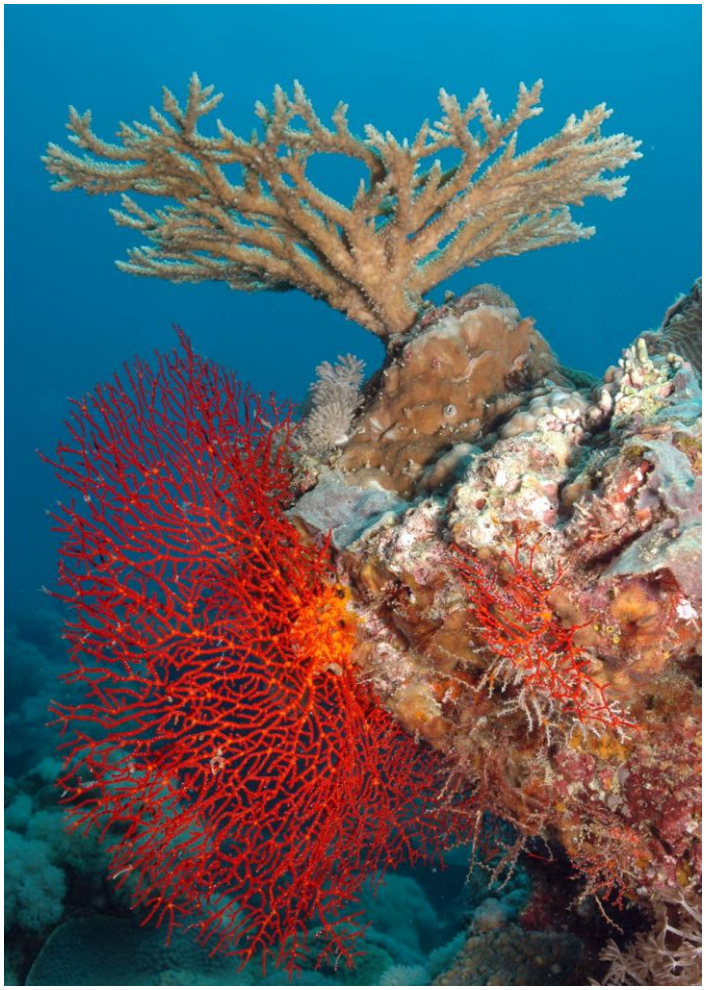
Benthic Habitat Assessment and Mapping in the Farasan Islands Marine Protected Area, May 2006

Preliminary Field Report



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Executive Summary

- A collaborative expedition between Khaled bin Sultan Living Oceans Foundation, the National Commission for Wildlife Conservation and Development (NCWCD) and the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) to the Farasan Islands was conducted onboard M.Y. Golden Shadow, 3 – 24 May 2006.

- The primary aim of the expedition was to use a CASI (Compact Airborne Spectrographic Imager) sensor onboard a seaplane to conduct large-scale habitat mapping of the marine environment of the Farasan Islands. CASI data was collected from 15 areas, totalling 2,700 km^2. In conjunction with *in situ* ground-truthing and spectral signature data, the maps produced will be the first modern seabed habitat maps of the region and will guide future marine management plans of the Farasan archipelago.

- Underwater baseline surveys (benthic and fish-census) were conducted to assess the present state of the reefs of the Farasan Islands. Benthic (seabed dwelling) transects were carried out using the photo-transect technique – a total of 58 photo-transects were conducted during the expedition. The photo-transect data will be analysed to calculate percentage benthic cover and coral diversity at each site. Fish were recorded by species, number and size both along the transect line and away from the transect line in order to record any additional species. 28 fish surveys were conducted during the expedition, and a total of 173 species were recorded.

- NCWCD scientists conducted surveys of marine mammals, marine turtles and seagrass. 175 dolphins were sighted in the Farasan Islands protected area. 4 species were observed – common, bottlenose, humpback and spinner dolphin. Eleven islands were surveyed for turtles. Hawksbill turtles were observed nesting on 6 islands and 1 hawksbill turtle was tagged at Kayrah Island. Seagrass was surveyed at four sites. Percentage cover by different seagrass species was estimated and specimens were collected for identification.

- Surveys of seabirds were conducted to assess the current status of breeding habitats for seabirds in the Farasan Islands. 45 islands were visited over the three week period and 17 seabird species were recorded.

- The expedition embraced the 'Education and Outreach' mission of Khaled bin Sultan Living Oceans Foundation by developing a 'live' educational web-site. The expedition scientists updated the website daily with a 'Science Diary', 'Fact of the Day', 'Vessel Log' and 'Questions and Answers'. 580,782 hits to the website were recorded throughout the expedition.

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1.0 Introduction

A collaborative expedition between Khaled bin Sultan Living Oceans Foundation, the National Commission for Wildlife Conservation and Development (NCWCD) and the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA), to the Farasan Islands was conducted onboard M.Y. Golden Shadow, from 3 – 24 May 2006. The primary aim was to use a CASI (Compact Airborne Spectrographic Imager) sensor onboard the seaplane Golden Eye to conduct large-scale mapping of the reefs and associated benthic (seabed) habitats of the Farasan Islands. The large aerial extent of the archipelago prohibited detailed *in situ* (situated in the natural position) seabed mapping using SCUBA divers over the relatively short duration of this expedition. However, the area was ideally suited to remote sensing techniques using a CASI sensor mounted onboard a seaplane. The results of the CASI surveys will provide the first modern scientific maps of the habitats within these locations. This much-needed information will subsequently be available for incorporation into future marine ecosystem management plans of these islands. These maps, and the information contained within them, will provide guidance to decision makers on the level of conservation and management which should be applied to this region. Thus, existing management strategies can be adjusted accordingly to better preserve these important reef resources in future years.

