 22 fishermen was the most challenging of all the questionnaires. Language difficulties, as well as cultural differences, were always encountered since fishermen were from a wide range of nationalities. Some fishermen didn't know some answers so it was impossible to go on with the complete questionnaire, in these cases non-applicable (n/a) is mention.

Most of the fishermen interviewed have been fishing in the east coast of UAE for 10 to 20 years (Figure 30). Although this vast years of experience, in general, almost half of the fishermen interviewed didn't known about the existence of MPAs in the region (Figure 31), and even the ones that knew about the existence, almost half of them could not give a correct definition of MPA (Figure 32).

Even though 12 fishermen knew about the existence of MPAs in the east coast, only 7 were in favour of the existence of MPAs (Figure 33). No fisherman was against the existence of MPAs, but the remaining 15 didn't have an opinion or didn't think it was their concern. The number of fishermen aware of the benefits of MPAs to the community was lower than expected and very close to the number of fishermen that think that the community has no benefits at all from the MPAs (Figure 34).

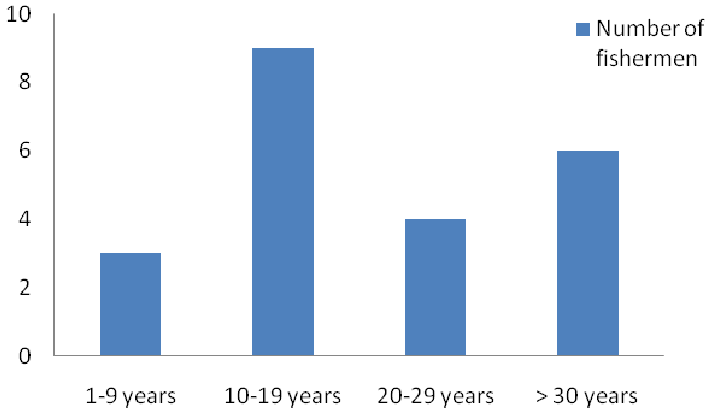


Figure 30 Number of fishermen regarding the experience years of fishing in the UAE East Coast.

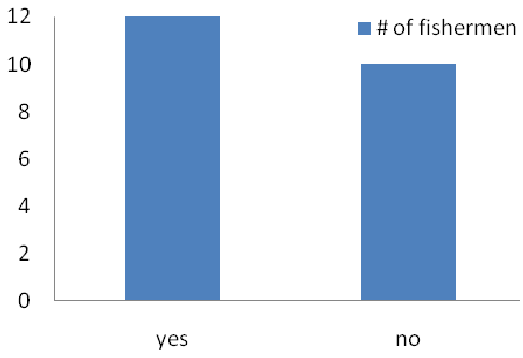


Figure 31 Number of fishermen that knew about the existence of MAPs in UAE East Coast.

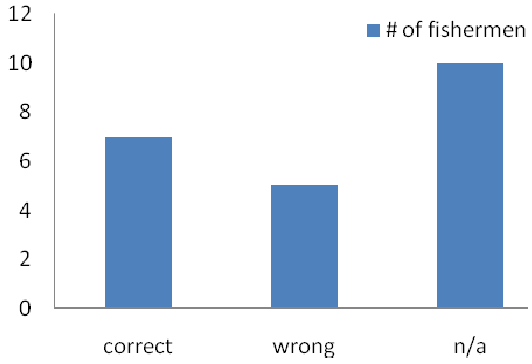


Figure 32 Number of fishermen that knew the definition of MPA.

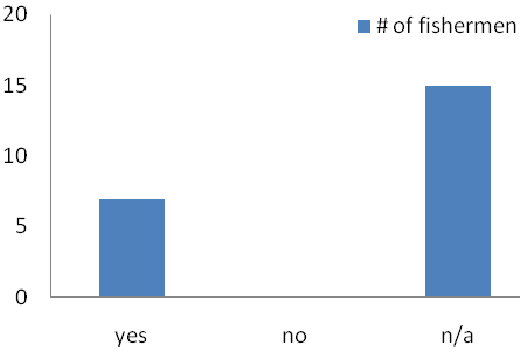


Figure 33 Number of fishermen that are in favour, or not, of the existence of MPAs.

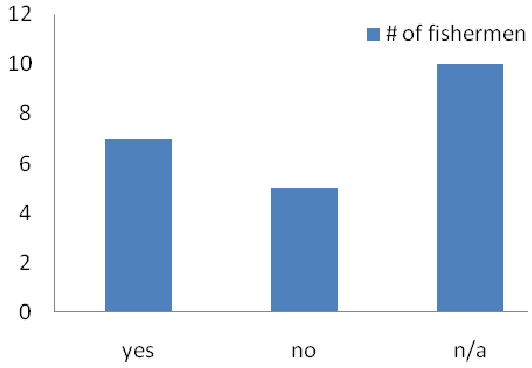


Figure 34 Number of fishermen that think that the community has benefit, or not, from the East Coast MPAs.

All fishermen use the *gargoor* technique to catch their fish, together with other techniques like *alyakh*, *hadaq* and *manshalla* (Figure 35 and for the description of techniques Table 5, page 16). Most of the fishermen thought that the fish catch as been decreasing over the past years, with only 5 fishermen saying that it has been increasing

(Figure 36). The main threats pointed out by fishermen to justify the decrease in fish catch was mainly overfishing, less rain, the competition from the Omani fishermen and the presence of the red tide. Surprisingly some fishermen pointed out sharks as one of the threats to fisheries, together with pollution and the heat (Figure 37).

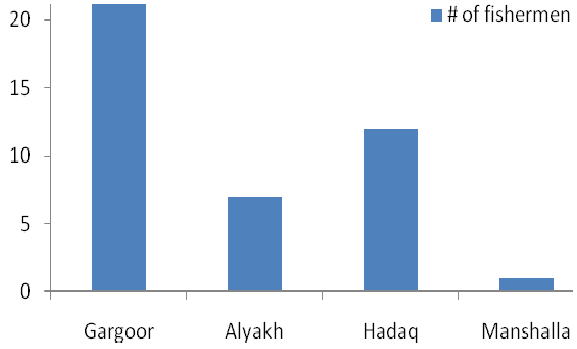


Figure 35 Number of fishermen that use the different fishing techniques.

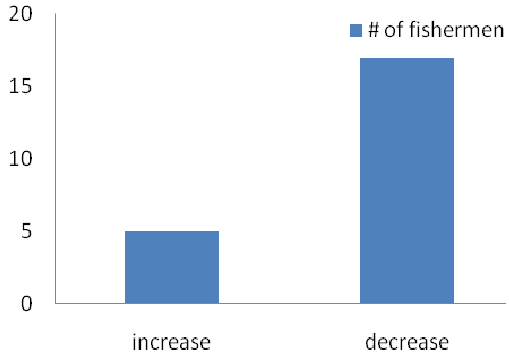


Figure 36 Number of fishermen that though the catch of fish in the East Coast has been increasing or decreasing in the last year.

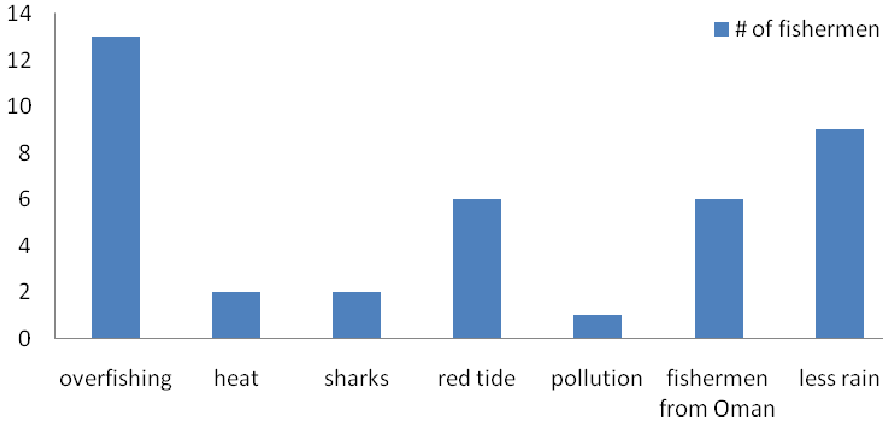


Figure 37 Main threats and reasons for the decreasing in fish catches pointed out by the interviewed fishermen.

The mainly fish family catch by fishermen are Serranidea (*summan* and *hamoor*) and Sparidea (*kufar*), followed by sharks, Carangidae (*jib* and *jash*) and Mullidae (*sultan ibrahim*) (Figure 38).

All fishermen were dependant on this activity for the family income, except for one single fisherman that had another income. From the fishermen that were aware of the existence of MPAs and that gave a correct definition, all said that the area has a good management, but more education and supervision is needed.

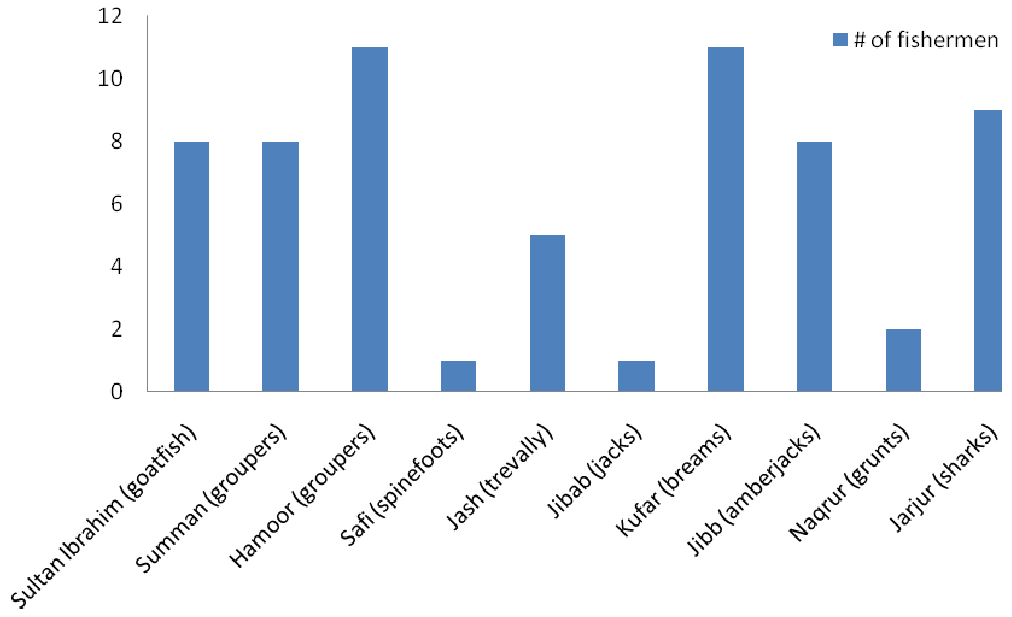


Figure 38 Number of fishermen at Dibba Port that catch different fish families

3.2.4 *Social survey conclusion*

The lack of information and education campaigns among the public and stakeholders of Dibba MPA is striking. From all the hotels and dive centres managers interviewed, only one knew for sure the location of the different MPAs in the east coast, and even more than half of the dive centres that use Dibba MPA as a dive site weren't willing to help with the questionnaire.

