Aus dem Institut für Polarökologie
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An Assessment of Grounding, Anchoring and Fishing Methods on Coral Reef Structures and Reef Fish near Kamaran and Uqban Seghir Islands, West Coast of Yemen, Red Sea

Dissertation
zur Erlangung des Doktorgrades
der Mathematisch-Naturwissenschaftlichen Fakultät
der Christian-Albrechts-Universität zu Kiel

vorgelegt von
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Kiel
June 2006

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Tag der mündlichen Prüfung	: 09. Juni 2006
Zum Druck genehmigt	: Kiel, Juni 2006
Der Dekan	: Prof. Dr. W. Depmeier

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Abstract

Kamaran and Uqban Seghir Islands are situated on the continental shelf and are located in relatively shallow water at the southern part of the Red Sea, west coast of Yemen. Kamaran Island is traditional characterized by a good condition of the coral reef, and is regarded as an area for tourism and fishing. The major problem in these islands was the fishing activities (grounding and anchoring), which had caused extensive coral destruction.

The studies were performed during the summer and autumn 2003 and autumn 2004 in order to evaluate the reef condition and those of the actual coral reef fishing activities. In addition the reefs were characterized and the related government policies investigated. Three and two transects were chosen at Uqban Seghir and Kamaran Island respectively. Underwater visual census (UVC) for 50 m long transects were used to assess the fish diversity. The fish transects were 50 x 5 m. Within the fish transects, underwater sequential photographs were taken (50 X 1 m) to assess benthic groups and coral reef coverage. Classification of the substrate type was based on benthic groups and life form categories.

Evaluation of the data obtained during summer and autumn 2003 and autumn 2004 revealed that the islands had as a mean 20 % live coral coverage. Live coral coverage was 29, 18, 21, 15, and 19 % in transects 1 to 5 respectively. Dead corals were dominant in all transects (range: 63 - 79 %). *Acropora* spp. are dominant at the study area as well as in all Yemeni reefs.

A total of 609 fishes were counted from two locations during the study period. In general, 33 fish species belonging to 12 families were observed. Altogether the dominant fish taxon was damselfish (Family Pomacentrida).

The study highly suggests this area to be implemented as MPA (Marine Protected Area) to maintain high coverage of hard corals and a diverse fish community and should encourage the management to intensify both surveillance frequency and law enforcement for the entire national park.

Yemeni reefs are stressed by human impacts resulting from trawling activities. Handlines, seine and trawling fishing were the commonly used methods at the study area, although trawling fishing was illegal according to government regulations.

Key words: Kamaran and Uqban Seghir Islands, Coral reefs, Red Sea, Underwater visual census (UVC) and Marine Protected Areas (MPAs).

Zusammenfassung

Die Kamaran und Uqban Seghir Inseln befinden sich auf dem Kontinentalsockel im verhältnismäßig flachen Wasser im südlichen Teil des Roten Meeres an der Westküste des Jemen. Kamaran zeichnet sich durch einen guten Zustand des Korallenriffs aus und gilt als ein Bereich für den Tourismus und die Fischerei. Das Hauptproblem in beiden Inseln ergab sich durch fischereiliche Tätigkeiten (Aufsetzen und Ankern), die umfangreiche Zerstörungen im Korallenriff verursachten. Die Untersuchungen wurden während des Sommers und Herbstes 2003 und des Herbstes 2004 durchgeführt, um den Riffzustand und die durch die Fischerei verursachten Schäden im Riff auszuwerten. Zusätzlich wurden die Riffe charakterisiert und die mit ihnen in Zusammenhang stehende Regierungspolitik untersucht. Drei Transekte wurden bei Uqban Seghir und zwei bei der Insel Kamaran regelmäßig ausgewertet.

Um die Fischdiversität zu bestimmen, wurde auf den 50 m langen Transekten die Unterwassersichtzählung (under water visual census) eingesetzt. Fischtransekte waren 50 m lang und 5 m breit. Innerhalb der Fischtransekte wurden aufeinander folgende Unterwasserfotografien aufgenommen (50 x 1 m), um benthische Gruppen und die Korallenriffbedeckung festzustellen. Eine Klassifikation der Bodensubstrate basierte auf benthischen Gruppen und Lebensformkategorien. Die Auswertung der Daten der Jahre 2003 und 2004 zeigte, dass die Inseln im Mittel 20 % Bedeckung mit lebenden Korallen hatten. Die Bedeckung der lebenden Korallen hatte Werte von 29, 18, 21, 15 und 19 % in den Transekten 1 bis 5. Tote Korallen waren in allen Transekten dominierend (zwischen 63 - 79 %). *Acropora* spp. waren überall am häufigsten. Insgesamt wurden 609 Fische in beiden Lokationen gezählt, die 33 Arten zugeordert werden konnten und 12 Familien angehörten. Das dominierende Fischtaxon waren Riffbarsche (Familie Pomacentrida).

Diese Untersuchung empfiehlt dringend, das Meeresgebiet um die beiden Inseln als Schutzgebiet auszuweisen (Marine Protected Area; MPA), um den bisherigen Bestand an Steinkorallen und die diverse Fischgemeinschaft zu erhalten. Weiterhin sollte die lokale Regierung ermutigt wurden, die Überwachung der Riffe zu intensivieren und die Durchsetzung der Bestimmungen zu verstärken.

Die Korallenriffe im Jemen werden durch menschliche Aktivitäten bedroht, vor allem durch die Grundschleppnetzfischerei. Handleinen-, Wadennetz- und Schleppnetzfischerei waren die am häufigsten verwendeten Methoden im Untersuchungsgebiet obwohl Grundschleppnetzfischerei durch die Regierung verboten ist.

List of Abbreviations

ALECSO	Arab League Educational, Cultural and Scientific Organization
ASD	Admiralty Sailing Directions
COTS	The crown-of-thorns starfish
EAFPF	Agriculture Encouragement and Fishing Production Fund
EU	European Union
EZ	Economic Zone
FAO	Food and Agriculture Organization
GCRMN	Global Coral Reef Monitoring Network
GPS	Global Positioning System
HP	Horse Power
IDA.	Industrial Development Agency
IFAD	International Fund for Agricultural Development
IOC	Intergovernmental Oceanographic Commission
IUCN	International Union for Conservation of Nature and Natural Resources
LIT	line intercept transects
MDS	Multidimensional scaling
NGOs	Non Government Organizations
NPA	National Programme of Action
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
SAP	Strategic Action Plan
SCUBA	Self Contained Underwater Breathing Apparatus
UNDP-GEF	United Nation Development Program-Global Environment Facility
UNESCO	United Nations Educational, Scientific and Cultural Organization
UVC	Underwater Visual Census
WB	World Bank
WWF	World Wide Fund for Nature

Chapter 1

1. Introduction

1.1 Background

The republic of Yemen is located in the south western corner of the Arabian Peninsula. The coastline is more than 2000 km long, roughly one third of which is along the Red Sea and the remaining two thirds facing the Gulf of Aden and Arabian Sea. Population on the coast is scattered, with major concentrations being near the wadi (ephemeral river) mouths, port towns and fishing centers. According to the last national census in 2005, Al-Hudaydah city, which is located at the west coast of Yemen, has a population of about 500,000 (Fig. 1-1.). Oil is exported through the offshore facility to the north-east of Al-Hudaydah at Ras Isa. The Ras Isa marine terminal is located on the As Salif peninsula north of Al-Hudaydah. About 16,000 ships pass Yemen Red Sea coastal waters per annum. There is small port at As Salif which serves the people living in Kamaran Island and surrounding areas (Fig. 1-1).

The Red Sea is a deep, semi-enclosed and narrow basin connected to the Indian Ocean. The Red Sea coast of Yemen extends about 730 km along the eastern side of the Red Sea. The northern Red Sea is highly saline but Yemen’s waters have only slightly elevated salinities. Water temperatures range between 30ºC offshore to 38ºC inshore in semi-enclosed bays during summer (April to October) and are about five degrees cooler in winter. The Red Sea south of 20^{o}N is subject to two annual monsoonal events. During the NE monsoon (October to May) winds blow into the Gulf of Aden from an easterly direction and into the Red Sea from the SSE. During the SW monsoon (June to September) winds are from the NNW over the southern Red Sea and from SW over the Gulf of Aden, causing strong upwelling along southern Arabia (Patzert 1974, Morcos & Varley 1990). The prevailing southeast wind in the southern Red Sea reinforces the northern surface currents where maximum velocities of 30-60cm s^{-1} have been recorded (Morcos 1970).

Morcos (1970) and Edwards & Head (1987) have described the tides in the Red Sea, which generally follow a completely different pattern from those of the Indian Ocean. Tides within embayments in the Red Sea are different again. Tidal height is not very marked anywhere in the Red Sea and ranges of 25cm to 75cm are most common. Red Sea tides are essentially oscillatory and mainly of semidiurnal type.

1.2. Coral reefs in the Red Sea

Red Sea coral reefs are renowned for their richness, abundant fish populations and, since the advent of SCUBA, for spectacular diving opportunities in clear water and on the sheer coral walls that drop hundreds of meters below sea level. Part of this fame was due to the fact that the Red Sea has the closest coral reefs to Europe, where much of the publicity originates. Though such reef habitats exist in many parts of the Red Sea, they are found mainly in the Gulf of Aqaba and northern shores in Egypt and Saudi Arabia. In fact, less well known or publicized, because of being less accessible, are the large areas of varied coral reef habitats on the Western shores (Sudan and Eritrea) and Southern parts of the Red Sea including Yemen (Turak & Brodie 1999).

The Red Sea has high biodiversity, including approximately 300 reef-building coral species and over 1400 fish species (PERSGA 2003). The biological diversity of other animals and plants associated with coral reefs is also high. Southern Red Sea reefs are mainly patchy fringing reefs growing on shallow, gently sloping bottoms and have been described as ‘marginal reefs’ with characteristics of higher latitude reefs (Sheppard 1985, Sheppard & Sheppard 1991, Sheppard *et al*. 1992). The coral reef zone at continental and island shelves is shallow but descends abruptly from the reefs zone to the sea bottom (Drake & Girdler 1964, Knott *et al*. 1966 and Morcos 1970).

The highest growth of *Porites* sp. are recorded in shallow depth at northern part of Red Sea (10 – 12.9 mm/year) (Schuhmacher *et al*. 1995). In general, massive corals tend to grow slowly, increasing in size from 0.5 cm to 2 cm per year. However, under favorable conditions (high light exposure, consistent temperature, moderate wave action), some species can grow as much as 4.5 cm per year. In contrast to the massive species, branching colonies tend to grow much faster (Barnes & Hughes 1999).

The status of coral reefs and coral communities in the Red Sea is generally good, with coral cover averaging 20-50% (GCRMN Global Coral Reef Monitoring Network 2000). This includes decreases and increases in live coral cover since 2002. A 1998 bleaching event caused major damage on parts of the southern Red Sea and Gulf of Aden, but caused no damage in the northern Red Sea; in some areas the recovery has been strong, and weak in others. Threats to coral reefs differ in the region, but are increasing with the increasing rate of coastal development (Douabul & Haddad 1999). The major local threats include land fills, dredging, sedimentation, sewage discharge and effluents from desalination plants, mostly around towns, cities and tourist development sites.

1.3. Coral reefs in Yemen

Though coral and reef growth can be found throughout the Red Sea waters of Yemen, reef development shows some characteristics distinctive to that region. Many of the reef characteristics for which the Red Sea is renowned, such as clear water, steep drop-offs and spur and groove structures, from the Gulf of Aqaba to central regions of the Red Sea (Sheppard *et al.* 1992, Behairy *et al.* 1992), are not found on reefs of Yemen. In the Yemen Red Sea major reef building by corals appears to be relatively limited, although coral growth is fairly widespread. Along most of the ~730 km mainland coastline and around all islands there is coral growth and some type of reef development (PERSGA 2003).

Yemen’s Red Sea coast, located on the continental shelf, is composed of consolidated and unconsolidated sediments and raised ‘fossil’ reefs. Only about 25 % of Yemen's Red Sea coastline supports coral reefs. Offshore islands are situated beyond the continental shelf and are of volcanic origin (Behairy *et al*. 1992, Sheppard *et al*. 1992). Contemporary coral growth is found both as coral reefs and coral communities on a variety of substrates. The coral reefs show two types of development: fringing reefs off the southern coast and some offshore islands and semi submerged patch reefs. Coral communities may be found either associated with red algal reefs, on relic Pleistocene/Holocene reef deposits, or on lava flow terraces and volcanic rock pinnacles (Table 1-1). The variations in these forms depend largely on the amount of reef building (net biogenic deposition or accretion rates by corals) reef destruction by bioerosion physical destruction and chemical dissolution rates and locality of growth (Davies 1982). Locality may have an influence on physical and biological characteristics such as water temperature water movement in the form of tidal and wind driven currents organic and inorganic dissolved nutrient contents and food particles such as phytoplankton, zooplankton and detritus. Each of these factors has an influence on coral growth, reproduction, survival and general physical fitness of individual corals (Turak & Brodie 1999).

Table 1-1. Forms of coral growth found in the Yemen's Red Sea.

Coral Reefs	Coral Communities
• Fringing reefs off the south mainland coast and islands • Submerged patch reefs scattered from offshore Al-Hudaydah to the southern Farasans Islands (South of Saudi Arabia).	• Limited sporadic growth in the form of coral communities on Red Algae Reefs • Coral growth on relic Pleistocene/Holocene reef formations • Coral communities on volcanic rock, around volcanic islands, on terraces formed by old larva flows.

These are true coral reefs in the sense that there is considerable biogenic carbonate accretion by corals. Live coral cover was generally higher (~10 %) in the southern and offshore areas than at most of the northern and central areas, and there were more large colonies (up to 3-4 m diameter) of considerable age, perhaps even several centuries. Island-fringing reefs are more like extensive flats, with gradual slopes of broken up patches and intermittent sand areas. Bottom topographical relief is generally high, varying from 1 m to 3 m height. Some of these coral patches and ridges were formed by coral rubble accumulations from storm activities. These rubble ridges were often covered with thick mats of *Dictyota* sp. Water clarity and coral species diversity was generally average. In addition to the most common corals, *Stylophora pistillata* and massive *Porites*, and in one reef *Psammocora contigua* was very abundant (Turak & Brodie 1999).

A large number of islands lie up to 100 km off the coast. Most of the offshore islands are generally uninhabited due to few infrastructures. However government policy tries to build infrastructure to encourage people to live on these islands. Other islands, particularly the mid-Red Sea Islands, have military garrisons and some aquaculture activity mainly fish aquaculture. The study area Kamaran & Uqban Seghir Islands (Fig. 1-1) is roughly 100 km north-west of Al-Hudaydah city and is located between 15° 25` 00 N, 15° 26` 00 N and 42° 31` 00 E, 43° 32` 00 E in the southern Red Sea. Survey sites of coral areas have been previously reported (Douabul & Haddad 1999) (Fig. 1-2).

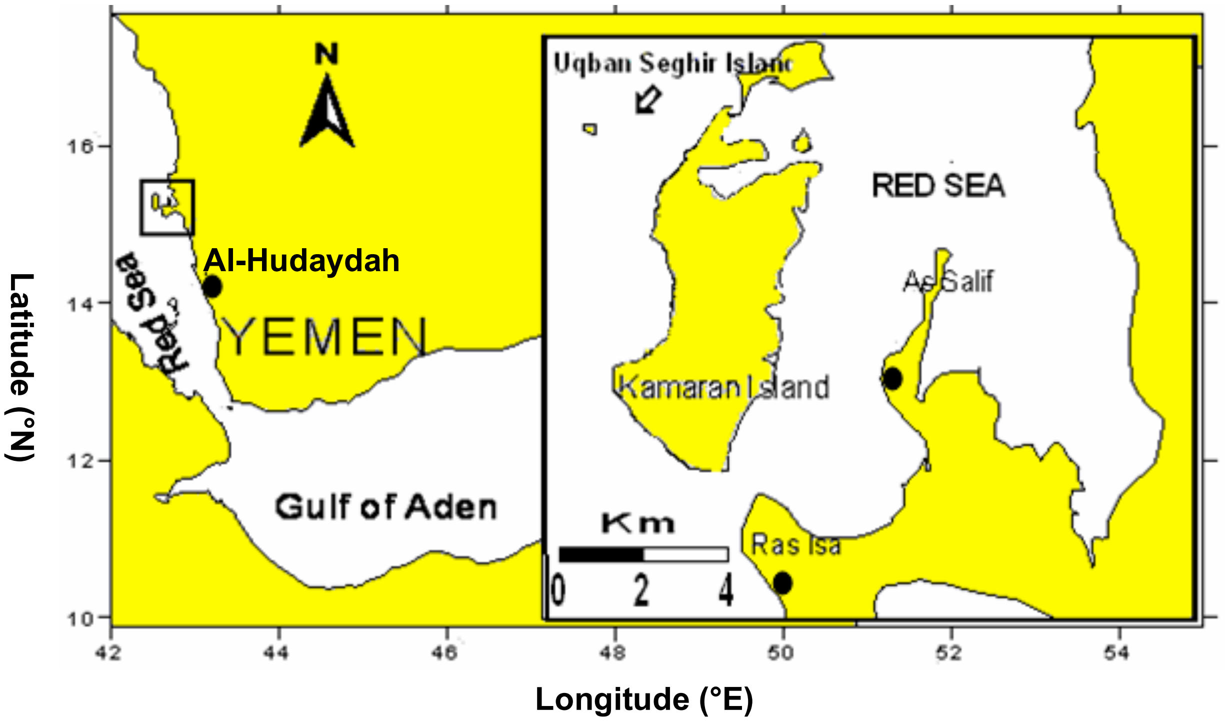


Fig. 1-1. Map of the study area

Fig. 1-2. Map of the coral reefs (shaded areas) at the study site (Douabul & Haddad 1999)

Coral communities were surveyed at coastal and offshore areas at two sites, namely Uqban Seghir and Kamaran Islands. Kamaran Island is one of the 70 offshore islands which are found off Yemen's Red Sea coast with approximately 5000 inhabitants, In contrast, Uqban Seghir is uninhabited, receiving infrequent visits from fishermen.

It is estimated that more than 220 000 people depend on fishing as their principal source of income. The Yemeni government has taken care of the fishery sector since 1980 and started new legislations to protect and regulate the fishing industry. These two islands are remote areas for fishing and tourist activity (Fig. 1-3).

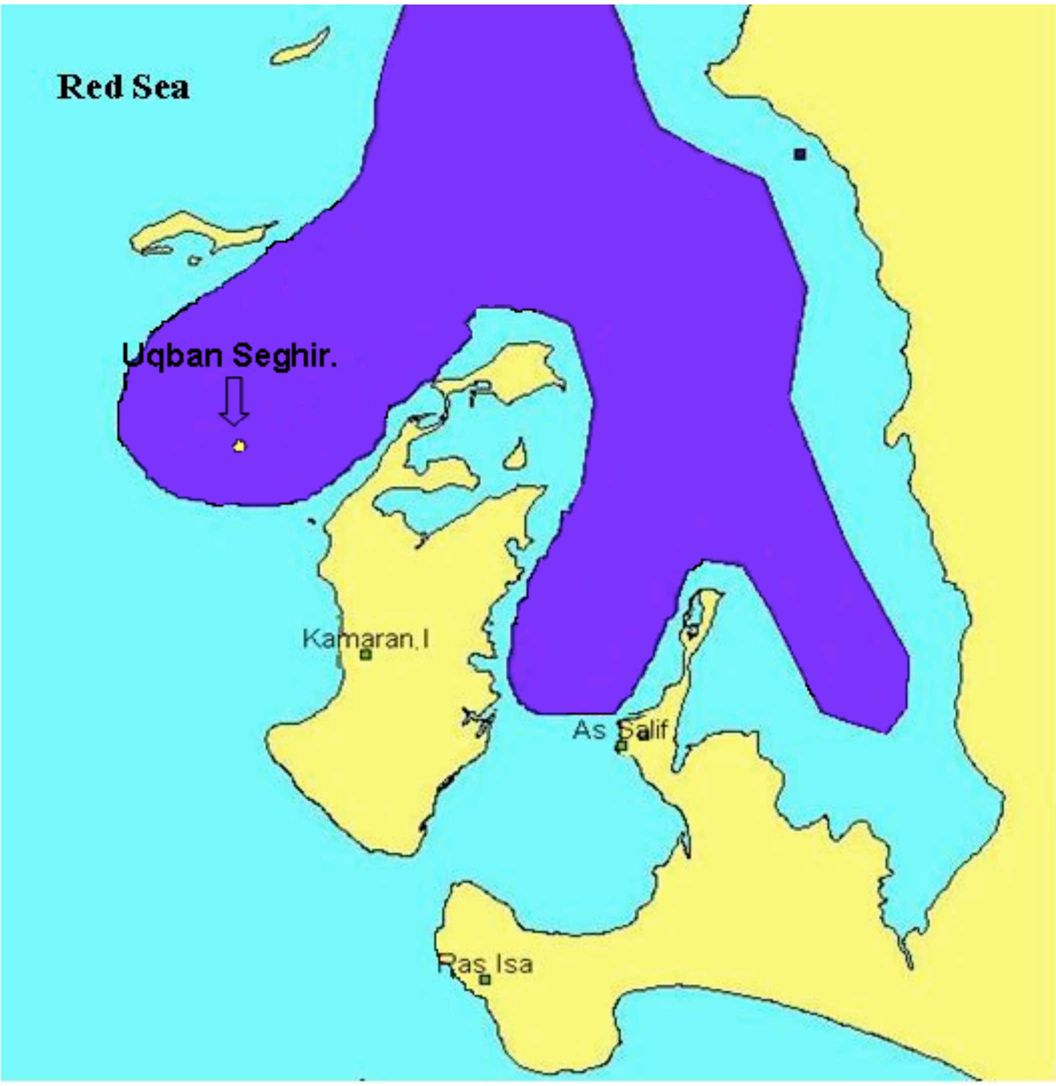


Fig. 1-3. Map of the fishing area (dark blue) at the study site
(Arc View CD-Rom 1997)

Reef damage has been observed at the study area, caused by grounding, anchoring and fishing for ornamental species. Destructive fishing methods are a major cause of worldwide coral reef degradation (Spalding *et al.* 2001). Therefore, it is important to understand the whole system of destructive fishing practices and the consequences for coral reef conditions. For these reasons, this study will be performed in order to measure the coral reef structure (species diversity and abundance) and the effects of major actual coral reef uses, especially fishing and related damage (e.g. grounding, anchoring).