Coral reefs are one of the most valuable ecosystems on earth, with the value of reef resources being estimated as approximately US$375 billion per year. They provide many essential commodities, including building material and food, as well as mass employment for thousands of people (through fisheries and tourism). With 8% of the world's population (0.5 billion people) living within 100 km of a coral reef, great demand is being put on these resources.

Reefs provide natural sea defences protecting the coastline from storm damage, erosion and flooding by dissipating wave energy, provide habitats for many species of marine flora and fauna and are an important source of food for people who live near

coral reefs. They also generate vast sums of money from tourism. Associated ecosystems such as seagrass beds and mangroves act as nursery grounds for many species and play an important role in rejuvenating fish stocks.

The Red Sea is a highly biodiverse (many species present) area of the world; approximately 150 coral species (within 50 genera) are found on the reefs here. The Red Sea has a narrow, shallow entrance to the Indian Ocean which limits water exchange and isolates the Red Sea ecosystem. The centre of the Red Sea reaches water depths of up to 2 km, inducing unique water circulation patterns. Being relatively cut off from any large oceans, many endemic species are found in the Red Sea – these are species which are found only in the Red Sea, and nowhere else in the world.

The Farasan Islands are situated in the south-central Red Sea, at 16°20'-17°20'N, 41°24'-42°26'E, approximately 40 km from the coastal town of Jizan, Saudi Arabia (Fig. 1). The 'Farasan Islands Protected Area' was established in 1996 and covers an area of 3,310 km^2. The area is managed the National Commission for Wildlife Conservation and Development (NCWCD). The archipelago consists of approximately 176 islands, the largest island being Farasan Kabir (66 km long, 5-8 km wide, maximum elevation = 72 m). It has the greatest biological diversity of any site in Saudi Arabian waters of the Red Sea.

Figure 1: Location of the Farasan Islands

Marine flora of the Farasan Islands includes dense stands of mangrove, mostly black mangrove (*Avicennia marina*) and red mangrove (*Rhizophora mucronata*). 7 species of seagrass are also present. Reefs of the Farasan Islands support 231 species of fish, 49 species of reef-building coral (Plate 1), several species of dolphin and a wide diversity of molluscs, crustaceans and breeding seabirds. There is a remnant population of the endangered dugong (*Dugong dugon*). The main threats to the marine ecosystem of the Farasan Islands are over-fishing, coastal development and recreation.

Plate 1: Hard coral community of the Farasan Islands.

Plate 2: Soft coral community of the Farasan Islands.

1.1 Expedition Personnel

The expedition scientists can be broadly categorized into five groups, according to their expertise. All expedition scientists are listed below.

Benthic Survey Team
- Capt Philip Renaud, Executive Director, Khaled bin Sultan Living Oceans Foundation (benthic survey team)
- Dr Annelise Hagan, Chief Project Scientist, Khaled bin Sultan Living Oceans Foundation (benthic survey team; expedition underwater photographer)
- Dr Ben Stobart, Spanish Institute of Oceanography (benthic survey team; expedition underwater videographer)
- Mr Martin Callow, Lantra, UK (benthic survey team; website coordinator)
- Mr Khalid Al-Shaikh, NCWCD (Reef Check survey team)
- Mr Hatem Al-Yami, NCWCD (Reef Check survey team)

CASI Ground-truthing Team
- Dr Bernhard Riegl, Associate Director, National Coral Reef Institute
- Dr Sam Purkis, National Coral Reef Institute
- Miss Elizabeth Lacey, Masters student, National Coral Reef Institute

CASI Operations Team
- Mr Herbert Ripley, Hyperspectral Imaging Limited, Canada
- Mr Jeff Parks, BirchHill GeoSolutions, Canada

Fish Survey Team
- Dr Raymond Buckley, University of Washington (fish survey team)
- Miss Frederique Kandel, PhD student, University of Hawaii (fish survey team)

Marine Mammal, Turtle, Seagrass and Seabird Survey Team
- Mr Omar Al-Khushaim, General Director, Research and Field Studies Department, NCWCD
- Dr Ahmed Al-Mansi, NCWCD (mammal and turtle specialist)
- Mr Anas Sambas, NCWCD (seagrass specialist)
- Mr Abdullah Alsuhaibany, PERSGA (seabird specialist)

1.2 Expedition Itinerary

Most of the science team arrived in Saudi Arabia on 30 April 2006, and joined the M.Y. Golden Shadow at the port of Jeddah. From here, the vessel travelled approximately 800 km south, to the port of Jizan. The remaining scientists embarked in the port of Jizan. Expedition data collection started on 4 May and the expedition travelled around the archipelago in a counter-clockwise direction. Table 1 lists the expedition itinerary for the science team onboard Golden Shadow but in addition to these sites, CASI data was collected from other sites within the archipelago. Island names have been taken from the British Admiralty chart number 15 ‘Approaches to Jizan’. Local names, if known, are shown in brackets.

Date	Itinerary
30 April	Science team arrives in Jeddah. Team boards M.Y. Golden Shadow
1 May	In transit: Jeddah to Jizan (~ 500 miles)
2 May	In transit: Jeddah to Jizan
3 May	In Jizan – Saudi Arabian scientists join M.Y. Golden Shadow
4 May	Abu Shuqar Bank
5 May	Abu Shuqar Island
6 May	Abu Shuqar Bank
7 May	Akbayn Island
8 May	Akbayn Island
9 May	Al Baghlah Bank
10 May	Al Baghlah Bank
11 May	Al Baghlah Bank
12 May	Zufaf Island
13 May	Zufaf Island
14 May	Dushuk Island
15 May	Zufaf Island
16 May	Sarad Sarso Island (Sasuh)
17 May	Dhi Dahaya Island (Lajhan)
18 May	Dhi Dahaya Island (Lajhan)
19 May	Sarad Sarso Island (Sasuh)
20 May	Hadifah Island
21 May	South Kulam Island
22 May	Aminah Island
23 May	No diving due to diving and flying regulations. In Jizan
24 May	End of expedition. Scientists depart.