The fact that not all the dive centres take a dive guide with the costumers, shows that there is not a total control about the ethic behaviour of tourist divers inside Dibba MPA. This is even more dramatic knowing that the number of divers per dive is not controlled, with one dive centre allowing more than 20 divers per dive.

The average percentage of guests in the hotels that perform water activities is more than 50%, but no information is given to them regarding the correct behaviour to have inside Dibba MPA. Since the activities are taken by external tourist operators, there is no control from the hotel side in this matter. Due to this gap between the hotels guests and the water activities, most of the hotel managers are not aware of the benefits that Dibba MPA can bring to them.

The education among the fishermen community at Dibba port is also poor, with almost all not knowing the definition and purpose of a MPA. The general knowledge regarding fisheries threats are also minute, having few fishermen for instance blaming sharks for the decrease in fisheries numbers. Unfortunately some answers to the questions were not given, or not truly answered, as most fishermen were afraid of the purpose of the

questionnaire, and for several times asked if it was for the Ministry of Environment and Water.

3.3 Major Issues and Problems

MPAs, such as Dibba MPA, are affected by the broader ecological, socioeconomic and political contexts of the area (island, coast, and ocean) where they are located. Besides the threats that directly affect the MAPs from inside (such as invasive species, tourist pressure and poaching) human activities outside the delimited boundaries of the protected area, ranging from marine transportation and fishing to land-based actions (*e.g.* coastal development and industry) have also a profound impact on the benefits that MPA could deliver. According to Christie et al. (2005) in the absence of mechanisms to buffer MPAs against exogenous sources and high-use areas, even well-managed MPAs are subject to continuous and cumulative stress which undermines the overall effectiveness.

3.3.1 *Ecological Issues*

Even though the main habitat in Dibba MPA is sand, the most productive habitat in term of diversity is the coral reef. Therefore this study focused on the most important natural threats to this habitat.

3.3.1.1 Temperature and salinity variations

Besides human impacts, the most powerful determinants of coral reef health are temperature and salinity. Surface seawater temperature (SST) higher than normal stress corals and cause coral bleaching, frequently with large scale mortality. In the 4th Intergovernmental Panel on Climate Change (IPCC) in 2006, it was stated "*Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1–3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals"*. When SSTs exceed the summer maximum by more than 1°C for 4 weeks or more under clear tropical skies, corals bleach. If warmer conditions persist for longer periods corals could die in large numbers (Bernstein et al. 2007).

During the periods where physical parameters were analysed in Dibba MPA, they remained in the average range of temperatures for the Gulf of Oman (maximum SST recorded of 29.48°C and maximum salinity observed was 37.27). However, in summer, if the high temperatures stay for longer periods than usual this can put in risk the coral communities. Sea surface temperature anomalies around reefs in the Indian Ocean region have increased through the 20th century by 0.50°C/century in the Middle East and Western Indian Ocean and by 0.59°C/century in Central and Eastern Indian Ocean. Although most

of the bleaching is associated with higher sea temperatures and coral death, an alternative hypothesis exist saying that corals, via their symbiont zooxanthellae, may evolve rapidly by acquiring more thermally tolerant symbionts within a few decades. This would make corals more thermally tolerant and keep pace with rapid climate change. But this would require an adaptation at a rate of at least 0.2–0.4°C per decade and there is no evidence that corals can change their symbiotic relationships or develop temperature tolerance so quickly. It would be interesting to study this hypothesis in Dibba MPA, since the local coral communities are already used to high temperatures in the summer. There might be a resistance of local coral communities in Dibba MPA to wide temperature variation since corals with higher SST temperature variation exist in the region, as for example the Arabian Gulf and Eritrean corals where local salinity regularly exceeds 45, and SSTs can annually fluctuate from winter lows less than 12°C to summer highs above 36°C , or even water temperatures that can reach 37.5°C in summer at 10m depth (Burt et al. 2008; Wilkinson 2008).

3.3.1.2 Diseases

In the Arabian Gulf, several coral diseases occur that can be a factor of coral mortality. Black Band Disease (BBD) is a common disease on branching corals during summer but tends to disappear in winter. Infection rates of 25% in some areas on *Acropora* species have been reported. White Band Disease (WBD) is usually rare and not infectious, even in physical contact situations and appears to infect all species. Yellow Band Disease (YBD) is the most widespread and contagious disease both in summer and winter and had fast within-colony spread (Al-Cibahy et al. 2008b). YBD is not species specific and was found on two sites in the Gulf of Oman by Rezai et al. (2004).

Often, coral diseases and coral coverage are positively correlated, particularly in *Acropora* dominated areas, where frequent physical contact aided spreading of contagious diseases. No coral disease was found in Dibba MPA, but regarding the high temperature, salinity and contact with alien species further monitoring should be done to monitor the know diseases.

3.3.1.3 Predation

Coral mortality caused by predators or diseases can also take catastrophic or near-catastrophic scale. Predator plagues like Crown-of-thorns starfish (COTS) (*Acanthaster* planci) are increasingly reported around areas of human activities with two strong hypotheses advanced: the plagues may be initiated and certainly exacerbated by either over-fishing of key starfish predators; and/or increases in nutrient runoff from the land favours the planktonic stages of the starfish (Goldberg and Wilkinson 2004). Although not reported in Dibba MPA the COTS is infamous for its dramatic population explosions that

have striped entire reefs of its living coral cover throughout the Indo-Pacific for decades, making it a major management issue (Al-Cibahy et al. 2008b). In the past 20 years, *A. planci* outbreaks have been reported in Musandam which have devastated stands of *Acropora* but left *Porites* reefs untouched (McClanahan et al. 2000; Pilcher et al. 2000). Interestingly, if outbreaks of predatory organism like the voracious COTS have not been observed in the Arabian Gulf waters, this species is regularly observed on the east coast of UAE (Vogler et al. 2008).

The predatory snail *Drupella cornus*, equally a major cause for reef degradation in the nearby Indian Ocean, have not been reported yet on the UAE coasts (Al-Cibahy et al. 2008a).

3.3.1.4 Natural Disasters

On 6th of June 2007 the first documented tropical storm occurred in the Arabian Sea (Figure 39). Tropical Cyclone Gonu was of category 5 and matched the strongest storm recorded in the whole of Northern Indian Ocean (Harrison 2008; Mooney 2008). The human and economic costs of Cyclone Gonu were considerable with about 75 deaths and 2.88 billion Euro in damage. In Oman and in the east coast of the UAE, including Dibba MPA, damages by the strong waves along the coast were noted. Corals on exposed shores were almost entirely eliminated, and the damage in sheltered bays, coves and islands was variable. Gonu affected colonies down to 7 meters depth with major impacts on *Sinularia*, *Sarcophyton* and *Acropora*. By March 2008, there was significant re-growth of some soft coral areas, although hard coral communities in shallow exposed areas have shown less resilience (Wilkinson 2008).

Figure 39 Satellite image of Tropical Cyclone Gonu captured on June 7, 2007 by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite <http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=18446l> (12/06/2009).

The shallow *Acropora* reefs, from the east coast of UAE, still with low area coverage, might be slow to recover from the Gonu impact because forecasts for SST indicate that future temperatures will be unfavourable for coral growth. As happened in the past, continuing landfill in the east coast arising from development will add stresses to near shore reefs, causing further degradation (Rezai et al. 2004). Nevertheless, many reefs are not irretrievably lost and will recover if human stresses can be reduced or if the devastating impacts of coral bleaching, diseases and predators are not repeated in the short-term (Wilkinson 2008).

3.3.2 ***Anthropogenic issues***

3.3.2.1 Pollution

As a major hydrocarbon producer, oil pollution is a major concern to the UAE, which has exerted great efforts to protect the marine environment and preserve marine life. Despite of these efforts, incidences of oil spills occur. In UAE hydrocarbon contaminant influx is mainly from tankers releasing ballast, tank cleaning, and leakage from drilling rig production and platform, ship accidents and seepage from land-based sources which is very common (Howari 2004).

Oil spills in the region have the potential to significantly impact the MPA's flora and fauna. The UAE offshore faces frequent occurrences of oil spills both in the Arabian Gulf and the Gulf of Oman (Al-Azab et al. 2005). In particular the Fujairah offshore has considerable spill concentrations found in multi-temporal image analysis. The frequent dust fallout in the area has an effect on the movement and density of oil spills on the sea surface, acting as a sinking mechanism for oil droplets.

One of the biggest oil spills in the east coast of UAE occurred in March 31, 1994. A total of 15,900 tons of crude oil leaked into the Arabian Sea after the Panamanian-flagged supertanker Seki spilled the crude 16 km off the UAE port of Fujairah, just outside the Gulf, when it collided with the UAE tanker Baynunah, which was in ballast. Oil reached the UAE coast north of Khor Fakkan close to the Strait of Hormuz. The oil slick severely polluted several beaches and threatened more than 40 km of coastline (Pearson et al. 1998; Howari 2004).

When an oil spill occurs the oil in water bodies rises to the top, forming a film that blocks sunlight, impairs photosynthesis, and prevents oxygen replenishment, which disrupts the oxygen cycle and enhances growth and reproduction of micro-organisms that use oil as a food source. This process leads to eutrophication, whereby available oxygen needed by fish and other living organisms that comprise the aquatic food chain is depleted (Howari 2004).