1.4. Hypothesis

Fishing has direct and indirect (anchoring and grounding) negative impacts for coral reefs, destructive methods are used to collect aquarium fish around the Kamaran Island, the expected fishing impact such as grounding and anchoring on coral reef coverage was higher in Kamaran Island than Uqban Seghir Island.

Kamaran Island and Uqban Seghir Island differ in the composition of the coral reefs and their associated fish assemblages.

The expected results of this research will provide biological data on coral reefs structures and fisheries and coral management, which can be used for planning and decision-making on the development of coral reefs and fisheries.

1.5. Objectives

In the frame of the PhD thesis we attempt to answer the following questions:

- To assess the coral reef habitats of the study area, identify benthic group and life form categories of coral reefs.
- To assess the abundance of coral reef fish, identify the fish species.
- To investigate the socio-economic effects on coral reefs.
- To provide the possibility of implementation of improved protection measures for coral reefs.

- What is the relative abundance of live and dead corals at the study sites?
- What is the composition and abundance of the reef fish assemblages at the study sites?
- What fishing methods are being employed and what are the fishing yields?
- Which changes in the coral reef and fisheries management are recommended?

1.6. Approaches

To assess the status of coral reef habitats at two sites differing in the impact of fishery activities (Kamaran Island vs. Uqban Seghir Island)

The scope of the present study is to investigate the status of coral reef conditions at Kamaran and Uqban Seghir Islands along the western coast of Yemen in the Red Sea. The survey was carried out in summer and autumn 2003 and autumn 2004.

The coral reef coverage was assessed by taking underwater sequential photographs. This technique has the advantage in that it takes relatively little time in the field and provides a permanent record (Done 1981). However it has also some disadvantages, like ineffectiveness in sampling small and hidden colonies, a very limited perception of depth (Done 1981), and it is very time-consuming to evaluate the pictures on the computer.

Underwater visual census (UVC) was used in this study to assess the reef fish community. UVC by SCUBA divers has been an important tool for fish ecologists in enumerating the abundance and composition of reef fish assemblages on coral reefs (Sale & Sharp 1983, Bell *et al*. 1985 and Harvey *et al.* 2002).

Social data were taken from communities close to coral reefs which have activities related directly to reefs. Data are only gathered randomly from fishermen. Socio-economic data were gathered from fishermen and from communities close to coral reefs by distributing questionnaires and interviewing the fishermen.

Chapter 2

2. Material and Methods

2.1. Marine and coastal environment

A west-east profile through Yemen's Red Sea region (Fig. 2-1) reveals four distinct marine and coastal environments:

1. Off-shelf Island: Off-Shelf Islands, including Az Zubayr Island and Zugar Island, are of volcanic origin. Composed predominantly of basalt, they range in size from <100 m² to 125 km² (Zugar Island).

2. Deep Sea Basin: Defined here as submerged land in water between 100m and 1600m deep, this environment includes the continental shelf slope.

3. Shelf Islands: Shelf islands, such as Kamaran Island are situated on the continental shelf and are located in relatively shallow water (≈10 to 100m). There are approximately 100 shelf islands off Yemen's coast, ranging in size from <100 m² to 112 km².

4. Continental Shelf: In Yemen the continental shelf, defined here as submerged land in water to100m depth, is widest (≈ 80 km) north of Zugar Island.

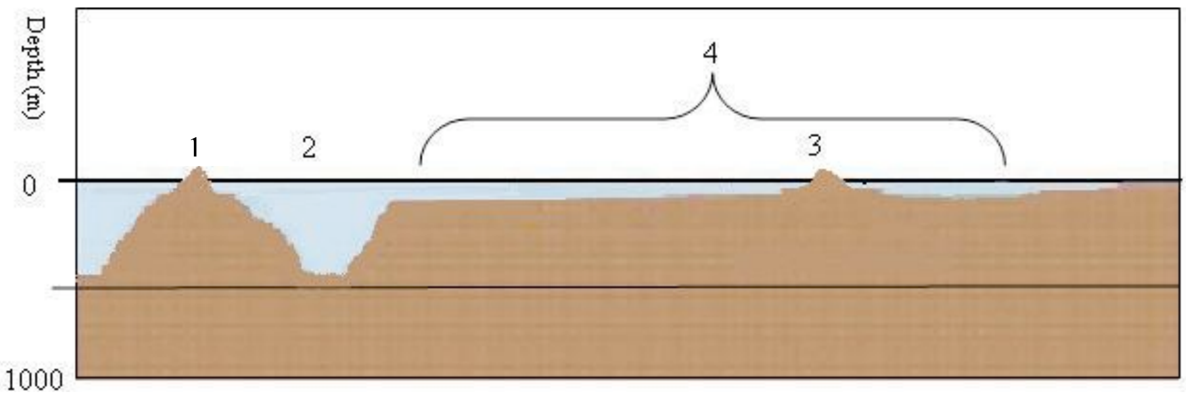


Fig. 2-1. Cross section of West-coast continental shelf of Yemen's Red Sea Environments: 1 Off-shelf Island, 2 Deep Sea Basin, 3 Shelf Island, 4 Continental Shelf (modification from Douabul & Haddad 1999)

2.2. The study area

The area of investigation is located between 15° 25` 00 N, 15° 26` 00 N and 42° 31` 00 E, 43° 32` 00 E in the southern Red Sea, including Kamaran and Uqban Seghir Islands which are situated on the continental shelf (Fig. 1-1 & 2-2). Similar to the coastline along the mainland, rainfall over these islands is low. Mean annual rainfall for Kamaran Island is 54 mm (ASD 1987).

Coral reef of Kamaran and Uqban Islands are mostly fringing reefs. The islands, in general, have narrow shores composed of coarse sand. In Kamaran and Uqban Seghir areas, water is very shallow and coastal reefs are rarely found at a depth greater than between 4 and 6 meters (Douabul & Haddad 1999). Kamaran is famous for its black and gold corals. It is also one of the most important centers of the aquarium fish trade. For our study, the former is of particular importance and will be quantified in the form of the PhD project.

2.3. Sampling sites

Before the permanent sampling sites were chosen, a pre-survey was performed in several locations: south and north of Al-Hudaydah city (Chapter 1, Fig.1-1). In a pre-survey, snorkeling has been conducted to find suitable places to perform transects. Thereafter coral reef transects have been placed according to the abundance of the coral reef. A Global Positioning System (GPS) has been used to record the precise locations of the sampling survey.

Based on the pre-survey, two offshore islands have been chosen namely Uqban Seghir and Kamaran Islands with five transects (for detailed position see Table 2-1 and Fig 2-1).

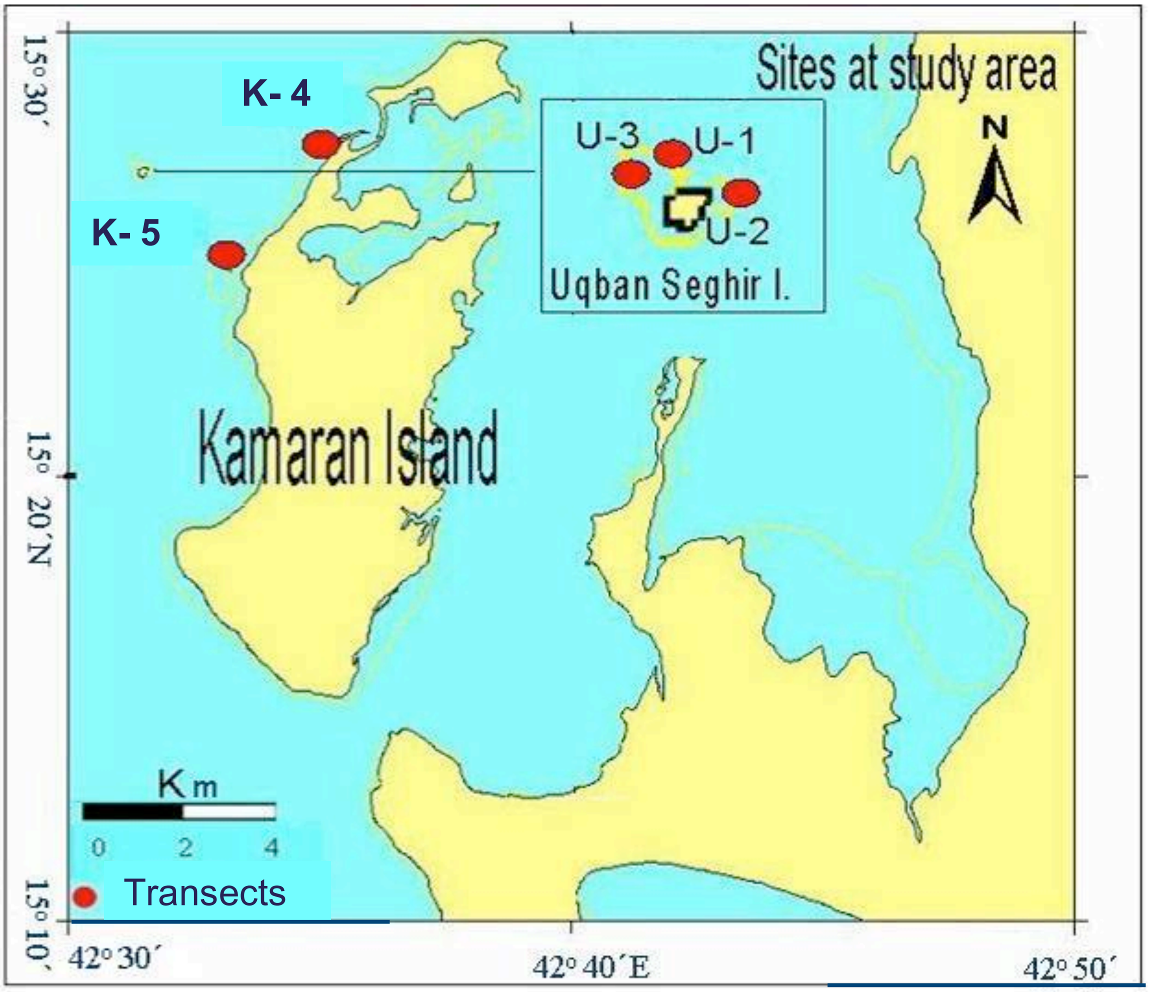


Fig. 2-2. Study sites at Uqban Seghir and Kamaran Islands

Table 2-1. The coordinates of sampling sites on the Uqban Seghir and Kamaran Islands.

Islands (code)	**Sites**		
Uqban Seghir (U)	U-1: 42°30'13 E 15°25'09 N.	U-2: 42°30'20 E 15°25'08 N.	U-3: 42°30'10 E 15°25'10 N.
Depth	8 m	10 m	5 m
Kamaran (K)	K-4: 42°35'00 E 15°25'10 N.	K-5: 42°30'30 E 15°20'40 N.	
Depth	8 m	3 m	

E = Longitude East; N = Latitude North, T= Transect

2.4. Time frame of study

The pre-survey and preparation of this study was carried out between summer and autumn 2003. The second assessment was performed on autumn 2004. The assessment was carried out for all transects. Social economical data were collected from communities close to coral reefs which have activities related directly to reefs. Underwater visual census (UVC) for all transects (section 2.7.) was done first and only for data 2003, followed by coral photography. It was always completed in a manner which tried to minimize disturbing the reef fish community. See Fig. 2-3 for further details.

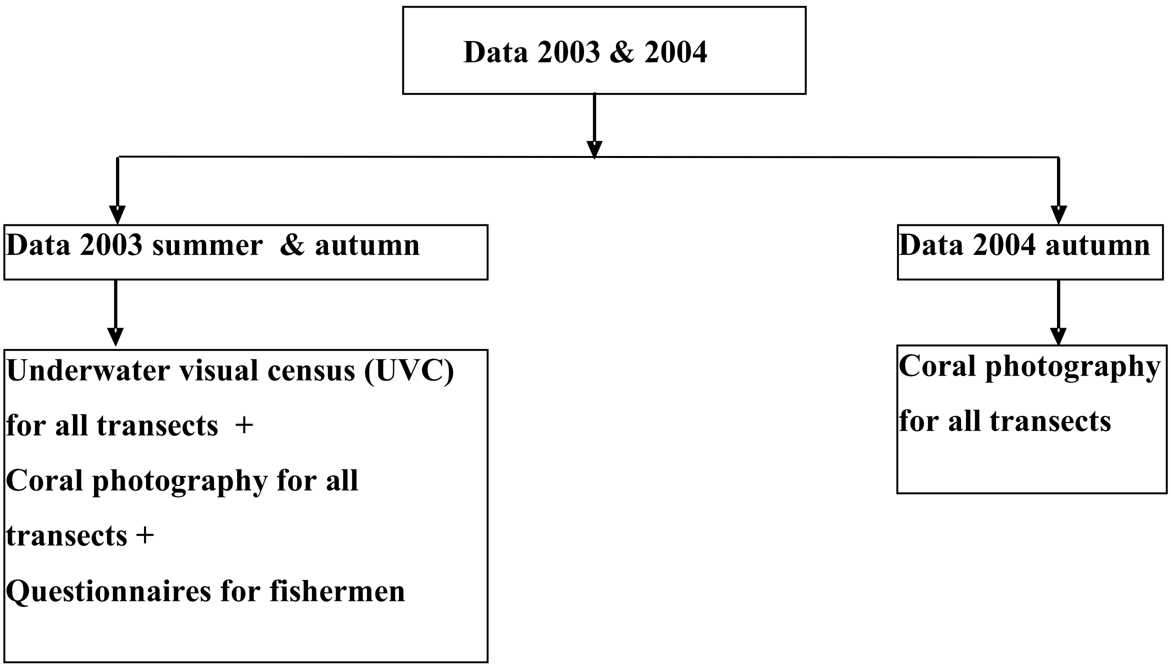


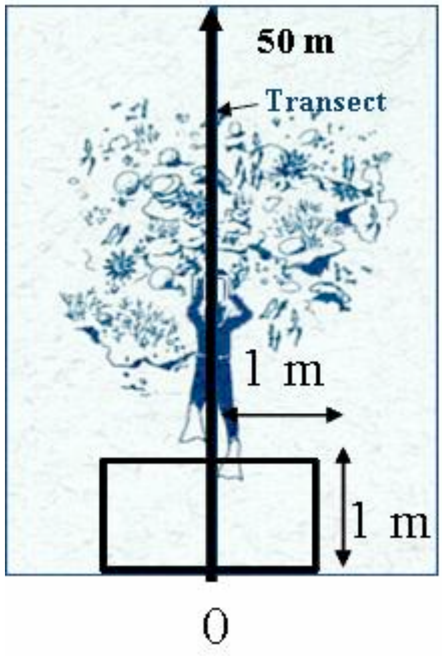
Fig. 2-3. Scheme of data processing

2.5. Permanent transects

Permanent transects (of 50 m length) for inventory fish and corals were installed at fixed locations (using the same line transects) at 3-5 and 8-10 m depth, depending on the occurrence of coral. The transect lines were straight, following the depth contour and were laid down parallel to the reef front. The morphology based on bathymetry obtained from (British Admiralty Chart #548). Both edges of the transect were marked by hammering iron/steel stakes into the reef framework at useful points for resetting the transect and relocate the lines on the second year precisely. Tape measures were laid out between both marks during each survey and then removed after each census. A Global Positioning System (GPS) was used to relocate the permanent transects.

2.6. Coral sampling

For coral and fish assessment a belt/quadrat sampling method was used. Data sheet for coral reef site identification were filled out (Appendix 1). For coral assessment, a combination of line intercept transects (LIT) and photogrammetry was applied (English *et al*. 1994 and Done 1981). The fish transect was 50 m x 5 m and the coral transect was 1 m wide and 50 m long (English *et al.* 1994). During summer and autumn 2003 and autumn 2004 the percent cover of corals was assessed. Therefore, photographic methods were combined with the line intercept transect. The entire length of each 50-m transect was photographed using a digital Olympus 750 camera with a 38- 380-mm lens and a tetrapod frame (Fig. 2-4) whereby the base of the rectangular frame served as reference bar. A total of 1,000 digital photos and the areas of the reef life-form categories were measured using ImageJ software (the same used by McCook 2001) and converted to percent cover of benthic groups and life form categories (Fig. 2-5). The life-form categories used in this study were based on English *et al*. (1994), see Table 2-2 for further details.



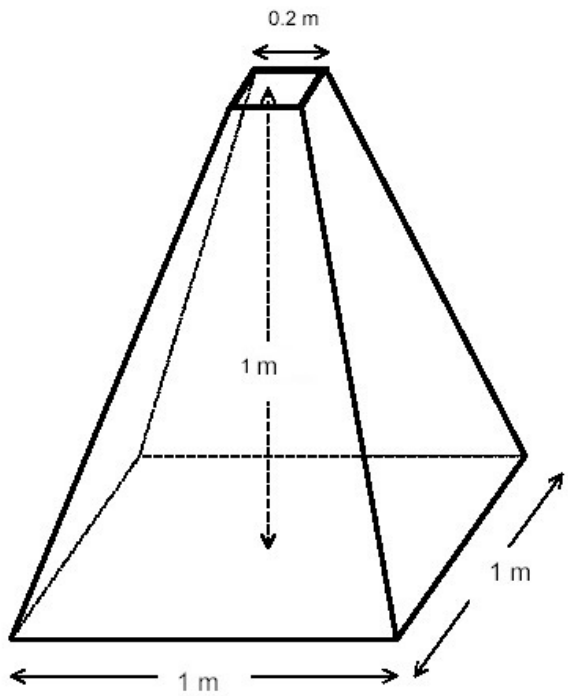


Fig. 2-4. Tetrapod frame for photography of coral coverage
(modification from English *et al* 1994).

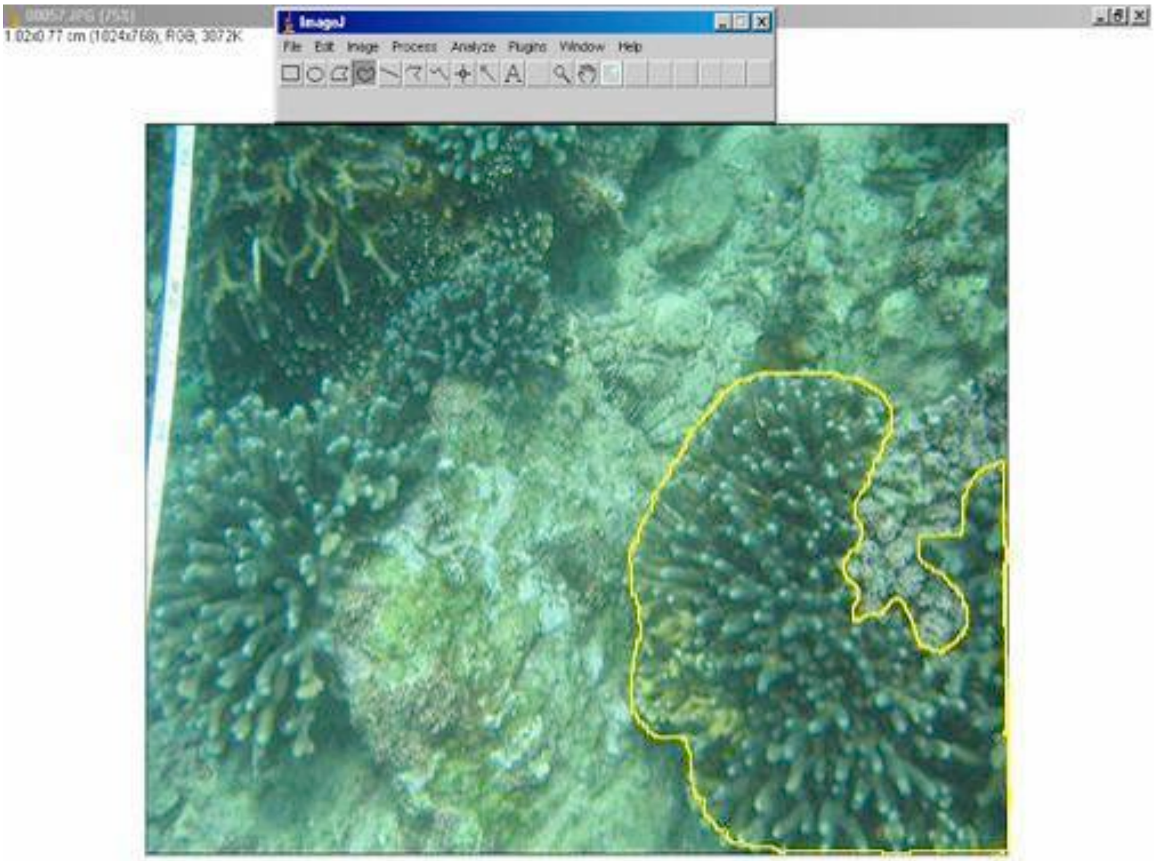


Fig. 2-5. Example of data processing using software ImageJ.

