PROJECT REPORT

Expedition dates: 9 - 15 October 2011
Report published: July 2012

Underwater pioneers: studying & protecting the unique coral reefs of the Musandam peninsula, Oman.

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Underwater pioneers: studying & protecting the unique coral reefs of the Musandam peninsula, Oman.

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Authors:
Rita Bento
Emirates Diving Association

Matthias Hammer (editor)
Biosphere Expeditions

Abstract

Coral reefs are globally important hotspots for biodiversity. They also provide human populations with important goods and services, such as food and coastal protection. Despite this, coral reefs are under threat worldwide from direct or indirect anthropogenic impacts such as pollution, overexploitation, coastal development and unmanaged tourist activities. Today reefs face additional pressure from thermal stress and emergent diseases that are closely linked to climate change. Due to the thermal sensitivity of most scleractinian corals, there has been a substantial increase in mass coral bleaching events and subsequent mortality of reefs with rapid changes in global sea-surface temperatures.

The coral reefs of the Musandam Peninsula, situated on the Arabian Peninsula in the Strait of Hormuz, endure very harsh conditions such as high salinity and temperatures, existing in what would be considered marginal and challenging environments for corals in other parts of the world. Surprisingly, reefs in this area are thriving and high mean percentages of coral cover of well over 50% were recorded by Biosphere Expeditions in 2010. Although resilience seems to exist among the Musandam corals, there is increasing concern that any additional stress, for example from natural disasters and/or anthropogenic impacts, may accelerate coral die-off.

Between 9 and 15 October 2011, Biosphere Expeditions, in collaboration with the Emirates Diving Association, ran for the third year a research project along the North Musandam peninsula coastline during which a coral reef survey using the Reef Check methodology was carried out at five sites. The main objectives of this study are to (1) monitor the health of and the impacts on the Musandam Peninsula’s coral reefs and (2) use and disseminate these findings for management, educational and conservation purposes by local government and NGOs.

Data obtained in the past three years of expeditions have revealed some improvements in the system. Besides the high mean coral coverage of 58% observed in North Musandam in 2011, the increase in the number of parrotfish observed during this expedition, as well as the decrease in the mean substrate coverage of nutrient indicator algae and silt, are encouraging signs of a largely intact reef habitat, which nonetheless remains threatened and in need of further conservation action.

The results of the 2009 to 2011 expeditions show clearly that Oman, in the North of Musandam, has in its stewardship (1) arguably the best reefs of the region and (2) a unique area of (a) natural beauty as well as (b) commercial importance, not just for fishermen, but also for the local economy as a generator of income from tourism.

The continuation of this research project is important for the constant monitoring of the valuable coral reefs of the Musandam peninsula; a habitat that not only guarantees high biodiversity in the area, but also provides local communities with essential goods, services and resources. However, without additional actions, Biosphere Expeditions’ annual Reef Check surveys are likely simply to document a continuing decline of yet another reef habitat in the Middle East. We therefore recommend that the following additional projects are instigated by local government and NGOs: (1) fisheries landings studies, (2) patrolling and new legislation for the diving and fishing communities, (3) creation of a Marine Protected Area (MPA) or a network of MPAs, including the installation and monitoring of fixed and marked mooring buoys (4) actions to declare the Musandam peninsula a UNESCO Biosphere Reserve and eventually a UNESCO World Heritage Site and (5) policy and enforcement action for any protected areas created.

ملخص

تحتل الشعاب المرجانية مكانة هامة على الصعيد العالمي للتنوع البيولوجي ؛حيث أنها ترفد المجموعات السكانية البشرية بالعديد من السلع الغذائية الهامة والخدمات ، إضافة إلى دورها الهام في حماية السواحل . ولكن ،وبالرغم من أهميتها القصوى ، فإن الشعاب المرجانية في جميع أنحاء العالم مهددة باستمرار؛ وذلك بتأثير الممارسات البشرية المباشرة أو غير المباشرة: كالتلوث، والاستغلال المفرط، بالإضافة إلى الأضرار الناجمة عن الحركة العمرانية على السواحل ،والأنشطة السياحية غير النظامية. تواجه الشعاب المرجانية في الوقت الحاضر ضغوطًا إضافية ناتجة عن الإجهاد الحراري والأمراض المستجدة التي ترتبط ارتباطًا وثيقًا بتغيّر المناخ. ونظراً للحساسية الحرارية لدى معظم الشعاب المرجانية الحجرية فقد ارتفعت معدلات إصابتها بالابيضاض الجماعي الذي يؤدي إلى وفيات لاحقة في الشعاب نتيجة التغيّر السريع في درجات حرارة سطح البحر في العالم.

لقد تحملت الشعاب المرجانية في شبه جزيرة مسندم الواقعة على مضيق هرمز في شبه الجزيرة العربية ، ظروفاً بيئيةً قاسية للغاية : كارتفاع درجات الحرارة والملوحة العالية التي تتركز في ما يمكن اعتباره أحد البيئات الهامشية التي تشكل تحدياً صعباً للشعاب المرجانية في أجزاء أخرى من العالم . ومن المثير للاستغراب أن تزدهر الشعاب في هذه المنطقة بالذات ،مسجِّلةً نسبة مرتفعة من متوسط الغطاء المرجاني الذي يغطي ما يزيد عن 50 % (وفقًا لسجلات بعثات بايوسفير الاستكشافية في عام 2010) .ولكن، على الرغم من المرونة التي تبديها الشعاب المرجانية في منطقة مسندم، فإن القلق يتزايد حول قدرة هذه الشعاب على تحمّل أي ضغوط إضافية : كالكوارث الطبيعية أو الممارسات البشرية ، أو كليهما معاً ، مما يؤدي إلى التعجيل في هلاك الشعاب المرجانية وفنائها.

وفي الفترة الواقعة بين 9 و 15 أكتوبر 2011 ، قام فريق "بعثات بايوسفير الاستكشافية" بالتعاون مع "جمعية الإمارات للغوص" بإجراء مشروع بحثي على امتداد الساحل الشمالي لشبه جزيرة مسندم، للسنة الثالثة على التوالي . تم خلال المشروع مسح الشعاب المرجانية في خمسة مواقع باستخدام " منهجية مراقبة الشعاب المرجانية " . وتتمثل الأهداف الرئيسة لهذه الدراسة في :

أولا : مراقبة الحالة الصحية للشعاب المرجانية في شبه جزيرة مسندم ، ورصد الآثار المترتبة عليها .

ثانيا: استخدام هذه النتائج ونشرها لغايات إدارية وتعليمية، ولأغراض حفظ البيانات من قِبل الحكومة المحلية والمنظمات غير الحكومية .

البيانات التي تم الحصول عليها في السنوات الثلاث الماضية للحملة أظهرت أن هناك بعض التحسن في النظام. إلى جانب ارتفاع الغطاء المرجاني بنسبة 58% في شمال منطقة مسندم عام 2011. كما أُوحظ أيضاً تزايد في عدد أسماك الببغاء أثناء هذه الحملة ، فضلاً عن مؤشرات النقص في متوسط التغطية السفلية للمغذيات الطحلبية والطمي . هذا ما تم ملاحظته خلال الحملة الاستكشافية لعام 2011. وهي بوادر مشجعة تشير إلى سلامة الشعاب المرجانية كموئل، إلا أن ذلك لا ينفي وجود التهديد ، مما يستدعي اتخاذ المزيد من الإجراءات.

أظهرت نتائج البعثات من عام 2009 إلى 2011 أن المنطقة الواقعة في الشمال من مسندم في سلطنة عمان تمتاز بكونها :

(1) تتوفر على أفضل الشعاب المرجانية في المنطقة .

(2) تتفرّد بالجمال الطبيعي فضلاً عن الأهمية التجارية ، ليس للصيادين فقط ولكن للاقتصاد المحلي أيضًا ،وذلك بوصفها مصدر هام للدخل في القطاع السياحي.

إن استمرار هذا المشروع البحثي له أهمية قصوى لإبقاء الشعاب المرجانية القيّمة في شبه جزيرة مسندم تحت المراقبة المتواصلة ، لكونها الموئل الذي يضمن بقاء التنوع البيولوجي في المنطقة، إضافة لما توفره للمجتمع المحلي من سلع أساسية وخدمات وموارد. إن الدراسات المسحية التي تجريها منظمة "بعثات بايوسفير الاستكشافية" لمراقبة الشعاب سنوياً- ودون مزيد من الإجراءات الإضافية- تعمل على توثيق التدهور المستمر في موطنٍ محتمل آخر للشعاب المرجانية في منطقة الشرق الأوسط.لذا ،فإننا نتقدم بالتوصية بأن تتولى الحكومة المحلية والمنظمات غير الحكومية مسؤولية المشاريع الإضافية التالية:

1- إجراء دراسات حول إنزال مصائد الاسماك.

2- تعيين دوريات خفر سواحل ،وإصدار تشريعات جديدة ، في مناطق الغوص ومجتمعات صيد الأسماك .

3- إنشاء منطقة بحرية محمية (MPA) أو شبكة من المحميات البحرية ، بما في ذلك تركيب عوّامات ثابتة وظاهرة للعيان تقوم بتحديد المنطقة.

4- اتخاذ الإجراءات الرامية إلى إعلان شبه جزيرة مسندم محمية ضمن مجموعة اليونسكو العالمية لمعازل المحيط الحيوي ، ليصار في نهاية المطاف إلى إعلانها كأحد مواقع اليونسكو للتراث العالمي.

5- وضع سياسات وإجرءات لحماية المناطق المحمية التي يتم انشاؤها.

Contents

Please note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this section, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

1. Expedition Review

M. Hammer (editor)
Biosphere Expeditions

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Our projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Our expeditions are open to all and there are no special skills (biological or otherwise) required to join. Our expedition team members are people from all walks of life, of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

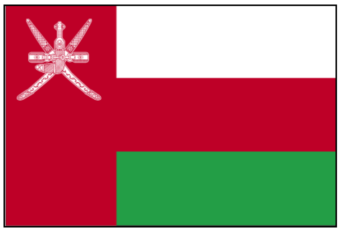
This project report deals with an expedition to the Musandam peninsula that ran from 9 to 15 October 2011 with the aim of monitoring the health of the Musandam peninsula's reefs, its fish and invertebrate communities so that informed management, education and conservation decisions can be made by the government and NGOs. Data on the current biological status of the reefs and of population levels of key indicator species are crucial for educational purposes and to be able to put forward ideas for future marine protection areas. Data collection followed an internationally recognised coral reef monitoring programme, called Reef Check, and will be used to make informed management and conservation decisions within the area. The expedition included training for participants as a Reef Check EcoDiver.

Although popular myth has Arabia down as a vast, flat and empty expanse of sand (and oil), Oman is quite different. In fact, there is a wide range of contrasting landscapes: high mountains, beaches, the desert landscapes of the Empty Quarter, coral reefs and even tropical habitats, where the monsoon touches Oman in the extreme south.

The 650 kilometre coastline of the Musandam peninsula is strewn with rocks and coves, gradual steps, steep rocky slopes and cliffs that plunge to great depths all over the fjord-like landscape. The coral reefs that grow along the margins of this stunning landscape are still relatively untouched as influences such as industrial-scale fishing, pearl or scallop extraction or large numbers of recreational divers have not wreaked their destructive influence there. The area is therefore a prime target for studying intact reef ecosystems, conserving them for future generations and using them in the education of people locally and all over the world.

1.2. Research Area

The Musandam peninsula (sometimes also called the Norway of Arabia) is the northernmost part of Oman jutting out into the Strait of Hormuz at the entrance to the Arabian Gulf. The province, or Governorate of Musandam as it is officially known, is separated from the rest of Oman by various parts of the United Arab Emirates including Ras al Khaimah and Fujairah. The Musandam peninsula more or less begins where the mountains rise from the plains of Ras al Khaimah.



Flag and location of Oman and study site.

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations is at Google Maps.

The remote and rugged mountains, which rise straight out of the sea creating fjords and stunning landscapes, have had isolated communities for centuries. Many coastal villages can be reached only by boat, as there are no roads on much of the peninsula. Pockets of flat land support subsistence agriculture. The population of approximately 29,000 is concentrated in the capital, Khasab (18,000 in 2004) in the north and Dibba (5,500) on the east coast. Fishing is the principal economic activity supported by employment in government jobs.

Geology

Rocks of the Hajar supergroup in the north appear to be flat-lying but are actually folded in a north-south trending anticline. Thinly-bedded yellowish-orange dolomitic limestones and mudstones indicating a near-shore environment progress upwards into highly fossiliferous shelf limestones. Shell fragments, brachiopods and micro-fossils in limestone indicate continental shelf conditions. These limestones were deposited from the early Jurassic to the Cretaceous period and are reckoned to be older than 65 million years.

"Round the bend"

The British arrived on a lump of rock they called Telegraph Island in the fjords back in the mid-19th century, staying for five years. They were laying a telegraph cable from India to Basra in Iraq. Taking the cable "round the bend" of the Gulf gave rise to the expression, since living on Telegraph Island in the extreme heat of summer must have sent them crazy! These days, the island is noted for its rich underwater life and dhows (the local type of fishing boat) stop off here.

1.3. Dates

The project ran over a period of one week, composed of a team of international research assistants, scientists and an expedition leader. Expedition dates were:

2011: 9 - 15 October

Dates were chosen when survey and weather conditions are most comfortable.

1.4. Local Conditions & Support

Expedition base

The expedition base was a modern and comfortable live-aboard dhow with eight air-conditioned cabins, some of them with on-suite toilet and shower facilities. The dhow had three decks, an air-conditioned lounge, a compressor and all facilities one would expect on a modern live-aboard boat. Tank refills and dive services were provided by the crew. A professional cook and crew also provided all meals and vegetarians and special diets could be catered for.

Weather & water temperature

The climate is tropical and maritime. The average day temperature during the expedition were 33-35°C with sunshine and some clouds, and for the first time during the expeditions there was two days of rain and strong winds. Water temperature during the expedition is ranged from 28-30°C.