Table 1: Expedition itinerary 30 April - 24 May 2006.

1.3 Expedition Aims

The Farasan Islands expedition set out to achieve three main aims:

Aim 1: To conduct aerial mapping of the shallow marine environment surrounding the Farasan Islands using 'remote sensing' techniques in order to produce large-scale marine habitat maps of the archipelago.

Aim 2: To conduct benthic (seabed dwelling) surveys and fish-census surveys to document baseline data of 1) the status of the coral community and 2) fish types and populations. Fish surveys specifically focussed on commercially important species (for example those targeted for food or for the aquarium trade).

Aim 3: To conduct a national and international education and outreach campaign in order to promote marine conservation awareness.

In order to achieve these aims, the following survey methodologies were employed.

1.4 Methods

1.4.1 Methods: Benthic Surveys

Benthic surveys were conducted using the photo transect technique. A 50 m long transect tape was laid down on the seabed at a pre-determined depth. The transect line followed the depth contour, thus a constant depth was retained throughout. A 1 m long piece of PVC piping was used as a guide along the transect tape and photographs were taken along the 50 m length at 0.5 m intervals (Plate 3). Approximately 100 photographs were taken along the transect line, allowing for some overlap between adjacent photographs. Two photo transects (each 50 m in length) were conducted during each dive, as shown in Figure 2. The positions of all transects were recorded by deploying a buoy to the surface and taking a GPS (Global Positioning System) reading.

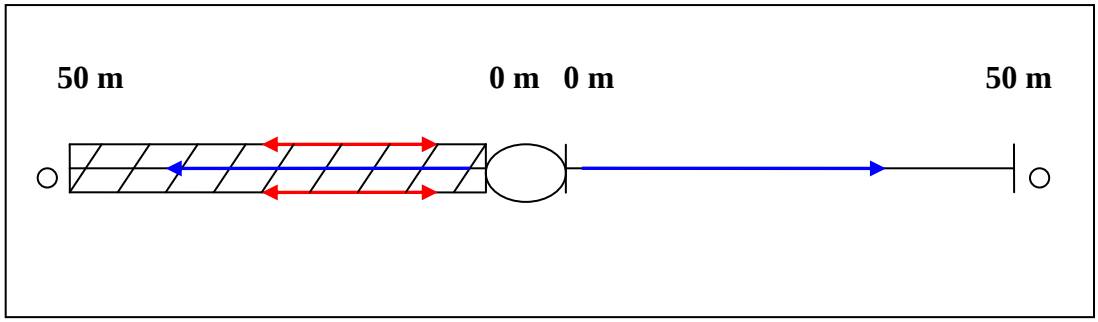

Figure 2: Plan view of benthic and fish survey transects. Oval indicates central buoy marked by GPS, small circles represent buoys deployed at end of transect line. Blue arrows indicate direction of benthic survey (photo transect methods), red arrows indicate direction of fish surveys. Shaded area represents area of fish survey (2 m either side of central transect line).

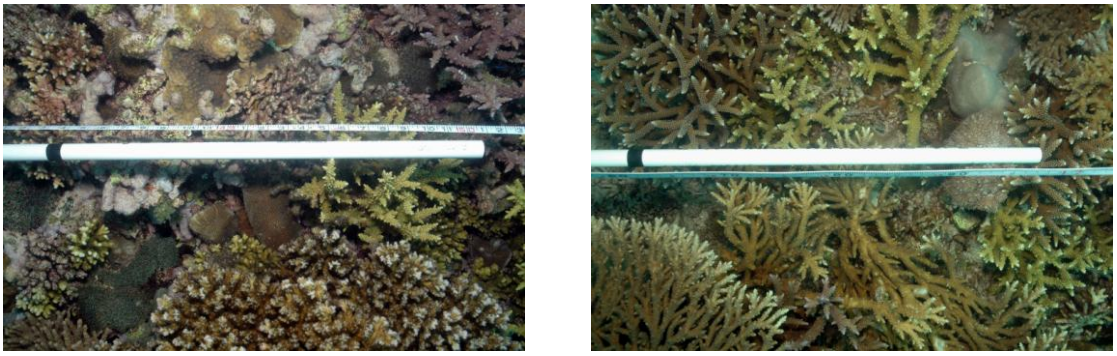

Plate 3: Examples of photographs taken at 0.5 m intervals along the transect line. Note use of PVC piping along transect line and overlap at either end of the 0.5 m section. Black marker on PVC piping represents 0.5 m point.

1.4.2 Methods: Fish Surveys

Fish surveys were conducted along the same 50 m long transect line that was used for one of the benthic surveys (Fig. 2). Actual counts of fish (quantified data) were made both along the transect line and away from the transect line in order to record any additional species in the area. Two SCUBA divers swam together along the transect line with each diver counting the fish on their side of the transect. Counts were made within a virtual column of water which was 2 m wide and extended from the seabed up to the surface.

The divers first counted the fish that were above the bottom and in the water column, and then returned back along the transect line counting any fish hiding in the holes and crevices in the reef. The fish were recorded by species, number and size on prepared underwater forms. Following each survey dive, the underwater forms were reviewed for clarity and any fish identification questions were resolved using identification resources.

1.4.3 Methods: CASI Data Collection and Associated Ground Techniques

CASI Data Collection

A Compact Airborne Spectrographic Imager (CASI) is a passive sensor used to measure the amount of light reflected from different objects, designed for remote sensing from a small aircraft.

The seaplane, with CASI sensor fixed, was flown in straight, parallel lines in a grid system (Fig. 3), to map the entire area of interest (marine environment to a depth of 20 m). The CASI sensor registered the amount of light energy reflected from different target objects e.g. coral, seagrass, sand etc. and compiled a colour image built from 1.5 m x 1.5 m pixels of the ground/sea surface. CASI data was recorded from 15 areas within the Farasan archipelago, totalling 2,700 km^2 (Fig. 4).