In the only documented study on the impact of an oil spill on the Fujairah coast, Pearson et al. (1998) estimated up to 33,203,781 Euro the total comprehensive environmental damages by the Seki Oil spill for habitat, commercial fisheries, sea turtles, marine birds, and marine-based recreation. Immediately after the spill, a fishing ban was declared that caused fishermen to lose from 20 to 40 days of fishing, market prices at Fujairah were reduced for 6 months to one year after the spill, due mainly to public reluctance to buy fish from the east coast that were believed to be contaminated. Polycyclic aromatic hydrocarbons (PAHs) could be indeed detected in fish tissues 19 months after the spill. Decrease in catch rates of total species and demersal species at Dibba in April and May 1994 were about 63% and 83%, respectively, of their average rate before the spill (Pearson et al. 1998).

Release of waste products from boats can also reduce water quality and may have the localised effect of increasing nutrient levels, with a consequent adverse impact on coral health. In case of material garbage, different marine life can be trapped as well as break and damage corals (Figure 40).

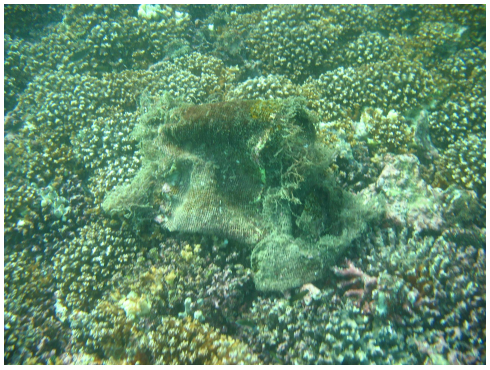


Figure 40 Garbage found in corals of Dibba MPA.

3.3.2.2 Alien Species

The existence of an HAB, by *Cochlodinium polykrikoides*, during the period of data collection, in Dibba MPA, changed completely the habitats and biodiversity in the area. Both the Arabian Gulf and Gulf of Oman have a high phytoplankton biodiversity where the presence of 38 potentially bloom-forming, or harmful algal taxa, were reported (Subba-Rao and Al-Yamani 1998). But the presence of *C. polykrikoides* in the region was for the first time notice during this period. A pattern of subsequent recurrence of *C. polykrikoides* blooms has been observed in other parts of the world, suggesting that this species may become a persistent HAB problem in this region and further monitor and protection in Dibba MPA is needed (Richlen et al. in press). It is known that increasing human population and demand for resources and development is one of the main reasons for the rise in the distribution and size of harmful algal blooms and dead zones around the globe

(Anderson 1997; Hinchley et al. 2007). Ballast water carried in ships has also been recognised as one of the main vectors for the translocation of non-indigenous marine organisms around the world. Based on preliminary analysis (Marquis unpublished), it is suspected that the algae bloom present in the east coast of UAE from August 2008 to May 2009 was due to a non-native algae species and therefore that ballast water discharge was involved at some point (Richlen et al. in press).

The UAE is dependent on international shipping for most of its trade and has a high level of ship traffic. Adding to the fact that, as mentioned before, the UAE are one of the main producer and exporter of oil and Fujairah being one of the largest bunkering port in the World, the chances of invasion by exotic species through intentional or accidental release of ballast waters are high (EAD-AGEDI 2006) and the risk they alter the marine life including Dibba MPA is of concern.

The UAE Federal Law No. 24 of 1999 concerning the protection of the environment strictly forbids the discharge of oil and ballast water into the sea by vessels, with severe punishments for violators. The UAE being member of ROPME, signed most of the International Maritime Organization (IMO) conventions, and only recently (15/01/2007) endorsed the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). However, ballast water management guidelines and regulatory practices are in their infancy in the country and should be revised by the government in an attempt to minimise the risk of new species becoming established.

Commercial scale aquaculture using sea net cage is being carried out off Dibba MPA. The main species currently cultured in this facility are the endemic Sobaity seabream (*Sparidentex hasta*) and the two exotic species: the Gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*). The nearest cage is located approximately 1.5 km off the coast of Dibba. Contacts with the aquaculture company during the data collection in Dibba MPA were tried but without success. Fish-farming has great potential economic benefits, often in areas where opportunities for livelihoods are small but there can also be severe problems of disease, pollution and accidental release to surrounding areas arising from the intensity of production. Some of the diseases of farmed fish may become endemic in wild fish, and as a result an entire wild fishery can become off-limits to fishing for decades (Kelleher 1999).

3.3.2.3 Coastal development

Due to coastal development, sediments from nearby dredging may contribute to mass mortality. The constant presence of construction in the Dibba MPA coast, with the upcoming resorts, will probably result in smother substrate that will exceed the clearing capacity of some filter-feeding animals on reefs, as well as reduce light penetration, which

may alter vertical distribution of plants and animals on reefs. Besides the direct influence of sediments in the marine habitats it may also absorb and transport other pollutants, especially pesticides, by absorbing them as suspended particles in the water column and transporting them to remote areas (SOMER 2003).

Besides the existing constructions in the coast of Dibba MPA, nearby developments can also influence negatively the protected area. The increasing number of hotel developments will also mean an increasing tourist pressure on the area and its ecosystems.

3.3.2.4 Commercial and recreational fishing

In the Gulf of Oman, fisheries represents the second most important natural resource, and the most important renewable natural resource; but on the other side it is a major human threat to coral communities (Carpenter et al. 1997; Rezai et al. 2004). During the data collection three lost *gargours* were spotted inside Dibba MPA, meaning that illegal fishing is carried out probably at night when patrolling does not exist. Reports of spearfishing in Dibba and Al Aqa MPA were also witnessed more than once (Tourenq personal communication 2009).

The changes in the location of the marking buoys were not related to any displacement due to storm in the region, so there is a high possibility that buoys were moved by fishermen, trying to fish in the protected area. A proper 24 hours patrol is urgently required to prevent these disturbs in the future.

3.3.2.5 Tourism

The tourism industry in Dibba is based primarily on the natural attractions and its image as an “unspoilt” holiday destination providing a variety of water and land based activities. Due to this selling image, the number of visitors to Dibba MPA is higher than the pressure capacity of Dibba MPA ecosystems. The soaring number of visitors (divers and non-divers) increase the potential of damaging fragile corals, either through deliberate or accidental contact, and the stress in marine life such as turtles (Figure 41 and Figure 42).

Figure 41 Tourists in Dibba MPA taking pictures while grabbing a turtle.

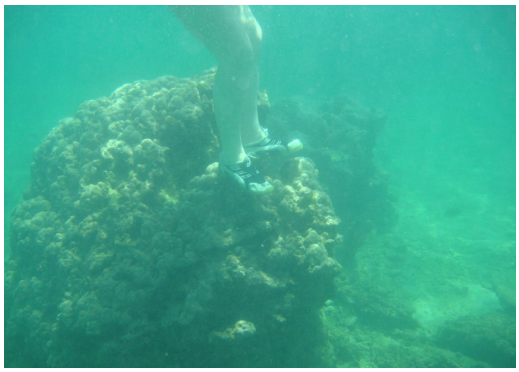


Figure 42 Tourists walking in the corals while snorkelling.

If visitation tends to increase significantly, damage minimisation strategies may need to be put in place, such as the installation of more moorings, division of small areas for each activity and awareness campaigns. Currently, diver pressure is within the carrying capacity at most sites, although tourism is being promoted throughout the region and number of divers per dive is rapidly increasing. Therefore, it is important to ensure that protective measures match rising tourist numbers.

3.3.2.6 Legal and Institutional Issues

As mentioned before, the UAE dispose of a wide range of laws, decrees and conventions concerning the protection of the marine environment, however, Dibba MPA suffers particularly from the non-application of international conventions and treaties concerning the protection of marine environment signed by the UAE, as well as the absence of federal law enforcement, mostly the Laws 23 and 24 and the absence of enforcement of the local Emiri Decree No. 1 for 1995 concerning the Fujairah Emirate marine protected areas. As such, the legal protection of Dibba MPA is inexistent, leaving gaps for infractions to be practised. Dibba MPA suffers notably from a lack of regular patrolling and monitoring by rangers/guards. The situation is worsened by the fact that there is no clear mandate for the 3 entities in charge of the monitoring and conservation of the marine environment in the area, namely: the Environment Protection and Development Department of Fujairah Municipality (EPDD), the Dibba branch of Fujairah Municipality and the Dibba Marine Environment Research Centre (DERC) of the Ministry of Environment and Water.

There is an urgent need to clarify and reinforce the mandates of the different authorities to ensure a proper conservation and management of marine ecosystems in Fujairah.

4. Conclusion - Dibba MPA Management Plan

4.1 General principles and guidelines

A management plan must provide protection and conservation of the designated protected area. For this it is imperatively necessary for the management of Dibba MPA:

1. Assign the Protected Area in an IUCN category;
2. Indicate the activities that are to be prohibited or regulated in the marine protected area, and the means of prohibiting or regulating them;
3. Align the institutional arrangements, assuring that police protection and awareness campaigns are covered.

This proposed management plan for Dibba MPA will not make any provisions that are inconsistent with the management principles for the IUCN category to which the protected area should be assigned.

A broad range of stakeholders, including government and non-government organizations, have an interest in the management of Dibba MPA. Implementing the targets requires to work together with stakeholders, namely the fishing communities on finding innovative solutions for sustainable use. According to Laffoley (2008) involving fishermen and other key stakeholders in MPA management, particularly at the community level, has proven very productive in several regions already. It is vital that government and the local community work in partnership to ensure effective conservation outcomes in Dibba MPA. Stakeholders should participate in all stages of the development and implementation of this Management Plan.

4.2 Specific management objectives

Underlying the local Emiri Decree No. 1 for 1995 concerning the Fujairah Emirate MPAs, the proposed Dibba MPA management plan main goal is to ensure the integrity and conservation of Dibba MPA ecosystem, habitats and wildlife for future generations. Therefore, the main objectives are to:

1. Minimize human impacts on the habitats of benthic and pelagic fauna, including migratory marine mammals, reptiles and seabirds, that depend on Dibba MPA for foraging, shelter and reproduction (especially species that are classified in the IUCN Red List and CITES);
2. Promote scientific research and environmental monitoring as primary activities associated with sustainable resource management and use of Dibba MPA;

3. Provide a scientific reference area for further studies of natural ecosystems in UAE;
4. Guarantee an adequate police protection according to an updated legal framework.

In this context, and in the absence of a proper scheme, regular monitoring is an essential and powerful tool to raise awareness on the problems in Dibba MPA and the need for management among local communities, tourists and management staff. To ensure that Dibba MPA management staff understands the resources they are managing, it is important that all managers and staff participate in some monitoring, whenever possible.