Field communications

The live-aboard boat was equipped with a satellite communication system. Mobile phones worked in some parts of the study site. The expedition leader also sent an expedition diary to the Biosphere Expeditions HQ every few days and this diary appeared on www.biosphere-expeditions.org/diaries.

Transport, vehicles & research boats

Team members made their own way to the Dubai assembly point. From there onwards and back to the assembly point all transport and vehicles were provided for the expedition team, for expedition support and emergency evacuations.

Medical support and insurance

The expedition leader and the expedition scientist were trained first aiders, and the expedition carried a medical kit. The standard of medical care in Oman is very high with a clinic in Khasab. There is also a recompression chamber in Muscat and one in Dubai. Safety and emergency procedures were in place. There were no serious medical incidences during the expedition and emergency procedures did not have to be invoked.

Diving

The minimum requirement to take part in this expedition was a PADI Open Water or equivalent qualification. Team members who had not dived for twelve months prior to joining the expedition were required to complete a PADI Scuba Review before joining the expedition.

Standard PADI diving and safety protocols were followed.

Dive groups were divided into different teams, each working on specific areas of survey work. Divers were allocated to teams based on a mixture of personal preference, diving skills and knowledge of the species.

1.5. Local Scientist

Biosphere Expeditions was working with Rita Bento of the Emirates Diving Association on this project. Rita Bento was born in Portugal. She has a degree in Marine Biology from the University of the Azores and a Masters in Science of the Sea – Sea Resources from Porto University and is currently doing her PhD with Porto University. Her first area of research was bioacoustics of baleen whales, working in the USA with Oregon State University and NOAA (National Oceanographic and Atmospheric Administration). In the last few years she has focussed her research on Marine Protected Areas (MPA) currently working with the Emirates Diving Association on the management plan of Dibba MPA in the UAE. Rita is also a Reef Check Course Director with hundreds of Reef Check dives. Besides her scientific career, she is also a CMAS diving instructor and published the first Portuguese diving guide in 2007.

1.6. Expedition Leader

Rossella Meloni was born in Italy and has lived and worked in the UK for 12 years before moving to Muscat, in the Sultanate of Oman where she currently lives. She studied languages in Italy and IT in the UK with Birkbeck University of London. Since her first cautious breath underwater, well over a decade ago, she has become increasingly interested in the beauty and welfare of the underwater world. Her love for the marine environment and the outdoors encouraged her to quit her 9-5 job to volunteer on a marine expedition in Madagascar in 2006 and later to continue training as an Open Water Diving Instructor. These days when she is not busy on expedition, at university or lecturing students on the wonders of breathing under water and the importance of preserving this fragile environment, she can be found exploring all sorts of outdoor activities that Oman has on offer. She is also a keen City & Guilds trained photographer, RYA Competent Crew and a qualified Emergency First Response trainer.

1.7. Expedition Team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of all ages, nationalities and backgrounds. They were (with country of residence):

9 – 15 October 2011

Tariq Al-Balushi (Oman, scholar), Marcus Benner (Germany), Elliott Catchpole (UK, scholar), Claire Donnelly (UAE, scholar), Anne Gregory (UK), Mike Hoff (UAE), Lauren Laing (UK, scholar), Tina Lehmuskoski (Finland), Janet & Graham McDermid (New Zealand), Michael Ratty (UK), Loredana Sementini (Belgium), Tony Woodward (UK, press).

Crew during the expedition: Ali (boat captain), Poli (cook), Chandu (deck hand), Abdullah (deck hand).

1.8. Other Partners

On this project Biosphere Expeditions is working with Reef Check, the Emirates Diving Association, local dive centres, businesses & resorts, the local community, Sultan Qaboos University, the Oman Ministry for Environment and Climate Affairs, the Oman Tourism Board, as well as the United Nations Environment Programme, the World Conservation Monitoring Centre and the International Coral Reef Action Network (ICRAN).

1.9. Expedition Budget

Each team member paid towards expedition costs a contribution of £1090 per person per 7 day slot. The contribution covered accommodation and meals, supervision and induction, special non-personal diving and other equipment and air, and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs etc., as well as visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	£
Expedition contributions	9,550
Grants & sponsorship	14,799
Expenditure	
Research vessel includes all board & lodging, ship's crew, fuel & oils, other services	6,856
Transport includes transfers & visas	1,096
Equipment and hardware includes educational & research materials & gear purchased in UK & Middle East	275
Staff Includes local and international salaries, travel and expenses	2,280
Administration includes registration fees, educational materials, distribution & sundries	2,321
Team recruitment Musandam as estimated % of PR costs for Biosphere Expeditions	4,774
Income – Expenditure	**6,747**
Total percentage spent directly on project	**72%**

1.10. Acknowledgements

This study was conducted by Biosphere Expeditions which runs wildlife conservation expeditions all over the globe. Without our expedition team members (who are listed above) who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The support team and staff (also mentioned above) were central to making it all work on the ground. Thank you to all of you, and the ones we have not managed to mention by name (you know who you are) for making it all come true. Biosphere Expeditions would also like to thank members of the Friends of Biosphere Expeditions and donors, Land Rover and Swarovski Optik for their sponsorship. Thank you also to Ben Rees and two anonymous assessors for their comments on the manuscripts. Biosphere Expeditions also gratefully acknowledges grant support from Six Senses (Zighy Bay), the Waterloo Foundation and the Ford Motor Company Conservation & Environmental Grants.

1.11. Further Information & Enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions via www.biosphere-expeditions.org.

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2. Reef Check Survey

Rita Bento
Emirates Diving Association

2.1. Introduction

Study site description

The Musandam peninsula, also known as Ru'us al-Jibal, is an exclave of Oman separated from Oman by the United Arab Emirates. It is situated on the Arabian Peninsula in the Strait of Hormuz, the narrow passage that links the Arabian Gulf and the Gulf of Oman (Rezai et al. 2004).

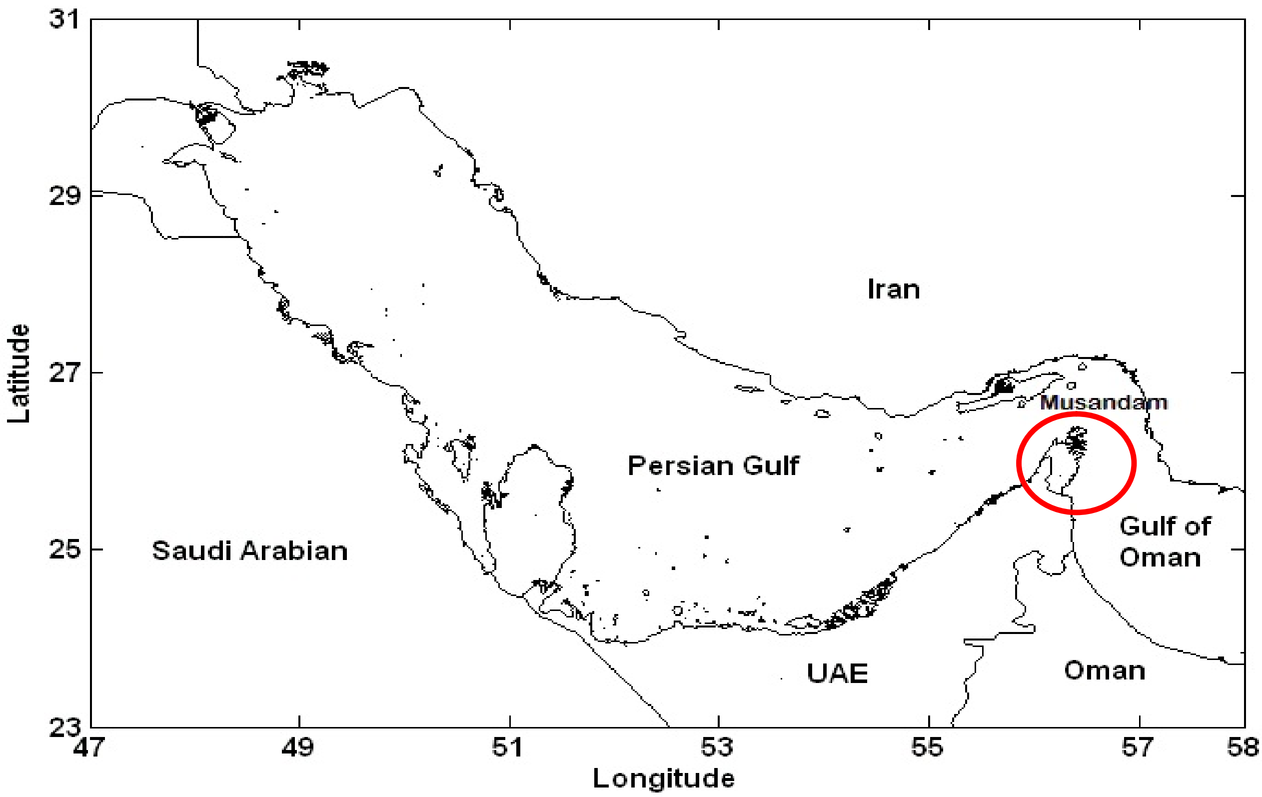

Figure 2.1a. Location of the Musandam peninsula in the Middle East.

The Persian Gulf is a shallow semi-enclosed basin measuring about 1,000 km by 200 - 300 km. It has an average depth of 35 meters, dipping down towards the north to a maximum of about 60 meters near Iran, and inclined downwards to about 100 meters deep at its entrance in the Strait of Hormuz, the only connection to the Gulf of Oman and the Indian Ocean (Sheppard et al. 1992; Carpenter et al. 1997; McClanahan et al. 2000; Pilcher et al. 2000). As a result of its shallow depth and restricted water exchange, the Persian Gulf is characterized by strong variations in sea surface temperatures (SSTs), ranging from 12ºC in winter and 36ºC in the summer, and high salinity values of 43 (no unit) year-around, hereby influencing water density, currents, water mixing, and a host of other environmental parameters that therefore influence species composition (Price et al. 1993; Riegl 2001; Coles 2003). In contrast with the Persian Gulf, the Gulf of Oman and Arabian Sea are deep seas (more than 2,000 meters deep) with more stable conditions (Wilson et al. 2002).

The Arabian Peninsula is among the hottest areas in the world, where temperatures above 49°C have frequently been recorded at some weather stations in the region (SOMER 2003). The extremely arid nature of the Arabian region, the high temperatures and the constant and intensive sunshine, especially along the coastal areas, results in some parts in a lack of four season variability.

The region lies at the edge of two global weather systems, the Asian and the North Africa weather systems, whose fluctuations cause varied and severe environmental conditions, the summers are hotter and the winters colder than most subtropical zones (Sheppard et al. 1992; Carpenter et al. 1997; McClanahan et al. 2000).

Evaporation by dry winds is as intense in winter as it is during the hot summer. Over the whole Persian Gulf, evaporation averages 144 to 500 cm/yr, most occurring in the shallow bays in the south where evaporation locally exceeds 2000 cm/yr. In these shallow bays salinity exceeds 50 over hundreds of square km, exceeding even 70 in large expanses (McClanahan 2000). These large evaporation rates over the Persian Gulf lead to the formation of a warm and salty water masses, which flow into the Gulf of Oman through the Strait of Hormuz; the mass and salt budget in the Gulf are closed by an inflow of Indian Ocean Surface Water coming from the northern Arabian Sea (Figure 2.1b) (Pous et al. 2004).

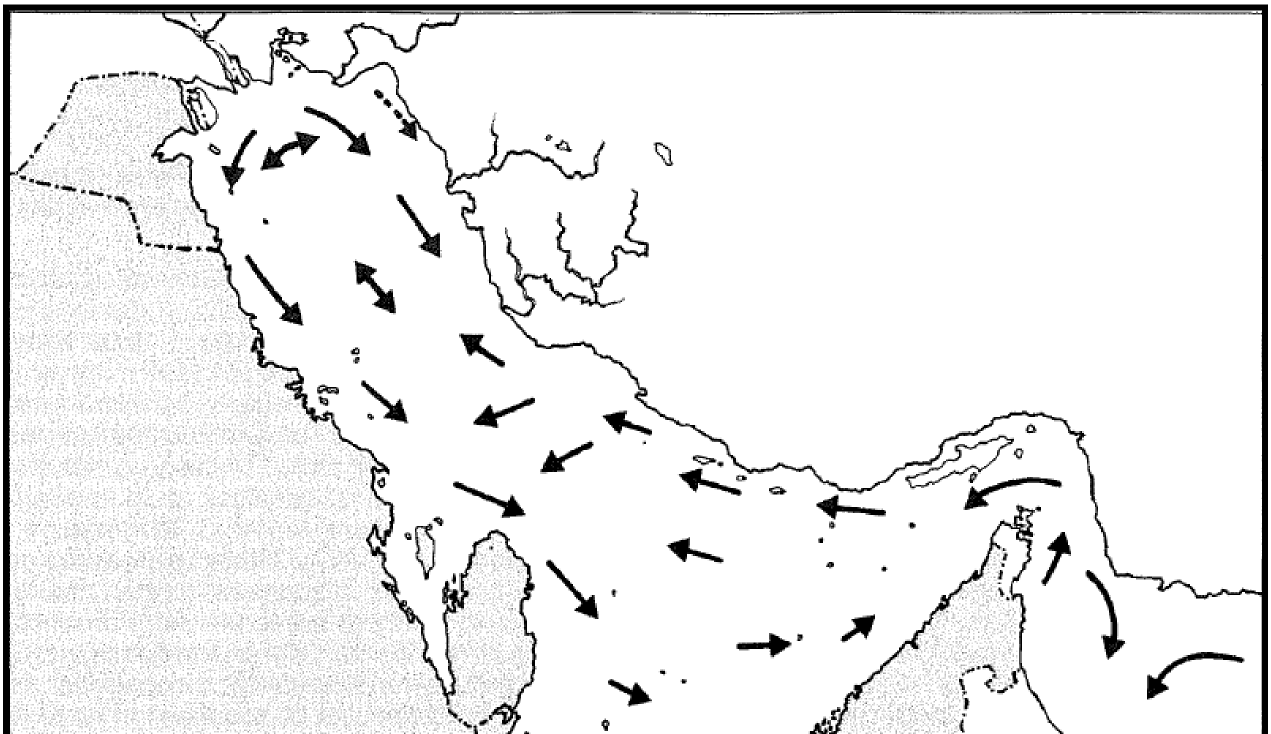

Figure 2.1b. Major current patterns of the Persian Gulf and northern Arabian Sea (Reynolds 1993).