The CASI sensor was flown for a maximum period of two hours in the morning and two hours in the afternoon, during pre-selected times based on times of sun-rise and sun-set. These times enabled the highest level of accuracy to be achieved in the CASI data collection by ensuring a high sun angle, and thus minimising sun-glint.

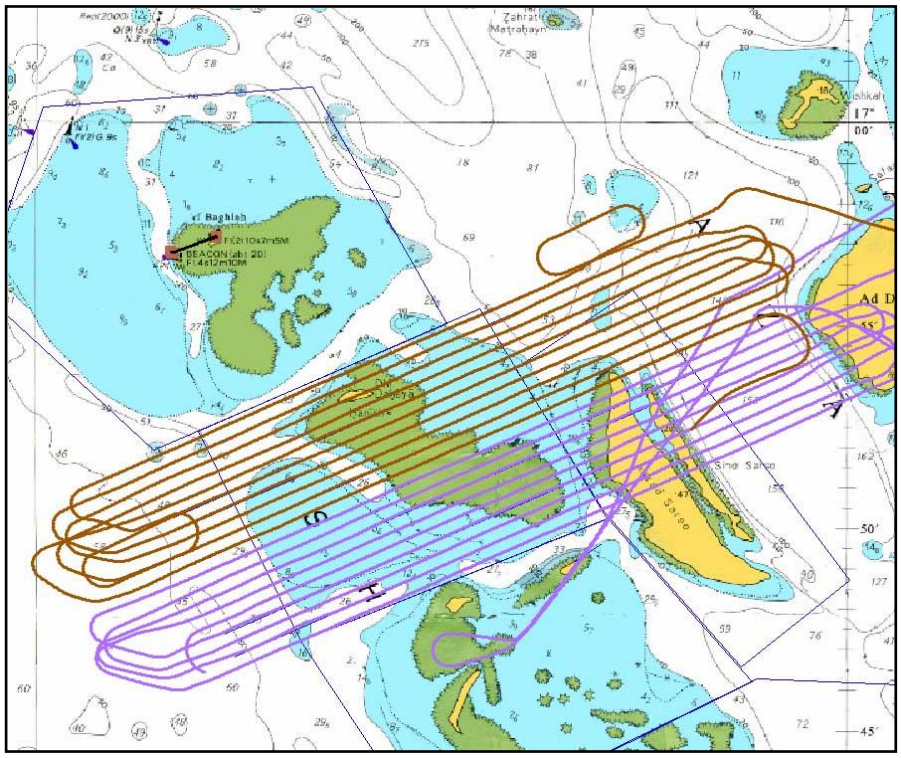

Figure 3: Detail of 'area 5' flight lines.

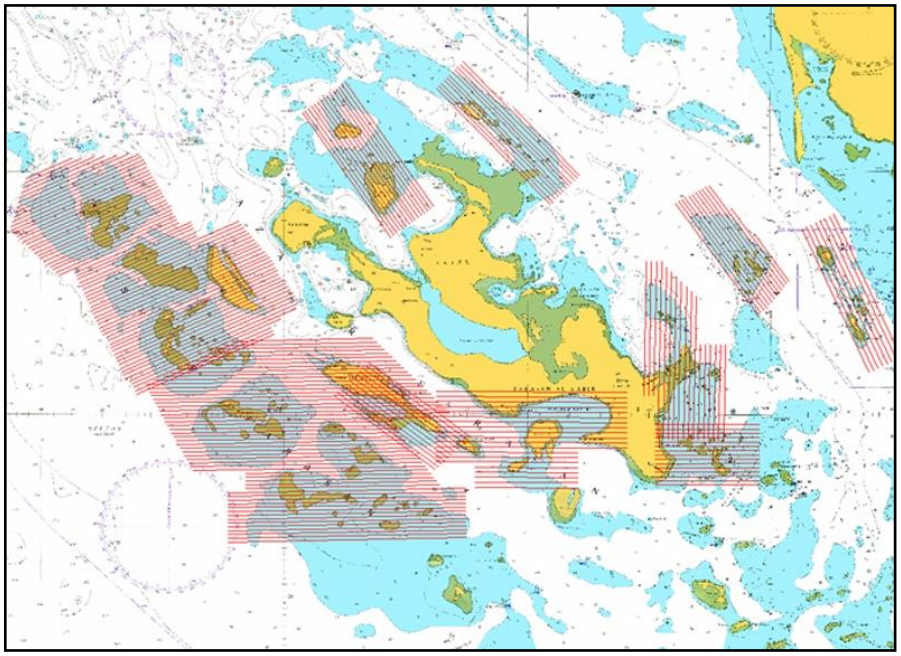

Figure 4: CASI flying areas of the Farasan Islands.

Ground-truthing and Collecting Spectral Signatures

The colour images produced by CASI will subsequently be classified into different habitat types. In order to do this, *in situ* measurements and observations were made. Spectral signatures (readings of the amount of light reflected by an object) were collected for numerous benthic habitat types (e.g. coral, seagrass, sand, bare rock etc.) using a hand-held spectroradiometer. 'Ground-truthing' was also conducted from a small boat using a glass-bottom viewing bucket to view the seabed. Periodically, the small boat was stopped and the bottom type observed through the viewing bucket was recorded along with the GPS position of that exact point. The ground-truthing team collected a total of 1,024 ground-control points. By knowing what type of habitat is on the seabed at an exact position, this ground-control data will allow classification of the entire CASI dataset and enable accurate habitat maps to be produced.

The ground-truthing team also collected bathymetric and current data at various locations using a grid sampling method across the area of interest. Current data was collected using an Acoustic Doppler Current Profiler (ADCP), which recorded both the speed and direction of water flow. In total, 138 km of bathymetric and current data was collected.