To achieve this goal it is necessary to consider several detailed issues as:

1. To preserve a representative sample of the corals ecosystem and a variety of its component and associated habitats, biotic communities and species (biodiversity);
2. To protect endangered, depleted, or rare species (*e.g.* hawksbill turtles, green turtles, whale-sharks, groupers);
3. To maintain a high quality coastal environment and water quality;
4. To safeguard the breeding stocks of fisheries species for replenishment of depleted areas;
5. To encourage and facilitate research compatible with the protected area's objectives;
6. To monitor natural processes and responses to climate change (bleaching, high sea temperatures, high salinity);
7. To preserve the natural character and scenic value of the site;
8. To control increasing activities that may damage or destroy all, or part, of the values of the area for conservation and development;
9. To promote uses compatible with conservation and sustainable development objectives;
10. To regulate all activities inconsistent with the objectives of the protected area;
11. To maintain the social and economic benefits of the area;
12. Involve and educate the community;
13. To prevent dredging or other manipulations of the environment and control construction activities within the protected area;
14. To prohibit anchoring, poling, and beaching of boats on the area;
15. To restrict snorkelling and SCUBA diving activities into readily monitored locations;
16. To control access by land, sea, and air.

4.3 Management strategies and actions

At each of the stages of decision-making in Dibba MPA according to the management plan, the following factors should be taken into account:

1. Government policies and MPA objectives;
2. Biogeographic classification;
3. Physical and biological resources;
4. Climate;
5. Accessibility;
6. Heritage;
7. Current usage of the MPA and adjacent areas;
8. Management resources including finance;
9. Community participation and benefits.

4.3.1 *IUCN classification*

According to the IUCN protected area management categories, Dibba MPA could be classified as Category II "National Park" (Dudley 2008):

> ***"Category II** protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities."*

Normally small areas, as Dibba MPA, are classified as Ia or IV, but size is not used as a distinguishing feature for classification. Even though Dibba MPA could be classified as Category IV, Category II is more adequate since its principal goal is to maintain ecological integrity at ecosystem scale, whereas Category IV is aimed at protecting habitats and individual species.

The other Categories are not applicable to Dibba MPA since:

1. Categories Ia and Ib do not allow tourist infrastructure and visitation;
2. Category III is focused around a single natural feature;
3. Category V protected areas are essentially cultural landscapes;
4. Category VI has resource use permit.

Once a category is assigned, governments are requested to report this to the UNEP World Conservation Monitoring Centre, so that information can be included in the World Database on Protected Areas (WDPA) and the "UN List of Protected Areas". Reporting is

voluntary, but is requested by a number of United Nations resolutions and policies, most recently in the “CBD Programme of Work on Protected Areas” (Dudley 2008).

Dibba MPA is one of the three marine protected area located in the Fujairah Emirates together with Dadna and Al Aqa. Connecting these three MPA together to create a network of MPA with the not yet officially declared, Al Bidiyah, could be done through biological corridors and steppingstones (sympathetic habitat used by migratory species) and buffer zones. Buffer zones and biological corridors may not be protected areas but instead areas where a combination of voluntary agreements and/or compensation packages helps to protect the integrity of the protected area through landscape approaches and connectivity conservation. Although larger MPA, or a MPA network, guarantees a more ecological protection of the environment it can be economically or institutionally impractical due to the higher economic effort, so all the objectives and strategies should be take in account carefully.

Ahead of such initiative however, a proper characterization and mapping of marine habitats along the coast is urgently required as a first step to help stakeholders and decision makers toward developing a comprehensive program for the conservation and management of these vital resources for biodiversity, fishery and tourism and propose management options for the marine protected area already in place.

4.3.2 *Research and Development*

Scientific research is fundamental to performance assessment, required to ensure that the identified management strategies and actions contribute effectively towards the achievement of the objectives of Dibba MPA.

Research project conducted inside Dibba MPA should be a non-intrusive scientific research that is compatible with the strategic objectives of the MPA and management goals. It is also essential to control activities and conduct research studies outside the MPA boundaries as that may affect the long-term viability of Dibba MPA. Research and monitoring should provide answers to the following broad questions that affect both terrestrial and marine ecosystems of Dibba MPA:

1. What are, or have been, the pressures on the system (whether natural, *e.g.* severe storms and tectonic events, or human-induced, such as pollution, habitat destruction and over-exploitation)?
2. What is the state of the managed system, in particular of its:
    a. Dominant biota;
    b. Rare, endangered or threatened species;
    c. Ecological processes (*e.g.* sedimentation, absorption of nutrients and toxic elements);

d. Ecological states (*e.g.* water quality, temperature, suspended sediment levels, nutrient levels)

3. What is, or has been, the effect of the management response?
4. Are the measures specified in the management plan being implemented?
5. Are people complying with the conditions in the plan?
6. Is management meeting its objectives?
7. What are the monitoring changes in fish stocks?
8. What is the level of impact from tourists as visitor numbers grow?
9. What are the changes in the socio-economic factors?
10. Are the values and needs of the human societies involved?
11. What are the capabilities and interests of the institutions that work with the management team?

4.3.3 *Development of entrepreneurial activities*

Actions regarding aquatic activities by hotels, resorts and tour companies should be performed considering the objectives of the management plan and the interests of the stakeholders. For this:

1. Visitor numbers should be managed through a limit on the number of commercial operators permitted to operate within Dibba MPA. A limit on visitor numbers will ensure that management is not inconsistent with the strategic objectives of the MPA;
2. Walking in the islet should not be permit;
3. Contact with commercial tour operators to foster a sense of ownership and responsibility for Dibba MPA and to cooperatively develop a code of practice for permitted activities within Dibba MPA should be accomplished;
4. Monitoring of the visitor impacts on biodiversity values of Dibba MPA should be conducted. This should include monitoring for the need for moorings and if required, new moorings should be installed.
5. Minimisation of the risk of damage to Dibba MPA from tourism and recreation activities should be enhanced through development and distribution of educational material on best environmental practices throughout all the entrepreneurial industries linked to the MPA;
6. Standard signs, information, and visitor logbooks should be enforced to provide basic interpretative information for visitors regarding the MPA;
7. Permitted visitors to Dibba MPA should be required to report on the number of visits, duration of stay, mooring/anchoring locations and activities carried out to the responsible authorities;

8. Construction or alteration of any existing or new facility, navigation aid or installation should only be carried out in accordance with a permit issued by the responsible authority.
9. Commercial tours (that not include fishing tours) may be carried on Dibba MPA, in accordance with a permit issued by the responsible authority. Permits may be issued where:
    a. The tour is to be conducted by a person with appropriate credentials, training and experience;
    b. Tour activities will not adversely affect the natural or cultural values of Dibba MPA;
    c. Tour activities will not conflict or cause undesirable overlap with other activities in Dibba MPA;
    d. Tour activities do not include animal feeding;
    e. The tour operator provide a brief report on tours conducted in the Dibba MPA, using a form provided by the responsible authority;
    f. The total number of participants in the tour does not exceed the number agreed by the responsible authority.
10. Establishing area boundaries for specific activities;
11. Issuing permits to control or limit the number of participants engaged in a form of use;
12. Limiting access by setting a carrying capacity which may not be exceeded.

4.3.4 *Intensified information, education and communication campaign*

According to Kelleher (1999) without the support of the public and stakeholders, management costs will rise and the effectiveness of the MPA will decline, failing to achieve its purposes. Therefore, winning the support of local people is particularly important at the planning stage. Liaison with users of Dibba MPA, relevant government agencies, industry groups and other stakeholders should be undertaken to prepare and distribute educational and interpretative material to raise compliance with management prescriptions for the MPA and awareness of its conservation values.

To be able to meet the challenges of unprecedented pressure from human activities and the effects of climate change, Dibba MPA managers must be adequately equipped, trained and informed to safeguard Dibba MPA. Involving community volunteers and tourists in monitoring not only will provide basic scientific data over a wider area, but also ensures that the community understands the need for coral reef management, and it also

creates a sense of awareness and position of the resources amongst the different stakeholders.

4.4 Institutional arrangements

4.4.1 *Staffing and training*

One of the most important ways of engaging the stakeholders with the objective of a MPA is to use an inter-disciplinary project team which pools knowledge and expertise. In an inter-disciplinary approach, an issue is treated as a whole by representation of different disciplines working the solution out together. Marine scientists and ecologists, social scientists, lawyers, engineers and economists are obvious candidates (Kelleher 1999).

Besides the existence of a team responsible for the coordination of studies and management actions carried out in Dibba MPA, it is essential to have regular patrols in the area to record, collect and remove marine debris, to maintain signs, and check on overall activity and impacts within the MPA. Without a proper police force in the area assuring the enforcement of the law, none of the objectives of the management plan will be easily attained.

To dispose of a team capable of leading the projects towards the main goals of Dibba MPA management plan, a training program should be taken in consideration regarding the following:

1. Ensure that staff at every level (including volunteers) are well trained initially and that their skills are continually developed and updated;
2. Include formal training in the work place, as well as through external courses;
3. Extend to local people, such as fishers, tourism operators and scientists, who are involved in the MPA;
4. Where possible, include staff exchanges.

Regarding budgetary requirements it is suggested that between 5 and 10% of the budget for the total Dibba MPA management should be put into monitoring (Hill and Wilkinson 2004).

4.4.2 *Facilities and equipment*

To ensure an efficient management of Dibba MPA, it is necessary to dispose of proper:

1. Explicative onshore (sign posts) and offshore (buoys) signaling;
2. Facilities for staff (offices) and equipment (storerooms);
3. Vessels for surveillance, monitoring, and survey patrols, equipped with VHF, GPS and safety devices;
4. Standard uniforms for staff.

4.4.2.1 Legislation update

A detailed update of the actual law regarding Dibba MPA has to be carefully performed. It is imperative the prohibition of certain uses, and the legal update should include:

1. VESSEL TRAFFIC

   Vessel traffic should be only permit to boats belonging to certified dive centres and tourists operators that got the authorization from the responsible authority. The prohibition of vessel traffic is not applied to necessary operations of public vessels that include operations essential for national defence, law enforcement, and responses to emergencies that threaten life, property, or the environment. Vessels without authorization may only enter Dibba MPA to seek shelter during times of distress, or to help other vessels in case of emergency.