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

In the Gulf of Oman water temperatures are moderate in comparison to the Arabian Gulf. Typical winter surface water temperatures fall to 22-23°C (minimum recorded of 12°C), while summer temperature is characterised by a highly fluctuating regime caused by the rise and fall of a shallow, but strong thermocline. Summer water temperatures range between 23-31°C (maximum recorded of 35°C), and can often cover this range within one day (Rezai et al. 2004). In the Arabian Sea the seasonally reversing winds induced by the monsoon create a strong upwelling, which causes the remarkable, low sea temperatures off the southeast Arabia peninsula in the hottest summer months (Sheppard et al. 1992; Carpenter et al. 1997). In the Gulf of Oman the cool water influences are less constant, although occasional upwellings occur and can replace surface waters very rapidly such that falls of up to 10°C over one or two days can happen. Such upwellings have a significant impact on the marine ecology, and therefore areas of reef development are few (Randall 1995; Spalding et al. 2001).

Salinity in the Gulf of Oman is generally at 36.5, but due to the influence of the Arabian Gulf 38.9 has been recorded in the surface waters of the Strait of Hormuz, in the Musandam peninsula, to Ra's Al-Hadd at the entrance to the Gulf of Oman (Rezai et al. 2004).

Salinity values experienced in the Persian Gulf exceeds the optimum range of coral reef in other tropical regions in the Atlantic and Pacific that normally show a salinity interval of 35 to 37 and an upper tolerance range between 40 and 45 (Price et al. 1993, Coles 2003). The SSTs values observed in the Persian Gulf are the highest encountered worldwide on reefs, varying by up to 25ºC annually (Sheppard and Loughland 2002; Coles 2003). In other tropical regions the changing range is normally 19ºC only, with the normal upper limits between 33ºC and 34ºC and the lower limits between 13 to 16ºC (Coles 2003). Species that establish populations in the area must therefore be capable of withstanding the stress of osmotic and temperature extremes. Many major shallow water taxonomic groups and species that are prevalent at similar latitudes elsewhere in the Indo-Pacific, and found in adjacent seas, are completely lacking in the area (Carpenter et al. 1997).

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

Some corals have the ability to acclimatise by phenotypic changes to more stressful environmental conditions, resulting in the readjustment of the organism's tolerance levels. They have evolved temperature thresholds close to the average upper temperatures of their area, so thermal tolerance varies from region to region. Similar corals in each location live under quite different temperature regimes and thus have different thermal tolerances (Grimsditch and Salm 2006, Marshall and Schuttenberg 2006).

Corals and reef communities in some areas (such as the Persian Gulf and Gulf of Oman) tolerate salinity and temperature conditions that are lethal when imposed rapidly on the same species in less extreme environments (Baker et al. 2004, Buddemeier et al. 2004, Riegl et al. 2006).

Rezai et al. (2004) describe coral communities of the Gulf of Oman and Arabian Sea as in good condition, due in part to the mitigating effects of a summer upwelling that cools summer seawater temperatures, possibly protecting the corals from bleaching.

There is a fairly distinct Arabian coral species grouping, and within it, there is a single, principal division into a Red Sea group and a Gulf of Oman/Arabian Sea group, which then fuses with the Persian Gulf (Sheppard et al. 1992). Although the species composition of Persian Gulf corals is typically Indo-Pacific, with a few regional endemics, the coral diversity in the Persian Gulf and parts of the Gulf of Oman is relatively low compared to most parts of the Indian Ocean where it is up to four times higher (Riegl 1999, Rezai et al. 2004). Of the 656 species among 109 genera of zooxanthellate corals for the Indo-Pacific, only about 10%, or 68 species among 28 genera, occur in the Persian Gulf and 120 species among 33 genera in the Gulf of Oman (Rezai et al. 2004). Some combination of factors has probably limited the recruitment, settlement, survival and growth of reef corals in the region, eliminating many species and perhaps favouring a few that are adapted to the uniquely harsh conditions of the region (Coles 2003).

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

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

The coral reef losses from climate-related devastation and massive coastal development on the Arabian Peninsula have made this region amongst the most damaged in the world with the lowest predictions for recovery. According to recent estimates, 30% of the coral reefs are at a threatened-critical stage and up to 65% of the coral reefs may have been lost already due to natural causes (fluctuation of temperatures, diseases) and anthropogenic stresses (oil pollution, unmanaged coastal development, unregulated commercial and recreational fishing and diving) (Wilkinson 2004). Unfortunately coral reef research and monitoring is often way behind other parts of the world (Wilkinson 2008).

In the past decades there have not been many studies on the Musandam peninsula coral reefs biodiversity. The latest research in the region that collected data in the Musandam peninsula includes different topics such as tropical harmful algal blooms (Bauman et al. 2010), kingfish fisheries (Claereboudt et al. 2004), shark fisheries (Henderson et al. 2007) and phytoplankton (Subba-Rao and Al-Yamani 1998). But the last published scientific study done exclusively in Musandam was conducted in 1971 and 1972 (Fraser et al. 1973).

Additional external factors affecting the area

On 6 June 2007 the first documented tropical storm occurred in the Arabian Sea. Tropical cyclone Gonu was a category 5 storm and matched the strongest storm recorded in the northern Indian Ocean (Mooney 2007; UNEP 2008). The human and economic costs of cyclone Gonu were considerable with about 75 deaths and 2.88 billion € (Euros) of damage. In Oman, including Musandam, and on the east coast of the UAE damage by the strong waves along the coast were noted. Corals on exposed shores were almost entirely destroyed and there was variable damage in sheltered bays, coves and islands. Before this natural catastrophe the Musandam Peninsula reefs were dominated by Porites and Acropora.

Rich coral communities such as *Porites lutae*, *P. solida*, *Acropora valenciennesi* and *A. valida* were common from Musandam to the capital area of Oman (McClanahan et al. 2000; Sheppard et al. 1992). Gonu affected colonies down to 7 meters with major impacts on *Sinularia*, *Sarcophyton* and *Acropora*. By March 2008 there was significant re-growth of some soft coral areas, although hard coral communities in shallow exposed areas have shown less resilience (Wilkinson 2008).

The existence of a harmful algal bloom (HAB), caused by the algal species *Cochlodinium polykrikoides*, between August 2008 and May 2009, when the marine life was still recovering from the cyclone Gonu, significantly changed the habitats and biodiversity in the area. Both the Persian Gulf and Gulf of Oman have a high phytoplankton biodiversity with 38 taxa potentially bloom-forming or harmful (Subba-Rao and Al-Yamani 1998). The presence of *C. polykrikoides* in the region was noticed for the first time during this period in 2008 and 2009. A pattern of subsequent recurrence of *C. polykrikoides* blooms has been observed in other parts of the world, suggesting that this species may become a persistent HAB problem in the region and further monitoring and protection in Musandam is needed according to Richlen et al. (2010). It is known that increasing human population and demand for resources and development is one of the main reasons for the rise in the distribution and size of harmful algal blooms and dead zones around the globe (Anderson 1997; Hinchley et al. 2007). Ballast water carried in ships has also been recognised as one of the main vectors for the translocation of non-indigenous marine organisms around the world. Based on preliminary analysis, it is suspected that the HAB on the east coast of the UAE and Oman from August 2008 to May 2009 was due to a non-native algae species and therefore that ballast water discharge was involved at some point (Richlen et al. 2010).

Reef Check

Reef Check's survey method uses simple techniques to collect scientifically robust data. This methodology is specially designed for recreational divers that might not have scientific background, so training has to be precise, rapid and understandable in order to guarantee that organism identification is accurate (Hodgson et al. 2006).

To understand the health of a coral reef, Reef Check bases its data collection on “indicator organisms” that are defined as organisms that reflect the conditions of the ecosystem. These indicators can be individual species or even a family. The important thing is that each of these indicators has an economic or ecological value, is sensitive to anthropogenic impacts and easy to identify. A Reef Check team collects four types of data (Hodgson et al. 2006):

1. A site description referring to environment, socio-economic and human impact conditions;
2. Fish indicator species count;
3. Invertebrate indicator species count;
4. Recording different substrate types (including live and dead coral).

Data for points 2-4 are collected along a 100 metre transect, at two depth contours, between 2 to 5 metres and between 6 and 12 metres (Hodgson et al., 2006). Data for point 1 is collected prior and after the dive.

Aims and objectives

The primary aim of this project was to provide data on the health of the Musandam Peninsula’s coral reefs and current threats. With the beginning of this project in 2009 it was possible, for the first time in Musandam, to collect data through Reef Check surveys in order to quantitatively assess benthic and fish communities and anthropogenic impacts. The data collected are now useful for comparison with the survey conducted in 2009, as well as future surveys, and to provide data from Musandam for the global Reef Check database.

2.2. Methods

Site selection & sampling design

Between 9 and 15 October, 2011, due to the bad weather during the expedition only 5 dive sites were surveyed using the Reef Check methodology (Figure 2.2a). All sites had been recorded by Global Positioning System (GPS) during the 2009 expedition and have been used since then for possible comparative Reef Check surveys every year. All positions were collected in degrees, minutes and seconds (Table 2.2a).

All the dive sites surveyed during the 2011 expedition were located in the North region of the Musandam Peninsula and included diving sites that are well-known diving spots regularly visited by divers, as well as areas that are known for their importance to fisheries. With all the dive sites located in the North area of Musandam we will be able to compare changes that might exist since 2009 in this area of Musandam.

Training of expedition team members

All data were collected by team members that passed through an intensive Reef Check training and testing procedure. Team members on the expedition were coordinated by a project scientist and an expedition leader. The primary responsibilities of both were to train the 13 team members in Reef Check methodology and also to coordinate and supervise the subsequent surveys and data collection.

Survey procedures & data collection

The Reef Check survey protocol utilises two transects at depths between 2 - 5 metres (shallow dive) and 6 - 12 metres (medium dive), chosen for practical reasons of dive duration and safety. Along each depth interval, shallow and medium, four 20 metre long line transects are surveyed with a 5 metre space interval between transects. The distance between the start of the first transect and end of the last transect is, therefore, 95 metres.

An ideal Reef Check team includes six members (three buddy pairs, each pair responsible for fish, invertebrate and substrate data collection respectively) plus support crew, each with different specialties and experience.

The Reef Check methodology is adapted by region, and the area used for this expedition was the Indo-Pacific region. Full details of the methodology and regular updates can be found on the Reef Check website www.reefcheck.org.

Note that during this expedition the dives were conducted only on the North area of the Musandam Peninsula Therefore for the data analysis in this report only data from 2009 and 2010 collected in the same dive sites were used.

Table 2.2a. Names and geographic coordinates of the 5 dive sites where Reef Check surveys were undertaken.

Site name	GPS log number	Coordinates	
Ra's Shuraytar	D3	N 26˚23'04''	E 056˚22'46''
Coral Garden	D7	N 26˚22'33''	E 056˚24'59''
Eagle Bay	D9	N 26˚22'55''	E 056˚25'06''
Khayl Island	D13	N 26˚21'56''	E 056˚27'08''
Faqadar Bay	D19	N 26˚20'50''	E 056˚28'51''

Figure 2.2a. Location of the 5 dive sites surveyed in the North Musandam Peninsula.

Fish belt transect

Four segments of 5 meters height, 5 m width by 20 m length (centred on the transect line) were sampled for fish that are typically targeted by fishermen or aquarium collectors and that are sensitive to impacts. In the Indo-Pacific these species and families are any grouper (Serranidae) over 30 cm, sweetlips (Haemulidae), snappers (Lutjanidae), parrotfish (Scaridae) over 20 cm, butterflyfish (Chaetodontidae) and moray eel (Muraenidae). Quantitative counts were made of each species/family. Three more species are counted in the Indo-Pacific Reef Check, but were not taken as species to look for since they do not exist in the Musandam area: the Barramundi cod (*Cromileptes altivelis*), the Humphead wrasse (*Cheilinus undulates*) and the Bumphead parrotfish (*Bolbometopon muricatum*).

The same four 5 m wide by 20 m long transects (centred on the transect line) were also sampled for invertebrate taxa typically targeted as food species or collected as curios. The taxa counted were: banded coral shrimp (*Stenopus hispidus*), long-spined black sea urchins (*Diadema* spp.), pencil urchin (*Eucidaris* spp.), collector urchin (*Tripneustes* spp.), three edible sea cucumbers species (*Thelenota ananas*, *Stichopus chloronotus*, *Holothuria edulis*), lobster (all edible species) and triton shell (*Charonia tritonis*). Quantitative counts were made of each species/family. The giant clam (*Tridacna* spp.) was not included in the species to count since it does not exist in the Musandam Peninsula area.

During the invertebrate survey, anthropogenic impacts were also assessed. These included coral damage by anchors, dynamite, or 'other' factors, and for trash. Trash is divided by type, i.e. fishing nets or simply 'other'. Divers valued the damage caused by each factor using a 0 to 3 scale (0 = none, 1 = low, 2 = medium, 3 = high).

The percentage cover of bleaching and coral disease in the coral reef (colony and population) was also measured along each 20 meter transect.

Substrate line transect

Four 20 m long transects were point sampled at 0.5 m intervals to determine the substratum types on the reef. The categories recorded at each 50 cm point were according to Reef Check definitions: hard coral (HC), soft coral (SC), recently killed coral (RKC), nutrient indicator algae (NIA), sponge (SP), rock (RC), rubble (RB), sand (SD), silt (SI) and other (OT).