Target Deployment

Data collected by the hand held spectroradiometer was not available at all sites, so instead, white targets were placed underwater. These targets, visible on the CASI imagery, will be used for subsequent depth correction and geo-referencing the CASI data.

Underwater, 3 m x 3 m square sheets of plastic were used as targets and placed at depths of 15 m, 10 m and 5 m. The targets were laid as horizontally as the reef allowed, so that the shape could easily be picked up by the CASI sensor. The targets were secured onto the reef in order to withstand underwater currents. Metal stakes were hammered into dead coral substrate or sand and each corner of the target was tied onto a metal stake.

On land, a white and a dark blue target were laid out on a flat area and secured with metal stakes (Plate 4). The land targets will be used for atmospheric correction of the CASI data.

Plate 4: Deploying white target on beach.

1.5 Marine Survey Results

1.5.1 Benthic Surveys

Although the benthic transect data has not yet been analysed, coral cover was generally high (over 60% cover) and the corals were in good condition (Plate 5). Most reefs were dominated by large table corals (*Acropora* spp.) which were often layered in tiers resulting in a structurally complex reef system. Some large, massive corals (*Porites* spp.) measuring over 1.5 m in diameter were observed. Corals this large are likely to be over 50 years old. Little damage was observed due to the ocean warming event on 1997-98 and although remnants of discarded fishing nets were observed at a couple of sites, there was no sign of boat anchor damage.

Plate 5: Healthy coral cover at Dhi Dahaya (17th-18th May 2006) at a water depth of 5 m. The reef here is dominated by table corals (*Acropora* spp.) which grow in tiers as they compete for space on the reef.

However, it is important to highlight the Crown-of-Thorns Starfish (COTS) outbreak that was observed on the reefs of Abu Shuqar Island.

COTS (*Acanthaster planci*) are one of the most significant coral predators on the reef. They are found throughout the Indo-Pacific region, from the Red Sea, across the Indian Ocean and through to the Pacific. These starfish look sinister - they are reddish-grey and blue in colour and are covered in 4-5 cm long spines (which give a nasty wound). They are voracious predators and are specially adapted to feed on coral tissue. COTS predation is very visible as it leaves behind a bright white scar which is the coral skeleton (Plate 6). An individual adult Crown-of-Thorns Starfish consumes coral at an average rate of 160 cm^2 per day and they are estimated to consume between 5-6 m^2 of coral tissue per year.

During the dive in the area infested with Crown-of-Thorns Starfish, two divers recorded the number and size of individuals present with a specific area. 87 starfish were counted within a 120 m^2 area, giving a density of 0.725 starfish per m^2. The starfish averaged 24 cm in diameter from arm tip to arm tip. Although COTS do occur naturally on a coral reef, it is thought that human intervention is increasing the prevalence of COTS outbreaks as humans remove their natural predators, the giant Triton shell (*Charonia tritonis*).

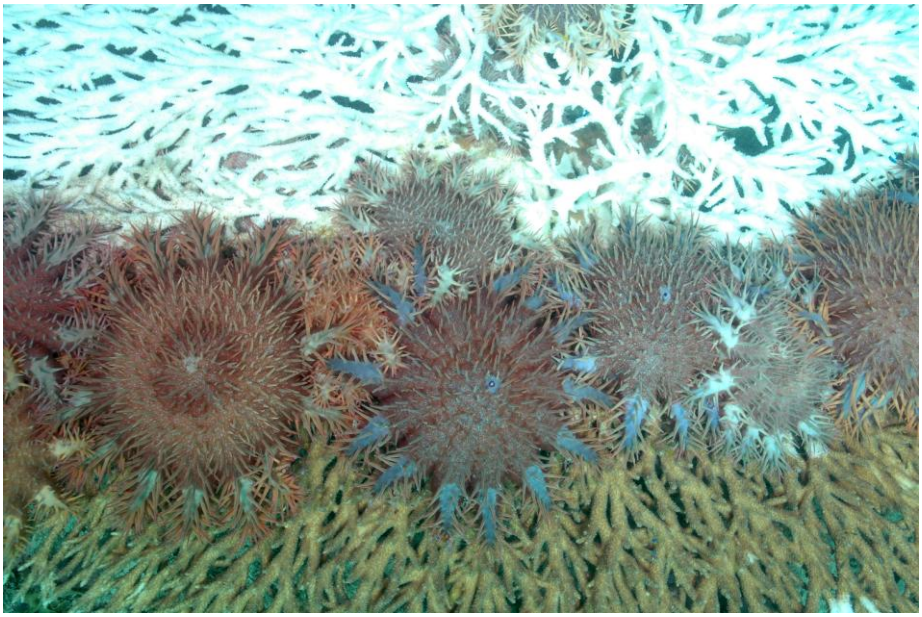

Plate 6: Crown of Thorns Starfish (*Acanthaster planci*) predating on a table coral at Abu Shuqar Island (6th May 2006). The brown area in the lower half of the picture is living coral tissue and the white area in the upper half is the exposed coral skeleton.

1.5.2 Fish Surveys

The 28 quantified fish-census surveys conducted documented the baseline species present as well as fish abundance and size. The total transect count of 20,491 fish represented 151 species from 40 families. Off-transect observations recorded an additional 22 species giving a check-list of 173 species. The surveys were dominated by small damselfish (Family Pomacentridae) in number of species (27 in total) and fish counted (9,914 fish, 48% of the total fish), followed by fusiliers (Family Caesionidae) in fish counted (5,189 fish, 25% of the total) and by wrasse (Family Labridae) in number of species (24 in total). Figure 5 displays example data of fish families and species diversity at one site – Abu Shuqar Bank and Island.