2. MINERAL AND HYDROCARBON LEASING, EXPLORATION, DEVELOPMENT, AND PRODUCTION

   No leasing, exploration, development, or production or minerals or hydrocarbons shall be permitted within Dibba MPA.

3. ACTIVITIES TO FORBID:
   a. Operating a vessel at more than 4 knots within Dibba MPA;
   b. Diving or snorkelling without a dive flag;
   c. Operating a vessel in such a manner which endangers life, limb, marine resources, or property;
   d. Releasing exotic species;
   e. Damaging or removing markers, mooring buoys, scientific equipment, boundary buoys, and trap buoys;
   f. Using or possessing explosives or electrical charges;
   g. Touching or standing on living or dead coral.
   h. Entry or activities without a Dibba MPA permit from the responsible authority;
   i. Commercial or recreational fishing;
   j. Possession of spearfishing equipment;
   k. Dumping of waste or littering in Dibba MPA.

5. Discussion

Dibba MPA was first established due to its exemplar of local marine biodiversity and habitats. The lack of a management plan after the legal implementation has lead the area to an abandon estate were the loss of habitats and species has been gradually noticed.

To guarantee the achievement of the primary interest of His Highness Sheikh Hamad Bin Mohammed Al Sharqi, it is necessary to address the issues facing Dibba MPA, mainly:

1. The lack of available data on natural resources;
2. The absence of proper fixed and marked limits;
3. The lack of patrolling and guarding;
4. The vague legislation and institution mandates;
5. The poor public awareness;
6. The non-use of a protected area for research purposes.

To achieve the goals of a proper management plan and overcome the major problems of Dibba MPA, several studies need to be done. The present study just provided the base and the necessary organization of data to initiate the proposed management plan.

To facilitate future research studies in Dibba MPA, it is mandatory the compilation of spatial data into a Geographic Information System (GIS) database, the most effective way to store, analyse and map relevant information relative to MPAs. This information can then be easily used in forefront software produced specifically for MPA management, such as MARXAN (http://www.uq.edu.au/marxan).

To guarantee the maintenance of Dibba MPA, a list of recommended studies that should be conducted as soon as possible, to answer some of the questions addressed in chapter 4.3.2, follows:

A. Short-term projects:

1. Percentage cover of corals (both live and dead), sponges, algae and non-living material;
2. Extent and type of coral disease;
3. Extent and nature of coral bleaching;
4. Opportunistic monitoring of marine turtles (tagging and measuring marine turtles);
5. Study of the breeding birds in the coast of Dibba MPA, especially the species classified in IUCN Red List and BirdLife International;
6. Provide financial support through ROPME, ICRI, ICRAN, ICLARM, IOC-UNESCO for training of coral reef monitors and scientists, and initiate coral reef monitoring, analysis and reporting projects;

7. Base maps: study region boundary, nautical charts, shoreline features, bathymetry, etc.

B. Long-term projects:

1. Resource status and long-term trends
    a. Evaluate the status of the resources and how are they changing over time;
    b. Establish a long-term ecological monitoring program and database, including methods to disseminate information on the management of the coral reef ecosystem;
    c. Develop national coral reef policies followed by establishing focal points within the existing institutions to coordinate research and monitoring among national and foreign scientists;
    d. Calibrate or standardise monitoring survey procedures, data storage, analysis and reporting, using regional (*e.g.* PERSGA - ROPME) and international protocols (*e.g.* Reef Check, GCRMN);
2. Status and long-term trends of user groups
    a. Identify the major users and stakeholders of Dibba MPA patterns of use and attitudes towards management, and how they are changing over time;
3. Impacts of large-scale disturbances
    a. Document impacts of coral bleaching, crown-of-thorns starfish outbreaks, oil spills, red tides and tropical storms that affect Dibba MPA;
4. Impacts of human activities
    a. Document the activities of people that have been affecting Dibba MPA and its resources, including outside fishing, land use practices, coastal developments, and tourism;
5. Education and awareness raising
    a. Provide support for Dibba MPA management through raising awareness and education of user communities, government, other stakeholders and management staff;

Regarding the species that are classified according to IUCN Red List (2009) and CITES list (2009) (see Chapter 3.1.1) these should be studied and monitored in more detail. Having a well managed MPA where these species can grow will bring the possibility to study and understand the threats and trends of each population. Following is the list of some of the conservation actions that could be conducted in Dibba MPA according to each species:

1. Corals (*Acanthastrea echinata, Acropora arabensis, Acropora paragemmifera, Favia matthaii, Favites pentagona, Galaxea fascicularis, Goniopora albiconus, Goniopora ciliatus, Hydnophora microconos, Platygyra daedalea, Pocillopora damicornis, Pseudosiderastrea tayami, Symphyllia radians*)
    a. Research in taxonomy, population, abundance and trends, ecology and habitat status, threats and resilience to threats and restoration action;
    b. Recovery management;
    c. Disease, bleaching pathogen and parasite management.
2. *Eretmochelys imbricata* and *Chelonia mydas*
    a. Tagging projects to understand the migratory pattern of these species;
    b. Research on their main threats as destruction of nesting habitats, destruction of foraging habitat, entanglement and ingestion of marine debris, bycatch, disease and oil pollution.
3. *Epinephelus stoliczkae*
    a. Research about its biology, ecology and fisheries. Specially in spawning aggregations to avoid fisheries of this species during this period;
    b. Fisheries market surveys.
4. *Epinephelus multinotatus*
    a. Research on the sub-population of Arabian Gulf and Gulf of Oman. According to Heemstra and Randall (1993) *E. multinotatus* has three separate sub-populations in the Indian Ocean based on differences in colour pattern and scale counts, being one of these the Arabian Gulf and Gulf of Oman sub-population.
    b. Fisheries market surveys.
5. *Cephalopholis hemistiktos*
    a. Fisheries market surveys.
6. *Aetobatus narinari*
    a. Research in the taxonomic resolution of the almost certain possibility known that *Aetobatus narinari* could be a species-complex of at least four different species;
    b. Fisheries market and bycatch surveys.
7. *Cephalopholis hemistikto*
    a. Research in spawning aggregations to avoid fisheries of this species during this period since it is expected that this species will become more of a focus of the fisheries (Choat et al. 2008);
    b. Fisheries market surveys.

8. *Carcharhinus melanopterus*
    a. Studies on abundance and distribution
    b. Fisheries market surveys
9. *Rhincodon typus*
    a. Tagging and photo-iddentification projects to understand the migratory pattern of these species.

To guarantee the effectiveness of the proposed management plan, periodic reviews should be undertaken. The period between reviews should not be either too short that lack of resources becomes a problem, nor too long that management is not responsive. A period of 5–7 years is the normal chosen time-scale according to Kelleher (1999). Review should be based on monitoring of impacts, patterns of use, and the effectiveness of the existing management arrangements in attaining the objectives and improved scientific understanding.

References

Agardy T, Staub F (2006) Marine Protected Areas and MPA Networks. Science Foundation United Sates Fish and Wildlife Service

Ahmad AA, Al-Janahi AAR (1999) The Fisheries in the United Arab Emirates Regional Workshop on Fisheries Monitoring, Control and Surveillance. Ministry of Agriculture and Fisheries, United Arab Emirates, Muscat, Sultanate of Oman 79-86

Al-Abed I, Hellyer P (2001) The United Arab Emirates: A New Perspective Trident Press, London

Al-Abed I, Vine P, Hellyer P, Vine P (2008) UAE Yearbook. Trindent Press, London

Al-Azab M, El-Shorbagy W, Al-Ghais S (2005) Oil pollution and its environment impact in the Arabian Gulf region. Developments in Earth & Environmental Sciences 236

Al-Cibahy A, Al-Addessalaam T, Al-Mubarak R, Launay F, Tourenq C (2008a) Coral Reef Conservation in Abu Dhabi and the United Arab Emirates. Reef Encounter 36:14-16

Al-Cibahy A, Al-Harthi S, Al-Moati A, Al-Mansoori A, Foster KA, Launay F, Al-Mubarak R, Purkis S, Riegl B, Tourenq C (2008b) Conservation and Management Plan of Abu Dhabi and Eastern Qatar Coral Reefs. Supreme Council for the Environment and Natural Reserves (SCENR) of the State of Qatar, Environment Agency of Abu Dhabi Emirate (EAD), National Coral Reef Institute (NCRI), Emirates Wildlife Society in association with the World Wide Fund for Natures (EWS-WWF) Qatar & Abu Dhabi

Anderson DM (1997) Turning back the harmful red tide. Nature 388:513-514

Aspinall S (1996) The breeding birds of the United Arab Emirates. Hobby Publications, Uk

Bagader A, El-Sabbagh ATE-C, Al-Glayand MA-S, Samarrai MYI-D, Llewillyn OA-a-R (1994) Environmental Protection in Islam. IUCN, Glan, Switzerlan and Cambridge, UK

Baker AC, Starger CJ, R.McClanahan T, Glynn PW (2004) Corals' adaptive response to climate change. Nature 430:741

Bernstein L, Bosch P, Canziani O, Chen Z, Christ R, Davidson O, Hare W, Huq S, Karoly D, Kattsov V, Kundzewicz Z, Liu J, Lohmann U, Manning M, Matsuno T, Menne B, Metz B, Mirza M, Nicholls N, Nurse L, Pachauri R, Palutikof J, Parry M, Qin D, Ravindranath N, Reisinger A, Ren J, Riahi K, Rosenzweig C, Rusticucci M, Schneider S, Sokona Y, Solomon S, Stott P, Stouffer R, Sugiyama T, Swart R, Tirpak D, Vogel C, Yohe G (2007) Climate Change 2007: Synthesis Report. Intergovernmental Panel on Climate Change, Valencia, Spain 73

BirdLife International (2000) Threatened Birds of the World Lynx Editions

Borrini-Feyerabend G (2007) The "IUCN protected area matrix" - A tool towards effective protected area systems IUCN World Commission on Protected Areas Task Force: IUCN Protected Area Categories, Andalusia, Spain 12p.