2.7. Fish sampling

Underwater visual census (UVC) was used for assessing reef fish communities. The record of the fish species was carried out for all transects between 10.00 hours – 12.00 hours. Census was done only once per site. Due to the difficulties of getting fish samples for closer taxonomic inspection of specimens, some taxa were identified only to genus level. Identification of fish species was based on Burgess & Axelord (1972), Masuda *et al.* (1984), Allen & Steene (1987), Kuiter (1992), Lieske & Myers (1997) and Allen (1999). The following procedure was used (modified from Russ 1985; Greene & Shenker 1993; English *et.al*. 1994):

1. A species list of reef fishes was developed for the studied area.
2. A 50-m measure tape was laid out followed by a waiting period of 45-60 minutes.
3. Two SCUBA divers swam very slowly (35-50 minutes) at 0.5 m above the substratum along the 50-m transect. A single observer recorded the fish species, while the other served as a dive buddy swimming behind the observer (Fig. 2-6).

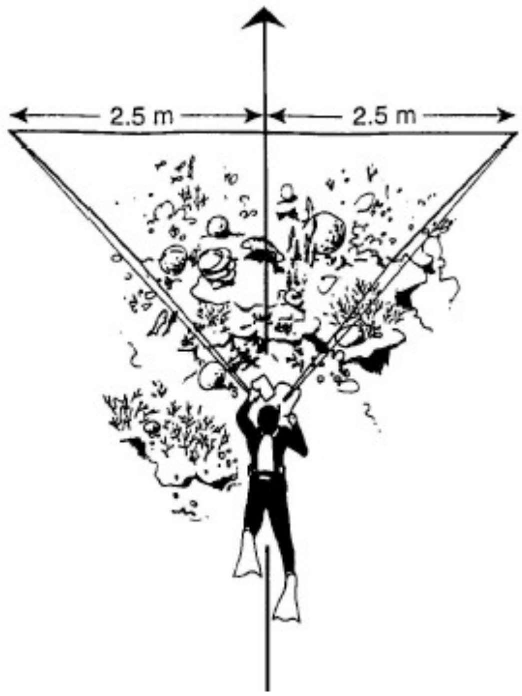


Fig. 2-6. Observer swims along the 50-m permanent transect at 0.5 m above the substratum to visually census the reef fish (English *et al.* 1994)

Table 2-2. Life-form categories used for line intercept transects. Slightly modified after English *et al*. (1994)

Code	Category	Notes
ACB	*Acropora* Branching	
CB	Corals Branching (Non-*Acropora*)	Mostly *Pocillopora damicornis* and *Stylophora pistillata*
ACT	Tabular *Acropora*	
CE	Corals Encrusting	E.g. *Montipora* spp.; *Pavona explanulata*
CF	Corals Foliose	E.g. *Montipora foliosa* and *Montipora* spp.
CM	Corals Massive	E.g. *Porites* spp.; *Galaxea astreata*; *Goniastrea retiformis*; *Leptoria phrygia*
CSM	Corals Submassive	E.g. *Porites* spp.; *Echinopora lamellosa*; *Echinopora gemmacea*
CMR	Corals Mushroom	
SC	Soft corals	E.g. *Sinularia*; *Xenia*; *Sarcophyton*
OT	Other Fauna	E.g. (including: Soft corals, Sponges and other benthic organisms)
AL	Algae	E.g. Macroalgae.
DC	Dead coral	Recently dead colonies with algae, rubble and massive dead coral.
S	Sand	

2.8. Physical measurements

Physical measurements as well as amount of sedimentation were checked at every transects for the data of 2003 and 2004. Measurements included temperature (sea surface temperature°C) with digital thermometer, transparency (m) with secchi disk, pH, and salinity with refractometer (Table 2-3).

All surveys of living resources of coral reefs should include environmental parameters, which characterize the conditions at the site when the data were collected. The parameters to be included with the survey methods are important to the health of the reef. The environmental parameters that should be measured are: temperature, salinity, and visibility (English et al, 1994). There were no extreme physical factors, which affected coral reefs at study area.

Table 2-3. Physical measurements at Kamaran and Uqban Seghir Islands (2003)

No.	Location	Salinity	pH	Surface temperature °C	Transparency (m)
1.	Uqban S. I.	Average: 38	Average: 7.5	Average: 26	Average: 7
2.	Kamaran I.	Average: 38.6	Average: 7.7	Average: 26	Average: 5.5

Physical measurements at Kamaran and Uqban Seghir Islands (2004)

No.	Location	Salinity	pH	Surface temperature °C	Transparency (m)
1.	Uqban S. I.	Average: 37	Average: 7.5	Average: 26	Average: 7
2.	Kamaran I.	Average: 38.3	Average: 7.7	Average: 26	Average: 5.5

2.9. Social-economic data

Social-economic data were gathered from fishermen and communities close to coral reefs. Aside from collecting data from the fish auction centers, data were only gathered randomly from fishermen and middlemen in accessible landing spots. The data comprise all fisheries aspects. The estimation of fishermen in the study area was 43 boat owners and 68 seamen. More than 40 questionnaires for fishermen were distributed to them and some of them were interviewed to gain the data (Appendix 5).

2.10. Data analysis

Percent cover data was obtained for life-form and abiotic categories. In addition, hard corals were identified whenever possible to genera and species (Sheppard and Sheppard 1991). Two multivariate methods used in the study were the ordination and clustering technique. The ordination technique was employed to visualize the relationship between the samples. The cluster technique was applied to form discrete groupings of samples (Clarke & Green 1988). Clarke & Green (1988) suggested that combining both techniques is a good strategy, although descriptive multivariate analysis make no parametric assumption at all. Multivariate analysis was used to visualize the species abundance matrix and the composition of benthic groups and life form categories (Clarke & Green 1988).

2.10.1. Multivariate analysis

Cluster analysis (CA) was used to group entities of the benthic groups and also the fish abundance into a dendrogram according to their similarities (Ludwig & Reynold 1988, Clarke & Warwick 1994, Legendre & Legendre 1998). For fish, the cluster analysis was based on the Bray-Curtis Similarity index with complete linkage method. Data was transformed with square root without standardizing. For the benthic data the same method was used but data was not transformed.

Multidimensional Scaling (MDS) was based on Bray-Curitis Similarity. The stress value that indicates how well 2D configuration represents the multidimensional similarity between the samples was based on the classification from Kruskal (1964):

Stress	Goodness of fit
20 %	Poor
10 %	Fair
5 %	Good
2.5 %	Excellent
0 %	Perfect

The process of the multivariate computation (CA and MDS) is summarized in (Fig. 2-7).

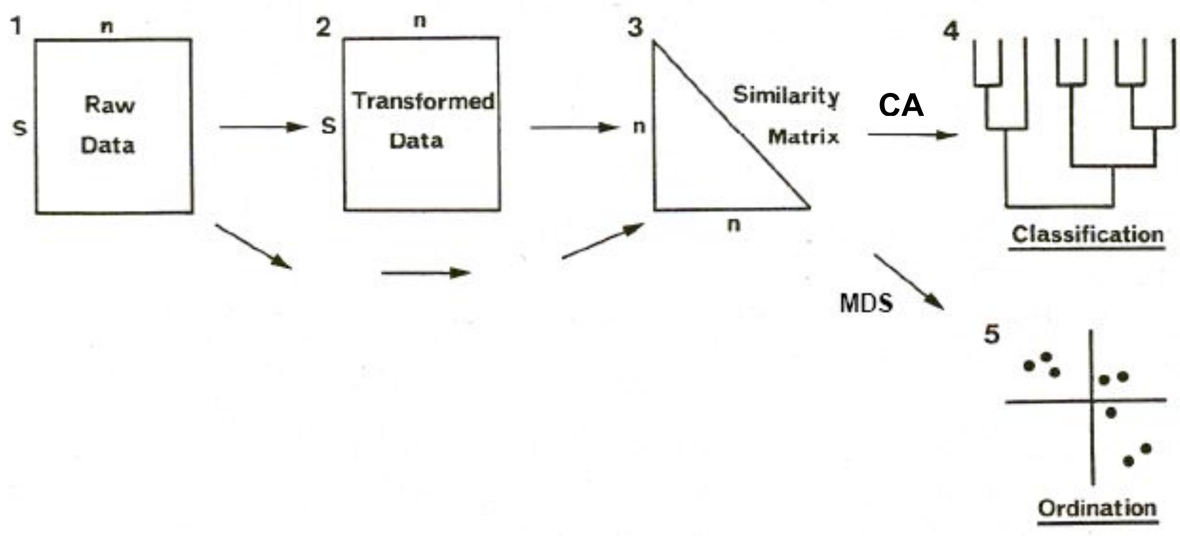


Fig. 2-7. The process of the multivariate analysis (modified from Field et al. 1982).
(CA: Cluster analysis, MDS Multidimensional scaling).

Multivariate computations were performed with PRIMER 5 (Plymouth Routines In Multivariate Ecological Research) software (Clarke & Warwick 1994). In order to test differences between data of 2003 and 2004 for percentage of coral reefs cover dependent t-test was performed using Excel software with significance level (0.05). Analysis questionnaires of fishermen were calculated by SPSS and Excel software.

Chapter 3

3. Results

3.1. Areas cover of benthic groups

The percent cover of the major benthic groups (the sum of all animals, plants and dead corals) was not highly variable among the surveyed islands (Fig. 3-1 to Fig. 3-4). Dead corals were the most dominant cover on the two islands surveyed; with lowest coverage at transect one Uqban Seghir Island (62.9%) and highest at transects four and five Kamaran Island (78.63 %) (Appendix 2). The highest coverage of hard coral occurred at transect one Uqban Seghir Island (28.56%) which the lowest percentages cover found at transect four Kamaran Island (14.58%) (Fig. 3-1).

The group of hard corals was divided into the two life-form categories *Acropora* and Non-*Acropora* (Fig. 3-2 & Fig. 3-3). The *Acropora* life-forms were further subdivided into three categories (*Acropora* Branching (ACB), *Acropora* Digitate (ACD) and *Acropora* Tabulate (ACT), and Non-*Acropora* life-forms were subdivided into eight categories (Coral Branching(CB), Coral Encrusting (CE), Coral Foliose (CF), Coral Mushroom (CMR), *Millepora* (CME), *Heliopora* (CHL), Coral Massive (CM) and Coral Sub-massive (CSM) (see Appendix 2). The average percent cover of both *Acropora* and Non-*Acropora* life-form categories was highly variable among the two islands (Fig. 3-2 & Fig. 3-3).

The other fauna (OT) group was present on the two surveyed islands, but the cover never exceeded 4 % (Fig. 3-1). This assembly consisted of 6 sub-categories, including soft corals. Soft coral was only occasionally encountered. Crown-of-thorns starfish and bleached corals were recorded during surveys. The algae set consisted of three parts (Macroalgae, *Halimeda* spp. and red coralline algae) and covered between 2.04% and 4.35% (Fig. 3-1, Appendix 2). The dominant of macroalgae were *Sargassum* spp. and *Laminaria* spp.

Kamaran Island was characterized by a high number of dead corals (Fig. 3-1). The coverage of dead corals in transect four and in transect five was 5.4 times and 4.2 times higher than the cover of hard corals, respectively, whereas Uqban Seghir Island which is uninhabited, was in better condition compared with the Kamaran Island which is settled.

Uqban Seghir Island had the lowest value of dead coral cover divided by live coral (2.2). The mean hard coral cover in Uqban Seghir and Kamaran Islands were 22.4 % and 16.56 % respectively. Large coral colonies were dominant on both islands. The comparisons of mean dead coral to hard corals cover at Uqban Seghir Island 3.1 and at Kamaran Island 4.7.

Among the other dead coral components rubble had the highest cover in all islands. The coverage of rubble was between 43.7% and 54.3% (Fig. 3-4 & Fig. 3-5). The highest dead coral was at transect four Kamaran Island (78 %) and the lowest at transect one Uqban Seghir (63 %).

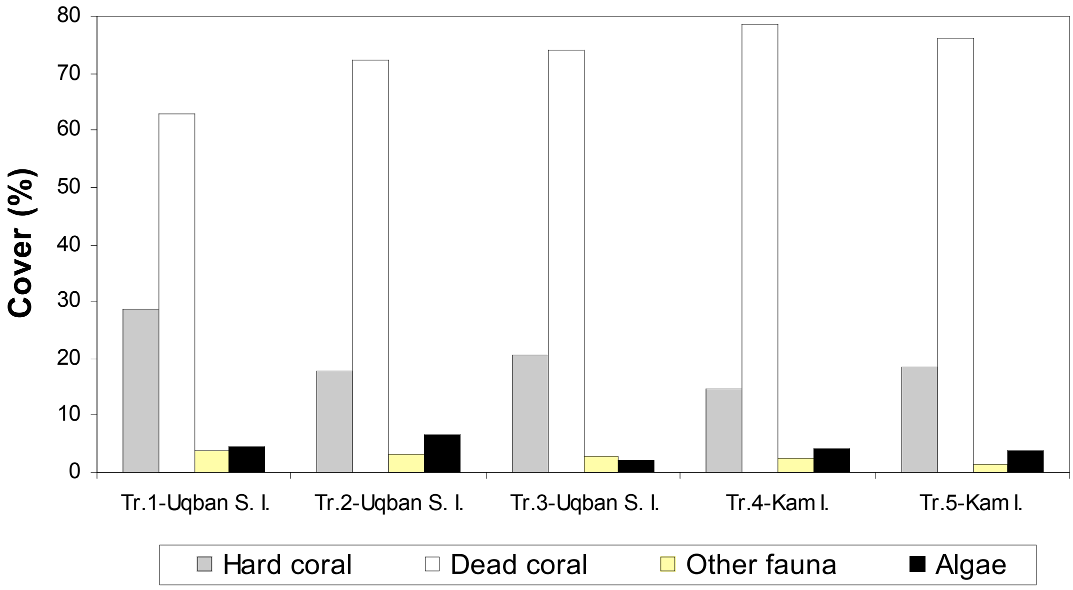


Fig. 3-1. Percent cover of the benthic groups: hard corals, dead corals, other fauna and algae, summer & autumn 2003. (Tr.: transect, Uqban Seghir and Kamaran Islands)

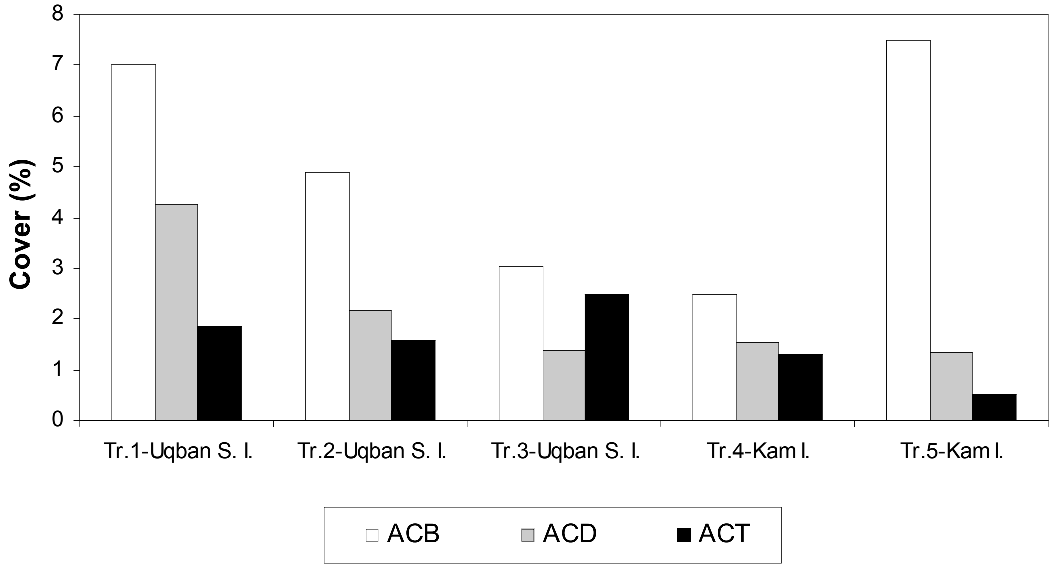


Fig. 3-2. Percent cover of *Acropora* life-form categories: *Acropora* Branching (ACB), *Acropora* Digitate (ACD) and *Acropora* Tabulate (ACT)

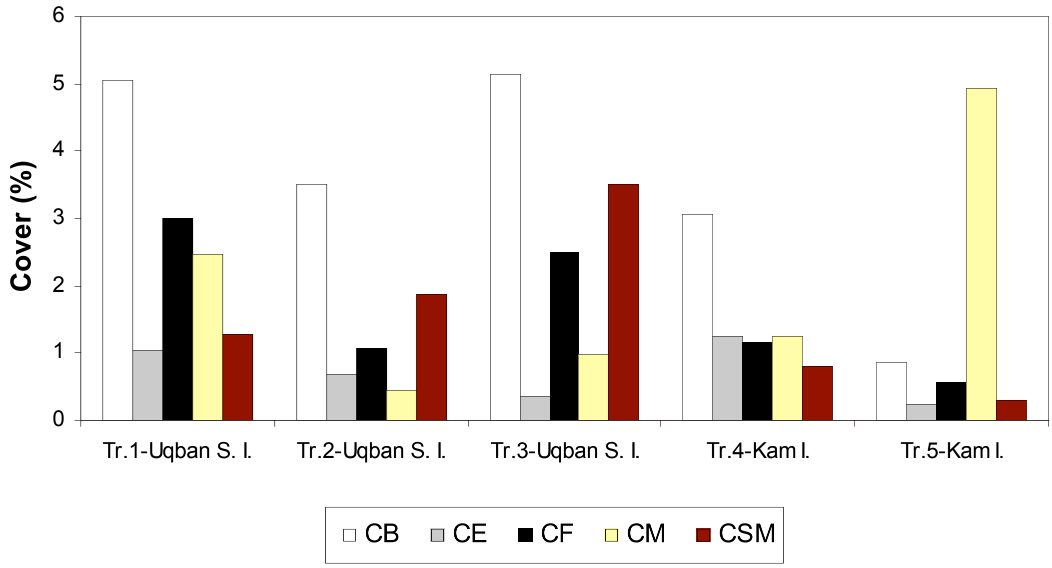


Fig. 3-3. Percent cover of Non-*Acropora* life-form categories: Coral Branching (CB), Coral Encrusting (CE), Coral Foliose (CF), Coral Massive (CM) and Coral Sub-massive (CSM)

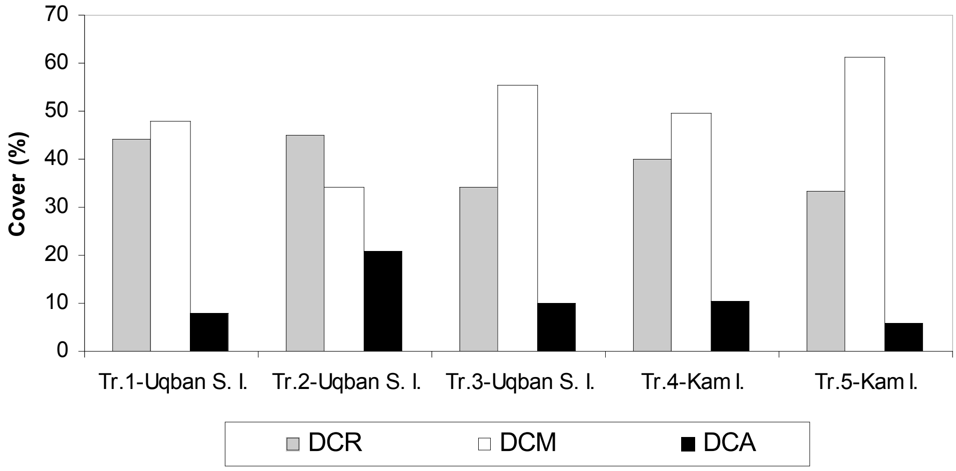


Fig. 3-4. Percent cover of dead coral at each island, consisting of rubble dead corals (DCR), massive dead corals (DCM), and dead corals with algae (DCA)

Fig. 3-5. Photos from rubble at the study area, each photo represent depicts approximately 1 m²

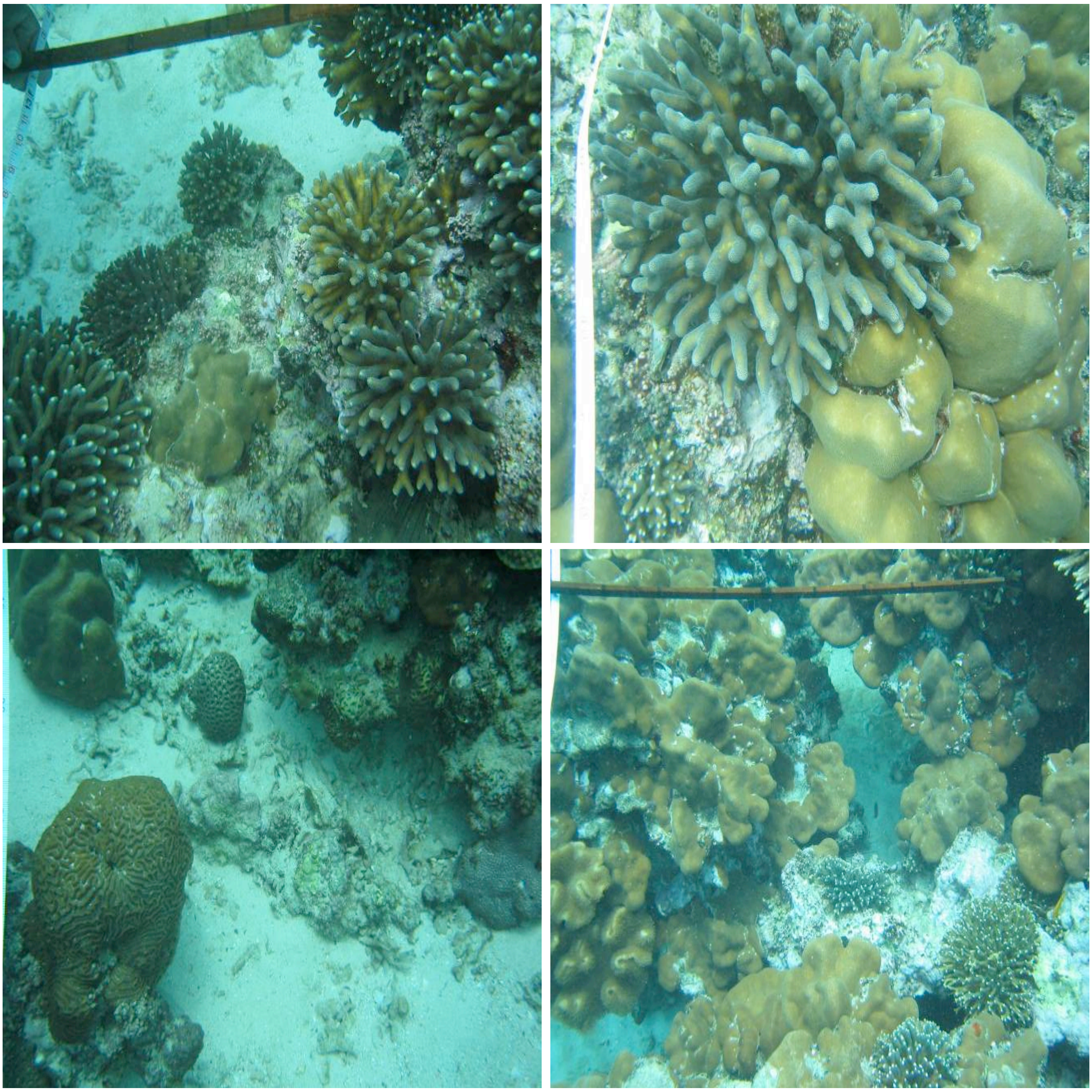


Fig. 3-6. Photos from benthic communities and life form categories at the study area, each photo represent depicts approximately 1 m²

3.2. Coral communities relief

Coral communities consisted of large and small numbers of individual hard coral colonies, generally growing on rock substrate, rubble or sand. The following transects were graphs by five transects and digital photos were obtained. In an overview the five transects are characterized (Fig. 3-7).