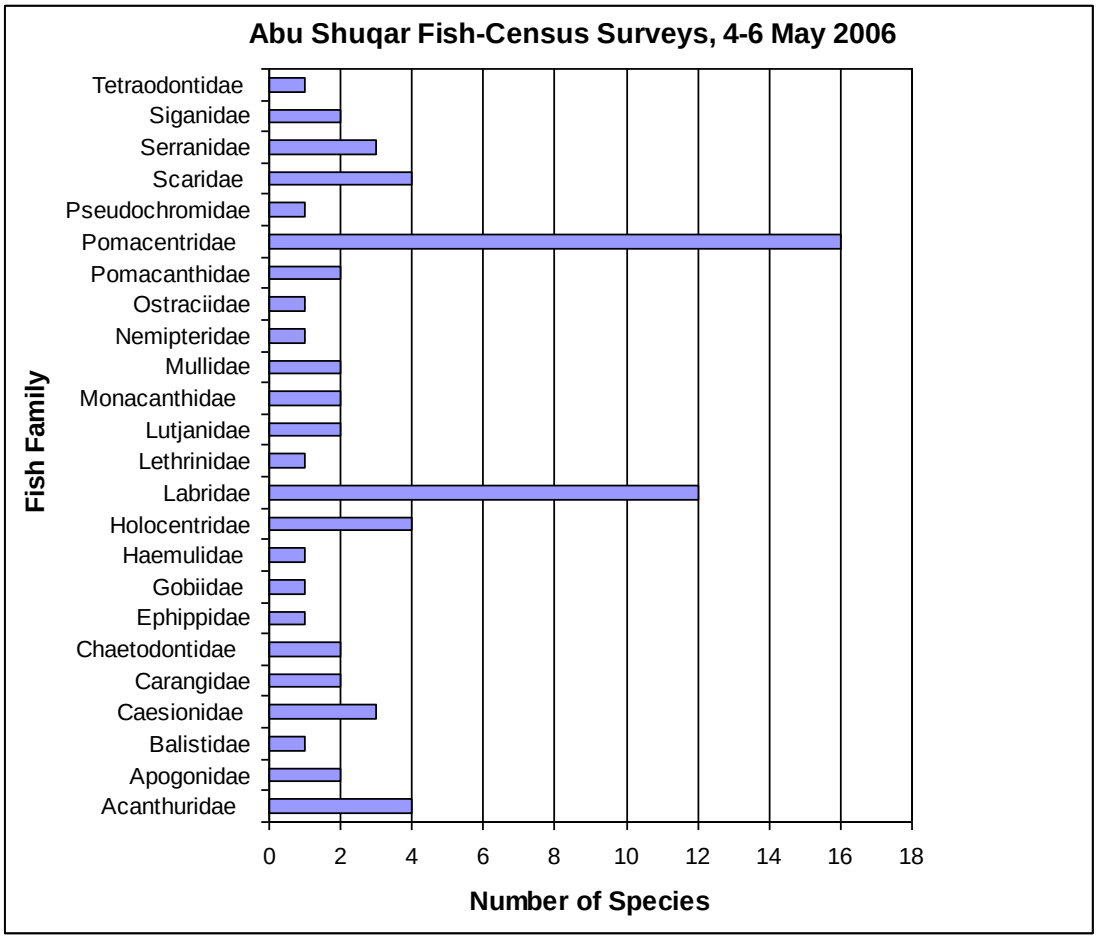

Figure 5: Fish families and species diversity in fish-census surveys of 5,301 fish at Abu Shuqar Bank and Island on 4th – 6th May 2006. 6 transects were conducted at 5-11m water depth, covering 550 m^2.

There were few large reef fish observed throughout the fish surveys (Fig. 6), indicative of a reef system that has been subjected to intense fishery harvests. Only 105 fish counted (<0.5% of the total) were in the 31-40cm Total Length (TL) interval, and only two fish were in the >40cm TL interval (a moray eel and a parrotfish). Comparisons with a 1999 survey of 22 species of reef fish important in artisanal and

industrial fisheries found close agreement in the percentages for each species, indicating that their relative abundances have likely changed little over the intervening six years.

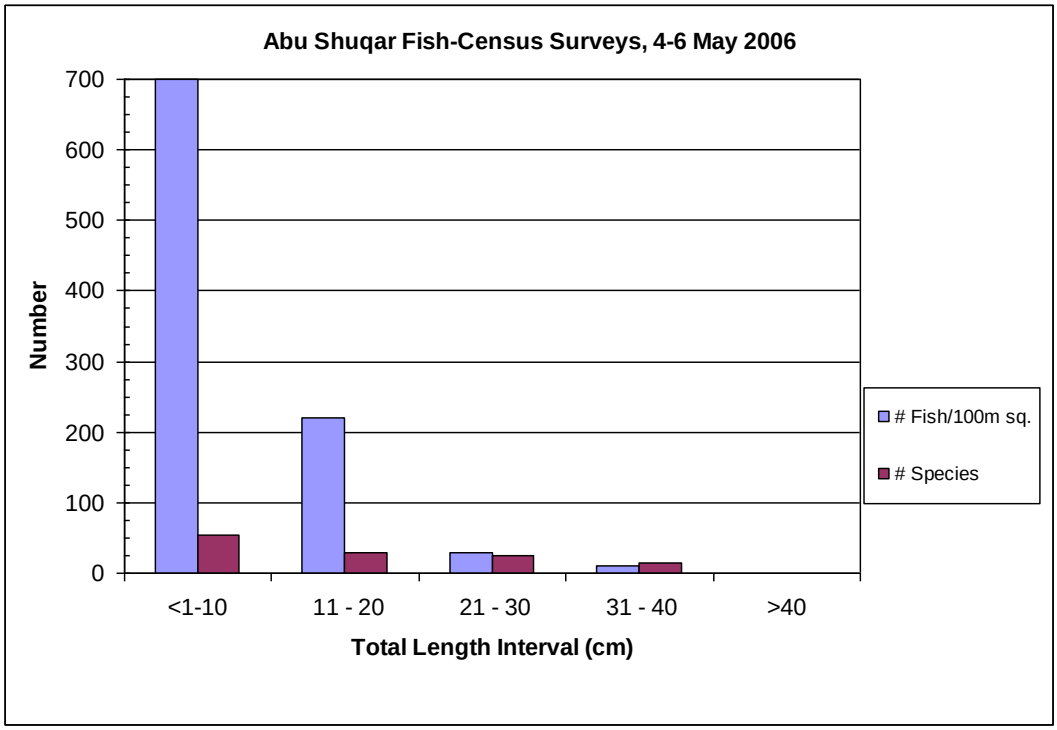

Figure 6: Density and species diversity in fish-census surveys of 5,301 fish at Abu Shuqar Bank and Island on 4th – 6th May 2006. 6 transects were conducted at 5-11m water depth, covering 550 m^2.