Botsford L, Hastings A, Gaines SD (2001) Dependence of sustainability on the configuration of marine reserves and larval dispersal distance. Ecology Letters 4:144-150

Brook M, Dawoud MA (2005) Coastal water resources management in the United Arab Emirates. In: Agency ERaWD (ed) Integrated Coastal Zone Management in the United Arab Emirates, Abu Dhabi 12

Buddemeier RW, Baker AC, Fautin DG, Jacobs JR (2004) The Adaptive Hypothesis of Bleaching. Coral Health and to Disease Meeting:427-444

Burt J, Bartholomew A, Usseglio P (2008) Recovery of corals a decade after a bleaching event in Dubai, United Arab Emirates Marine Biology 154:27-36

Carpenter KE, Krupp F, Jones DA, Zajonz U (1997) The living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates FAO species identification guide for fishery purposes. FAO, Rome 293

Choat JH, Rocha L, Ferreira B, Bertoncini AA, Craig M (2008) *Cephalopholis hemistiktos* IUCN 2009 Red List of Threatened Species Version 20091. www.iucnredlist.org

Christie P, White AT (2007) Best practices for improved governance of coral reef marine protected areas. Coral Reefs 26:1047–1056

Christie P, Lowry K, White AT, Oracion EG, Sievanen L, Pomeroy RS, Pollnac RB, Patlis JM, Eisma R-LV (2005) Key findings from a multidisciplinary examination of integrated coastal management process sustainability. Ocean & Coastal Management 48:468-483

CITES (2009) Convention on International Trade in Endangered Species of Wild Fauna and Flora. Appendices I, II and III. Available online at http://www.cites.org/

Claereboudt MR (2006) Reef Corals and Coral Reefs of the Gulf of Oman. The Historical Association of Oman, Sultanate of Oman

Coles SL (2003) Coral species diversity and environmental factors in the Arabian Gulf and the Gulf of Oman: a comparison to the Indo-Pacific region. Atoll Research Bulletin 507:1-19

Dudley N (2008) Guidelines for Applying Protected Area Management Categories. IUCN, Gland, Switzerland x + 86

Dunnigan JH (2008) Revised Draft Framework for Developing the National System of Marine Protected Areas and Response to Comments. Federal Register 73:14227-14228

EAD-AGEDI (2006) Marine and Coastal Environment Sector Paper. Environmental Agency Abu Dhabi, Abu Dhabi, UAE 151

Evans M (1994) Important Bird Areas in the Middle East. BirdLife International, Uk

Everett GV (1999) An Outline Overview of Issues of Concern to Fisheries Monitoring, Control and Surveillance in the Northwest Indian Ocean - Technical Paper 2 FAO/FISHCODE Report of a Regional Workshop on Fisheries Monitoring, Control and Surveillance, Muscat, Oman 117-130

EWS-WWF (2008) Final report January 2005 - December 2007 Coral Reef Investigations in Abu Dhabi and Eastern Qatar, Dubai 74

FAO (1981) Demersal resources of the Gulf and the Gulf of Oman. Regional Fishery Survey and Development Project 122

FAO (2007) The state of the world fisheries and aquaculture 2006. Food and Agriculture Organization of the United Nations, Rome, Italy 162

Fujairah Municipality (2001) Fujairah.. Roots and Flowers. Sea Protectorates. Fujairah Municipality, Fujairah, UAE

Game ET, Watts ME, Wooldridge S, Possingham HP (2008) Planning for Persistence in Marine Reserves: A question of catastrophic importance. Ecological Applications 18:670-680

Goldberg J, Wilkinson C (2004) Global Threats to Coral Reefs: Coral bleaching, global climate change, disease, predator plagues, and invasive species In: Wilkinson C (ed) Status of Coral Reefs of the World: 2004, pp67-92

Government of Fujairah (2007) Fujairah Statistics Yearbook. Statistics and Planning Department Government of Fujairah, Fujairah

Government of Fujairah (2008) Fujairah Statistics Yearbook. Statistics and Planning Department Government of Fujairah, Fujairah

Grandcourt E, Al-Abdessalaam TZ, Francis F, Al-Shamsi AT, Al-Ali K, Al-Ali S (2004) Biological reference points, resource status and management options for the key demersal species of Abu Dhabi Emirate. Environmental Research and Wildlife Development Agency, Abu Dhabi, UAE

Grandcourt EM, Abdessalaam TZA, Francis F, Shamsi ATA (2005) Population biology and assessment of the orange-spotted grouper, Epinephelus coioides (Hamilton, 1822), in the Southern Arabian Gulf. Fisheries Research 74:55-68

Grimsditch GD, Salm RV (2006) Coral Reef Resilience and Resistance to Bleaching. IUCN, Gland, Switzerland 52

Harrison P (2008) UNEP Year Book 2008: An Overview of Our Changing Environment. UNEP Division of Early Warning and Assessment (DEWA)

Hartmann S, Grandcourt EM, Shamsi AA, Francis F, Ali KA, Ali SA, Suwaidi AA (2005) Annual Fisheries Statistics for Abu Dhabi Emirate 2004. Environmental Research and Wildlife Development Agency, Abu Dhabi

Heemstra PC, Randall JE (1993) Groupers of the World (Family Serranidae, Subfamily Epinephelinae): An Annotated and Illustrated Catalogue of the Grouper, Rockcod, Hind, Coral Grouper and Lyretail Species Known to Date. FAO Fisheries Synopsis 125:vii + 382

Hellyer P, Aspinall S (2005) The Emirates: A Natural History. Trident Press, Ltd, London

Hilborn R, Stokes K, Maguire JJ, Smith T, Botsford LW, Mangel M, Orensanz J, Parma A, Rice J, Bell J, Cochrane KL, Garcia S, Kirkwood GP, Sainsbury K, Stefansson G, Walters C (2004)

When can marine reserves improve fisheries management? Ocean and Coastal Management 47:197-205

Hill J, Wilkinson C (2004) Methods for Ecological monitoring of Coral Reefs. A Resource For Managers Version 1. Australian Institute of Marine Science, Townsville

Hinchley D, Lipsett-Moore G, Sheppard S, Sengebau FU, Verheij E, Austin S (2007) Biodiversity Planning for Palau's Protected Areas Network: An Ecoregional Assessment TNC Pacific Island Countries Report No 1/07. The Nature Conservancy, Indo-Pacific Resource Centre, South Brisbane, Australia

Hodgson G, Hill J, Kiene W, Maun L, Mihaly J, Liebeler J, Shuman C, Torres R (2006) Reef Check Instruction Manual: A guide to REef Check Coral Reef Monitoring. Reef Check Foundation, California, USA 86

Howari FM (2004) Investigation of Hydrocarbon Pollution in the Vicinity of United Arab Emirates Coasts Using Visible and Near Infrared Remote Sensing Data. Journal of Coastal Research 20:1089–1095

Hutchings JA (2000) Collapse and recovery of marine fishes. Nature 406:882-885

IUCN-WCPA (2008) Establishing Marine Protected Areas Networks - Making it Happen. IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy, Washington, D.C. 118

IUCN (1994) Guidelines for Protected Areas Management Categories. IUCN, Cambridge, Uk and Gland, Switzerland 261

IUCN (2004) Managing Marine Protected Areas: A Toolkit for the Western Indian Ocean. IUCN Eastern African Regional Programme, Nairobi, Kenya xii + 172pp

IUCN (2009) The IUCN Red List of Threatened species. Available online at: http://www.iucnredlist.org/

Javed S, Khan SB (2003) Important Islands for bird conservation in the Abu Dhabi Emirate. Unpublished Report. Environmental Research and Wildlife Development Agency, Abu Dhabi

Jongbloed MVD, Feulner GR, Boer B, Western AR (2003) The comprehensive guide to the wild flowers of the United Arab Emirates. E.R.W.D.A. , Abu Dhabi

Kelleher G (1999) Guidelines for Marine Protected Areas. In: Phillips A (ed). IUCN, Gland, Switzerland and Cambridge, UK xxiv +107pp

Kritzer JP, Sale PF (2004) Metapopulation ecology in the sea: from Levins' model to marine ecology and fisheries science. Fish and Fisheries 5:131-140

Lack M, Sant G (2006) World shark catch, production & trade 1990-2003. Australian Government Department of the Environment and Heritage 29

Laffoley DdA (2008) Towards Networks of Marine Protected Areas. The MPA Plan of Action for IUCN's World Commission on Protected Areas. IUCN-WCPA, Galn, Switzerland 28

Marshall P, Schuttenberg H (2006) A Reef Manager's Guide to Coral Bleaching. Great Barrier Reef Marine Park Authority, Townsville, Australia 166

McClanahan TR, Sheppard CR, Obura DO (2000) Coral reefs of the Indian Ocean: theirs ecology and conservation. Oxford University Press, NY

Miththapala S (2008) Coral Reefs. Coastal Ecosystems Series (Vol 1). Ecosystems and Livelihoods Group Asia, IUCN, Colombo, Sri Lanka iii + 36

Mooney C (2008) Storm World: Hurricanes, Politics, and the Battler Over Global Warming. Houghton Mifflin Harcourt

Mora C, Andréfouët S, Costello MJ, Kranenburg C, Rollo A, Veron J, Gaston KJ, Myers RA (2006) Coral Reefs and the Global Network of Marine Protected Areas. Science 312:1750-1751

Olson D, Dinerstein E (1998) The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. Conservation Biology 12:502-515

Olson DM, Dinerstein E (2002) The Global 200: Priority Ecoregions for Global Conservation. Annals of the Missouri Botanical Garden 89:199-224

Pauly D, Christensen V, Guénette S, Pitcher TJ, Sumaila UR, Walters CJ, Watson R, Zeller D (2002) Towards sustainability in world fisheries. Nature 418:689-695

Pearson WH, M. S, Al-Ghais SM, Neff JM, Brands CJ, Welman K, Green T (1998) Assessment of Damages to Commercial Fisheries and Marine Environment of Fujairah, United Arab Emirates, Resulting from the Seki Oil Spill of March 1994: A Case Study. Yale P. & ES Bulletin 1-17

Pilcher NJ, Wilson S, Alhazeem SH, Shokri MR (2000) Status of coral reefs in the Arabian/Persian Gulf and Arabian Sea region (Middle East) Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science, pp55-64

Pous SP, Carton X, Lazure P (2004) Hydrology and circulation in the Strait of Hormuz and the Gulf of Oman-Results from the GOGP99 Experiment: 2. Gulf of Oman. J Geophys Res 109

Randall JE (1995) Coastal Fishes of Oman. University of Hawaii Press, Honolulu

Raouf MA (2007) State of the environment in GCC countries: assessment of year 2006 and outlook for year 2007 Gulf Yearbook 2006-2007. Gulf Research Center, Dubai, pp461-481