Transect 1 – Uqban Seghir Island: This transect represent high hard coral cover (28 %) dominated by *Acropora* coral branching. Branching corals were represented by small colonies. Corals were often patchily distributed and exposed among sand and coral rubble.

Transect 2 – Uqban Seghir Island.: Branching *Acropora* patches in the sand and rubble. The hard coral cover was 18%. High relief of coral reached 1.5 m high.

Transect 3 – Uqban Seghir Island: Dominated by *Pocillopora* spp. (Coral Branching) and large colonies of *Porites* reaching 3 m in diameter and 1 m in height. This massive and sub massive colonies were solitary and separated by sand or rubble. Hard coral reached 21 %.

Transect 4 – Kamaran Island: This transects separated by meters of sand and rubble, so the hard coral cover was comparatively low 15 %. Most colonies were coral branching. Low relief of coral was 0.5 m.

Transect 5 – Kamaran Island: Large colonies of *Porites* (Massive Coral), no sand found in this transect. Most colonies were *Porites*. Hard coral cover was 19%.

3.3. Comparison of benthic cover in 2003 and 2004

No significant differences in percentage cover for benthic habitat were found between data 2003 and 2004 using dependent t-statistic (Fig. 3-8). Table 3-1 shows the values of dependent t- statistic using significance level (0.05) for each transects.

Table 3-1. Values of dependent t- statistic for each transects at study area.

Sites code	U-Tr.1	U-Tr.2	U-Tr.3	K- Tr. 4	K- Tr.5
Dependent t- statistic	0.08*	0.12*	0.09*	0.15*	0.07*
P	0.06	0.09	0.07	0.10	0.06

* No significant

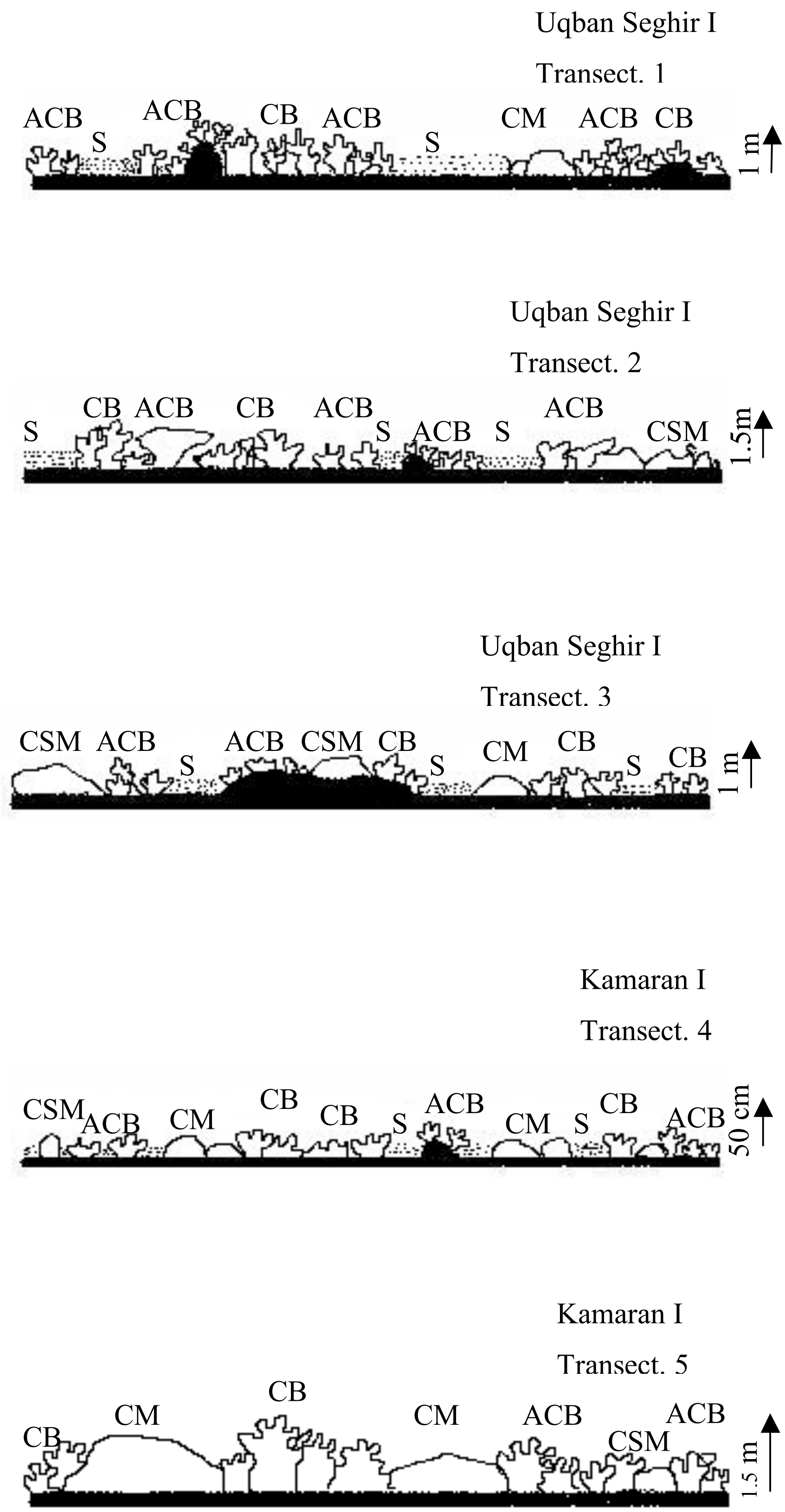


Fig. 3-7. Schematic representation of the transects of coral communities in the study area. Black area represents underlying bedrock and dotted area sand. Categories coded as in Table 2-2

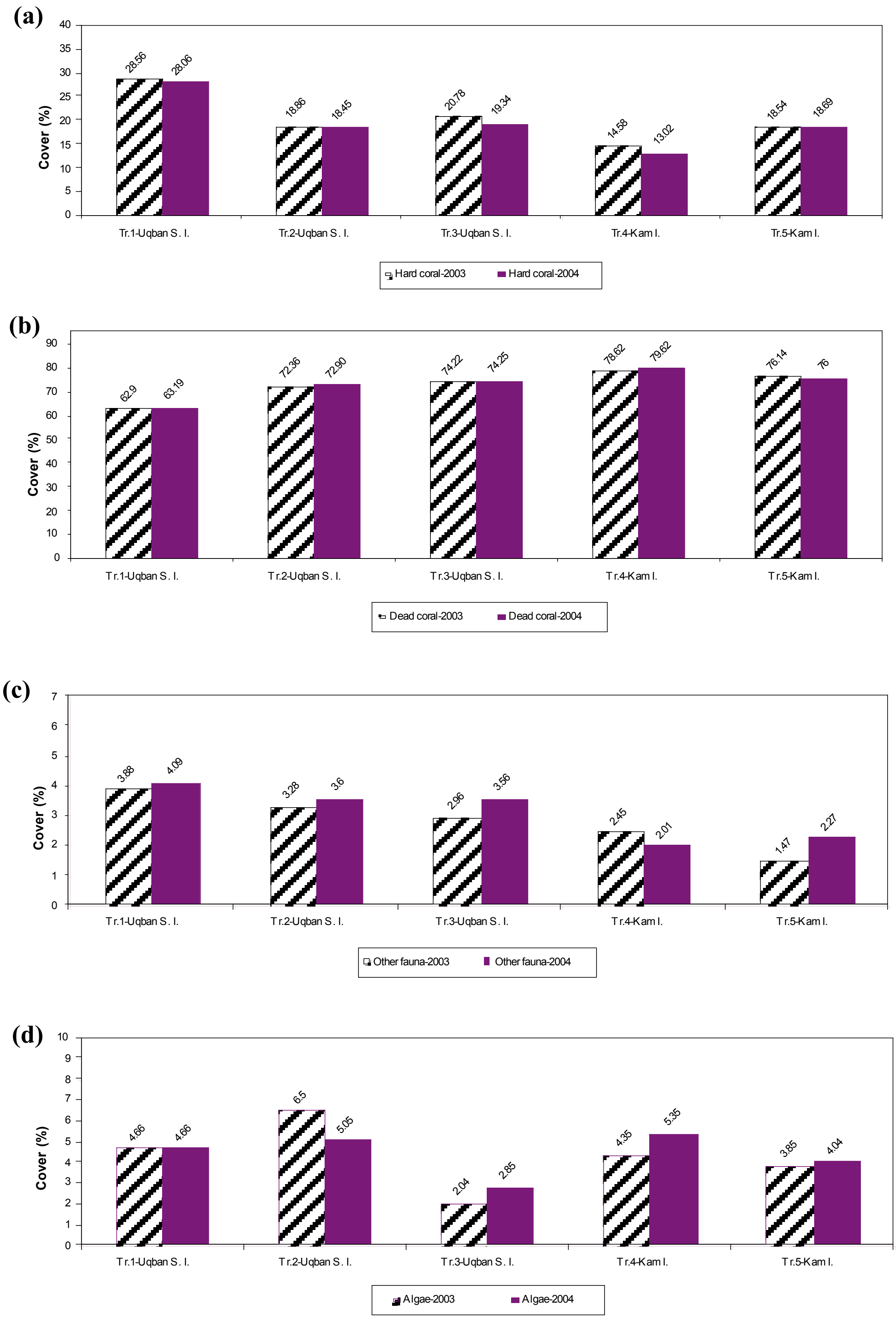


Fig. 3-8. Comparison of benthic cover for data 2003 and 2004, (a) for hard coral, (b) dead coral, (c) other fauna, (d) algae.

3.4. Pattern of major benthic groups and life-form categories

Between the surveyed islands the composition of the benthic habitat was slightly variable. Multivariate analysis were used to find similarities among them. Fig (3-9) shows a hierarchical dendrogram. At a similarity level of 84 % two different benthic groups were distinguished. The first group consisted of the Uqban Seghir Island transects and transect four from Kamaran Island. The second group was transect 5 (Kamaran Island) and had a 73 % similarity.

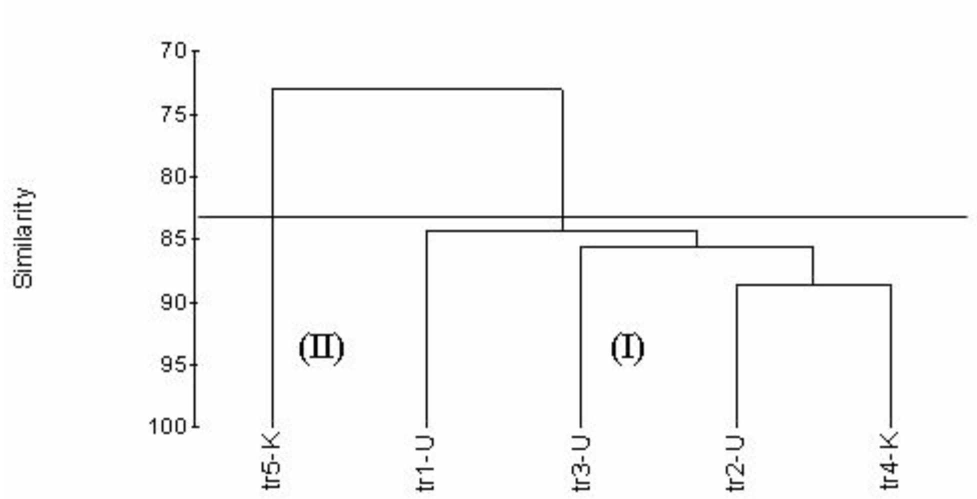


Fig. 3-9. The hierarchical dendrogram for all components of benthic groups and life form categories produced by group average linkage

The MDS-plot of all components of benthic groups and life form categories showed two different groups. In the MDS-plot, all transects at Uqban Seghir Island and transect 4 from Kamaran Islands grouped together. Transect five at Kamaran Islands constituted the other group (Fig. 3-10). The stress of MDS-plot was perfect.

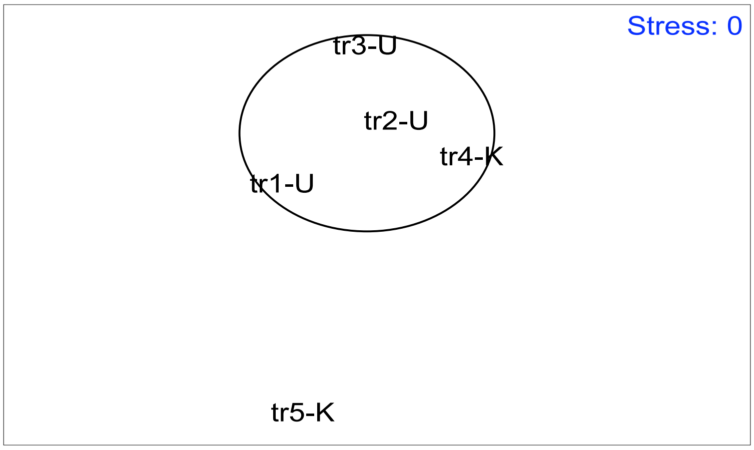


Fig. 3-10. MDS-plot of all components of benthic groups and life form categories

3.5. Reef fish community

A total of 609 fishes were counted from two locations during the study period (Appendix 3). In general, 33 fish species belonging to 12 families were observed (Table 3-2. and Table 3-3). Altogether the dominant fish taxon was damselfish (Family Pomacentrida), from which 65 individuals were found, followed by Acanthuridae, Chaetodontidae, Labridae and Scaridae (Fig 3-11 and Fig 3-13). Other families, from which a low number of individuals were encountered, were Ephippidae and Mullidae.

The most common fish on Uqban Seghir Island were *Pomacentrus sulfureus, Scarus ferrugineus,* and *Dascyllus trimaculatus* (Appendix 3). Kamaran Island was characterized by high numbers of fish such as *Dascyllus marginatus, D. trimaculatus, and Pomacanthus maculosus,* which never were among the ten most abundant fish species at Uqban Seghir Island except *D. trimaculatus* (Appendix 3).

Omnivore and benthic feeder fish were the two most abundant trophic groups in each island and the whole surveyed area followed by benthic feeder, herbivores and piscivores (Fig. 3-12; Appendix 4).

Table 3-2. Fish distribution at two locations

Sampling sites	Total Nr. of species	Total Individual
Tr.1-Uqban S. I.	26	189
Tr.2-Uqban S. I.	18	104
Tr.3-Uqban S. I.	20	117
Tr.4-Kam I.	17	93
Tr.5-Kam I.	16	106

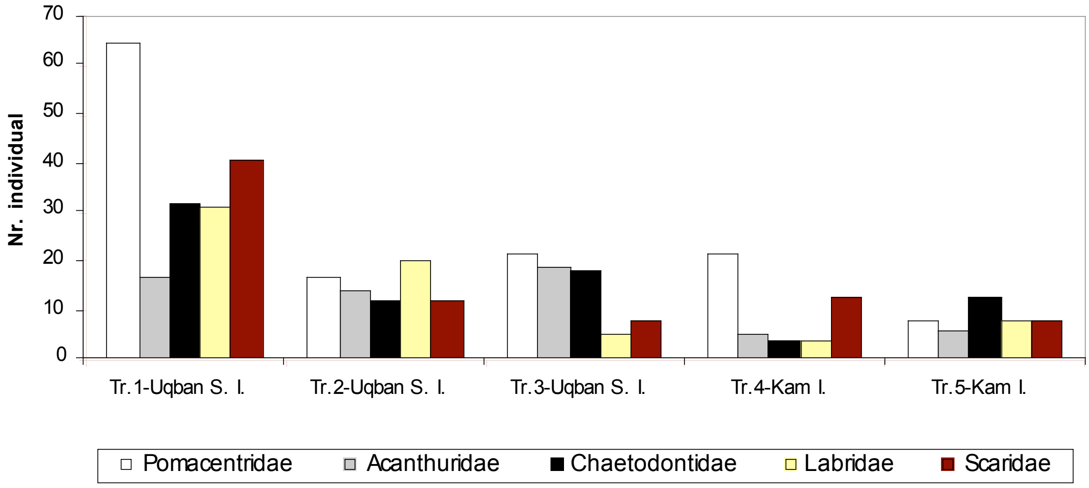


Fig. 3-11. Number of individuals of most fish families at the study sites

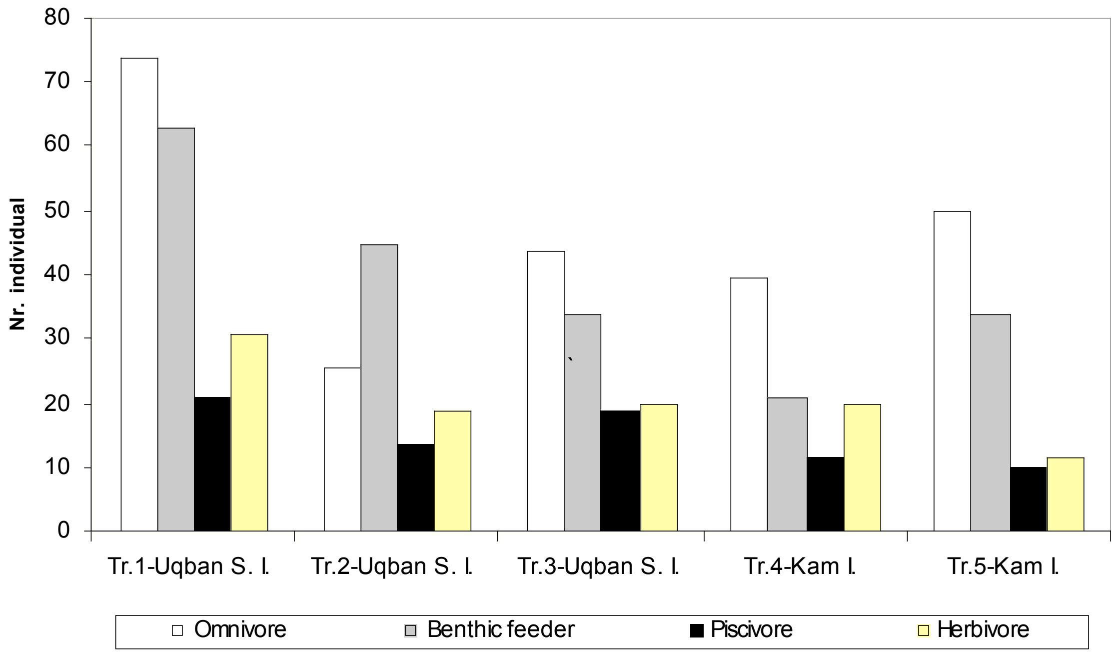
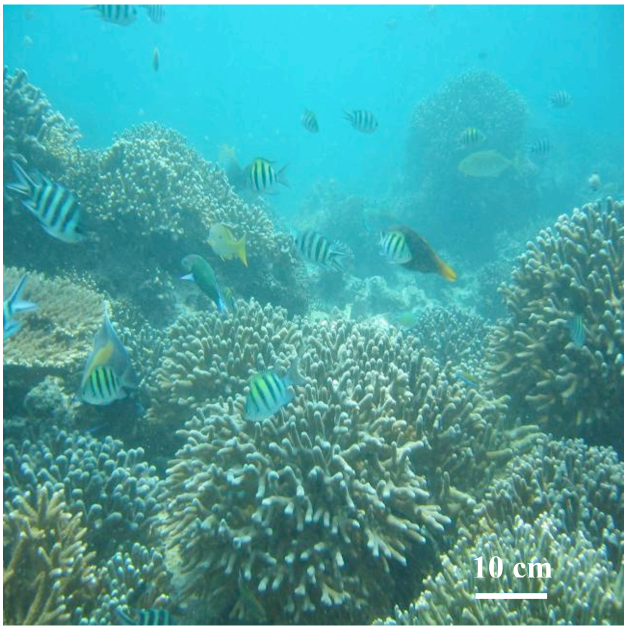


Fig. 3-12. Number of individuals of different trophic fish groups at the study area

Table 3-3. Complete list of fish families and species according to the systematic order produced by the visual census method in all surveyed (transects).