Plate 7: a) Damselfish (Family Pomacentridae), one of the most abundant fish on the reefs of the Farasan Islands and b) parrotfish (Family Scaridae), one of the few larger fish observed.

1.6 Mammal, Turtle and Seagrass Surveys

NCWCD scientists conducted surveys of marine mammals, marine turtles and seagrass. Marine mammals were sighted, identified using binoculars and photographed. The location of the mammals was designated using GPS (Fig. 7). 175 dolphins were sighted in the Farasan Islands protected area (23 schools ranging between 2 - 25 dolphins). Species included: *Delphinus delphis* (common dolphin), *Tursiops truncatus* (bottlenose dolphin), *Sousa chinensis* (humpback dolphin) and *Stenella longirostris* (spinner dolphin). One *Megaptera novaeangliae* (humpback whale) was observed in water approximately 100 m deep.

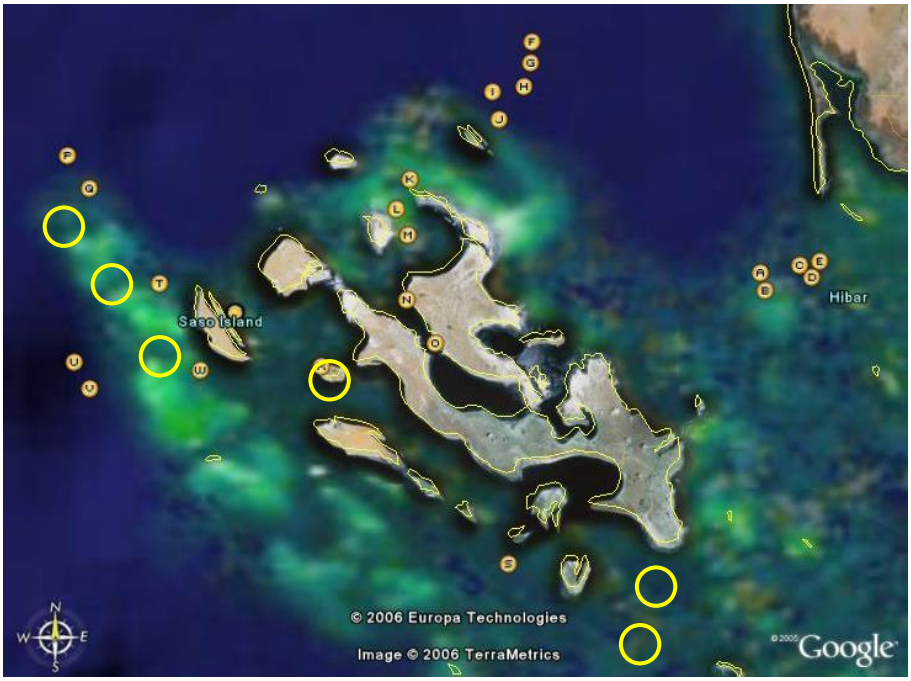

Figure 7: Map to show mammal and turtle sightings. Letters represent sites of dolphin observations and circles represent turtle nesting sites on islands (islands may not be visible).

Plate 8: Common dolphin (*Delphinus delphis*) riding Golden Shadow's bow wave.

Eleven islands were surveyed for turtles. Turtle tracks and nesting pits were observed and the number of upward tracks (both 'fresh' and 'old') was recorded. The beaches of Kayrah Island and Shawmah Island were patrolled nightly. Hawksbill turtles (*Eretmochelys imbricata*) were observed nesting on 6 islands; Kayrah, Al-Baghlah, Al-Ajhan, Zahrat Saymar al-'Ulya, Zahrat Saymar as-Sufla and Shawmah. Kayrah Island is considered to be the most important nesting site for hawksbill turtles in the Farasan protected area. One hawksbill turtle was tagged at Kayrah Island. This turtle was the first ever to be measured and tagged within the Farasan protected area.

Plate 9: Dr Al-Mansi measuring hawksbill turtle (*Eretmochelys imbricate*) prior to tagging at Kayrah Island (13th May 2006). The 'curve carapace' (shell) measured 74.5 cm x 67 cm.

Seagrass was surveyed at four sites. A quadrat (50 cm × 50 cm) was randomly placed on each seagrass bed (ten replicates) and the percentage cover by different species of seagrass was estimated. Specimens of seagrass were also collected for later identification. Four species of seagrass were found in the Farasan Islands: *Thalassia hemprichii*, *Halodule uninervis*, *Halophila ovalis* and *Thalassodendron ciliatum*. The seagrass beds often exhibited zonation in shallow water, although mixed beds of seagrass were also observed.

1.7 Seabird Surveys

The Farasan Islands are an important regional and global location for seabirds. Several endemic taxa occur here, including the White-eyed Gull (*Larus leucophthalmus*), Red-billed Tropicbird (*Phaeton aethereus indicus*), Spoonbill (*Platalea leucorodia archeri*) and Brown Noddy (*Anous stolidus plumbeigularus*).

Threats on breeding seabirds in the Farasan islands are numerous and include human disturbance, human exploitation, habitat destruction, pollution and over fishing. Egg collection and accidental introduction of ground predators such as feral cats and dogs are probably the most immediate threats on seabird populations.