Reynolds RM (1993) Physical oceanography of the Gulf, Strait of Hormuz, and the Gulf of Oman—Results from the Mt Mitchell expedition. Marine Pollution Bulletin 27:35-59

Rezai H, Wilson S, Claereboudt M, Riegl B (2004) Coral reef status in the ROPME sea area: Aranian/persian gulf, gulf of Oman and Arabian. In: Wilkinson C (ed) Status of Coral Reef of the World 2004, pp155-170

Richlen ML, Morton SL, Jamali EA, Rajan A, Anderson DM (in press) The catastrophic 2008-2009 red tide in the Arabian gulf region, with observations on the identification and phylogeny of the fish-killing dinoflagellate Cochlodinium polykrikoides. Harmful Algae In Press, Corrected Proof

Riegl B (1999) Corals in a non-reef setting in the southern Arabian Gulf (Dubai, UAE): fauna and community structure in response to recurring mass mortality. Coral Reefs 18:63-73

Riegl BM, Purkis SJ, Kohler KE, Dodge RE (2006) Spatial patterns in Arabian Gulf coral assemblages (Jebel Ali, Dubai, U.A.E.) in response to temperature-forcing. 10th International Coral Reef Symposium:683-687

Romano A (2004) A Historical Atlas of the United Arab Emirates Historical atlases of South Asia, Central Asia, and the Middle East. The Rosen Publishing Group, pp64

Sale PF, Cowen RK, Danilowicz BS, Jones GP, Kritzer JP, Lindeman KC, Planes S, Polunin NVC, Russ GR, Sadovy YJ, Steneck RS (2005) Critical science gaps impede use of no-take fishery reserves. Trends in Ecology & Evolution 20:74-80

Salm RV, Clark JR, Siirila E (2000) Marine and Coastal Protected Areas: A guide for planners and managers. IUCN, Washington DC xxi + 371pp

Shallard B (2003) Fish Resource Assessment Survey Project of Abu Dhabi and UAE Waters. Environmental Research and Wildlife Development Agency Abu Dhabi, Abu Dhabi 66

Sheppard C, Price A, Roberts C (1992) Marine Ecology of the Arabian Region. Patterns and Processes in Extreme Tropical Environments. Academic Press, London

Siddeek MSM (1999) Marine fisheries resources, fisheries and marine environmental management, coral reefs and marine parks in the Northwest Indian Ocean Regional Workshop on Fisheries Monitoring, Control and Surveillance, Muscat 101-115

SOMER (2003) State of the Marine Environment Report. Regional Organization for the Protection of the Marine Environment, Kuwait 217

Soorae PS, Das HS, Al-Mazrouei H (2006) Records of sea snakes (subfamily Hydrophiinae) from coastal waters of the Abu Dhabi Emirate. Zoology in the Middle East 39:109-110

Spalding M, Ravilious C, Green EP (2001) World Atlas of Coral Reefs. University of California Press

Stefansson G, Rosenberg AA (2005) Combining control measures for more effective management of fisheries under uncertainty: quotas, effort limitation and protected areas Philosophical Transactions of the Royal Society Biological Sciences 360:133-146

Stefansson G, Rosenberg AA (2006) Designing marine protected areas for migrating fish stocks. Journal of Fish Biology 69:66-78

Subba-Rao DV, Al-Yamani F (1998) Phytoplankton ecology in the waters between Shatt Al-Arab and Straits of Hormuz, Arabian Gulf: A review. Plakton Biology and Ecology 45:101-116

Tourenq C (2007) Oral communication on Coral reef monitoring in Fujairah. In: Emirates Diving Association (ed), Dubai Media City, Dubai

Tourenq C, Launay F (2008) Challenges facing biodiversity in the United Arab Emirates. Management of Environmental Quality: An International Journal 19:283-304

Tourenq C, Shuriqi MK, Foster K, Foster G, Chellapermal C, Rein D (2008) First record of a Bowmouth Guitarfish, *Rhina ancylostoma*, in Northern Oman, with an up-date on the status of elasmobranchs (sharks and rays) in the United Arab Emirates. Zoology in the Middle East 44:114-118

van Harten A (2009) Arthropods encyclopaedia of UAE. Dar Al Ummah, Dar Al Ummah, Abu Dhabi, UAE

Veron JEN (2000) Corals of the World. Australian Institute of Marine Sciences, Townsville, Australia

Vogler C, Benzie J, Lessios H, Barber P, Worheide G (2008) A threat to coral reefs multiplied? Four species of crown-of-thorns starfish. Biology Letters 4:696-699

Wehe T, Fiege D (2002) Annotated checklist of the polychaete species of the seas surrounding the Arabian Peninsula: Red Sea, Gulf of Aden, Arabian Sea, Gulf of Oman, Arabian Gulf. Fauna of Arabia 19:7-238

Wilkinson C (2004) Status of Coral Reef of the World 2004

Wilkinson C, Green A, Almany J, Dionne S (2003) Monitoring Coral Reef Marine Protected Areas. Version 1. Australian Institute of Marine Science, Townsville, Australia

Wilkinson CR (2008) Status of coral reefs of the world : 2008. Global Coral Reef Monitoring Network, Reef and Rainforest Research Centre, Townsville, Australia

Wilson S, Fatemi SMR, Shokri MR, Claereboudt M (2002) Status of Coral Reefs of the Persian/Arabian Gulf and Arabian Sea region. In: Wilkinson C (ed) Status of Coral Reefs of the World: 2002. Australian Institute of Marine Sciences, pp53-62

WWF (2005) Marine Protected Areas: Providing a Future for Fish and People. WWF, Washington, D.C.

ANNEXES

A. List of species and families identified in Dibba MPA

(📷 indicates species that are presented by photo in the attached CD)

Phylum: ANNELIDA

Class: Polychaeta

Order: Sabellida

Family: SABELLIDAE

- *Branchiomma* sp.

Family: SERPULIDAE

- *Spirobranchus* sp.

Order: Terebellida

Family: TEREBELLIDAE

Phylum: ARTHROPODA

Class: Malacostraca

Order: Decapoda

Family: ALBUNEIDAE

- *Albunea* sp.

Family: ALPHEIDAE

- *Alpheus* sp.

Family: DIOGENIDAE

- *Clibanarius* sp.
- *Dardanus* sp.

Family: PAGURIDAE

Family: PALINURIDAE

- *Panulirus versicolor* 📷

Family: PORCELLANIDAE

- *Petrolisthes* sp.

Class: Maxillopoda

Order: Sessilia

Family: BALANIDAE

- *Balanus* sp.

Family: CATHMALOIDAE

- *Chthamalus* sp.

Phylum: CHORDATA

Class: Actinopterygii

Order: Perciformes

Family: ACANTHURIDAE

- *Acanthurus sohal* – Sohal surgeonfish 📷
- *Zebrasoma xanthurum* – Yellow-tail surgeonfish 📷

Family: APOGONIDAE

- *Apogon fleurieu* – Flower cardinalfish

- *Apogon holotaenia* – Copperstriped cardinalfish
- *Archamia fucata* – *Orangelined cardinalfish*
- *Cheilodipterus* sp.

Family: ATHERINIDAE

- *Atherinomorus lacunosus* - Hardyhead silverside

Family: BALISTIDAE

- *Odonus niger* – Red-toothed triggerfish
- *Rhinecanthus assasi* – Picasso trigerfish

Family: BELONIDAE

- *Ablennes hians* - Flat needlefish
- *Tylosurus crocodilus crocodilus* – Hound needlefish

Family: BLENNIIDAE

- *Antennablennius* sp.
- *Ecsenius pulcher* – Gulf blenny

Family: CAESIONIDAE

- *Caesio lunaris* – Lunar fusilier
- *Caesio varilineata* – Variable-lined fusilier

Family: CARANGIDAE

- *Alepes djedaba* – Shrimp scad
- *Atule mate* - Yellowtail scad
- *Carangoides badaj* – Orange-spotted trevally
- *Carangoides ferdau* – Blue trevally
- *Carangoides fulvoguttatus* – Yellowspotted trevally
- *Caranx heberi* – Blacktip trevally
- *Caranx sexfasciatus* – Big-eye trevally
- *Elagatis bipinnulata* – Rainbow runner
- *Gnathanodon speciosus* – Golden trevally
- *Selar crumenophthalmus* – Bigeye scad

Family: CHAETODONTIDAE

- *Chaetodon collare* - Collared butterflyfish
- *Chaetodon melapterus* – Arabian butterflyfish
- *Chaetodon nigropunctatus* – Black-spotted butterflyfish
- *Heniochus acuminatus* – Pennant coralfish

Family: CLUPEIDAE

- *Herklotsichthys quadrimaculatus* - Bluestripe herring

Family: DIODONTIDAE

- *Chilomycterus reticulates* – Spotfin burrfish
- *Diodon hystrix* – Spot-fin porcupinefish
- *Diodon liturosus* – Black-blotched porcupinefish

Family: ECHENEIDAE

- *Echeneis* sp. - Remora

Family: FISTULARIIDAE

- *Fistularia commersonii* – Bluespotted cornetfish

Family: GOBIIDAE

- *Valenciennea sexguttata* – Six-spot goby

Family: HAEMULIDAE

- *Plectorhinchus schotaf* – Minstrel sweetlip

Family: HEMIRAMPHIDAE

- *Hemiramphus far* - Blackbarred halfbeak

Family: KYPHOSIDAE

- *Kyphosus vaigiensis* – Brassy sea chub

Family: LABRIDAE

- *Bodianus diana* – Diana's hogfish
- *Choerodon robustus* – Robust tusk-fish wrasse
- *Coris caudimacula* – Tail-spot wrasse
- *Gomphosus varius* – Bird wrasse
- *Thalassoma lunare* – Moon wrasse

Family: LETHRINIDAE

- *Lethrinus microdon* – Small-tooth emperor 

Family: LUTJANIDAE

- *Lutjanus bengalensis* – Bengal snapper
- *Lutjanus ehrenbergii* – Black-spot snapper
- *Lutjanus fulviflamma* – Dory snapper
- *Lutjanus lutjanus* – Big-eye snapper
- *Lutjanus quinquelineatus* – Five-lined snapper
- *Lutjanus russellii* – Russell's snapper

Family: MONACANTHIDAE

- *Stephanolepis diaspros* – Reticulates filefish
- *Ostracion cyanurus* – Blue-tail trunkfish