Dammselfish
Family Pomacentridae
1 *Abudefduf sexfasciatus*
2 *Abudefduf vaigiensis*
3 *Chromis viridis*
4 *Dascyllus aruanus*
5 *Dascyllus marginatus*
6 *Dascyllus trimaculatus*
7 *Neopomacentrus xanthurus*
8 *Paraglyphidodon melas*
9 *Pomacentrus sulfureus*
Goatfish
Family Mullidae
10 *Parapeneus forsskali*
Spadefish
Family Ephippidae
11 *Platax orbicularis*
Sweetlips
Family Haemulidae
12 *Plectorhinchus gaterinus*
Emperors and Breams
Family Lethrinidae and Sparidae
13 *Acanthopagrus bifasciatus*
14 *Scolopsis ghanam*
Snappers
Family Lutjanidae
15 *Lutjanus argentimaculatus*
16 *Lutjanus ehrenbergi*
Groupers
Family Epinephelinae
17 *Epinephelus summana*
Wrasses
Family Labridae
18 *Halichoeres scapularis*
19 *Larabicus quadrilineatus*
20 *Thalassoma lunare*
Butterflyfish
Family Chaetodontidae
21 *Chaetodon mesoleucos*
22 *Chaetodon paucifasciatus*
23 *Chaetodon semilarvatus*
24 *Gonochaetodon larvatus*
25 *Heniochus intermedius*
Parrotfish
Family Scaridae
26 *Scarus ferrugineus*
Angelfish
Family Pomacanthidae
27 *Pomacanthus maculosus*
28 *Pomacanthus asfur*
Unicornfish, Surgeonfish and Tangs
Family Acanthuridae
29 *Acanthurus gham*
30 *Acanthurus sohal*
31 *Ctenochaetus striatus*
32 *Zebrasoma veliferum*
33 *Zebrasoma xanthurum*



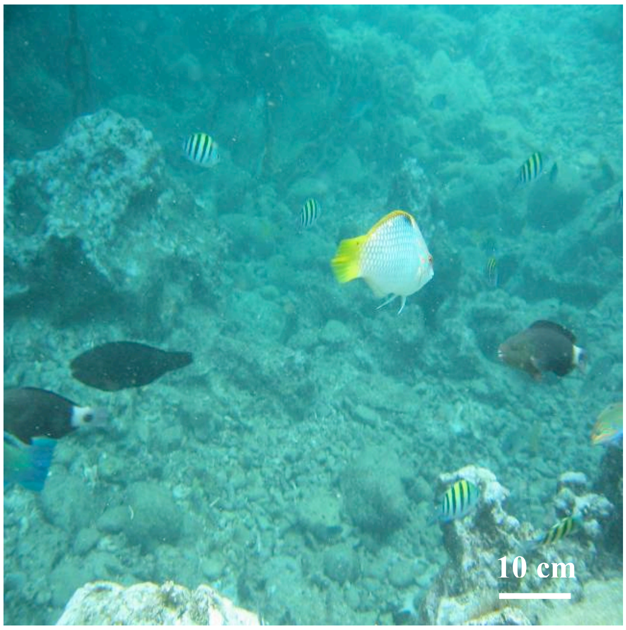


Fig. 3-13. Photos from fish species at the study area.

3.6. Pattern of the fish community structure

The cluster analysis based on the Bray-Curtis similarity and complete linkage of all fish species did not show any group. Generally there is no similarity pattern between all transects at study sites with regard to fish community (Fig. 13-4).

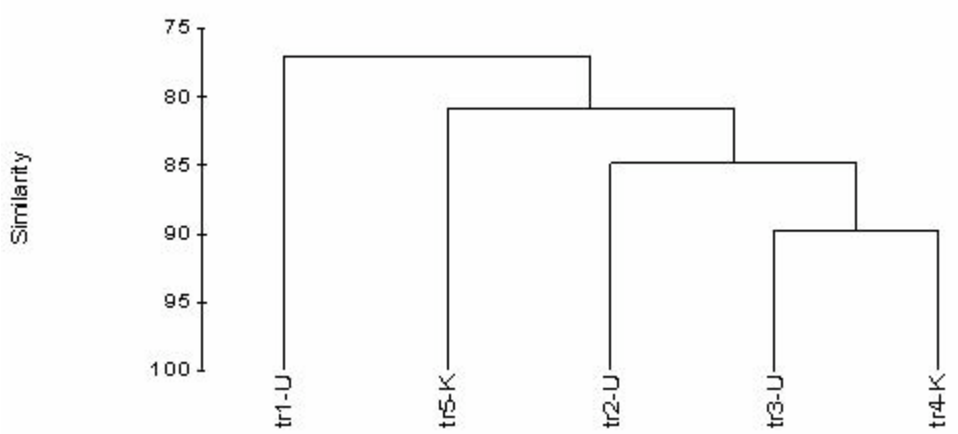


Fig. 3-14. The hierarchical dendrogram for fish community, based on species abundance

3.7. Notes on the fishing activities at study area

Many tropical coastal areas are utilized by large hotels and tourist ventures. Mangroves are removed for construction of these facilities. The consequences of such activities cause coastal erosion. The presence of tourist stimulates the local community to involve in fishing activities. According to the data obtained (questionnaires for fishermen-Appendix 5) the study area shows degradation of the coral reefs.
In Kamaran Island males work as fishermen and the women work on micro handicraft projects. Most of land at Kamaran and Uqban Seghir Island is an arid area and sabkhah (salt marsh), so no areas are available for agricultural activity.

In the study area two harbors are situated, Ras Isa and As Salif. Here the numbers of fishermen are 500 using 100 boats (FAO 1998). The caught fish is brought to the major fishing center along the Yemen Red Sea coast to be auctioned. One or several auctioneers appointed by the Ministry of Fish Wealth, carry out auctions and in some places the auctioneer is the buyer.
However, the auction operation appears to work quite efficiently in the sense that fish are quickly sold. In Al-Hudaydah, which represents a high population on the west coast of Yemen and the second largest port in Yemen after Aden port, the average price of fish is $1 per kilo. Every auction market has its own officially appointed government tax collector. In some places the fishermen are required to pay extra money to the auctioneer. The auction centers gather the fish captured from the surrounding area of the fishing villages (Fig. 3-15).
Generally, no taxes are imposed on the fishermen because government policy would like to encourage the fishermen. There are, however, certain nominal fees to be paid by exporters, usually 2%. The industrial fisheries sector must also pay fees for fishing licenses, as well as fees based upon the quantity of fish caught by the vessels. These fees are calculated according to the vessel's gross tonnage.

3.7.1. Fishing methods

A variety of fishing methods was employed in the study area (Fig. 3-16). At the study area, most of the fishermen used handlines (30 %). Other popular methods were followed by trawling, gillnets, seines and trap. The artisan fishermen use different fishing methods depending upon the target species and season. These include seines, handlines, gillnets and traps. Fig (3-17) shows the trap and seines at Kamaran Island.

Fig. 3-15. Auction centers at Al-Hudaydah city

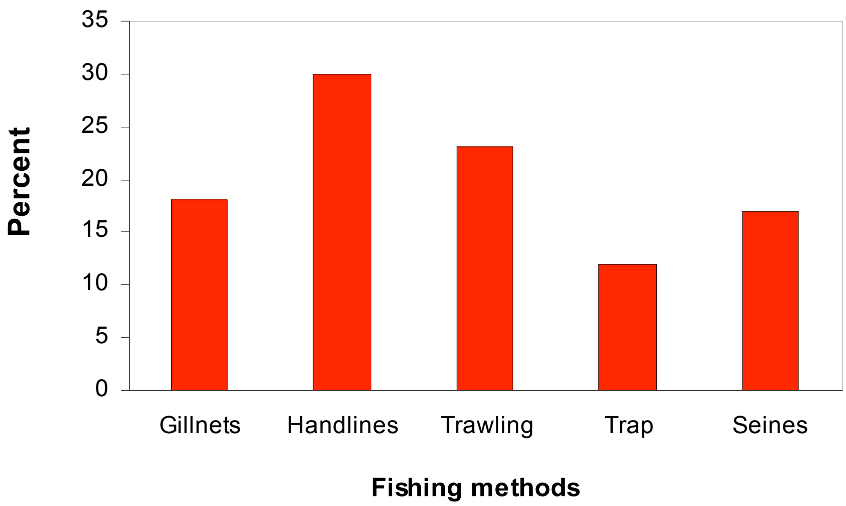


Fig. 3-16. Percent of fishing methods employed at the study area

Fig. 3-17. Trap and seines fishing methods at Kamaran Island.

3.7.2. Illegal fishing

From the questionnaires of fishermen, 20 % of the fishermen conducted illegal fishing activities in the form of trawling method. Trawling may damage benthic ecosystems through the continued action of heavy trawl gear on the bottom (Watling & Norse 1998). Some fishermen will not use trawling around the coral reefs at Kamaran Island because they fear being reported to the local officers who oversee the fishing activities. If often occurs that the fishermen bribe the person who is responsible for checking and controlling their fishing method to stay unprosecuted. Table 3-4 shows characteristics of trawling fishing.

Table 3-4. Data on Yemeni trawling activities at the study area

Fishermen	**Number**
a. boat owners (person)	9
b. seamen (person)	38
Fishing boat	
a. total number (unit)	9
b. maximum length (m)	15
c. minimum length (m)	12
Engine	
a. maximum power (HP)	200
c. minimum power (HP)	150

The government institutions still continue patrolling, but not routinely, and apply enforcement against inhabitants who practice illegal utilization of coral reefs organisms. The trawling method must be banned from coral reef areas completely and replaced by alternative methods. Brodie *et al.* (1999) and this study observed no other kinds of destructive fishing such as dynamite fishing and cyanide fishing at the west coast of Yemen.

The boats used by the traditional fisheries are of 3 types:

- Arbi (large sambouks 12 - 15m long with 150 - 250 hp diesel engines).
- Ghadifa (10m long) with 75 – 150 hp diesel engines.
- Hori (6 - 8m long) with 15 - 75 hp outboard engines.

The arbi (sambouks) are built of either wood or fiberglass (Fig 3-18a). The ghadifa and hori are built of fiberglass (Fig. 3-18b).

Fig. 3-18. Fiberglass and wood boats near from the study area

Gill nets, trawling and handlines are used from sambouks and ghadifa, most of the catch includes barracuda, tuna and shark. Large quantities of shark are reported at the fisheries auction centers at Al-Hudaydah (Fig. 3-19). Seines and handlines are commonly used from horis. Reef fish, kingfish and tuna are the dominant catch by horis. Sharks are caught by lines and nets which damage the coral reefs.

Fig. 3-19. Shark being landed at Al-Hudaydah fish market.

Local fishery offices only offered a fishing permit, while the proper test of fishing boat was carried out by local government. Fishing boats and engines are inspected 2 times per year. Fishermen usually start their activities around 6.00 am and are back to their fishing base on 4.00 pm. Most fishermen in Yemen are not fishing on Fridays (54 days/year) and holidays (17 days/year). Too strong winds and waves during October to December (90 days/year) along the west coast of Yemen prevent fishing in the traditional areas. During this period the fishermen seek other areas specially near the shelf waters of Eritrea. The closest and main fish market is Al-Hudaydah fish market. Most fishermen at the study area sold their products at Al-Hudaydah. Al-Hudaydah has the advantage of being close to transportation centers.

Generally fishermen on Kamaran Island used smaller boats and engines compared to fishermen on Al-Hudaydah (Fig. 3-20). Normally large boats have strong engines and more crew. More than 50 % of the ships have an engine of 50 and 75 HP (Horse Power) (Fig 3-21).

Most the boats were between 6 to 8 m long. Boats of these sizes prove to be most effective in use, and preferred by the local fishermen. This size boats are also the most affordable to the generally poor population. Most daily catches resulted in 50 to 60 kg of fish (Fig. 3-22), although in some boats up to 200 kg of fish were caught by some fishermen per day.

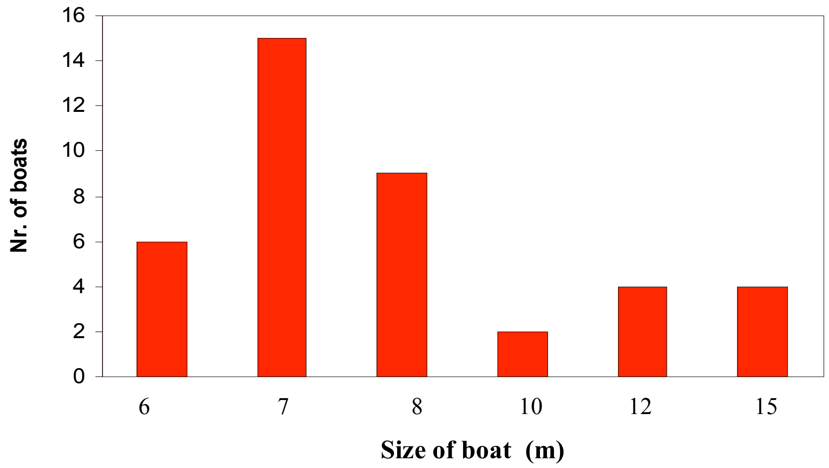


Fig. 3-20. Size categories of the boats at the study area.

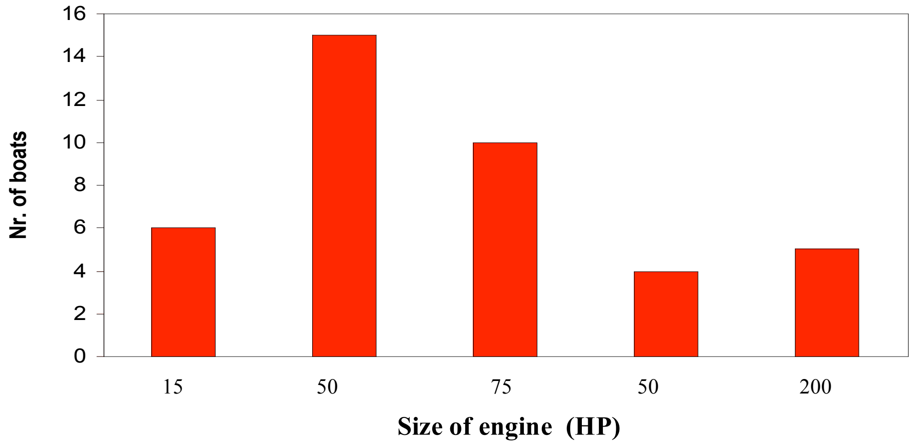


Fig. 3-21. Sizes of the engines at the study area in HP

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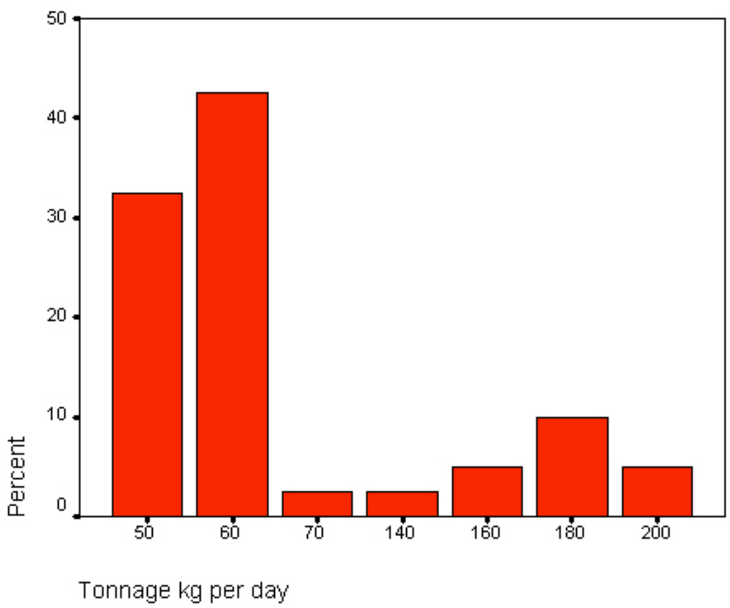

Fig. 3-22. Tonnage of fish landed per day at the study area in kg

3.7.3. Coral collecting

Yemen has extensive reef areas, rich in targeted aquarium fish species and popular ornamental corals, such as Kamaran Island. 8 % of boats contained coral collectors (3 boat owners with 5 seamen) who collected live corals and sold their product at Al-Hudaydah to coral exporting traders. All coral species are the target of coral collecting, especially the high price corals (*Acropora* sp.). Coral collectors are coming form the same area and also collected other invertebrates, such as lobster, sea star, sea urchin, coral crab, and octopus. Most of the collectors are free divers. Occasionally, they used SCUBA equipment. Coral targets are identified by snorkelling and then one or more collectors dived to that coral area. Corals are taken by collectors using chisel and hammer, and then carefully put into collecting boxes. Table 3-5 shows characteristics of coral collector.

Table 3-5. Characteristics of coral collector at study area

Coral collector	**Number**
a. boat owners (person)	3
b. seamen (person)	5
Collecting boat	
a. total number (unit)	3
b. maximum length (m)	8
c. minimum length (m)	7
Engine	
a. maximum power (HP)	75
c. minimum power (HP)	50

3.7.4. Impact of fisheries

The impact of fishing on coral reef comes from the tools and the methods that fishermen use, e.g. boat anchors, grounding, trawling and if it is a very shallow area holding, kicking and trampling on corals. Also damaging the marine habitats e.g. coral reefs using illegal fishing may reduce and effect the fish stock. Recently, Kamaran Island has allowed hotels and dive operators to settle. The two islands (Kamaran & Uqban Seghir) still had been open to indirect human impacts, such as risk of an oil pollution accident, anchoring, grounding, and collecting of aquarium fish. It is evident that anchoring and grounding have been identified as the major actual activities at study area (Fig. 3-23).

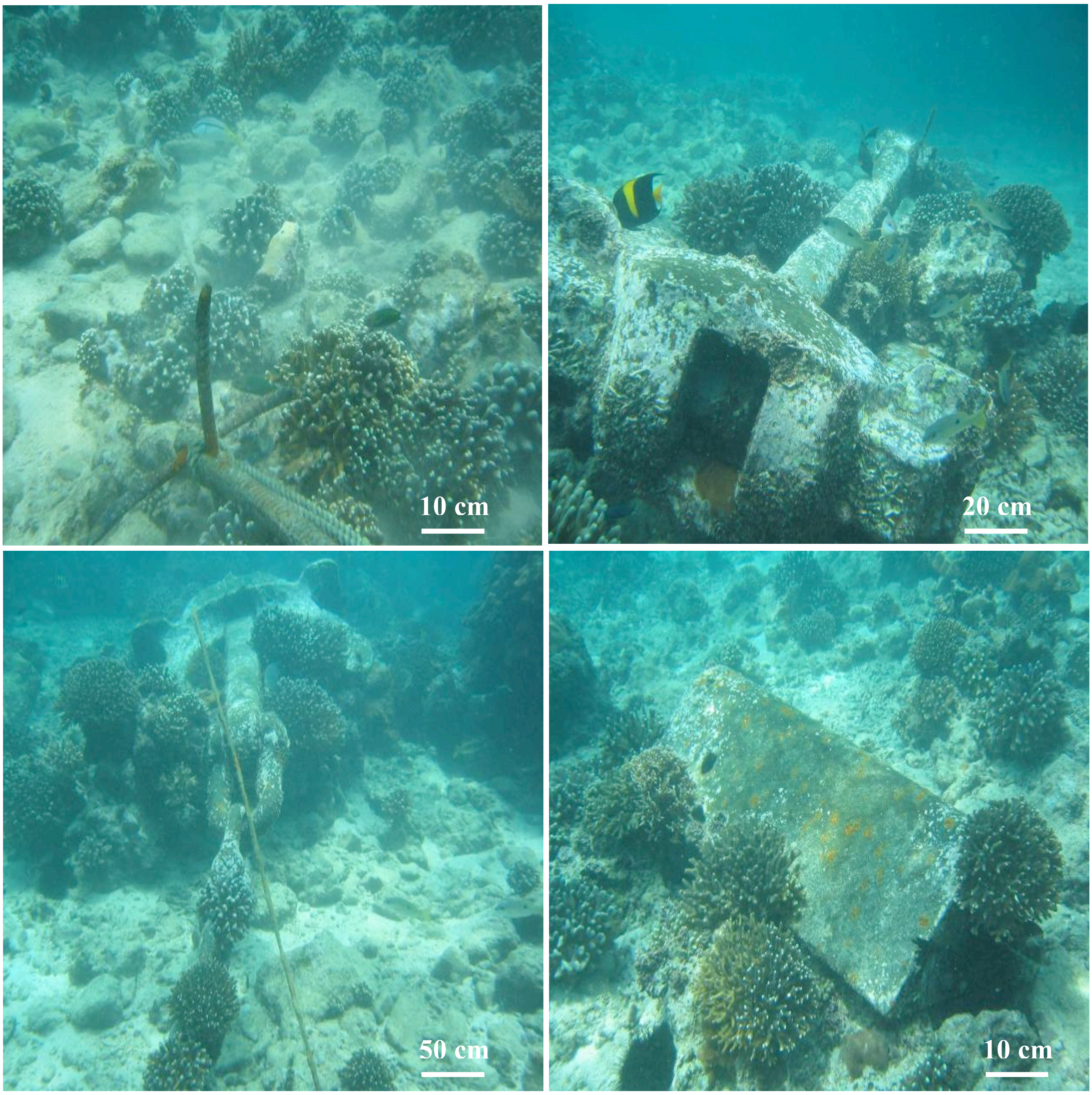

Fig. 3-23. Evidence of anchoring and grounding at study area.