Data analysis

All data were entered on underwater slates and subsequently transferred onto Reef Check Excel sheets. Belt transect data were used to calculate the mean abundance of each fish and invertebrate taxa. The substrate line transect data were converted to mean percentage cover of each substratum category. Anthropogenic data were represented by mean abundance of each impact.

Fish, invertebrates and substrate data were tested using one-way ANOVAs with post-hoc Tukey's test to assess differences in abundance between the past three years of surveys. Percentage cover data from the substrate survey were arcsine square-root transformed to improve normality and data from fish and invertebrate surveys were log10 transformed prior to analyses. For impacts, ordinal data, Kruskal-Wallis ANOVA test were used to assess differences between the three years of surveys.

Note on statistical conventions: the results of statistical tests are given by showing the ‘p’ (probability) value of the test. Results that are significant at the p <.05 level are commonly considered statistically significant, and p <.005 or p <.001 levels are often called "highly" significant.

2.3. Results

Basic oceanographic and climatic conditions were recorded during the expedition. Air and sea surface temperatures during the 2011 expedition were similar to the values registered during previous years. Visibility in 2011 was lower than in previous years, probably due to the heavy rains that occurred during the expedition (Table 2.3a).

Table 2.3a. Average values of air temperature, sea surface temperature and visibility during the Musandam expedition from 2009 to 2011 (standard deviation values in parentheses) and the respective minimum and maximum values registered in 2011.

	2009	2010	2011	Min – Max 2011
Air temperature	34.2ºC (±0.6ºC)	32.6˚C (±1.9˚C)	34.8 ºC (±0.4 ºC)	33 – 35 ºC
Sea surface temperature	27.8ºC (±1.1ºC)	30.0˚C (±1.1˚C)	28.6 ºC (±0.9 ºC)	28 – 30 ºC
Visibility	9.9 m (±2.5 m)	11.8 m (±4.3 m)	8.0 m (±2.3 m)	6 – 11 m

Site description

The Site Description Sheet includes basic information based on observational and historical data regarding impacts and protection of the site. These data are important for interpreting local, national and global trends in the dataset, especially to understand the impacts and local knowledge of the area. Looking at the general impacts levels in 2011, only commercial fishing and sewage are below low level, with the three remaining impacts, tourism diving/snorkelling, artisanal fishing and the harvest of invertebrates for food between low and medium levels of impact (Figure 2.3a).

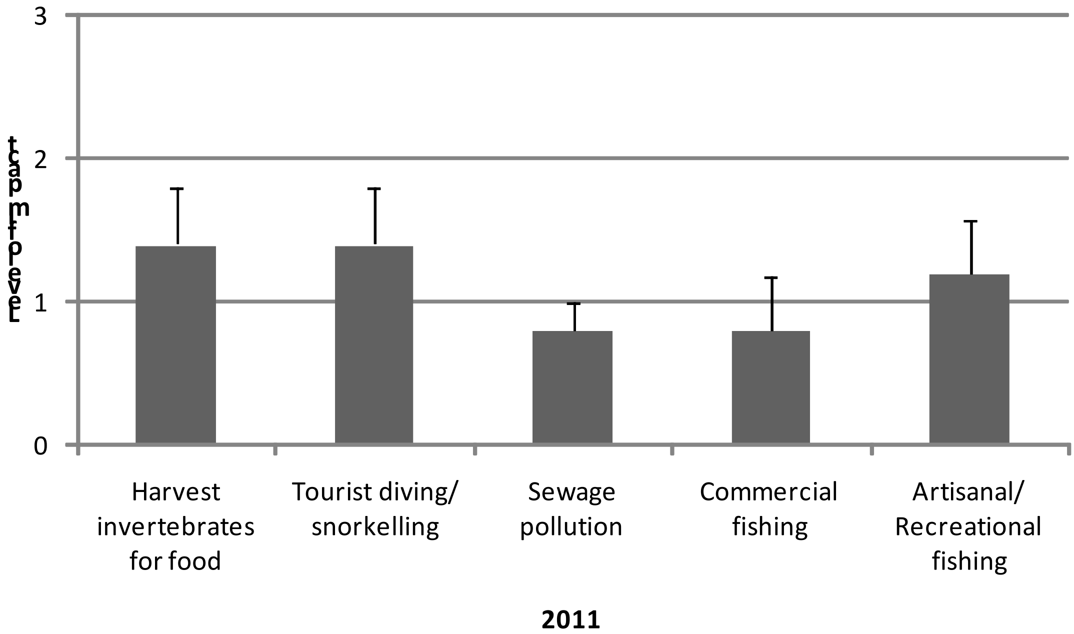

Figure 2.3a. Average level of impacts found in North Musandam in 2011 surveys during site description (0=none, 1=low, 2=medium and 3=high). Lines indicate standard error.

As shown in Table 2.3b from 2010 to 2011 there has been a large increase in the harvest of invertebrates for food in almost all dive sites in North Musandam, with sites that showed no pressure of this kind in 2010 now showing medium pressure. When comparing the data with what was observed in 2010, a decrease in commercial fishing, tourist diving/snorkelling and sewage pollution was noticed. It should be noted there that the data gathered in the site description are anecdotal. These results should be used to understand the uses and the knowledge of the local population about the area and not as a result of the actual impacts on underwater habitats.

Table 2.3b. Level of known general impacts found on the 5 dive sites surveyed in North Musandam, 2011. Different values found in 2010 are shown in parentheses. Where an increase in impact level was noticed, the relevant field is coloured red; where a decrease in level of impacts was noticed the relevant field is coloured green.

Site name	Harvest invert. for food	Tourist diving/ snorkelling	Sewage pollution	Commercial fishing	Artisanal/ Recreational
Ra's Shuraytar	Medium (None in 2010)	Medium	Low	None (Medium in 2010)	None (Low in 2010)
Coral Garden	None	Medium	Low	Medium	Low
Eagle Ray	Medium (Low in 2010)	Medium	None (Low in 2010)	Low	Medium (Low in 2010)
Khayl Island	Medium (None in 2010)	None (Medium in 2010)	Low	None (Medium in 2010)	Medium (Low in 2010)
Faqadar Bay	Low	Low	Low	Low	Low

Fish community

Mean fish abundance did not vary significantly between the three years of investigations of North Musandam (Figure 2.3b). In general, for the 2011 expedition in north Musandam the fish observations were dominated mainly by snappers (70.9% of all fish surveyed), followed by butterflyfish and parrotfish, together making up 19.5 and 6.2% of all fish, respectively (Figure 2.3c).

When comparing different fish data over the three years surveyed, only parrotfish abundance showed significant variance (ANOVA $F_{(2,20)} = 4.0$, $p < 0.05$). Post-hoc Tukey's tests indicated that there were significantly more parrotfish in 2011 than in 2009 (Figure 2.3d).

In some of the different dive sites surveyed a significant increase in some fish groups since 2009 was observed. Post-hoc Tukey's tests show increases in parrotfish abundance at Khayl Island (ANOVA $F_{(2,20)} = 4.8$, $p < 0.05$), as well as in butterflyfish abundance at Ra's Shuraytar (ANOVA $F_{(2,20)} = 5.8$, $p < 0.05$) and in snapper abundance at Faqadar Bay (ANOVA $F_{(2,20)} = 3.8$, $p < 0.05$) (Figure 2.3e., 2.3f. and 2.3g. respectively).

No significant difference in grouper abundance was observed between the years. For the 2011 surveys, from the total number of groupers observed 77.4% had a body size between 30 and 40 cm, followed by 20.8% between 40 and 50 cm. Only 1.9% of the all groupers seen were larger than 60 cm (Figure 2.3h.).

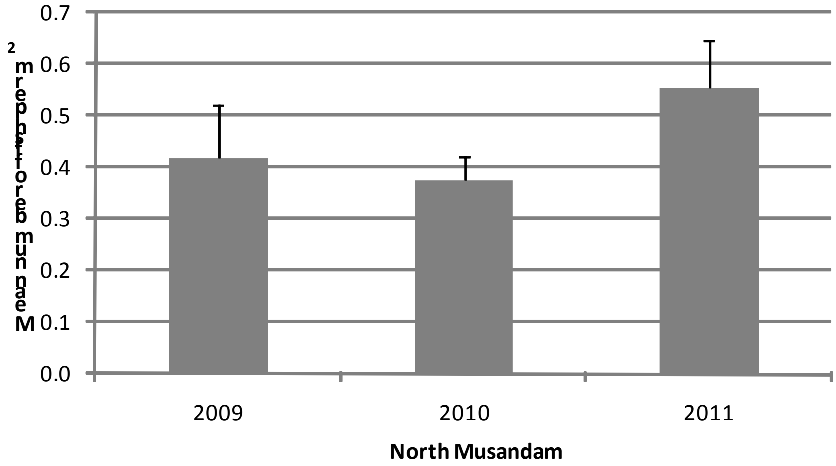

Figure 2.3b. Total fish mean abundance per m^2 in North Musandam.
Lines indicate standard error.

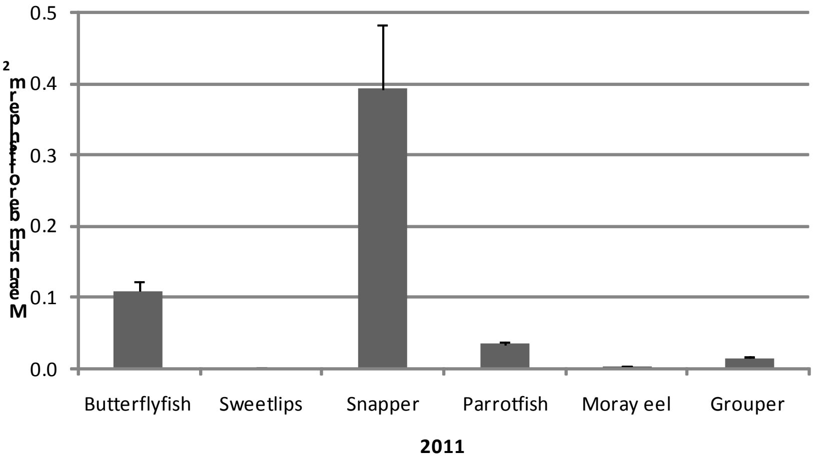

Figure 2.3c. Mean number of each fish group per m^2 observed in North Musandam, 2011.
Lines indicate standard error.

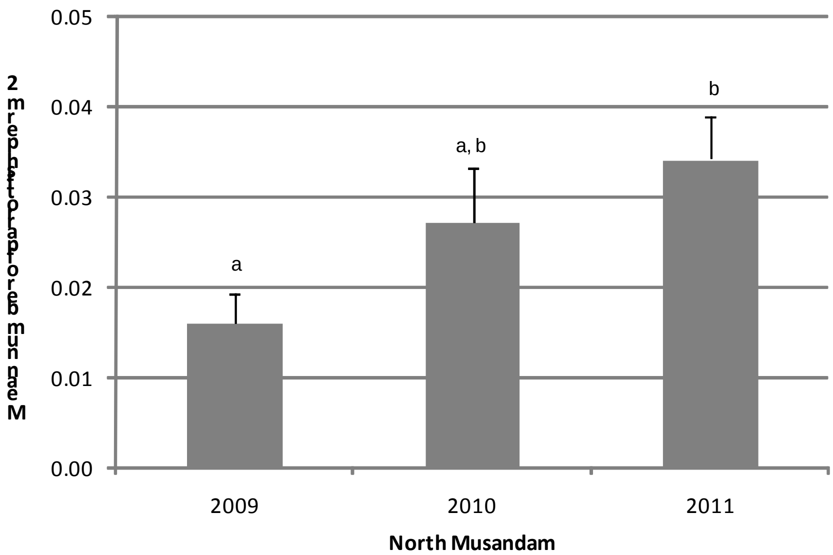

Figure 2.3d. Mean number of parrotfish per m^2 in North Musandam. Lines indicate standard error.
Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$)

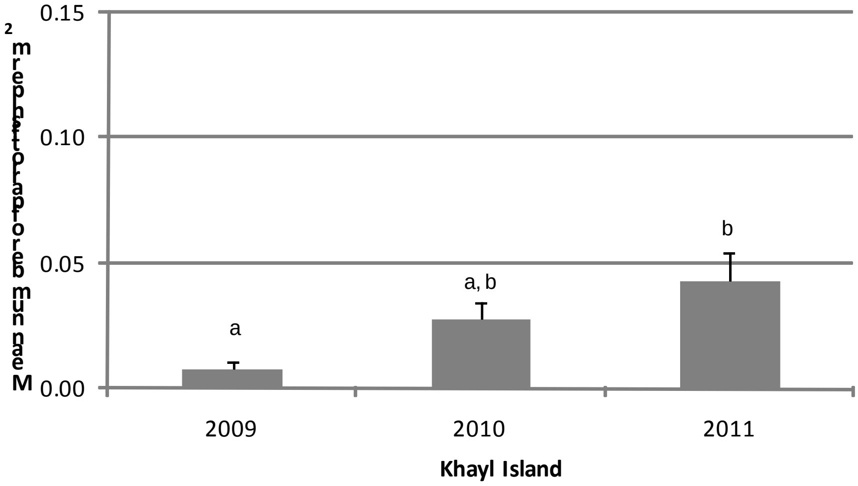

Figure 2.3e. Mean number of parrotfish per m^2 in Khayl Island. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$).