Family: MONODACTYLIDAE

- *Monodactylus argenteus* – Silver moonfish

Family: MULLIDAE

- *Parupeneus margaritatus* – Pearly goatfish 
- *Parupeneus rubescens* – Rosy goatfish

Family: MURAENIDAE

- *Echidna nebulosa* – Snowflake moray
- *Gymnothorax flavimarginatus* – Yellow-edge moray
- *Gymnothorax undulatus* – Undulated moray 

Family: NEMIPTERIDAE

- *Scolopsis ghanam* – Arabian monocle bream 

Family: PINGUIPEDIDAE

- *Parapercis maculate* – Harlequin sandperch

Family: POMACANTHIDAE

- *Pomacanthus maculosus* – Yellow-bar angelfish 

Family: POMACENTRIDAE

- *Abudefduf vaigiensis* – Indo-Pacific sergeant damselfish 

- *Abudefduf septemfasciatus* – Banded sergeant
- *Amphiprion clarkia* – Yellowtail clownfish
- *Chromis flavaxilla* – Arabian chromis
- *Dascyllus marginatus* – Marginate dascyllus
- *Pomacentrus leptus* – Slender damsel

Family: PSEUDOCHROMIDAE

- *Pseudochromis aldabraensis* – Arabian blue-striped dottyback
- *Pseudochromis dutoiti* – Dutoiti
- *Pseudochromis nigrovittatus* – Black-stripe dottyback

Family: SCARIDAE

- *Scarus ferrugineus* – Rusty parrotfish
- *Scarus persicus* – Persian parrotfish

Family: SCOMBRIDAE

- *Rastrelliger kanagurta* – Indian mackerel

Family: SCORPAENIDAE

- *Pterois antennata* – Broad-barred firefish
- *Pterois mombasae* – Frillfin turkeyfish

Family: SERRANIDAE

- *Cephalopholis hemistiktos* – Yellow-fin hind
- *Epinephelus multinotatus* – White-blotched grouper
- *Epinephelus stoliczae* – Epaulet grouper

Family: SIGANIDAE

- *Siganus javus* – Streaked spinefoot

Family: SPARIDAE

- *Acanthopagrus bifasciatus* – Two-bar bream
- *Diplodus sargus capensis* – Cape porgy

Family: SPHYRAENIDAE

- *Sphyraena flavicauda* – Yellow-tail barracuda
- *Sphyraena qenie* – Blackfin barracuda

Family: SYNGNATHIDAE

- *Trachyrhamphus bicoarctatus* – Double-ended pipefish

Family: TETRAODONTIDAE

- *Arothron stellatus* – Starry toadfish

Class: Ascidiacea

Order: Enterogona

Family: ASCIDIIDAE

- *Ascidia* sp.

Family: POLYCLINIDAE

- *Aplidium* sp.

Class: Elasmobranchii

Order: Carcharhiniformes

Family: CARCHARHINIDAE

- *Chacharhinus melanopterus* – Black-tip reef shark

Order: Myliobatiformes

Family: MYLIOBATIDAE

- *Aetobatus narinari* – Spotted eagle ray
- *Manta thurstoni* – Smooth-tail mobula

Class: Reptilia

Order: Testudines

Family: CHELONIIDAE

- *Chelonia mydas* – Green turtle
- *Eretmochelys imbricata* – Hawksbill turtle

Class: Tunicata

Order: Enterogona

Family: ASCIDIIDAE

- *Phallusia nigra*

Phylum : CNIDARIA

Class: Anthozoa

Order: Actinaria

Family: ALICIIDAE

- *Triactis producta*

Family: EDWARDSIIDAE

Family: STICHODACTYLIDAE

- *Entacmaea quadricolor*
- *Heteractis* sp.

Order: Alcyonacea

Family: ALCYONIIDAE

- *Eleutherobia sp.*
- *Lobophytum sp.*

Family: NEPHTHEIDAE

- *Dendronephthya* sp.

Family: PLEXAURIDAE

- *Echinomuricea* sp.

Order: Scleractinia

Family: ACROPORIDAE

- *Acropora arabensis*
- *Acropora downingi*
- *Acropora valida*
- *Montipora cf. danae*

Family: FAVIIDAE

- *Favites pentagona*
- *Favia matthaii*
- *Leptastrea* sp.
- *Platygyra daedalea*

Family: MERULINIDAE

- *Hydnophora microconos*

Family: MUSSIDAE

- *Acanthastrea echinata*

- *Symphyllia* sp.

Family: OCULINIDAE

- *Galaxea fascicularis*

Family: POCILLOPORIDAE

- *Pocillopora damicornis*

Family: PORITIDAE

- *Goniopora albiconus*
- *Goniopora ciliatus*
- *Porites* sp.

Family: SIDERASTREIDAE

- *Pseudosiderastrea tayami*

Order: Zoanthidea

Family: ZOANTHIDAE

- *Palythoa* sp.

Class: Hydrozoa

Order: Leptothecata

Family: SERTULARIIDAE

- *Amphisbetia* sp.
- *Diphasia* sp.

Phylum : EQUINODERMATA

Class: Asteroidea

Order: Valvatida

Family: OREASTERIDAE

- *Culcita coriacea*
- *Culcita schmideliana*

Class: Equinoidea

Order: Diadematoida

Family: CURCULIONOIDEA

- *Echinothrix diadema*
- *Echinometra mathaei*

Family: DIADEMATIDAE

- *Diadema setosum*

Class: Holothuridae

Order: Apodida

Family: SYNAPTIDAE

- *Euapta godeffroyi*

Order: Aspidochirotida

Family: HOLOTHURIIDAE

- *Holothuria atra*

Class: Ophiuroidea

Order: Ophiurida

Family: AMPHIURIDAE

- *Amphioplus* sp.

Phylum : MOLLUSCA

Class: Cephalopoda

Order: Sepioidea

Family: SEPIIDAE

- *Sepia latimanus* – Broadclub cuttlefish 

Class: Gastropoda

Order: Aplysiomorpha

Family: APLYSIIDAE

- *Stylocheilus longicauda*

Order: Cephalaspidea

Family: AGLAJIDAE

- *Philinopsis reticulate*

Family: BULLIDAE

- *Bulla* sp.

Family: HYDATINIDAE

- *Hydatina physis* – striped bubble shell

Order: Hypsogastropoda

Family: BUCCINIDAE

- *Cantharus* sp.

Family: CYPRAEIDAE

- *Cypraea* sp.

Family: RANELLIDAE

- *Cymatium* sp.

Order: Neogastropoda

Family: BUCCINIDAE

Family: CINIDAE

- *Conus* sp.

Family: CYSTISCIDAE

- *Giberula* sp.

Order: Nudibranchia

Family: CHROMODORIDIDAE

- *Hypselodoris nigrostriata*

Family: FACELINIDAE

- *Godiva quadricolor*

Family: GYMNODORIDIDAE

- *Gymnodoris ceylonica* 

Family: PHYLLIIDIIDAE

- *Fryeria rueppelii* 

Order: Sorbeoconcha

Family: CERITHIIDAE

- *Cerithium* sp.
- *Clypeomorus* sp.

Phylum: PORIFERA

Class: Demospongidae

Order: Haplosclerida

Family: CHALINIDAE

- *Adocia* sp.

Order: Poecilosclerida

Family: MICROCIONIDAE

- *Clathria* sp.

Kingdom: PLANTAE

Phylum: RHODOPHYTA

Class: Florideophyceae

Order: Ceramiales

Family: CALLITHAMNIACEAE

- *Callithamnion* sp.
- *Ceramium* sp.

Kingdom: CHROMISTA

Phylum: HETEROKONTOPHYTA

Class: Phaeophyceae

Order: Dictyotales

Family: DICTYOTACEAE

- *Dictyota* sp.

B. Questionnaires

Questionnaire to Dive Centres

Dive Centre:	
Location:	
How long does the dive centre exist?	
Do you have dive guides?	
If yes, how often do they dive with your costumers?	
Do you normally anchor?	Yes / No
If yes, in which situations?	
Do you do briefings to your costumers before the dive?	Yes / No
If yes, in which situations / dives?	
Which Marine Protected Areas (MPA) of the East Cost do you know?	
Does your centre dive in Dibba Rock MPA?	Yes / No
If yes, How often do you dive per week?	
How many divers (average) per dive?	
What do you think about the management of the Marine Protected Areas in the East Coast?	
Do you benefit from the MPAs? How?	
Do you have any suggestion regarding the Dibba Rock (Al Faqeet) MPA?	

Questionnaire to Hotels

Hotel:	
Location:	
Date of creation of the hotel	
Number of guests/year	
High season? (months)	
Estimated number of guests practising activities linked with the marine environment:	
Fishing / Snorkelling / Diving / Boating / jet-skiing	
Are you aware of the existence of any marine protected areas (MPAs) in the East coast? If yes, which ones?	
Do you think that your hotel has benefited from the establishment of a MPA in the East Coast? If yes, which one and how?	
What are the existing tourism related activities that your hotel does in the MPAs of the East Coast?	
Do you have any special guide/ranger/skipper with the tourists for these activities	Yes / No

If yes, what is the guide background?	
What is the mean percentage of the hotel guests that do the activities related to the MPA? (in the high season)	
What do you think about the management of the Marine Protected Areas in the East Coast?	
Do you have any suggestion regarding the Dibba Rock (Al Faiqit) MPA?	

Questionnaire to Fishermen

Address (village/town):	
Since how long do you fish?	
In which area do you fish?	
What kind of gear do you use?	
What species of fish do you fish?	
Do you know of the existence of any marine protected areas (MPA) in the East coast?	Yes / No
If yes, which one ?	
What is for you the definition of a marine protected area?	
Are you in favour of the existence of a MPA in your coast?	Yes / No
Why?	
Do you think that you or your community has benefited from the establishment of the MPA? How and why?	Yes / No
If yes, what are these?	
In your own observation and experience, do you think that the fish catch in your area has	Increased / Decreased
Why?	
Do you think that the MPA in the East Coast have something to do with this increase / decrease?	Yes / No
Why?	
Aside from fishing, what are the other sources of income of residents in your community?	
According to you what are the main threats to your fisheries resources?	
What do you think about the management of the Marine Protected Areas in the East Coast?	
Do you have any suggestion regarding the Dibba Rock (Al Faiqit) MPA?	