3.8. Correlation between the distances of the islands from the mainland Al-Hudaydah and the hard coral cover

The linear relationship between coral cover and distance from shoreline shows a positive sloping trend with a regression of 0.5 indicating that 50% of the time coral densities should fall along the linear line (Fig. 3-24).

The percentage of coral cover near the Kamaran Island showed lower values due to human disturbance like reef walking. Normally affected are different types of branching corals that are more fragile. The offshore reef area such as Uqban Seghir Island was less influenced exhibiting a high percentage in coral cover because of less human activity. In other words, the further the island from land the better is the condition of its reefs (Hutomo & Adrim 1986).

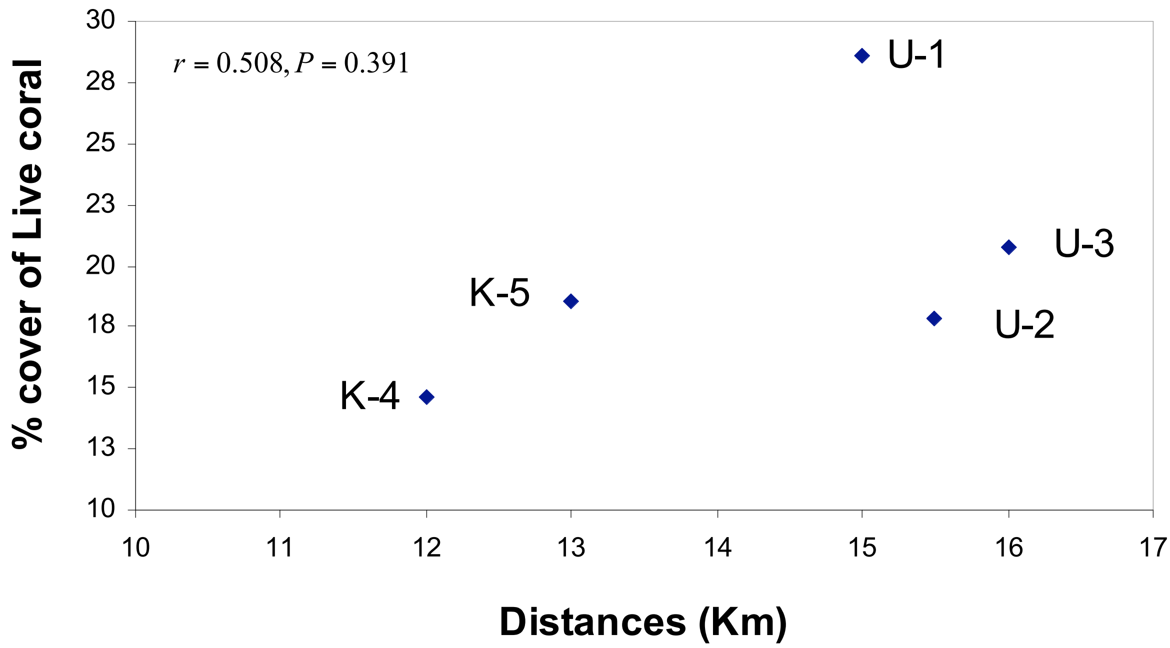

Fig. 3-24. Correlation between the distances of the islands from the mainland Al-Hudaydah and the hard coral cover, No significant correlation (r=0.508, P=0.391)

3.9. Relationship between number of fish species and percentage cover of hard coral

Coral reefs have many functions, which include providing a habitat for living organisms, such as fish. As a habitat for fish this ecosystem provides shelter and also forms the feeding, spawning and nursery grounds. Logically, reef fishes are strongly dependent upon the condition of a coral reef which is usually indicated by the percent cover of living coral (Hutomo & Adrim 1986).

Fish diversity is also directly correlated with coral cover. It is evident that more fish species occur in areas with a high percentage cover of corals. There was a close correlation (r = 0.93) between the number of fish species and percent coverage of hard corals (Fig. 3-25).
The relationship between percentage cover and distribution of fish assemblages has been shown to be significant at the study area. The higher the percentage cover of living coral, the higher the number of fish species is that inhabit it (Hutomo & Adrim 1986).

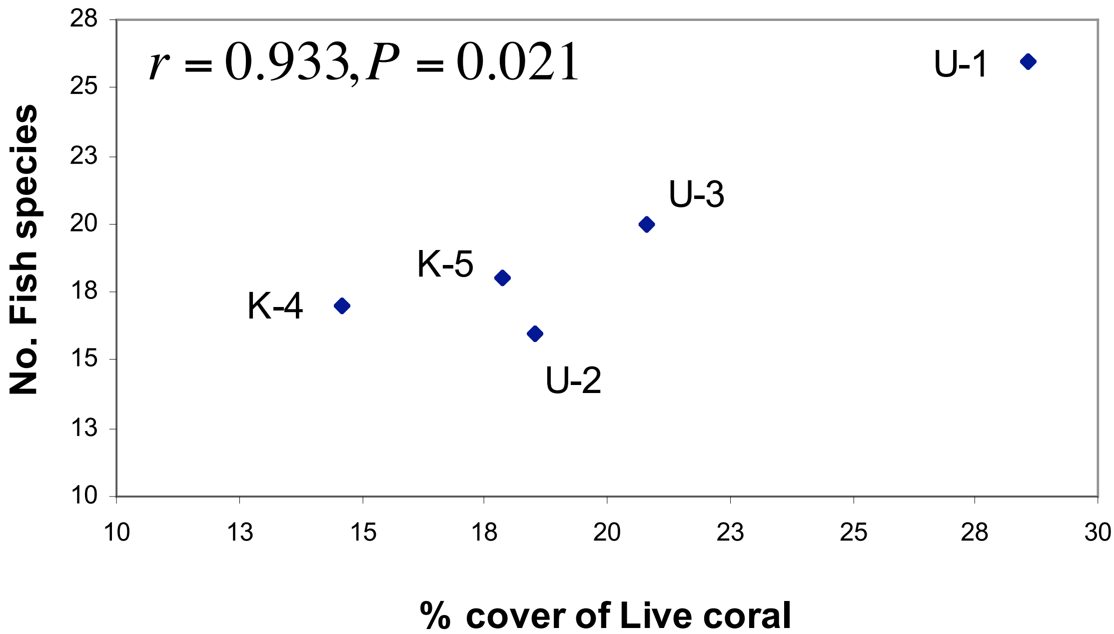

Fig. 3-25. Relationship between number of fish species and percent coverage of hard coral, Significant correlation (r=0.933, P=0.021)

Chapter 4

4. Discussion

The coral reef and reef fish communities in two islands were studied during the summer and autumn 2003 and autumn 2004. The study focused on the assessment of coral reef structures at Kamaran and Uqban Seghir Islands and investigated the socio-economic effects on coral reefs.

The present study has shown that on average more than 20 % of the investigated area are covered by live corals. Reef base 2004 has estimated the percentage of coral cover in the Red Sea being between 28 to 63 %. During my surveys many dead coral reefs were observed around the islands which were covered with rubble and algal growth. This could be due to the small area of the study area and because of fishing activities. The high damage of coral reefs at the study areas may be the result of fishing methods or of collecting of ornamental fish and shark. The results of my social economic data indicate that the reefs at the study area are at risk. The shelf waters of Yemen appear to contain large areas of complex bottom structure and trawling may be causing damage to these areas. These areas are often an important habitat for commercially important fish such as Lethrinidae and shark (RERSGA 2003). Kamaran Island until now is not declared as a protected area. Such a declaration will have a major impact on the global heritage of coral reef and fish diversity for future generations.

Most of the reefs in Yemen are better protected than other reefs in South Asia, mainly because most reefs are isolated from human activity. The main damage to reefs occurs around those islands that are heavily populated and where there is a high level of development (Rajasuriya *et al*. 2000). The understanding of the diversity of live, the complexity of ecological interactions and the structures and patterns within coral reefs are still limited (Sale 1976, Smith 1977, Hodgson 1999 and Spalding *et al*. 2001). Bombed or anchor-damaged coral reefs in Indonesia are around 50 % less diverse in shallow water as compared to undamaged areas (Edinger *et al*. 1998).

4.1. Methodological aspects

4.1.1. Assessment of life form categories and benthic groups

The photographic method is usually used for monitoring biological condition, growth, mortality and recruitment of corals in a permanent quadrate (English *et al*. 1994). However, in this study the photographic method was used for mapping and assessment of the cover of coral life form categories and benthic groups, instead the of line intercept transect (LIT) method. The photographic method was used at the beginning and at the end of the study. It has advantages, but also disadvantages.

Taking photos little time is spent in the field for the assessment of the substrate coverage compared to LIT. It also provides details and allows for a careful observation, a permanent record, and constitutes a non-destructive sampling method (English *et al*. 1994). However, a relatively flat area (English *et al*. 1994), which sometimes is difficult to find is a prerequisite. The permanent transect along 50-m was also difficult to be maintained during the entire study, therefore only the average percent cover was used for the following analysis.

Much time was spent to determine the life form categories and to measure the cover in the computer. To analyze one photograph around 30-50 minutes was needed, depending on the complexity of the picture. One thousand photographs were analyzed. Another limitation was that the photograph resolution was not high enough to determine all corals to the genus level, therefore just the life form categories could be determined. The reef rugosity could not be measured with this method since it only gives a two-dimensional picture. The photographic method, however, fulfilled most of the important requirements for substrate mapping better than LIT.

4.1.2. Fish visual census

According to Russell *et al*. (1978), the fundamental problem in quantitative assessments of fish in coral reefs is caused by the sampling. Whereas many fish are highly mobile, others are sedentary (Russell *et al*. 1978). Underwater visual census (UVC) has errors and biases, caused by the observer, the proper fish behavior, and the sampling method, most of which result in an underestimation of the population densities (e.g. Chapman *et al*. 1974, Brock 1982, Buckley & Hueckel 1989, Greene & Alevizon 1989, English *et al*. 1994, Harvey *et al*. 2002 and Labrosse *et al*. 2002). In one study, Sale & Sharp (1983) underestimated the density of fish between 11.1-26.7% in a 1-m wide transect.

The ability to spot all fish present was also dependant on the fish behavior and the diver's activity; fish are neutral, shy, curious and secretive (Chapman *et al*. 1974). If the observer moves too slowly, an overestimation will be the result, and vice versa (Sale & Sharp 1983 and Smith 1988). The air bubbles originating from an open circuit SCUBA also influence the behavior of the fish (Chapman *et al.* 1974). While writing data on a slate, the observer may overlook fish when starting again to count (Sale & Sharp 1983). The other sources of bias were the distance of the diver from the substratum, the diver's experience, and the diver's physiology in the aquatic environment (Sale & Sharp 1983, Smith 1988, Harvey *et al*. 2001 and Labrosse *et al*. 2002). The surrounding environment also gave some limitation for UVC, the visibility of the water, the state of the ocean and the weather conditions (Labrosse *et al*. 2002). However, according to Bell *et al*. (1985), a trained observer provides consistency in estimating abundance and length frequency estimations of the same population.
During this study only one observer counted all the fish, in order to minimize errors and to keep the bias constant (also done by Samoilys & Carlos 2000).

4.2. Coral reef coverage

The impact of human activities during fishing or collecting ornamental fish was evident by many fields of dead coral, particularly dead coral rubble, throughout Kamaran Island.

The results showed that fishing impacts from grounding and anchoring of boats had the most influence on coral reef coverage on both islands. Anchoring has been found to have significant effects on coral reefs habitats (Davis 1977, Creed & Filho 1999 and Milazzo *et al*. 2004), and has the potential to cause damage to temperate reef habitats. Additional, often serious damage occurs when misplaced boat anchors scour the reef (Hawkins & Roberts, 1994).

The best live coral cover was found at Uqban Island, and the lowest coral cover was at Kamaran Island. This could be due to the fact that Kamaran Island is inhabited whereas Uqban Seghir is uninhabited. This investigation showed that there was more coral diversity on Uqban Seghir Island. *Acropora* sp. was the dominant species on both islands.

In this study, dead coral rubble was found to cover the largest part of the study area (Fig 3-4). Some of the live hard corals, from all transects, grew on substrate with coral rubble underlying them. The average percentage of hard coral cover at Kamaran Island was 16.56

and this could be classified as in ‘bad’ condition according to Gomez & Alcala (1984) whereas at Uqban Seghir Island the percentage cover was 22.4 which can be classified as in ‘fair’ condition (Fig. 3-1).

Cluster analysis and MDS-plot showed two groups, the first group contained transects 1, 2 and 3 at Uqban Seghir and transect 4 at Kamaran Island, these groups were classified due to bathymetry factor (Fig. 3-9 & Fig. 3-10). The transects of the first group are referred to deep water whereas transect five in group two is classified due to its location in the shallow water.

Russ & Alcala (1989) noted that drive-net fishing reduced live coral cover in reserve areas of Sumilon Island (Philippines) from 50 to 25 %. Plathong *et al*. (2002) found that snorkelers caused significant damage to corals along their trails. Branching corals (non-*Acropora* branching corals and *Millepora* spp.) were most affected by snorkeling.

Broken coral litters the reef and many broken colonies appear bleached or overgrown with algae (Hawkins & Roberts 1994). Coral reefs at Eilat, northern Red Sea, are among the most heavily used in the world for recreational diving, with more than 250,000 dives per year on only 12 km of coastline. Frequencies and types of recreational SCUBA dives varied widely between 12 coral reef sites, with more than 30,000 dives per year at most heavily-used sites. Diver behavior caused about 10 incidents of reef contact per dive, mostly via raising of sediments onto the reef and direct breakage of corals. The proportion of damaged coral colonies varied significantly with the frequency of SCUBA diving, and did not depend upon site topography (Zakai & Chadwick-Furman 2002).

There is correlation between the distances of the islands from the mainland Al-Hudaydah and the hard coral cover. The percentage covers decrease toward the coast. However, Kamaran Island was dominated by higher coverage of dead coral rubble, while Uqban Seghir was characterized by higher coverage of branching *Acropora* and *Acropora* Digitate. Uqban Seghir island indicated an increasing coral cover and better overall conditions due to that Uqban Seghir is an uninhabited island and of some distances from the mainland.

It is difficult to distinguish damage from natural causes or from other forms of human-induced damage (Rogers *et al*. 1988). Anchoring by ships on coral reefs can destroy and degrade a significant portion of these fragile and valuable habitats. The dragging and swinging of large anchor cables and chains destroys coral heads and creates gouges and scars that destabilize the reef structure, which can take thousands of years to build. On New Providence dredging, landfill, sedimentation and the construction of a cruiser ship port have led to the loss of 60 percent of the coral reef habitat (Spalding *et al*. 2001). The suggestion to make mooring buoys, which are built in favorite zones for diving, shallow depth and snorkelling, can reduce the negative impact from boat anchors. Mooring buoys have been installed to prevent boats from dragging their anchors near fragile coral reefs.

The coral reef as a substrate is biologically generated and coral growth, form and distribution are influenced by may factors (Luckhurst & Luckhurst 1978b). Destroyed coral reefs can recover naturally or by engineering processes (Veron 1993, English *et al*. 1994 & Nontji 2000). The natural process can be supplemented by preservation of coral reefs, such as conservation measures to make sure that people exploit it in a reasonable way.

There has been much focus on transplanting fast-growing branching corals, which in general naturally recruit well but tend to survive transplantation and relocation relatively poorly. This creates short-term increases in live coral cover, at the expenses of slow-growing massive corals, which generally survive transplantation well but often recruit slowly. In those cases where transplantation is justified, it is advocated that a reserved stance, which focuses on early addition of slowly recruiting massive species to recovering community, rather than a short-term and sometimes short-lived increase in coral cover, may be more appropriate in many cases (Edwards & Clark 1999).

Reef affected by mechanical damage can recover form that damage, if two conditions are met:

- They are protected from further damage; and
- some reefs in the area are undamaged (Pearson 1981; Done 1995).

Although coral reefs are of great ecological and economic importance, little is known how coral reefs respond to human destructive fishing activities. Particularly the process of recovery and natural regeneration of the coral reef itself and associated animals lacks detailed studies (Saila *et al.* 1993, Riegl & Luke 1998, Hodgson 1999 and Fox *et al.* 2001). Mechanical damage, like anchor damage and ship groundings cause significant damage, but do not persist; the reef can, and usually will, recover if protected form further assaults (Pearson 1981).

Overfishing, destructive fishing and land runoff of freshwater, sediment and pollutants are seen by Done (1995) as the principal issues for remediation of degraded coral reefs. On a global scale, concerns are also being raised about the long-term effects of climate change on coral reefs. Wide scale bleaching of corals, often followed by mortality, has occurred world-wide over the last 15 years. Glynn (1991) believes that this may be linked to the greenhouse effect and global climate change. In addition, increasing concentrations of carbon dioxide in the surface of the ocean may cause decreasing calcification in organisms such as coral, coralline algae and molluscs.

4.3. Reef fish

Thirty-three species of fish were identified by underwater visual census on the two locations surveyed. The most abundant family recorded, were damsel fish (Family Pomacentrida). Damsel fish usually live in shallow water around coral reefs, mangroves, and beds of sea grass. Some species, like the bicolor damselfish, occur at depths of over 80 m. Kamaran Island generally had a lower number of individuals than Uqban Seghir Island which has generally more kind of fish species (Fig. 3-11). This was due to the higher coverage of dead coral found in Kamaran Island.

It seems that fish community distribution is influenced by the composition of benthic and life form categories. Williams (1982) found that coral reef fish appear to be strongly influenced by physical (wave exposure, sediment loads, water depth and topographical complexity) as well as by biological factors. Galzin *et al*. (1994) stated that species diversity of reef fishes within a given family appears to be affected more by ecological parameters, such as living coral cover, food diversity, and reproductive behavior, than morphological features.

Aktani (2003) found that a fish community is more dependent on benthic groups and life form categories than the coverage of hard coral. Reef degradation is also partly responsible for a decline of reef fisheries. The reduction in the percentage of living coral as well as the decrease in the amount of shelter that the reef provides leads to a decline in the number of reef fish and the number of species (Rogers 1990).

The relationship between the number of fish species and living coral cover have been studied for several times by many researchers; some of these studies resulted in positive correlation (e.g. Hutomo & Adrim 1986 and Gomez *et al*. 1988) and others in no correlation (e.g.

Luckhurst & Luckhurst 1978a and Mc Manus *et al*. 1981). Concurrence in the distribution of reef fishes with the benthos is due to the prevailing environmental conditions and/or the benthic cover itself (Chave & Echert 1974). This study found a relationship between number of fish species and percent coverage of hard coral. This relation was observed at transect one at Uqban Seghir Islands where the highest numbers of fish species and high percentage cover of coral were found.

As many researchers have noted, nowadays coral reef ecosystems face natural and anthropogenic disturbances, which cause a reduction in their topographic complexity and the loss of habitats (e.g. Carpenter *et al*. 1981, Sorokin 1995, Mc Manus *et al*. 1997, Edinge *et al*. 1998 and Hodgson 1999). Sano *et al*. (1984) found that the destruction of hermatypic corals leads to changes in fish community structure because of the change of food resources and the decrease in structural complexity of coral colonies. The high diversity of reef fish communities may on the other hand be maintained by unpredictable environmental changes that prevent development of a community in equilibrium (Sale 1977). Therefore most fishes living in coral reefs have a special form, color and behavior, suitable for a coral reef biotope (Smith 1977). Their specialization allows many species to live together without direct competition for the coral reef's limited resources (Smith 1977). Bell & Galzin (1984) noted that the presence and amount of live coral cover may be more important in structuring fish communities than previously thought.

Weather and currents were two important major factors in determining reef fish community (Walsh 1983). The difficulties to measure the actual impact of destructive fishing practice is due to the fact that the effect of human activities and natural processes (wave action, storm, temperature fluctuation, tectonic events, climatic disruptions, terrestrial runoff, diseases, and predator outbreaks) were difficult to separate (Cesar *et al*. 1997 and Pet-Soede *et al*. 1999).

The crown-of-thorns starfish has been observed in the study area. Outbreaks of crown-of-thorns starfish are suspected to be caused by overfishing of reef associated fish predators in the families Lethrinidae, Balistidae and Teraododontidae (Ormond *et al*. 1990). Kaufman (1983) found that the destruction of reef fish habitats was followed by changes in predator abundance, herbivore feeding behavior, and the distribution of territorial damselfishes. Sano *et al*. (1984) observed that the destruction of hermatypic corals led to changes in fish community structure resulting form a change of food resources and the decrease in structural complexity of coral colonies.