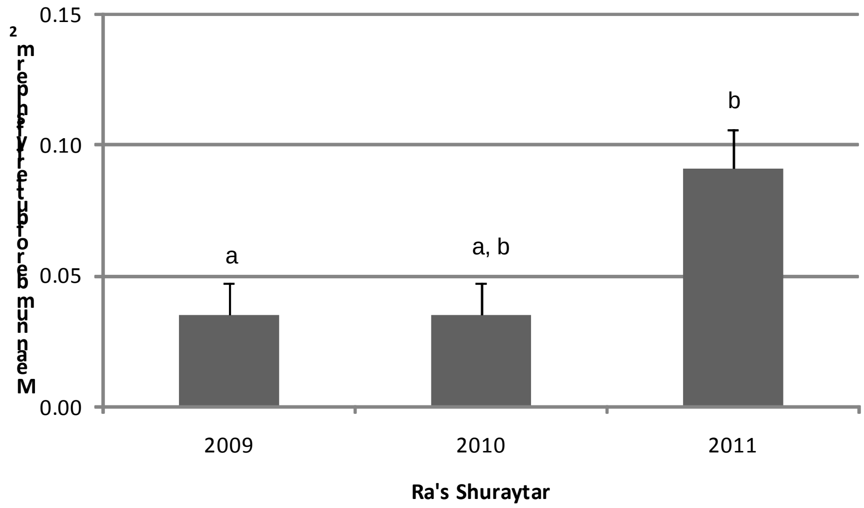

Figure 2.3f. Mean number of butterflyfish per m^2 in Ra's Shuraytar. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$).

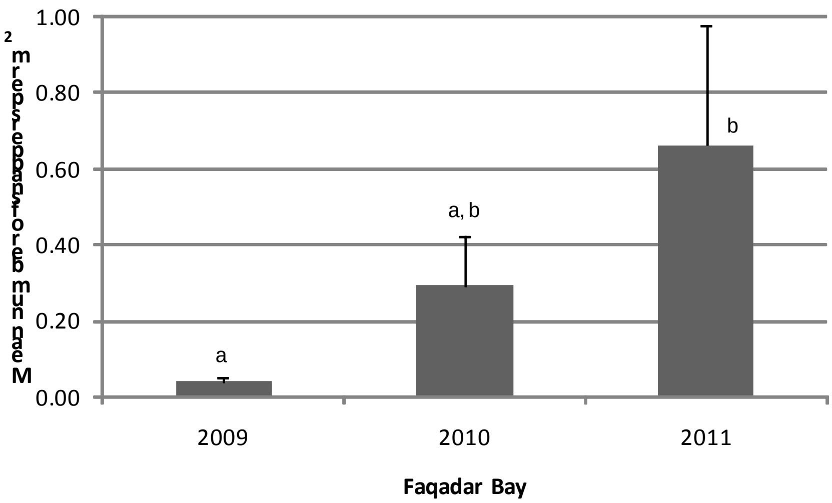

Figure 2.3g. Mean number of snappers per m^2 in Faqadar Bay. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$).

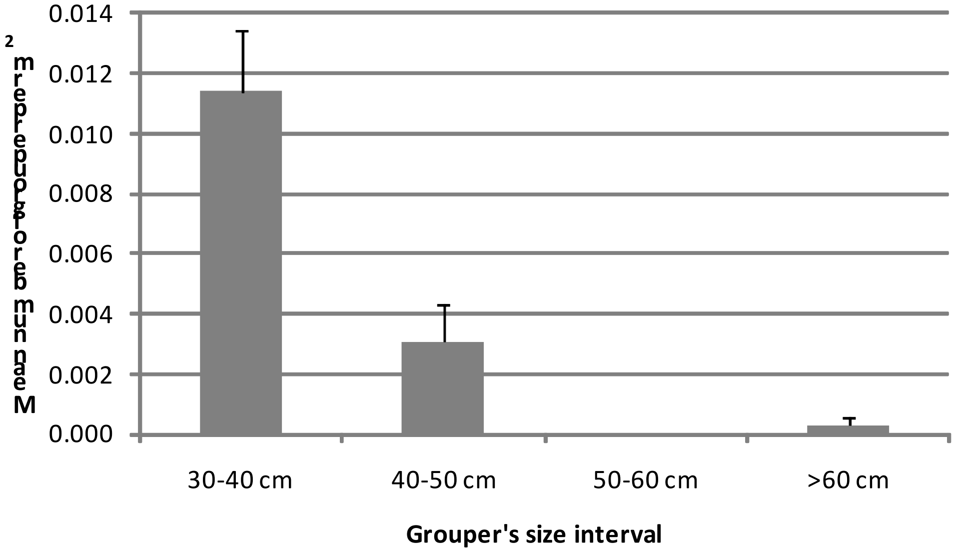

Figure 2.3h. Mean number of groupers with different size intervals per m^2 in North Musandam, 2011. Lines indicate standard error.

Invertebrate community

From the six different invertebrate groups that were counted in the 2011 Reef Check surveys, Diadema urchin was once again the group most often observed making 97.4% of all invertebrate observations. The remaining observations were divided among pencil urchins, sea cucumbers and banded coral shrimps, making 1.6%, 0.8% and 0.2% of the total observations respectively. There were no observations of collector urchins and lobsters in 2011 (Figure 2.3i.).

In general no significant changes in North Musandam were noticed over the past three years regarding invertebrate abundance when data were pooled together. Nevertheless some significant decreases were observed at two particular sites: Ra’s Shuraytar and Coral Garden. In the former site the number of sea cucumbers has significantly decreased since 2010 (ANOVA $F_{(2,20)} = 4.6$, $p<0.05$) (Figure 2.3j.). In Coral Garden decreases were observed in the abundance of diadema urchins (ANOVA $F_{(2,20)} = 15.0$, $p<0.001$), pencil urchins (ANOVA $F_{(2,20)} = 10.4$, $p<0.005$) and lobsters (ANOVA $F_{(2,20)} = 4.0$, $p<0.05$) (Figure 2.3k., 2.3l., 2.3m. respectively).

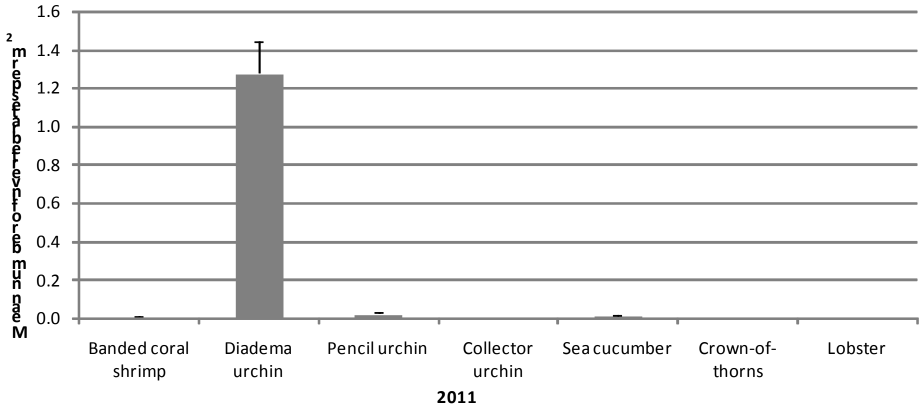

Figure 2.3i. Mean number of invertebrates per m^2 in North Musandam, 2011. Lines indicate standard error.

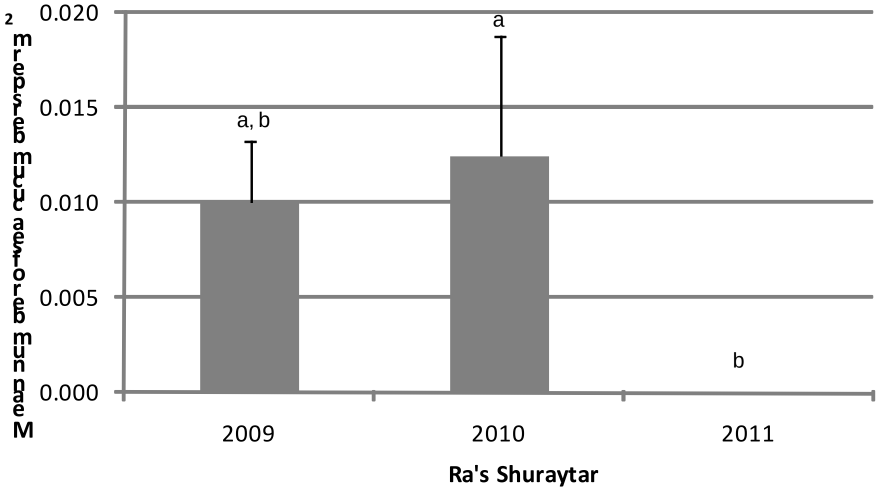

Figure 2.3j. Mean number of sea cucumbers per m^2 in Ra's Shuraytar. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$)

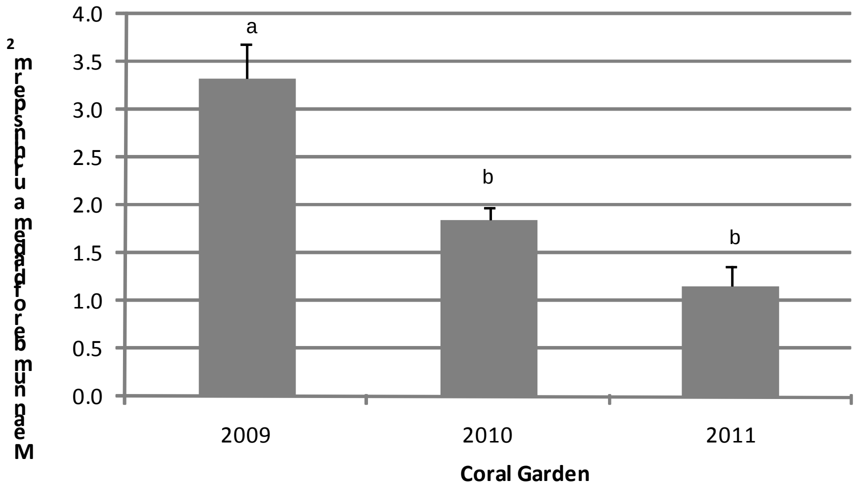

Figure 2.3k. Mean number of diadema urchins per m^2 in Coral Garden. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.001$)

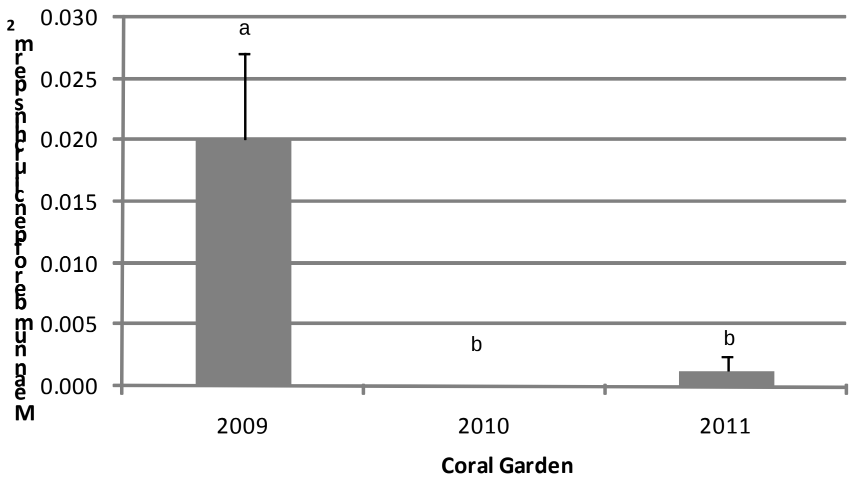

Figure 2.3l. Mean number of pencil urchins per m^2 in Coral Garden. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.005$)

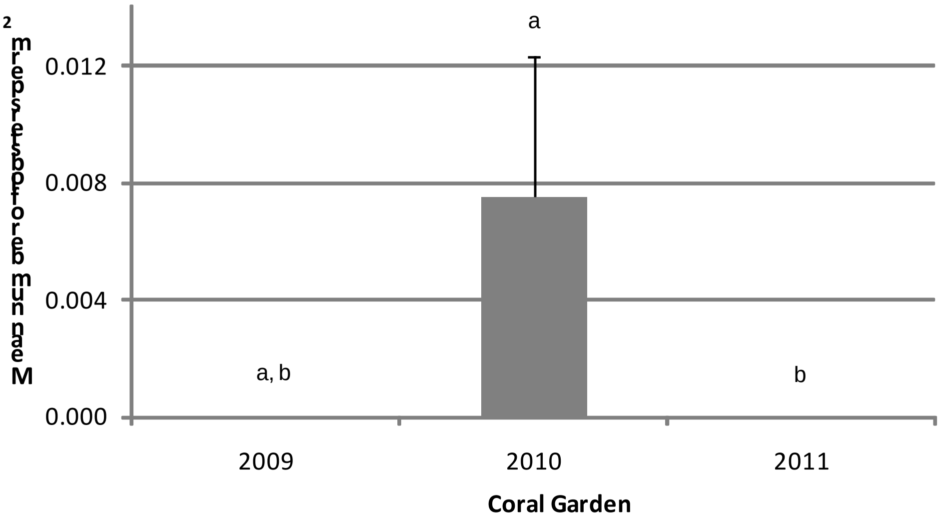

Figure 2.3m. Mean number of lobsters per m^2 in Coral Garden. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, $p<0.05$)

Substratum / benthic community

In the 2011 surveys at North Musandam, hard coral was the substrate with highest coverage (58.0%). Other living substrate, such as soft coral, sponge, nutrient indicator algae and others had much lower coverage, with values below 1.1%. Non-living substrate was dominated by sand (16.0%), followed by similar values of rubble and rock. No silt was observed during the 2011 expedition (Figure 2.3n.).