The overall aim of the seabird survey was to assess the current status of breeding habitats for seabirds in Farasan Islands. More specifically, the survey aimed to:

1) Resurvey all important sites identified by previous surveys
2) Investigate the feasibility of initiating more detailed surveys on breeding seabirds on some of Farasan islands

The breeding season in the Farasan Islands starts in June, so many birds had already selected their breeding sites at the time of the expedition surveys. For example, Bridled Terns, White-checked Terns and White-eyed Gulls were observed with empty nest (shallow scrapes with some nesting materials). It was therefore decided that the 'Flush Counts' methods would be suitable to conduct the surveys as it would identify the species that are likely to use a particular island as a breeding site. Surveys were undertaken between 0600 and 0900 in the morning and between 1630 and 1900 in the afternoon to minimise heat-stress on breeding birds.

A total of 45 islands were visited over the three week expedition period and 17 seabird species were recorded during these visits (Table 2).

Common Name	Scientific Name	Numbers in Farasan Islands	Breeding Season	Status
Red-billed Tropicbird	*Phaethon aethereus*	About 5 pairs	June - Aug	R
Brown Booby	*Sula leucogaster*	About 1,500 pairs	June - Sept	R
Pin-backed pelican	*Pelecanus rufescens*	150 pairs	Oct - Feb	R
Striated Heron	*Butorides striatus*	120 pairs	June - Aug	R
Cattle Egret	*Bublicus ibis*	27 birds recorded at Farasan Kabir on 10th May, 17 birds recorded in Gandal area on 12th May	May - June	V
Western Reef Heron	*Egretta gularis*	250 pairs	June - Aug	R
Goliath Heron	*Ardea goliath*	About 25 pairs	Dec - Feb	R
Eurasian Spoonbill	*Platalea leucorodia*	Over 100 pairs	May - Aug	R, WV
Sooty Gull	*Larus hemprichii*	1,700 pairs	June - Aug	R
White-eyed Gull	*Larus leucophthalmus*	1,200 pairs	June - Aug	R
Caspian Tern	*Sterna caspia*	100-150 pairs	Jan - April	WV
Swift Tern	*Sterna bergii*	300 pairs	June - Aug	SV
Lesser- crested Tern	*Sterna bengalensis*	About 2,000 pairs	June - Aug	SV
Bridled Tern	*Sterna anaethetus*	About 35,000 pairs	June - Aug	SV
White-cheeked Tern	*Sterna repressa*	About 800 pairs	June - Aug	SV
Common Noddy	*Anous stolidus*	About 400 pairs	June - Aug	SV
Crab Plover	*Dromas ardeola*	240 birds recorded in this survey	June - Aug	R

Table 2: Seabird species observed in the Farasan Islands during the expedition. Table also lists the total number of each species known to be present in the Farasan Islands and the breeding season. In 'Status' column, R = Resident Breeder, V = Visitor to Farasan Islands, WV = Winter Visitor, SV = Summer Visitor.

Plate 10: Swift Terns (*Sterna bergii*). This species was recoded in two locations; 2 pairs on Sumayer (6th May 2006) and 1 pair on Dissan (10th May 2006). Swift Terns breed in the centre of small sandy islands but on larger or vegetated islands they locate their colony near the edge, in open areas or on peninsulas or headlands.

Plate 11: Red-billed Tropicbird (*Phaethon aethereus*). This species was observed close to high cliff islands. A total of 4 birds were observed at the islands of Abulad (one pair) and Sulain (one pair) on 6th May 2006.

1.8 Educational Component

Khaled bin Sultan Living Oceans Foundation's 'Education and Outreach' theme was supported through a 'live-science' expedition website, available at:
www.livingoceansfoundation.org

The expedition scientists updated the website daily with a 'Science Diary', 'Fact of the Day', 'Vessel Log' and 'Questions and Answers'. The main aims of the website were to:

- Provide 'real-life' scientific information of direct benefit to the UK Key Stage 4 (14-16 year olds) science curriculum.
- Raise marine environmental awareness within schools.
- Motivate and enthuse young people about the exciting and rewarding careers available through the pursuit of a science orientated curriculum.

88 'live' pages were created during the expedition containing over 300 digital images and 21 video clips. 580,782 hits to the website were recorded throughout the expedition. Although website access was freely available, 15 selected schools (from UK, USA and Saudi Arabia) were invited to post questions to the scientists and crew. Over 50 questions were answered by the scientists during the expedition.

Plate 12: Updating website from cabin onboard Golden Shadow.

Plate 13: Bellarmine Preparatory High School, Takoma, Washington, USA, students using the 'live' Living Oceans Foundation Red Sea expedition website.

1.9 Follow-up Work and Expected Outcomes

Expedition data is now in the early stages of analysis. Specifically, the following processes must be conducted in order to fully utilise the data collected:

- Analyse benthic transect data to calculate percentage benthic cover and coral diversity at each site.

- Relate fish survey data to benthic habitat data to assess the overall health of the reefs of the Farasan Islands and gain insight into the level of fishing pressure in these waters.

- Analyse bathymetric and current data and combine this with benthic and fish data in order to get a holistic overview of the marine environment of the Farasan Islands.

- Pre-process (atmospheric correction, geo-referencing etc.) and process CASI data using ground-truthing and spectral signature data in order to construct habitat maps of the marine environment.

The analysed data will give baseline descriptions for the reefs of the Farasan Islands (the first ever baseline data for some of the islands). The CASI data, in conjunction with the extensive ground-truthing undertaken, will enable detailed large-scale habitat maps to be constructed. These maps will guide future marine management plans within the Farasan Islands and will act as an important resource for wider plans of the biodiversity conservation within Saudi Arabia.

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Please note: Detailed reports on the educational component, turtle, mammal and seagrass surveys and seabird surveys are available on request.