Herbivore fishes, zooplankton feeders and omnivores were significantly more abundant and of higher species richness on the living coral colonies than on damaged coral colonies; or vice versa: when the structural complexity of the coral reef decreased du to bio-and physical-erosion, the diversity and abundance of resident reef fishes decreased as well. Bell & Galzin (1984) stated that the presence and amount of live coral cover may be more important in structuring fish communities than previously thought.

The other potential factor lowering the fish diversity might be ongoing illegal fishing in this area with destructive methods. The impact of grounding and anchoring was noticeable during the study at these two islands, as indicted by the presence of many transects of dead coral (particularly dead coral rubble). Destructive fishing have reduced the productivity of coral reefs around the world and led to a substantial reduction in cover of live coral and an increase of dead coral rubble (Spalding *et al*. 2001). This increase may attract fish species, which are specialized in feeding on settling on or coral rubble or both, e.g. Labridae (Russ & Alcala 1989).

The theoretical and management implications are numerous. Knowledge of habitat requirements of fish species can be furthered. The assessment of fish stocks and fishing gear/methods will also be facilitated by comparing fish composition predicted from benthic cover, and actual catch. Delineation of zones in coastal areas for management purposes need not be restrained by the lack of baseline data on reef communities since the collection of data is simplified (Gomez *et al*. 1988).

Detailed descriptions of coral reefs management, policy and strategy in Yemen are given in chapter 5 .

Chapter 5

5. Coral Reef Management

5.1. Coral reef management in Yemen

The role of science in the management of natural resources has been discussed in a number of recent publications (Bernal & Holligan 1992; Ehrlich & Dailey 1993; Healey & Hennessey 1994; Levin 1993 and Ludwig *et al*. 1993) and research priorities have been hotly debated among reef scientists.

The status of benthic organisms is directly related to the economic and conservation value of reefs. A primary objective of the long-term monitoring program is to detect changes in reef assemblages through time. Hard corals form an important part of the structure of coral reefs and hard oral cover is often taken as an indicator of overall reef status since it indicates potential for reef growth (Sweatman 1997). Coral reefs can play a significant role to support Yemeni economic. Unfortunately, Yemeni coral reefs may have received impact from destructive fishing practice and shipping activities (anchoring and grounding).

There are many kinds of human pressure to coral reefs, ranging from indirect pollution from lowland agriculture to direct impact from destructive fishing practice. The major sources of the threat to coral reefs are different in every country. To understand what threats to reefs deserve most attention it is necessary to evaluate which threats have the greatest impact on biodiversity (Pearson 1981).

Destructive fishing practices such as trawling in fragile habitats is increasing in Yemen. The government has been prohibited destructive fishing methods and imposes minimum sizes on a number of reef species. Unfortunately over-fishing is widespread and is almost continuous in all regions. In addition a number of destructive fishing such as trawling is employed in some areas, including many remote coral reefs and other marine habitats. Illegal fishing, in particular, is having an extremely detrimental effect across the country. Collection of fish and corals for export in the ornamental and aquarium trade is considerable.

In addition to many kinds of human pressures to the coastal area, especially coral reefs, there are several unclear regulations and confusions among regulations in Yemen. The Authority of Environmental Protection, which involves various monitoring and management schemes, is known by government regulations. Although Yemen has a Ministry of Water & Environment and Ministry of Fish Wealth, the responsibilities of fisheries management are still dispersed over different government organizations without coordination mechanisms. Government regulations did not seriously acknowledge the role of NGO, though many NGOs have taken responsibilities of coral reefs and fisheries management in Yemen.

5.1.1. Community management

Community or traditional marine and coastal resource management mechanisms are still unapplied in several areas of Yemen, both in the form of fishing ground management and catching season management. Traditional fishing management usually comes in the form of local zoning. Fishing management in special areas or seasons is not effective due to the inconsistency in application as well insufficient regulation.

Artisanal fishermen have established forms of traditional management of their resources, including the rotation of fishing activities among reefs to prevent over–fishing and decline of stocks. An extensive knowledge of the sea, fishing techniques, and habits of species caught by fishermen are retained by a few individuals who serve as leaders in each fishing community.

5.1.2. Government management

There is no clear vision in government institutions on the management of reef fishery resources. This can be seen from, among others, the comprehension on fisheries management in government institutions. Besides that, there are several confusions as can be seen below:

1. Confusion between fishery management and fishery business management.
   Fishery management consists of three aspects: the quality of life of the people, the quality of the habitat, and economic aspects (exploitation and trading). In contrast fishery business management is generally profit oriented. Fishery management in the private sector, is mostly concerned about financial profit.
2. Confusion between monitoring and managing fishery activities.

The regulatory management of marine and coastal resources in Yemen is centralistic. However, the government started in 2003 to give the decision to the provinces and local authorities.

5.1.3. Problems of Yemeni coral reef management

Fishermen from neighboring villages, who do not know the boundary of their fishing area, were attacked by other fishermen who claimed that they were fishing in the wrong area. In last years Egyptian and foreign vessels have been captured in economic zones of the Red Sea and Gulf of Aden.

There is no mechanism for export fish that regulates the quota and quality. The fish export business can be done easily without any monitoring mechanism, nor incentives for the exporter to report their activities. There are no requirements for the fish exporters to interact with the Ministry of Fish Wealth as a sector ministry. Exporters are only required to have a Trading Permit from the Ministry of Industry and Trade and an obligation to report to the customs.

Export data do not show the real export volume, since it relies only on the reporting exporters. Data collecting methods are not representative. Aside from the fish auction centers, data is only gathered randomly from fishermen and middlemen in accessible landing spots. The data comprises all kind of marine products, not focused on reef fish.

Moreover, Yemen is facing a major problem in law regulation enforcement. The effects on coral-associated organisms and their recovery rates have not been documented. The consequences of repeated exposures are much less known.

The commercial and some traditional fisheries have used trawling, which has resulted in significant damage to the coral reefs. Other impact of reefs is anchoring and grounding which has been noted in the study area. Fish exports for the live fish markets of East and Southeast Asia have also been significant through the late 1990s, and this is having an impact on grouper stocks (Spalding *et al*. 2001). On a global scale, concerns are also being raised about the long-term effects on coral reefs of climate change. Wide scale bleaching of corals, often followed by mortality, has occurred world-wide over the last 15 years (Glynn 1991).

The other major threats are from pollution and shipping accidents i.e. oil spill, and future bleaching. Potential sources of oil contamination along Yemen's coast include:

- ships passing through the Red Sea
- the oil export terminal at Ras Isa (Fig. 1-1).
- shipping operations in the Al-Hudaydah port area
- oil derived from land runoff or groundwater discharge.

In addition, there is potential for significant environmental damage in the event of an oil spill from the Marib-Ras Isa pipeline, where it crosses the sabkhah (salt marsh) on the As Salif peninsula (Pencol 1992). In Yemen, harbors are regulated and managed by harbor authorities, while the oil companies manage oil terminals. Oil spill response is coordinated through the Public Corporation for Maritime Affairs (Det Norske Veritas 1996). The Red Sea shipping route carries approximately 60 oceangoing commercial vessels per day, of which 20 % are oil tankers (Haskoning 1991). One hundred million tonnes of oil transit the Red Sea annually. The Red Sea is defined as a special area under MARPOL (MARine POLlution) where more stringent requirements for the discharge of waste water are required. Oil is received through the Marib-Ras Isa pipeline at the rate of 165,000 barrels/day and stored in the Safir tanker, a 409,000 tone supertanker converted for storage. Safir sits about 10 km offshore, at the end of the seabed pipeline. Loading from Safir to export tankers occurs via tandem mooring or, in heavy wave conditions, via floating hoses at a distance of 100 m. Crude oil export tankers are normally less than 100,000 tones, and approximately 80 tankers use the facility annually (Det Norske Veritas 1996). The terminal has no waste reception system. Some chronic pollution of areas adjacent to the seabed pipeline and loading operation may occur, but the principal concern at this site is the potential for a catastrophic spill from the Safir taker or an export tanker due to collision, fire, storm or warfare (Douabul & Haddad 1999).

Evidence from tarballs (little, dark-colored pieces of oil) were found along the beach of the west coast of Yemen. These vessels may use Yemen waters for tank washing or some ships use ballast water (water taken up or released by a ship to stabilize it). Damage around major tourism areas are caused by coral collectors which use it as jewelry or souvenir (Fig. 5-1). The coral collecting should be prohibited because no other single method could reduce the destruction caused by coral collecting until now. Harriott (2001) states that coral harvest will have fewer impacts and is more sustainable if the collecting effort is spread over a wider area,

rather than being concentrated in small areas. Large scale in-filling for coastal reclamation has destroyed fringing coral reefs along remote cities i.e. Al-Hudaydah and Kamaran Island.
The need to monitor the use of illegal fishing methods and the use of mooring buoys at shallow depth will improve coral reef conditions.

Fig. 5-1. Coral and gastropods for sale people near Al-Hudaydah city

5.1.4. The role of NGOs in Yemeni coral reef management

Several non government organizations (NGOs) have been working to help the Yemeni government manage fisheries and coral reefs. Some of them are international organizations such as International Union Conservation Nature (IUCN), Reef check, and World Wide Fund for Nature (WWF). The international NGOs have been collaborating with some local NGOs to carry out their programs, because local NGOs can easier monitor and evaluate the long-term programs. Their programs are ranging from increasing public awareness to facilitating institutional creation to managing fisheries and coral reefs all over Yemen. The successful experience of NGOs on separately aspects, ranging from bio-physic monitoring and developing public awareness of coral reefs, could not reduce destructive fishing practices. Therefore collaborative programs across local and international NGOs have been established since 2004.

Yemen government has addressed the situation by implementing conservation oriented projects and raising public awareness to rehabilitate and manage its coral reefs. It established the Environmental Protection Council (EPC) in 1990 and Ministry of Tourism and Environment in 2000.

5.1.5. The implementation of policy recommendations

5.1.5.1. Actual management of Yemen coral reef

The Yemeni government has ratified agreements within the last years which regulate coral reef exploitation. The Ministry of Fish Wealth and Ministry of Water & Environment were created in order to manage fishery resources, including coral reefs. Government regulation is the legal base for local regulation by each province. Although, there will be a legal gap, since complete rules of law on the management of marine and coastal resource is on the ministerial decree level. During the period of 1990 to 2003, the government of Yemen implemented the existing policies and regulation through several projects, such as Protected Red Sea and Gulf of Aden Ecosystem UNDP-GEF projects in 1997, Socotra Biodiversity in 1999, Strategic Action Plan (SAP) in 2003 and the National Programme of Action (NPA). Yemen established in 2004 the first Yemeni program for Protection of the Marine Environment from Land-Based Activities. NPA is envisioned as an integrated management and policy framework. Land-based impacts and threats to the marine and coastal environment are complex and demand long-term monitoring.

Yemen and other countries in the Red Sea Region have enacted national legislation for coral reef conservation, and signed multinational agreements with assistance from the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA). The Programme of PERSGA, with its Secretariat in Jeddah, Saudi Arabia, represents the regional organization for cooperation and coordination between the countries in this region, within the framework of the Jeddah Convention. PERSGA and Reef check established, Marine Monitoring Program in 2000 which was focused on fishing destructive fishing practices in Red Sea coral reefs. Collaboration with local NGOs and government offices is implemented.

Coral collection should be prohibited because no other single method reduces the quality of coral reefs in such a severe way. Harriott (2001) reports that coral harvest will have fewer impacts and is more sustainable if the collecting effort is spread over a wider area, rather than being concentrated in small areas.

Unfortunately, in the Yemen distribution of responsibilities of coral reef management among the different government agencies was not followed by a clear coordination mechanism. Therefore conflicts of interest among agencies in central and local governments and among central and local governments cannot be avoided.

Although the Yemeni government has signed many agreements for marine ecosystem management such as fisheries and coral reefs, many of these documents exist only on paper since there has been no commitment to staffing and operational funding.
Inconsistency of regulations has led to the lack of standardization in exploitation and trade of fishing and coral. On the one hand, the central government continued to give licenses to big scale companies for exploiting fishing in certain reef locations. Coastal communities, which have low-level education and limited access to the capital, could not escape from the government power that reduced their traditional fishing rights. Therefore local communities tried to get as much profit from fish as fast as they could without considering the methods of exploitation and the consequences of their applications.

5.1.5.2. The implementation of policy recommendation

Local NGOs are needed to initiate the integration of these groups into one formal institution based on coral reef areas. Local NGOs are also important to correlate this institution to the national groups. The national groups can help to initiate motivation of innovation of a new technique of resource uses.

Local NGOs can provide stakeholders with information on improved coral reef use and encourage local leaders to embark on the management of coral reef areas. In the short time of the process of resource management there are three streams of thought which must be reconciled:

(1) the wish of the stakeholders to share the benefits from coral reefs resources while protecting their coral reef areas from outsiders,
(2) the desire of local governments to extract resource rents, and
(3) the push by national groups and other participants to develop viable local coral reef management plans. It is also necessary to define the institution structures, powers and responsibilities within the framework of provincial and national legislation, to provide

local institutions with more capacity to deal with external threats and become involved in development planning, execution and evaluation (Fahrudin 2003).

Besides direct regulation (common property right), a strategy to manage coral reefs can be achieved by stimulating voluntary agreements of market participants and moral suasion via conveying information to the public, direct communication, and education (van den Bergh, 1996). Perhaps the main obstacle to be overcome is poor communication (Harmon 1994). Many reef scientists are already strongly convinced of the need to communicate their results and the implications of these for management and conservation policy (Hatcher *et al*. 1989), but they may however need to understand that reef managers are not always able or willing to act on their advice because of political, economic or social factors. The successful common property management often occurs in areas where there are a well defined and limited communities, locally-defined management rules, locally-developed institutions that are accepted; higher levels of authority which support local institutions and help to monitor and enforce compliance, and the right to exclude others from participating in the fishery (Heylings & Cruz 1998).

International NGOs can also bring together the stakeholders of coral reef products, which are well organized by EPA (Environment Protection Authority), to promote their green products. The involvement of international NGOs in coral reefs management can be formed as a joint work with local NGOs and government institutions.

Public awareness regarding coral reef conservation is low in Yemen and the legal framework to protect coral reefs is not highly developed, except for Socotra Island, which is located at the Gulf of Aden and a declared Marine Protected Area which receives much attention in research and international funding. There is a need to create long-time oriented regulation for coral reef management. This regulation must be involved in the Yemeni political system to stimulate creation of a coral reef management act and in order to accommodate the change of government policies over time. It is suggested to build a new institution based on coral reef conservation, which include the coral reefs users, traders, and tourism operators, and to manage coral reefs resources. This strategy can reduce the use of destructive methods on coral reefs. Thirdly, there is a need to raise international public awareness in order to promote green products and to stimulate Yemeni government to increase the concern about coral reef management. An integrated approach is recommended to protect and rehabilitate linked coastal ecosystems within the context of cultural tourism policies (Knight *et al*, 1997).

5.2. Fisheries

5.2.1. Overview on fisheries in Yemen

Yemen has important fisheries in both the Red Sea and the Gulf of Aden. There are two categories of fishing in the Yemen Red Sea, artisanal and foreign commercial. Artisanal fishermen have fished the region's waters for thousands of years in a sustainable manner and in many places continue to do so with little advancement in technology. The total Yemen fish catch was approximately 100,000 tones in 1992, and it was expected that it could be increased to 300,000 tones using modern gear (Rushdi *et al*. 1994). Of the catch, 70% is consumed locally and 30 % is exported. The Red Sea catch was about 40,000 tones in 1997 (Brodie *et al.* 1999). The data from Ministry of Fish Wealth showed that the fish sector increased from $500,000,000 in 2000 and to an estimate of $1,000,000,000 in 2005. Since the early 1980s, investment in Yemen fisheries has increased rapidly with Yemen Government and aid funding. Investment has gone into new fishing boats, fishing centers, an organized auction and marketing scheme, and ice plants (personal communication). Fish taken out of Yemen waters are:

- Large pelagic fisheries e.g. tuna.
- Small pelagic fisheries e.g. sardines, indian mackerel, chub mackerel and anchovies.
- Demersal fisheries e.g. groupers, emperors, scavengers, snappers, sea breams, barracuda, sharks and rays (Fig. 5-2).

The management measures with regard to industrial fisheries include the fishing vessels must operate beyond five miles from the coast in the Gulf of Aden and the Arabian Sea, and beyond six miles from the coast in the Red Sea. No discarding of fish is allowed. According to the legislation two or more supervisors must be deployed on board each fishing vessels.
The mesh size for the cod end should measure not less than 75 mm, and nets must be single layered.

Fig. 5-2. Fish species for sale (left: groupers, right: tuna)

The Yemeni government cooperates with international organizations such as FAO to:

- Protect marine resources within the Economic Zone (EZ) for the benefit of the country;
- Promote scientific fisheries research;
- Cooperate with neighboring countries in the management of shared and migratory stocks;
- Develop and improve fisheries extension, especially in fishing gear, fish processing and fish quality;
- Promote aquaculture experiments;
- Develop and modernize the fishery sector;
- Enhance economic diversification of the country through fishery development;
- Develop fishery exports and improve their quality;
- Ensure effective enforcement of existing fishery laws and regulations;
- Protect the coral reef and other environments;
- Develop aquaculture projects and encourage investment in this field;
- Cooperate with neighboring and regional countries in implementing studies on marine pollution in order to protect the marine environment.

The fishery activities in Yemen include (a) Artisan and (b) Industrial.

a) Artisan. It is estimated that the artisan fisheries sector has 41 322 fishermen utilizing 9157 boats (8 475 boats with outboard engines, 682 with inboard engines) (FAO 1998).

The purchasing of new boats, fishing gear and engines is frequently subsidized by the Agriculture Encouragement and Fishing Production Fund (EAFPF), or by loans from the Cooperative Credit Bank.

The total catch of the traditional sector in 1998 was 108 205 tons. The most important species included tunas, large jacks, sardines, mackerel, barracuda, snappers, solefish, shrimp, lobster and cuttlefish.

b) Industrial. There are 23 fishing companies in the industrial sector working in Yemen waters, 11 in the Red Sea and 12 in the Aden Gulf and the Arabian Sea. These companies caught 17 858 tons of fish in 1998, principally demersal fish and cuttlefish (FAO 1998).

According to the FAO report in 1998 the industrial fishing fleet included 131 boats, 63 in the Red Sea and 68 in the Gulf of Aden and the Arabian Sea. The total catch was 17 858 tons, 4186 in the Red Sea and 13 669 in the Gulf of Aden and the Arabian Sea. These fishing companies are all privately-owned, and are both foreign and local.
The investment boats have freezing plants and package facilities for the fish for export.

One of the target fish group are sharks. Sharks are slow growing, with reproduction relatively late in life, and production of only a small number of offspring. They are very vulnerable to stock collapse from overfishing, and recovery takes several decades. The traditional artisanal fishery in the region catches only small numbers of sharks and the whole animal is utilized. However, there is a large–scale illegal fishery for the East Asian shark fin market involving fishermen working outside their normal territorial boundaries. Shark is a very important fish for the export of fins. For local fishermen who concentrate on shark fishing, the fins are removed for export and the carcass sold locally (PERSGA 2003). As top predators, sharks are critical to the health of the region’s marine ecosystems and a management scheme has to be established.

Fish production is exported, mainly to Europe, Japan, Jordan and other countries. Fisheries product exports for 1998 were estimated at 29 858 tons, valued at US$40 000 million. There is no need for Yemen to import fish products, as they are available in large quantities on the local market.

However the fishery export data in Yemen are not reliable. This may be due to incomplete policy on trading fisheries. There is no export standard for fish that regulates the quota and quality. There are no requirements for the fish exporters to interact with the Ministry of Fish Wealth. Exporters are only required to have a trading permit from the Ministry of Industry and Trade. Reports from branches of Ministry of Fish Wealth at provinces are not clear. These branches in the regions are not obliged to report the fishery/marine products and their trading (including export) to the central government in Sana'a.

Fish is a major and growing food item in Yemen. Fisheries can be exploited to a far greater degree in order to meet both local and export market demand. In addition, the fisheries sector is expected to absorb a greater proportion of the national workforce in the future. Long term monitoring of fishery induced changes in the coral reef structure will provide a scientific base for coastal zone management. The results obtained may represent a database for future environmental monitoring of coral reefs and fisheries at Kamaran Island which is on of the major fishing areas along the west coast of Yemen.

5.2.3. Government strategy and sustainability

Environment Protection Authority (EPA) in Yemen created planning and carried out control of coral reefs resource uses based on sustainable development approaches. Yemeni government tries to raising public awareness between fishermen to reduce the effect of fishing activity in coral reef. Yemeni government has created integrated coastal management under the Environment Protection Authority namely Coastal Zone Management (CZM) where the members were the heads of all relevant agencies. Similar to other countries, it also proposes a National Council for Sustainable Development and Environmental Impact Assessment.

Furthermore, the function of management authority under a technical ministry, such as the Ministry of Water & Environment, Ministry of Marine Affairs and Ministry of Fish Wealth, is not appropriate. In general, the vision of a technical ministry is aimed at exploitation of natural resources to give maximum financial profit. This is the opposite to the aim of natural resource conservation, which is to limit the exploitation of natural resources for the sake of sustainability.
The main goals of the Government's strategy for fisheries include:

- Rational exploitation and sustainable use of marine resources, to be achieved through the maintenance and development of fishery coast management, fishery research and fisheries extension.
- Increasing the fisheries' contribution to national income by the development of fish exports, technology transfer and infrastructure completion.
- Enhancing the private sectors role in fishery development and expanding its activities in infrastructure completion.
- Increasing the contribution of fisheries to food security, to be achieved through increasing the annual catch and improving fish distribution throughout the country.
- Construction of new coastal fishing facilities in those regions which were not included in previous projects.
- Supporting supervision and marine surveillance by utilizing modern equipment and enhancing its role in implementing fisheries regulations.