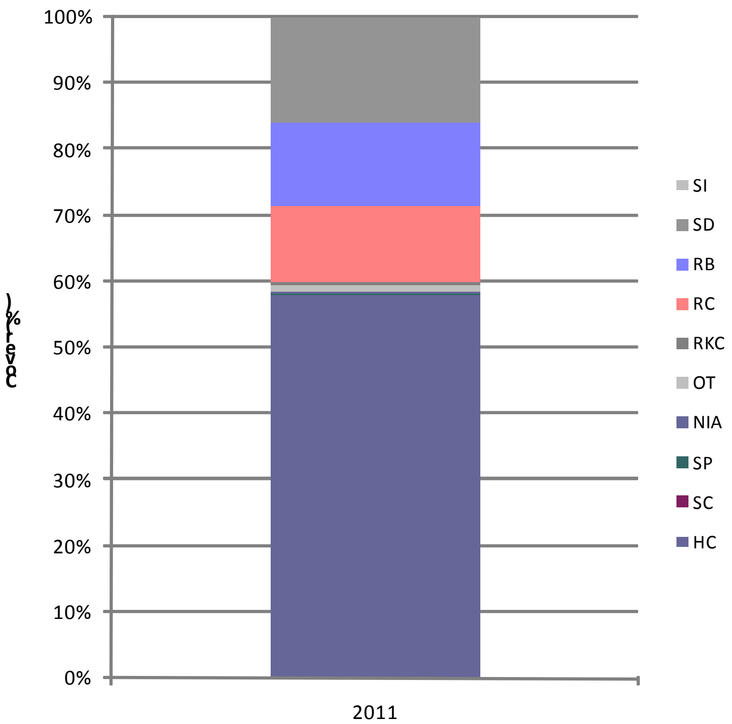

Figure 2.3n. Average substrate cover of North Musandam in 2011 (HC=hard coral; SC=soft coral; SP=sponge; NIA=nutrient indicator algae; OT=others; RKC=recent killed coral; RC=Rock; RB=rubble; SD=sand; SI=silt).

Significant differences in the substrate composition of North Musandam from 2009 to 2011 were noticed with hard coral, nutrient indicator algae and silt coverage. Although there was an increase from 2009 to 2010 in hard coral cover (ANOVA $F_{(2,40)} = 8.1$, $p<0.001$), no significant difference was seen from 2010 to 2011 (Figure 2.3o.). On the other hand, a significant decrease in nutrient indicator algae and silt coverage was observed in 2011 (ANOVA $F_{(2,40)} = 5.8$, $p<0.005$ and ANOVA $F_{(2,40)} = 9.9$, $p<0.001$ respectively) (Figures 2.3p. and 2.3q. respectively).

A significant decrease in silt cover was observed in Ra's Shuraytar and Coral Garden, where silt was only registered in 2010 (ANOVA $F_{(2,20)} = 18.0$, $p<0.001$ and ANOVA $F_{(2,20)} = 549.2$, $p<0.001$ respectively) (Figure 2.3r. and 2.3s. respectively).

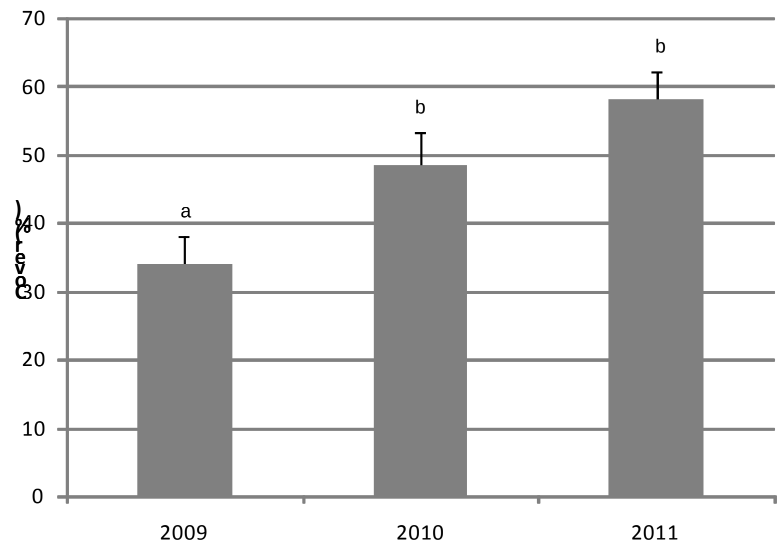

Figure 2.3p. Mean percentage cover of hard coral in North Musandam in 2009, 2010 and 2011. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, p<0.001)

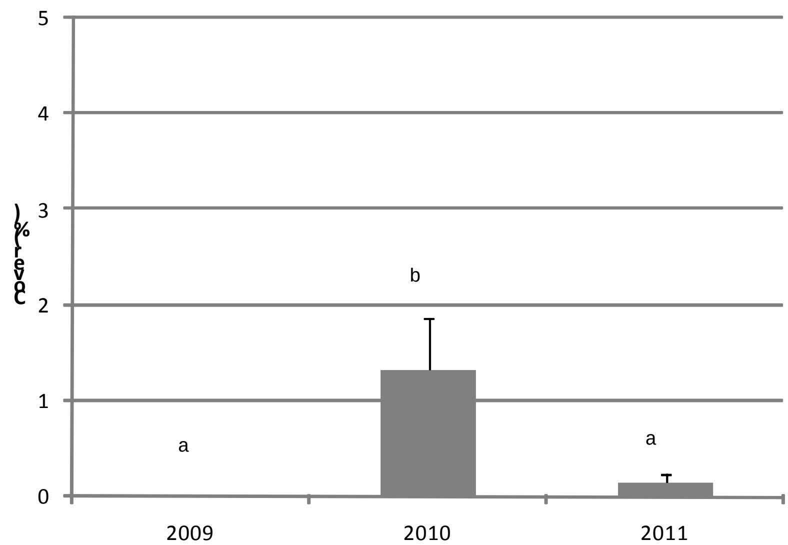

Figure 2.3p. Mean percentage cover of nutrient indicator algae in North Musandam in 2009, 2010 and 2011. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, p<0.005)

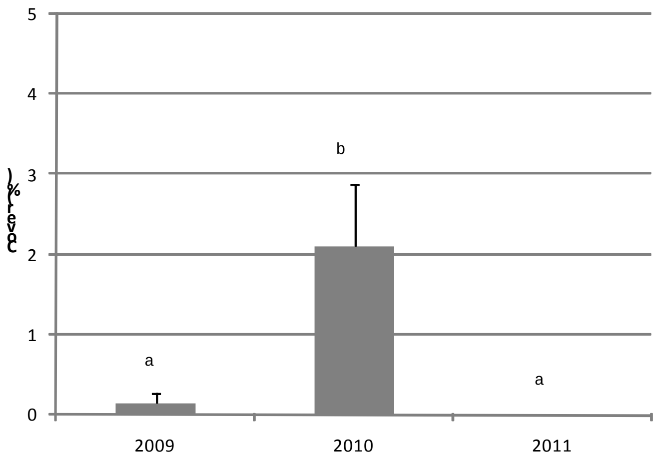

Figure 2.3q. Mean percentage coverage of silt in North Musandam in 2009, 2010 and 2011. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, p<0.001)

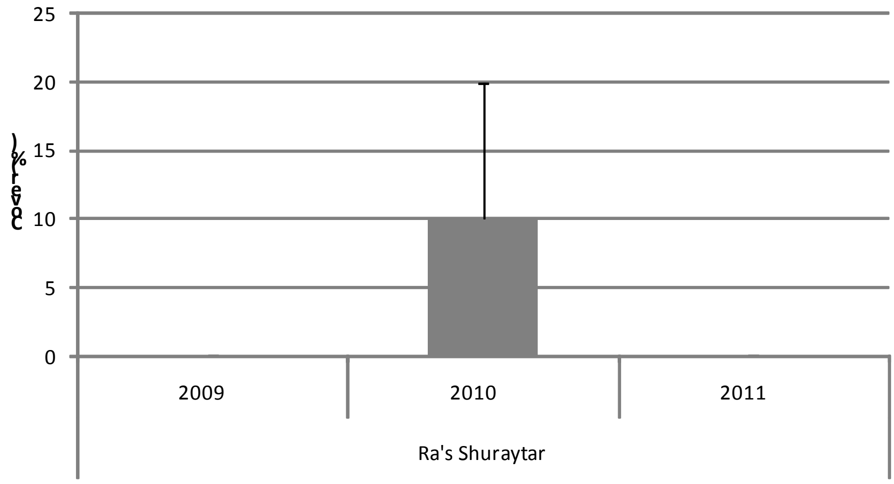

Figure 2.3r. Mean percentage coverage of silt in Ra's Shuraytar in 2009, 2010 and 2011. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, p<0.001)

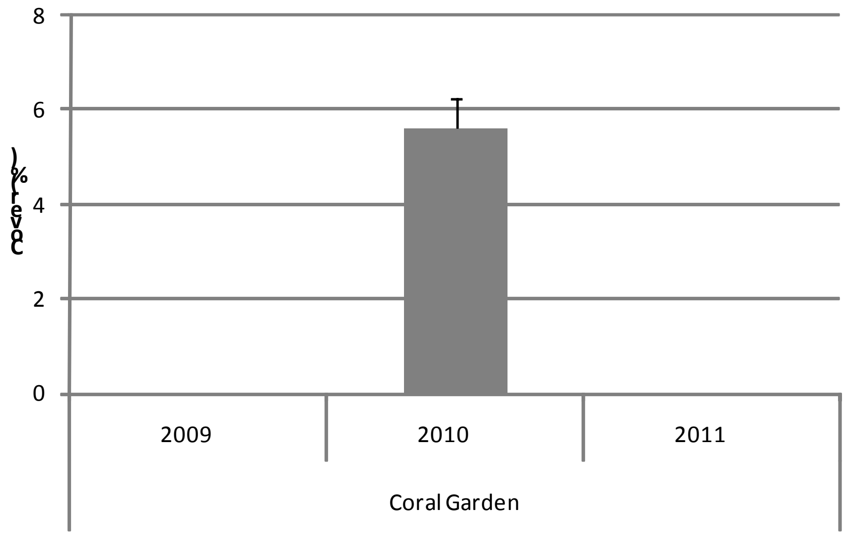

Figure 2.3s. Mean percentage coverage of silt in Coral Garden in 2009, 2010 and 2011. Lines indicate standard error. Bars with different letters indicate significant differences (Tukey's tests, p<0.001)

Underwater impacts, coral bleaching and coral disease

Overall the 2011 level of impacts and trash in North Musandam was low. Only impacts classified as “other” reached medium level impact levels (Figure 2.3t.) and in doing so have significantly increased since 2009 ($H_{(2,104)}$= 10.6, $p<0.05$) (Figure 2.3u.). A Kruskal-Wallis ANOVA test showed that this increase was mainly seen at Ra’s Shuraytar ($H_{(2,20)}$ = 13.2, $p<0.005$) (Figure 2.3v.).

General trash impact has a significantly decreased since 2009 ($H_{(2,104)}$ = 6.5, $p<0.05$) (Figure 2.3w.). This decrease was mainly observed at Eagle Bay ($H_{(2,24)}$ = 9.6, $p<0.01$) (Figure 2.3x.).

Levels of corals affected by bleaching or disease were very low in 2011 for North Musandam, with values bellow 0.015% and 0.002% respectively (Fig. 2.3y. and 2.3z.). There were no significant changes regarding bleaching and diseases between the three years of surveys in North Musandam and none of the five sites showed any different values between the years.

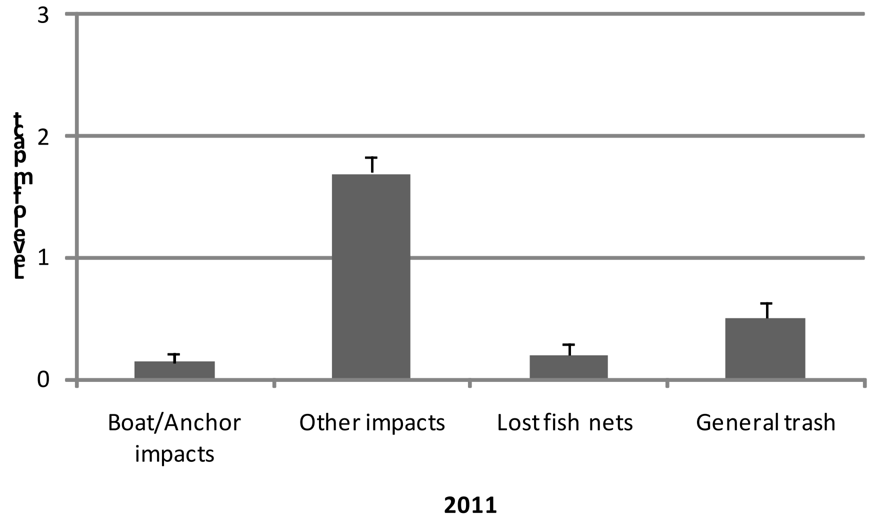

Figure 2.3t. Level of impacts and trash in North Musandam, 2011 (0=none; 1=low; 2=medium; 3=high). Lines indicate standard error.