5.2.4. Enforcement

The enforcement of fishery legislation is carried out by the Ministry of Fish Wealth, with the assistance of the Coast Guard (Ministry of the Interior) and the Ministry of Defense. The Ministry of Fish Wealth, as the country's primary fisheries development and management organization, collaborates with other ministries such as the Ministry of Tourism and Environment, the Ministry of Transport and Marine Affairs, the Ministry of Planning and Development, as well as with the Sana'a, Aden, Al-Hudaydah and Hadramout Universities.
The constraints present in fisheries management include its weakness in key fisheries information gathering, processing and utilization, as well as a serious weakness in enforcing fishery laws and regulations. The causes of biodiversity loss were not fully understood when some pilot phase projects were designed. As a result, some projects were insufficiently geared to addressing the social, political and economic forces that have a bearing on conservation.

5.2.5. Investment in fisheries

During the past fourteen years, gross investment in the fisheries sector amounted to approximately US$276 million. Government investment has also been directed toward the creation of fishing harbors, ice plants, workshops, cold storage facilities, shelters, research, training, fish quality control centers, and canning plants (Fig. 5-3). These projects were funded through Fisheries Projects I, II, III, IV and V financed by the I.D.A. (Industrial Development Agency), the World Bank (WB), the European Union (EU) and IFAD (International Fund for Agricultural Development), as well as by the cooperation agreements between Yemen and other countries and organizations such as the former Japan’s government and the Islamic Bank.

Fig. 5-3. Ice block near fish market center, Al-Hudaydah.

The fishing industry has made significant progress during the past twenty years. Fish production from the artisan sector has been improved through government subsidy programmes funded by the Fisheries Development Projects, which have provided subsidies for fishermen for the purchase of modern fishing boats, fishing gear and equipment including winches, traps, fish preservation boxes and high-powered engines. The development of the industry has been supported by the Government's construction of ports, roads, radio communications networks, ice plants, workshops and cold storage and other necessary facilities throughout Yemen. About 85% of the country's fish resources are being exploited by the artisan sector, while 15% are being exploited by the industrial sector.

5.2.6. The implementation of fisheries management policy.

Proper management of living marine resources is important to sustain the livelihoods of people dependent on the resources, to maintain the ecological integrity of marine communities, and to conserve biodiversity. Yemen, with its large population, understands the importance of increasing the annual fishing catch in order to help guarantee food security for its people. This can be achieved in two ways; first, by renewing the stock assessment studies in order to know what stocks are available at present; second, by studying the offshore fish species in the economic zone, particularly migratory fish such as tuna, mackerel and marlin and by exploiting mesopelagic fish. Subsequently, the exploitation of the country's fish resources must be both rational and sustainable.

In 1994 and 1998 Agreements between Yemen and Eritrea are currently involved in working together to administer the fish resources throughout the southern Red Sea region. One of the agreements mention that both the State of Eritrea and the Republic of Yemen shall permit fishermen who are citizens of the two States, without limiting their numbers, and who carry cards to engage in the occupation of fishing, to fish in the territorial waters of the two States, the contiguous zone and the Exclusive Economic Zone of the two countries in the Red Sea (with the exception of the internal waters), provided that the fishermen of the two countries be enumerated and that they be granted official licenses to engage in the occupation of fishing specifying the locations where they will be received and may market their products (Shifman 2005).

Management capabilities are further stretched by the impacts of foreign fishermen in national waters, and trends in seafood consumption in international markets. This is exemplified by the demand for shark fins that are increasingly being supplied from the region. Although it is understood that there is a great reliance for subsistence by coastal populations on marine resources, the extent, intensity, and types of human uses vary throughout the region. Information about use as well as socio–economic values is inadequate. In some instances there is also very little scientific information available on the species targeted. Tools for management include legislation, specific management programmes (e.g. stock quotas, seasonal closures) (PERSGA 2003).

Chapter 6

6. Conclusions

This study showed that the impacts of grounding, anchoring, and fishing activities such as trawling on coral reefs are reflected by much dead coral rubble. The number of reef fish in this area may decrease in abundance as a result.

Kamaran Island was dominated by a higher cover of dead coral rubble, while Uqban Seghir was characterized by higher coverage of *Acropora* branching and branching coral and *Acropora* Digitate.

There was a weak positive but non-significant correlation between the distances of the transects from the mainland fishing port Al-Hudaydah and the live coral cover.

This study found a relationship between number of fish species and percent coverage of hard coral. This relation could be demonstrated at transect one at Uqban Seghir Islands where the highest numbers of fish species and a high percentage cover of coral was found.

The government has distributed responsibilities of coral reefs management to different agencies without a clear coordination mechanism, resulting in inconsistency of management regulation on coral reefs. Some of the government institutions are confused between monitoring and managing fishery activities and reef fish management.

6.2. Outlook

The installation of mooring buoys in shallow zones especially near coral reef habitats could reduce the degradation of coral. Monitoring coral reefs and fisheries are becoming increasingly important and will provide a scientific basis for coastal zone management.

Fishing management in special areas or seasons is not effective due to the inconsistency in operation, such as insufficient regulation and weak law enforcement

Establishing MPAs (Marine Protected Areas) is a current, popular coastal management strategy in protecting coral reefs from new threats. At the same time MPAs minimize effects on the socio-economic conditions.

One of the major gaps in the process of coral reef conservation is the lack of funding to establish and implement regulations in marine protected areas. Funding is also needed for further research to acquire baseline information.

Long term monitoring for coral reefs is urgently needed in order to have better understanding of the long term effects.

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Acknowledgments

I would like to thank the German Academic Exchange Service (DAAD) for their support during my PhD study. Special thanks to Mrs. Kirsten Roehring for her kind and professional cooperation.

I would like to express my special gratitude to my supervisor Professor Dr. Michaeal Spindler for all his suggestions, advising and fruitful discussions. My special gratitude also goes to Prof. Dr. Ferderico Foders for discussion of social-economic aspects of this thesis.

I would like to thank Aref Hamud for directly helping in my sampling, survey, diving and collecting data that was vital to my research.

I appreciate Rebecca Langlois for reviewing and correcting my English grammatik.

I am indebted to all IPÖ´s for their help, pleasantness and hospitality. Special thanks to Prof. Dr. Dieter Piepenburg, Prof. Dr. Kai Bischof, Jutta Seegert, Frank Peter, Michael Schmidt and Michael Bartz.

Finally, I would like to thank my family (father and mother) for their support. Many thanks for my wife for support, standing with me and taking care of our kids (Abdulmalek, Ammar and Reham).

Appendices

Appendix (1) Data sheet for coral reefs site identification

Site name:

Transect number:

Date:

Time of day that work started:

Time of day that work ended:

Longitude of transect start point:

Latitude of transect start point:

From chart or by GPS? (If GPS, indicate units) : chart ____ GPS ____

Distance from shore: ____ m

Weather: sunny ____ cloudy ____ raining ____

Air temperature: ____ degrees Celsius

Water temperature at surface: ____ degrees Celsius

Water temperature at 3m: ____ degrees Celsius

Water temperature at 10 m: ____ degrees Celsius

Distance to nearest population centre: ____ km

Horizontal visibility in water: ____ m

Any major coral damaging storms in past years? yes____ no____ unknown____

How do you rate this site overall in terms of anthropogenic impact?

none____ low____ moderate____ heavy____

What types of impact do you believe occur?

Dynamite fishing: none____ low____ moderate____ heavy____

Aquarium fish collection: none____ low____ moderate____ heavy____

Harvest of invertebrates for food: none____ low____ moderate____ heavy____

Tourist diving: none____ low____ moderate____ heavy____

Sewage pollution: none____ low____ moderate____ heavy____

Industrial pollution: none____ low____ moderate____ heavy____

Other forms of fishing? (Specify): none____ low____ moderate____ heavy____

Other impacts? (Specify): none____ low____ moderate____ heavy____

Is there any form of protection (statutory or other) at this site? : Yes ___ No ____

If yes, what type of protection?

Other comments:

Submitted by (enter your name)

Appendix (2) Complete list of the percent cover of the major benthic communities and life form categories at study sites

Categories	Sampling sites				
	Tr.1-Uqban S. I.	Tr.2-Uqban S. I.	Tr.3-Uqban S. I.	Tr.4-Kam I.	Tr.5-Kam I.
Hard Coral	**28.56**	**17.86**	**20.78**	**14.58**	**18.54**
Acropora Branching	7.02	4.89	3.05	2.5	7.5
Acropora Digitate	4.25	2.15	1.37	1.52	1.35
Acropora Tabulate	1.84	1.57	2.5	1.29	0.5
Coral Branching	5.06	3.51	5.15	3.05	0.85
Coral Encrusting	1.05	0.68	0.35	1.25	0.24
Coral Foliose	3.01	1.08	2.5	1.16	0.55
Coral Massive	2.47	0.46	0.98	1.24	4.94
Coral Mushroom	0.96	0.22	0.8	0.68	0.13
Coral Sub-massive	1.29	1.86	3.5	0.81	0.29
Millepora	0.75	0.68	0.58	0.69	1.32
Heliopora	0.86	0.76	0	0.39	0.87
Dead Coral	**62.9**	**72.36**	**74.22**	**78.62**	**76.14**
DC (Rubble)	43.65	44.86	54.27	54.27	49.31
DC (Massive)	19.25	27.5	19.95	24.35	26.83
Other Fauna	**3.88**	**3.28**	**2.96**	**2.45**	**1.47**
Sea Star	0.05	0.06	0.03	0	0
Sea Urchin	0.12	0.09	0.06	0.05	0.01
Sponges	2.25	2.68	1.97	2.06	1.26
Soft Coral	0.10	0	0	0	0
Sea Anemone	0.06	0.15	0.9	0	0
Bryozoan	1.3	0.3	0	0.34	0.2
	3.88	3.28	2.96	2.45	1.47
Algae	**4.66**	**6.5**	**2.04**	**4.35**	**3.85**
Macro Algae	2.65	3.52	1.25	2.48	2.06
Halimeda spp.	0.68	1.25	0.39	0	0
Red coraline algae	1.33	1.73	0.4	1.87	1.79

Appendix (3) Complete list of fish species according to their systematic order and their abundances at transects throughout the study period.

Nr.Sp	Name of species and families	Sampling sites				
	Dammselfish	Tr.1-Uqban S	Tr.2-Uqban S	Tr.3-Uqban S	Tr.4-Kam I	Tr.5-Kam I.
	Family Pomacentridae	**individuals**				
1	*Abudefduf sexfasciatus*	7	2	0	4	0
2	*Abudefduf vaigiensis*	6	2	0	0	4
3	*Chromis viridis*	0	3	3	0	0
4	*Dascyllus aruanus*	6	4	5	8	9
5	*Dascyllus marginatus*	4	0	6	6	10
6	*Dascyllus trimaculatus*	15	0	5	12	2
7	*Neopomacentrus xanthurus*	9	6	11	0	0
8	*Paraglyphidodon melas*	0	0	0	0	8
9	*Pomacentrus sulfureus*	18	0	2	1	8
	Sum	**65**	**17**	**32**	**31**	**41**
	Goatfish					
	Family Mullidae					
10	*Parapeneus forsskali*	5	1	0	0	6
	Sum	**5**	**1**	**0**	**0**	**6**
	Spadefish					
	Family Ephippidae					
11	*Platax orbicularis*	6	0	2	1	0
	Sum	**6**	**0**	**2**	**1**	**0**
	Sweetlips					
	Family Haemulidae					
12	*Plectorhinchus gaterinus*	10	3	6	4	0
	Sum	**10**	**3**	**6**	**4**	**0**
	Emperors and Breams					
	Family Lethrinidae and Sparidae					
13	*Acanthopagrus bifasciatus*	4	0	0	3	0
14	*Scolopsis ghanam*	0	9	6	5	7
	Sum	**4**	**17**	**6**	**8**	**7**
	Snappers					
	Family Lutjanidae					
15	*Lutjanus argentimaculatus*	4	8	0	4	0
16	*Lutjanus ehrenbergi*	9	0	6	0	2
	Sum	**13**	**8**	**6**	**4**	**2**
	Groupers					
	Family Epinephelinae					
17	*Epinephelus summana*	0	5	8	0	0
	Sum	**0**	**5**	**8**	**0**	**0**
	Wrasses					
	Family Labridae					
18	*Halichoeres scapularis*	8	0	0	4	7
19	*Larabicus quadrilineatus*	6	0	2	0	6
20	*Thalassoma lunare*	8	5	2	0	0
	Sum	**22**	**5**	**4**	**4**	**13**
	Butterflyfish					
	Family Chaetodontidae					
21	*Chaetodon mesoleucos*	4	8	9	0	0
22	*Chaetodon paucifasciatus*	0	0	0	5	0
23	*Chaetodon semilarvatus*	2	0	4	0	0
24	*Gonochaetodon larvatus*	10	4	5	0	0
25	*Heniochus intermedius*	6	7	0	0	8
	Sum	**22**	**19**	**18**	**5**	**8**

Continue

Nr.Sp	Parrotfish Name of Spec ies and families	Sampling sites					
	Family Scaridae	Tr.1 -Uqban S.	Tr.2 -Uqban S.	Tr.3 -Uqban S.	Tr.4 -Kam I.	Tr.5 -Kam I.	
26	*Scarus ferrugineus*	8	6	13	8	8	
	Sum	**8**	**6**	**13**	**8**	**8**	
	Angelfish **Family Pomacanthidae**						
27	*Pomacanthus maculosus*	0	0	10	8	9	
28	*Pomacanthus asfur*	3	9	0	0	0	
	Sum	**3**	**9**	**10**	**8**	**9**	
	Unicornfish, Surgeonfish and Tangs **Family Acanthuridae**						
29	*Acanthurus gham*	5	8	6	8	0	
30	*Acanthurus sohal*	0	0	0	4	8	
31	*Ctenochaetus striatus*	8	6	0	8	4	
32	*Zebrasoma veliferum*	7	0	6	0	0	
33	*Zebrasoma xanthurum*	11	0	0	0	0	
	Sum	**31**	**14**	**12**	**20**	**12**	
	Total sum	**189**	**104**	**117**	**93**	**106**	**609**

Appendix (4) Trophic group of all fish species observed (Source: Lieske & Myers 1997; Fish base www.fishbase.org).

Nr.Sp	Name of species and families	Sampling sites					Trophic group
	Dammselfish	Tr.1-Uqban S	Tr.2-Uqban S	Tr.3-Uqban S	Tr.4-Kam I	Tr.5-Kam I.	
	Family Pomacentridae	individuals					
1	*Abudefduf sexfasciatus*	7	2	0	4	0	Omnivore
2	*Abudefduf vaigiensis*	6	2	0	0	4	Omnivore
3	*Chromis viridis*	0	3	3	0	0	Omnivore
4	*Dascyllus aruanus*	6	4	5	8	9	Omnivore
5	*Dascyllus marginatus*	4	0	6	6	10	Omnivore
6	*Dascyllus trimaculatus*	15	0	5	12	2	Omnivore
7	*Neopomacentrus xanthurus*	9	6	11	0	0	Omnivore
8	*Paraglyphidodon melas*	0	0	0	0	8	Omnivore
9	*Pomacentrus sulfureus*	18	0	2	1	8	Omnivore
	Sum	**65**	**17**	**32**	**31**	**41**	
	Goatfish						
	Family Mullidae						
10	*Parapeneus forsskali*	5	1	0	0	6	Benthic feede
	Sum	**5**	**1**	**0**	**0**	**6**	
	Spadefish						
	Family Ephippidae						
11	*Platax orbicularis*	6	0	2	1	0	Omnivore
	Sum	**6**	**0**	**2**	**1**	**0**	
	Sweetlips						
	Family Haemulidae						
12	*Plectorhinchus gaterinus*	10	3	6	4	0	Benthic feede
	Sum	**10**	**3**	**6**	**4**	**0**	
	Emperors and Breams						
	Family Lethrinidae and Sparidae						
13	*Acanthopagrus bifasciatus*	4	0	0	3	0	Benthic feede
14	*Scolopsis ghanam*	0	9	6	5	7	Benthic feede
	Sum	**4**	**17**	**6**	**8**	**7**	
	Snappers						
	Family Lutjanidae						
15	*Lutjanus argentimaculatus*	4	8	0	4	0	Piscivore
16	*Lutjanus ehrenbergi*	9	0	6	0	2	Piscivore
	Sum	**13**	**8**	**6**	**4**	**2**	
	Groupers						
	Family Epinephelinae						
17	*Epinephelus summana*	0	5	8	0	0	Herbivore
	Sum	**0**	**5**	**8**	**0**	**0**	
	Wrasses						
	Family Labridae						
18	*Halichoeres scapularis*	8	0	0	4	7	Benthic feede
19	*Larabicus quadrilineatus*	6	0	2	0	6	Benthic feede
20	*Thalassoma lunare*	8	5	2	0	0	Benthic feede
	Sum	**22**	**5**	**4**	**4**	**13**	
	Butterflyfish						
	Family Chaetodontidae						
21	*Chaetodon mesoleucos*	4	8	9	0	0	Benthic feede
22	*Chaetodon paucifasciatus*	0	0	0	5	0	Benthic feede
23	*Chaetodon semilarvatus*	2	0	4	0	0	Benthic feede
24	*Gonochaetodon larvatus*	10	4	5	0	0	Benthic feede
25	*Heniochus intermedius*	6	7	0	0	8	Benthic feede
	Sum	**22**	**19**	**18**	**5**	**8**	
	Parrotfish						
	Family Scaridae						
26	*Scarus ferrugineus*	8	6	13	8	8	Piscivore
	Sum	**8**	**6**	**13**	**8**	**8**	

Continue

Nr.Sp	**Name of species and families** **Angelfish**	**Sampling sites**					**Trophic group**
	Family Pomacanthidae	Tr.1 -Uqban S. I	Tr.2 -Uqban S. I	Tr.3 -Uqban S. I	Tr.4 -Kam I.	Tr.5 -Kam I.	
				individuals			
27	*Pomacanthus maculosus*	0	0	10	8	9	Omnivore
28	*Pomacanthus asfur*	3	9	0	0	0	Omnivore
	Sum	**3**	**9**	**10**	**8**	**9**	
	Unicornfish, Surgeonfish and Tangs						
	Family Acanthuridae						
29	*Acanthurus gham*	5	8	6	8	0	Herbivore
30	*Acanthurus sohal*	0	0	0	4	8	Herbivore
31	*Ctenochaetus striatus*	8	6	0	8	4	Herbivore
32	*Zebrasoma veliferum*	7	0	6	0	0	Herbivore
33	*Zebrasoma xanthurum*	11	0	0	0	0	Herbivore
	Sum	**31**	**14**	**12**	**20**	**12**	

Appendix (5) Questionnaire for fishermen

Respondent identity: name ___________, age ___________, location ___________

Number of time spend on this activity: __________/week/month/year

Fishing method: Fishing gear:

Tonnage:

How many person in this fishing ground doing the same activity?

Where they came from?

Are they legal or not?

Do you know another method to catch a fish? _______ yes, _______ no

If yes, have you ever tried that method? _______ yes, _________no

What is the facility that local government gives you?

Do you have NOGs in your village? How did you react with civil society?

Is this boat for you or for owner?

If you are owner how much labour in your boat?

Where did you sell your products?

Comments:

If you are coral collector or ornamental fish:

How many person in this coral reefs area doing the same activity?

Do you know another method to collecting live coral or ornamental fish? _______ yes, _______ no

If yes, have you ever try that method? _______ yes, _________no

Did tourist collect coral or buy it from you?

Where did you sell this corals or ornamental fish?

Comments:

Lebenslauf

Curriculum vitae

Name	Adel Mohammed Yahya.
Family name	Alhababy.
Date of the Birth	15/March/1974
Place of Birth	Sana`a, Yemen
Nationality	Yemeni.
Family status	Married, three kids.
Languages	Mother language (Arabic language), English language fluently and good in German language.
Permanent address (Yemen)	Republic of Yemen, Sana`a, Old University Post, P.O. Box 12220.
Education & Experiences	**October 1989 - August 1992** General Secondary School Examination, Scientific department, Kalid bin Alwalied School, Yemen. **October 1993 - June 1997** B.Sc in Marine Science, Sana`a University, Yemen. **March 1998 – August 1998** Participant in UNDP/GEF project (Protection of Marine Ecosystems of the Red Sea Coast). **October 2000 - June 2002** M.Sc in Geo-science & Engineering, Christian Albrechts University of Kiel. **April 2003 – September 2006** PhD Student at the Institute for Polar Ecology, Christian Albrechts University of Kiel, Germany.
Skills	Microsoft office, window server and security, Photoshop, Adobe illustrator, Macromedia and HTML, Linux and Unix, Delft 3D, Edrisi, Matlab, Surfer, Model flow, C++ and Arc View (GIS).
Hobby	Swimming and traveling.

Erklärung

Hiermit erkläre ich, dass die vorliegende Dissertation – abgesehen von der Beratung durch meine akademischen Lehrer – nach Inhalt und form meine eigene Arbeit ist. Sie wurde keiner anderen Stelle im Rahmen eines Prüfungsverfahrens vorgelegt. Dies ist mein erster Promotionsversuch.

Kiel, im April 2006