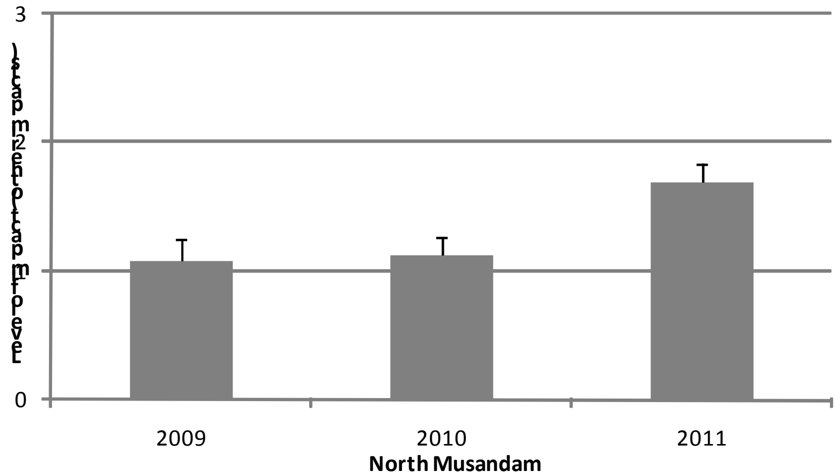

Figure 2.3u. Level of other impacts in North Musandam 2009, 2010 and 2011 (0=none; 1=low; 2=medium; 3=high). Lines indicate standard error. (Kruskal-Wallis test, p<0.05)

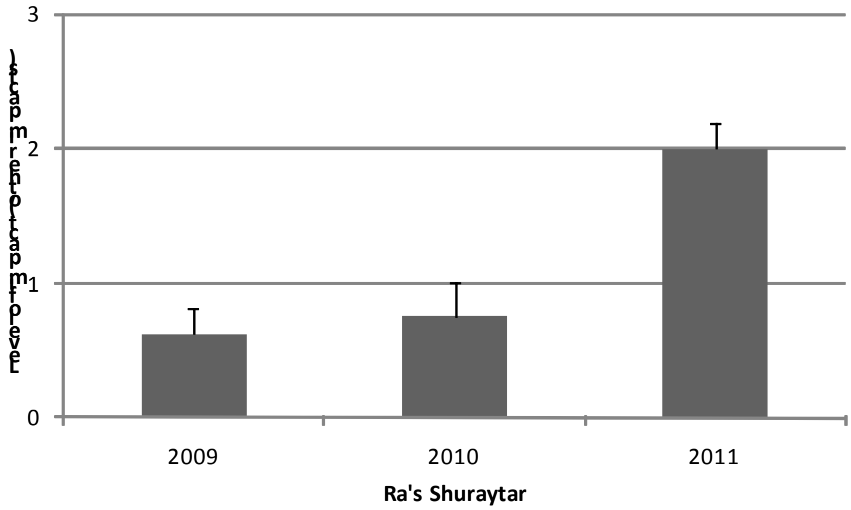

Figure 2.3v. Level of other impacts in Ra's Shuraytar in 2009, 2010 and 2011 (0=none; 1=low; 2=medium; 3=high). Lines indicate standard error. (Kruskal-Wallis test, $p<0.005$)

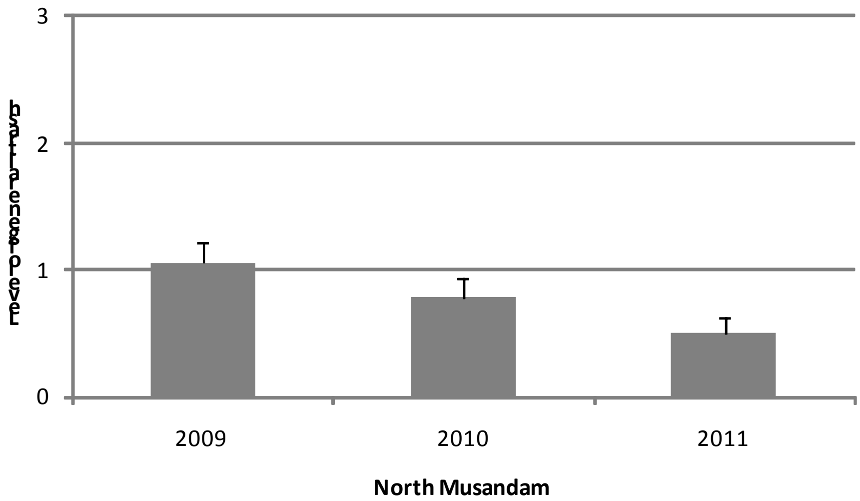

Figure 2.3w. Level of general trash in North Musandam in 2009, 2010 and 2011 (0=none; 1=low; 2=medium; 3=high). Lines indicate standard error. (Kruskal-Wallis test, $p<0.05$).

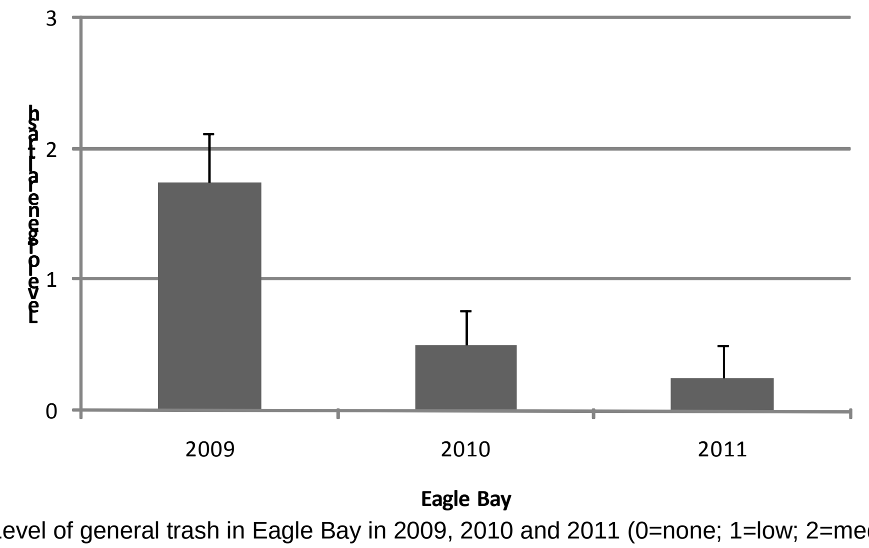

Figure 2.3x. Level of general trash in Eagle Bay in 2009, 2010 and 2011 (0=none; 1=low; 2=medium; 3=high). Lines indicate standard error. (Kruskal-Wallis test, $p<0.01$).

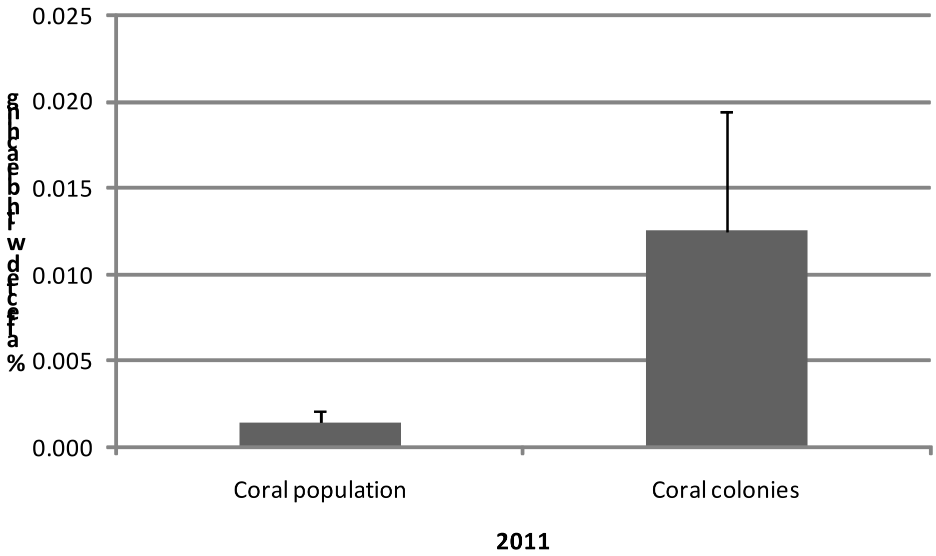

Figure 2.3y. Mean percentages of bleached coral population and colonies in North Musandam in 2011. Lines indicate standard error.

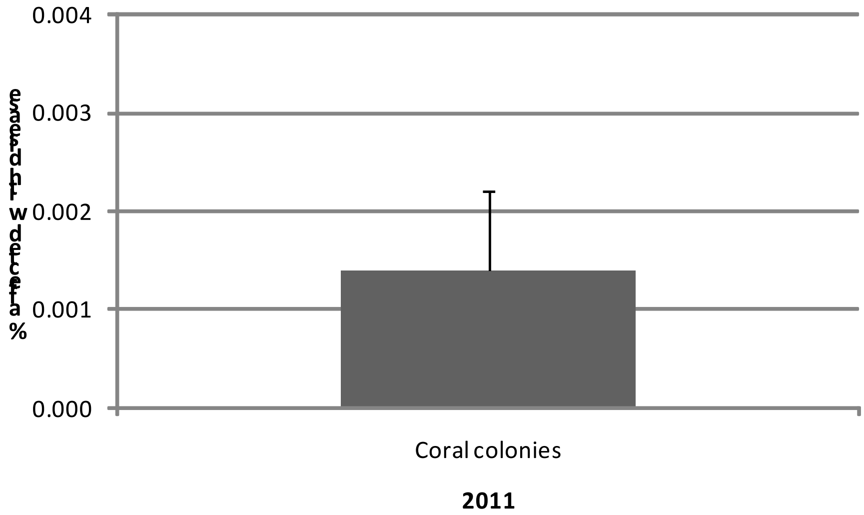

Figure 2.3z. Mean percentages of coral colonies with disease in North Musandam in 2011. Line indicates standard error.

2.4. Discussion & conclusions

One of the main objectives of this expedition, besides elucidating the possible source of impacts on the health of the Musandam coral reefs, is also to understand for the first time what characterises the marine life of the area, so that comparative data over the years can be used in management and conservation decisions as well as in local and international education.

Data obtained in 2009, 2010 and 2011 reveal some improvements in North Musandam's underwater habitat. Significant changes were seen especially regarding the level of impacts in the area. Although "other" impacts reached medium levels, all other impacts observed low. A decrease in the mean percentage coverage of silt, nutrient algae and trash are also an indication of fewer anthropogenic impacts, as normally these are related to coastal development and general pollution. Because corals require clear, sediment-free water to ensure sufficient sunlight for photosynthesis by their symbiotic algae, siltation is one of the most important parameters to measure (Rogers 1990). The continuous low incidence of siltation found by the expedition since 2009 shows that dredging in this area is still not an issue. Likewise, the scarce observations of corals with disease in North Musandam in 2011 are probably also a result of the low anthropogenic impact in this area.

Besides human impacts, other powerful determinants of coral reef health are temperature and salinity. Higher than normal surface seawater temperature (SST) stress corals and cause coral bleaching, frequently with large-scale mortality. When SSTs exceed the summer maximum by more than 1°C for four weeks or more under clear skies, corals bleach. If warmer conditions persist for longer periods, corals can die in large numbers (Bernstein et al. 2007). Although the SST values observed in the Persian Gulf are the largest range encountered worldwide on reefs, ranging up to 24 degrees ºC annually (Sheppard and Loughland 2002, Coles 2003), corals in this region survive what is considered extreme conditions for corals in other regions of the world. It is worth noting that the mean percentage of corals affected by bleaching since 2009 in North Musandam observed in this study was very low. This observation concurs with previous studies that showed that coral reefs in this region are believed to be more resilient than coral in other regions (Burt et al. 2008; Wilkinson 2008).

In general, fish abundance in North Musandam has not showed any significant changes since 2009 and remains low. Nevertheless, when looking at particular fish groups, positive changes can be discerned: the abundance of parrotfish in this area has increased from 2009 to 2011. It is likely that the increase in this number of grazers may also be related to the decrease observed in the mean average of nutrient indicator algae. However, this remains to be demonstrated in future studies.

On the other hand, groupers observed during the 2011 surveys were still in the smallest size class. The highest grouper size class observed was again the smallest class, 30-40 cm. It is likely that these observations are related to the high commercial value of this family (Serranidae) for fishermen in the region (Grandcourt et al. 2005; Siddeek 1999) and the high fishing pressure in North Musandam, which is not allowing this species to grow.

Many of the fish populations in the Persian Gulf have been heavily exploited and concerns that fishing effort may already have exceeded optimum levels for most species are now receiving some attention from local communities (Grandcourt et al. 2005). Fisheries that remove large individuals can easily eradicate all sexually mature fish and/or create a highly skewed sex ratio with the possibility of reproductive failure (Sadovy and Vincent 2002).

There is still a strong need for conservation and management measures in this region, as well as more research in this field.

Significant changes in the substrate mean coverage in North Musandam were observed especially in the hard coral results from 2009 to 2011 surveys, increasing from a mean coverage of 34 to 58% respectively. Not only the increase in the coral cover shows how important it is to preserve North Musandam, but also by comparing these results with studies conducted in the Indo-Pacific indicates how theses reefs, although located in an area with extreme environment, comprise high coral cover. During the 2003 surveys conducted by Bruno and Selig (2007) in the Indo-Pacific, results showed that the region-wide average of coral cover was merely 22.1% and only 1.8% of 390 reefs surveyed had coral cover higher than 60%. The Indo-Pacific encompasses 75% of the world's coral reefs and recent studies indicate that probably 100-1000 years ago the average coral cover was around 50% (Wilkinson 2002). When comparing the results obtained in this study for North Musandam with the results obtained in the Indo-Pacific, the area with the highest number of coral reefs, it is surprising how, even though not in favourable conditions, the reefs in North Musandam show a high coral coverage (58%).

2.5. Recommendations & future expedition work

The work of the 2009, 2010 and 2011expeditions shows clearly that Musandam Governorate, and specially in the North of Musandam, has in its stewardship what are probably the best reefs of the region and a unique area of natural beauty as well as commercial importance, not just for fishermen, but also for the local economy as a generator of income from tourism.

However, there is also high demand and stress on them from the diving and fishing community. The contrast values of a high coral coverage of 58% and the low average numbers or absence of lobsters, moray eels, groupers and sweetlips show the potential that this ecosystem holds, but also that it is probably on the brink. Further surveys are needed as they will generate a better understanding of population sizes and trends, as well as the trend in the level of impacts and pressures for the area.

If environmental awareness can be created in time, and if the level of impacts can be controlled, there is a good chance that the number of species can be held stable or increased. Studies on Musandam ports fisheries landings would help our understanding of the demands on this ecosystem, as well as its biodiversity and population levels. More information about the catch of shells, lobsters, groupers and sweetlips will give a good indication of possible future trends for the area and the correct legal framework and enforcement needed in the Musandam region.

It is essential not to neglect the Musandam Peninsula and ensure that its marine environment is preserved. Involving local people in the surveys and explaining results, such as the relationship between high coral coverage and high species diversity, might be enough for the empiric understanding of a healthy ecosystem and control the pressure level of artisanal fisheries in Musandam. In order to understand the full impact of fishing in this region, the impacts of selective mortality on specific size classes, colour phases or morphs, and social structure in target population, such as groupers, should be studied (Sadovy and Vincent 2002).

All the studies, new policies and regulations that could be applied in Musandam have to take into account the need to improve the social resilience by helping local communities to adapt to these changes. More strategies and approaches, done by management activities and planning for change are needed to minimise impacts and build resilience. To achieve this resilience, focus should primarily exist on land-based sources of pollution, over-fishing and climate change.

Musandam as a Marine Protected Network

A number of Marine Nature Reserves were declared in the nineties by the Ministry of Environment and Municipality to protect vulnerable marine habitats in Oman (Siddeek 1999). There is Ras' Al-Had Nature Reserve for the protection of green turtle nesting grounds, Damaniyat Island Nature Reserve for the protection of green and hawksbill turtle nesting grounds, coral reefs, birds, and fish, Dhofar Khowrs Nature Reserve (fresh as well as brackish water lagoons) for the protection of sea birds and fish. All of these reserves are located outside Musandam governorate and no protected area has been declared there yet. However, it is a stated government policy to have more reserves in each governorate.

We therefore recommend the implementation of a new marine protected area (MPA) in Musandam governorate or a network of MPAs for the protection of this unique marine environment. The Musandam is an ideal place for an MPA or MPAs as impacts and population levels are still relatively low and coral coverage is high. Having said this, although there was an increase in some important fish families and substrate, the low number or absence of lobsters, moray eels, groupers, sweetlips and parrotfish shows that this coral reef system may be at the threshold of collapse, and the increase of some impacts are a concern.

The strong military presence in the area, due to its proximity to the Strait of Hormuz, is also significant for the implementation of an MPA, since military exclusion zones could form part of an MPA and policing of protected areas could be done by the military with relatively little additional training.

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

The Musandam Peninsula or parts of it could also be established as a Biosphere Reserve under UNESCO's Man and the Biosphere (MAB) Programme. Biosphere Reserves are areas of terrestrial, coastal and marine ecosystems established to promote and demonstrate harmonious and sustainable interactions between biodiversity conservation and socio-economic well-being of people, through research, education, monitoring, capacity building and participatory management. By being protected under this classification, UNESCO can provide advice and occasionally source funds to start local efforts; it can also help broker projects or set up durable financial mechanisms.

Knowing that implementing an MPA can take several years to accomplish, and with the increase of the diving industry observed, it is necessary to take additional action until an MPA is in place. We therefore recommend the following actions:

- Deployment and maintenance of standardised mooring buoys in all known dive sites would help to decrease the impacts of anchor and boat damage.

- Create, implement and police regulations for the diving industry, such as (1) regulating the number of boats and divers allowed per dive site, (2) not permitting anchoring and (3) rules to have an obligatory dive guide from the dive centres with every dive group.

- Standard signs, information, and visitor logbooks should be enforced in all dive centres conducting dives in Musandam to provide basic interpretative visitor information regarding Musandam and also to serve as a first control of the number of divers in the area.

Involving the local community in future studies is extremely important in order to mitigate the lack of awareness and knowledge. If awareness can be created in time and if the impacts can be controlled, then there is a good chance that the number of species can be held stable or increased.

Studies on Musandam ports fisheries landings will help our understanding of the demands on this ecosystem, as well as its biodiversity and population levels. More information about the existence of shells (such as *Charonia* spp.) is also needed, since their harvesting can lead to an outbreak of COTS in the region.

Future Reef Check surveys of the Musandam Peninsula are required in order to understand the average number of indicator species with lower standard error. Further surveys will also yield a better understanding of trends, population sizes and pressures for the area.

2.6. References

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

Anderson, D.M. (1997) Turning back the harmful red tide. Nature 388, 513-514.

Baker, A.C., Starger, C.J., R.McClanahan, T. & Glynn, P.W. (2004) Corals' adaptive response to climate change. Nature 430, 741.

Bauman, A.G., Burt, J.A., Feary, D.A., Marquis, E., and Usseglio, P. (2010). Tropical harmful algal blooms: An emerging threat to coral reef communities? Marine Pollution Bulletin *60*, 2117-2122.

Bento, R., and Hammer, M. (2010). Underwater pioneers: studying & protecting the unique coral reefs of the Musandam peninsula, Oman. In Expedition Report, M. Hammer, ed. (Biosphere Expeditions), p. 51.

Bernstein, L., Bosch, P., Canziani, O. et al. (2007) Climate Change 2007: Synthesis Report, pp. 73. Valencia, Spain: Intergovernmental Panel on Climate Change.

Bruno, J.F. & Selig, E.R. (2007) Regional Decline of Coral Cover in the Indo-Pacific: Timing, Extent, and Subregional Comparisons. PLoS ONE 2, e711.

Buddemeier, R.W., Baker, A.C., Fautin, D.G. & Jacobs, J.R. (2004) The Adaptive Hypothesis of Bleaching. Paper presented at: Coral Health and to Disease Meeting, Israel.

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

Carpenter, K.E., Krupp, F., Jones, D.A. & Zajonz, U. (1997) The living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates. In: FAO species identification guide for fishery purposes, pp. 293. Rome: FAO.

Claereboudt, M.R.G., Al-Oufi, H.S., McIlwain, J., and Goddard, J.S. (2004). Relationships between fishing gear, size frequency and reproductive patterns for the kingfish (Scomberomorus commerson Lacépède) fishery in the Gulf of Oman. In Management of Shared Fish Stocks, A.I.L. Payne, C.M. O'Brien, and S.I. Rogers, eds. (Oxford: Blackwell), pp. 56-67.

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

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

Fraser, F.C., Falcon, N.L., Falcon, M., Cornelius, P.F.S., Hugh-Jones, P., Bertram, G.C.L., Shearman, D.J., Glennie, K.W., Glennie, M., Shotton, F.W., Vita-Finzi, C., Roberts, D.G. & Robinson, G.P.G. (1973) The Musandam Expedition 1971-72 Scientific Results: Part I: Discussion. The Geographical Journal 139, 422-425.

Fritz, H.M., Blount, C.D., Albusaidi, F.B. & Al-Harthy, A.H.M. (2010) Cyclone Gonu storm surge in Oman. Estuarine, Coastal and Shelf Science 86, 102-106.

Goldberg, J. & Wilkinson, C. (2004) Global Threats to Coral Reefs: Coral bleaching, global climate change, disease, predator plagues, and invasive species In: Status of Coral Reefs of the World: 2004 (ed. C. Wilkinson), pp. 67-92.

Grandcourt, E.M., Abdessalaam, T.Z.A., Francis, F. & Shamsi, A.T.A. (2005) Population biology and assessment of the orange-spotted grouper, Epinephelus coioides (Hamilton, 1822), in the Southern Arabian Gulf. Fisheries Research 74, 55-68.

Grimsditch, G.D. & Salm, R.V. (2006) Coral Reef Resilience and Resistance to Bleaching, pp. 52. Gland, Switzerland: IUCN.

Henderson, A.C., McIlwain, J.L., Al-Oufi, H.S., and Al-Sheili, S. (2007). The Sultanate of Oman shark fishery: Species composition, seasonality and diversity. Fisheries Research *86*, 159-168.

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

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

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

Hodgson, G. & Liebeler, J. (2002) The Global Coral Reef Crisis: Trends and Solutions, pp. 78. Reef Check.

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

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

McClanahan, T.R., Sheppard, C.R. & Obura, D.O. (2000) Coral reefs of the Indian Ocean: theirs ecology and conservation, NY, Oxford University Press.

Mooney, C. (2007) Storm World: Hurricanes, Politics, and the Battler Over Global Warming, Houghton Mifflin Harcourt.

Pilcher, N.J., Wilson, S., Alhazeem, S.H. & Shokri, M.R. (2000) Status of coral reefs in the Arabian/Persian Gulf and Arabian Sea region (Middle East). In: Status of Coral Reefs of the World: 2000, pp. 55-64. Australian Institute of Marine Science.

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

Price, A.R.G., Sheppard, C.R.C., and Roberts, C.M. (1993). The Gulf: Its biological setting. Marine Pollution Bulletin *27*, 9-15.

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

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

Rezai, H., Wilson, S., Claereboudt, M. & Riegl, B. (2004) Coral reef status in the ROPME sea area: Aranian/persian gulf, gulf of Oman and Arabian. In: Status of Coral Reef of the World 2004 (ed. C. Wilkinson), pp. 155-170.

Richlen, M.L., Morton, S.L., Jamali, E.A., Rajan, A. & Anderson, D.M. (2010) The catastrophic 2008-2009 red tide in the Arabian gulf region, with observations on the identification and phylogeny of the fish-killing dinoflagellate Cochlodinium polykrikoides. Harmful Algae 9, 163-172.

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

Riegl, B. (2001). Inhibition of reef framework by frequent disturbance: examples from the Arabian Gulf, South Africa, and the Cayman Islands. Palaeogeography, Palaeoclimatology and Palaeoecology *175*, 79-101.

Riegl, B.M., Purkis, S.J., Kohler, K.E. & Dodge, R.E. (2006) Spatial patterns in Arabian Gulf coral assemblages (Jebel Ali, Dubai, U.A.E.) in response to temperature-forcing. Paper presented at: 10th International Coral Reef Symposium, Okinawa, Japan.

Rogers, C. S. (1990). Responses of coral reefs and reef organisms to sedimentation. Marine Ecology Progress Series *62,*185-202.

Sadovy, Y.J. & Vincent, A.C.J. (2002) Ecological Issues and the Trades in Live Reef Fishes. In: Coral Reef Fishes. Dynamics and diversity in a complex ecosystem (ed. P. F. Sale), pp. 391-420. San Diego: Elsevier Press.

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

Sheppard, C.R.C., and Loughland, R. (2002). Coral mortality and recovery in response to increasing temperature in the southern Arabian Gulf. Aquatic Ecossystem Health and Managemenr *5*, 395-402.

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

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

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

Subba-Rao, D.V. & Al-Yamani, F. (1998) Phytoplankton ecology in the waters between Shatt Al-Arab and Straits of Hormuz, Arabian Gulf: A review. Plakton Biology and Ecology 45, 101-116.
Wilkinson, C. (2004) Status of Coral Reef of the World 2004

Wilkinson, C.R. (2002) Status of Coral Reefs of the World: 2002. Australian Institute of Marine Science, Cape Ferguson, Queensland, and Dampier, Western Australia.

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

Wilson, S., Fatemi, S.M.R., Shokri, M.R. & Claereboudt, M. (2002) Status of Coral Reefs of the Persian/Arabian Gulf and Arabian Sea region. In: Status of Coral Reefs of the World: 2002 (ed. C. Wilkinson), pp. 53-62. Australian Institute of Marine Sciences.

3. Expedition leaders' diary: Musandam 2011 by Rossella Meloni

7 October

Welcome to the first diary entry for the 2011 Musandam expedition. My name is Rossella Meloni and I will be your expedition leader for this project.

I am writing to you from Muscat, the capital of Oman, where I am getting the last things ready before flying to Dubai to meet you there in a few days (see also short video on www.facebook.com/biosphere.expeditions1; remember you do not need to have a Facebook account yourself to see this; just click on the link and go to the "Wall").

One of the pre-expeditions jobs is to prepare an itinerary (attached). As you can see, it's a packed schedule, especially on the first three days with lots of training and some tests before we let you lose on the reef, collecting data and experiencing conservation in action. No doubt you'll need a holiday after the expedition ;) but please try to come rested and fresh, ready for the challenges ahead.

No doubt you must be really excited by now and if you are anything like me ahead of an adventure you are probably all packed and ready to go (and maybe have been for a week).

In all the anticipation please make sure you do your last checks: ensure your PADI medical statements are in order (or no jumping off the deck with a reg. in your mouth for you!), that your dive gear is working and you have all your travel documents ready.

Finally my mobile number during the expedition will be +968 97005916. Remember that this is for emergency purposes only (such as being late for assembly, for example). Safe travels and see you all at the Holiday Inn Express Jumeira on 9 October at 09:00 (please be on time!).

Best wishes,

Rossella

P.S. This diary is now also on www.biosphere-expeditions.org/diaries and excerpts of it are also on www.facebook.com/biosphere.expeditions1, so please feel free to pass this on to your families & friends for updates on what we are up to.

11 October

Greetings from the MS Sindbad. All is good in the world of Poseidon.

We have had an eventful beginning with the weather trying some tricks on us and some rain on the menu (can you believe we are in the Gulf?) but we kept the ball rolling, managed to fit practice dives in and have now reached the end of our training days. Everybody's been learning like a sponge and the results have shown in the tests - we have a team with lots of Reef Check stars! Everyone is looking forward to the first transect dives tomorrow. We are now stationed in the bay of Khumzar a tiny coastal village where we have been very pleased to see the locals doing some creative re-using and recycling of polystyrene boxes.

16 October

As the saying goes, "all good things must come to an end", so too has our Musandam expedition for 2011.

We disembarked the MS Sindbad on Saturday, said goodbye to some of the volunteers who were leaving us in Khasab, then made our way back to Dubai and on separate ways.

It's been a memorable week and it was great to see such a diverse group of individuals increasingly bonding together while working as a team. During the week and up until the end there was no shortage of funny moments. Just to mention a couple here, such as Elliott, our bursary student sponsored by the Anglo-Omani Society, who one night started to mumble "Reef Check, Reef Check" in his sleep; or Dana, our bubbly Italian volunteer, who on the last day, after a shoeless week, forgot to keep some foot-wear handy before having the bag loaded onto the bus and ended up wandering bare foot through border posts and gas station shops all the way to Dubai (and all this on top of leaving her passport behind on the dhow. What an adventure!).

As you can imagine it was sad to say our goodbyes, but it is great to know that everybody has had a great time, has learnt lots of new skills and has taken away lots of great memories, while contributing to an important and worthwhile cause. As I am writing, some will have already reached home, some are still journeying homeward-bound, while others will have moved on to their next journey.

I would like to take this occasion to once again thank all our volunteers, our scientist Rita and the crew from MS Sindbad for being such a fantastic group. I hope to see you all again on one of our expeditions soon.

All the best.

Rossella