WWF for a living planet®

Marine and coastal resources assessment of the Eastern Region of Libya

Background study for the preparation of a Conservation Plan

July 2005

WWF Mediterranean Programme Office

The Environmental General Authority
Of the Great Socialist People's
Libyan Arab Jamahiriya

WWF for a living planet®

Contents

Acknowledgements

This report is the result of a corporative effort between WWF Mediterranean Program (WWF MedPO) and the Libyan Environmental General Authority (EGA) with the technical assistance of Shoreline Società Cooperativa. WWF MedPO would like to acknowledge the Secretary of the People's Committee of EGA, the assigned facilitators, as well as the Secretary of the People's Committee of the Marine Biology Research Centre, for their crucial contributions to the successful execution the survey. Special thank for the Coast Guard , the Maritime Authority of the Eastern Region, as well as the Port Authority in Benghazi, for their help during the field operations.

Thanks are also due to Catherine Roberts, WWF MedPO, for the revision of the English version. WWF MedPO, would like to thank the project sponsor, the MAVA Foundation, for supporting the study, and welcomes any prospective partners for future conservation-led development work in the area.

Project Team

ENVIRONMENTAL GENERAL AUTHORITY - EGA:
Mr. Mohamed ALSHARIF
Mr. Saleh M. Amnissi
Mr. Abdulfatah Boargob
Mr. Esam BURAS
Mr. Khaled DOFFANI
Mr. Khaled Etayeb
MARINE BIOLOGY RESEARCH CENTRE
Mr. Daw HADOUD
Mr. Mustapha TALHA
WWF MEDITERRANEAN PROGRAMME OFFICE:
Dr. Paolo Guglielmi
Dr. Alessandra Pomè
Dr. Atila Uras
SHORELINE:
Dr. Saul Ciriaco
Dr. Claudio Franci
Dr. Carlo Franzosini
Dr. Erik Merson
Dr. Roberto Odorico

Executive Summary

The Mediterranean basin hosts a remarkably high number of ecosystems, which together make it one of the most biologically diverse regions on earth. In 1998, WWF Mediterranean Programme (WWF MedPO) conducted a Mediterranean Marine Gap Analysis, which helped identify key marine and coastal areas for biodiversity in the Mediterranean where there is an urgent need for new reserves and changes in coastal management practices. According to this study, the coastal area of the Eastern Region of Libya, with its almost untouched rocky cliffs and dune systems and lagoons, has been identified as one of the “10 last paradises" of the Mediterranean.

The marine and coastal environment of the Eastern Region of Libya is today experiencing increasing human pressure and exploitation of its resources. Unregulated solid waste disposal, untreated sewage discharges, crude oil and petroleum derivates spills represent the major threats to the marine and coastal ecosystems of this area. Unsustainable urban sprawl and uncontrolled mass tourism development may cause, in the near future, the destruction of important and unique natural coastal habitats, with negative repercussions for the nearby marine areas. Unsustainable fishing activities on sensitive ecosystems, such as *Posidonia* beds, and unregulated commercial exploitation of one of the last extensive formations of *Corallium rubrum* to be found in the Mediterranean sea, may contribute to the irreversible destruction of fragile marine habitats.

For all these reasons, the Libyan Government has listed the Eastern Region of Libya among the priority areas for conservation in the National Action Plan of the Strategic Action Programme for the Conservation of Biological Diversity (SAP BIO) in the Mediterranean Region of the Barcelona Convention.

In July 2004, the Libyan Environmental General Authority (EGA) and WWF MedPO started a joint initiative to assess the value and status of the biological diversity of the coastal area of the Eastern Region of Libya, as the first step towards the establishment of a multi-purpose conservation and sustainable management scheme. Nearly 280 km of coast, from Benghazi to the east of Darnah, were covered to assess environmental features - benthic communities, coastal habitats, representative/protected marine species - their conservation status, and existing and potential threats to their preservation.

By means of the Geographical Information System, relevant data have been elaborated into a final map that provides a detailed understanding of the coastal area under study. The coastline has been divided

into a sequence of coastal stretches characterized by different overall quality value (that is, the result of the combination of landscape, human impact and bioquality values).

Based on this analysis, the coastal areas stretching from Al Dressia (Tulmaythah) to Qasi ad Disah and from Darnah to Sidi Awn have been identified as areas of special environmental and cultural interest for their almost pristine systems of islets, rocky cliffs, sand dunes, and lagoons, underwater sea gorges, extensive *Posidonia* meadows and nursery grounds and well preserved archeological sites, such as Apollonia and Cirene. For all these reasons, WWF MedPO believes that further study, as well as the development and implementation of preventive measures aimed at preserving such outstanding natural and cultural assets, are urgently needed. The establishment of a network of Marine Protected Areas (MPAs) in the Eastern Region of Libya, fully included in an Integrated Coastal Area Management Plan (ICAM), would ensure the long term viability of such exceptional ecosystems, while allowing for the sustainable development of local communities.

WWF Mediterranean Programme Office, August 2005

1 Introduction

This report provides the results of a rapid assessment of the value and conservation status of the coastal and marine biodiversity of the Eastern Region of Libya, as well as the existing and potential threats to it. The data on marine biodiversity were gathered by the staff of Shoreline through an extensive field survey undertaken in June 2004 along the coastline of the Eastern Region of Libya, from Benghazi to the east of Darnah (see Figure 1, Annex I).

The survey aimed to:

- Define marine/coastal biodiversity targets for the area pertaining to the conservation of focal species and habitats;
- Define the conservation needs and requirements of the marine/coastal area;
- Identify major threats that may prevent the achievement of biodiversity targets;
- Define objectives and priority activities to reduce the impact of major threats and facilitate progress towards achieving conservation targets.

The rapid biodiversity assessment encompassed the following activities:

- identify and describe the habitat types of the area;
- identify focal species, to be used as environmental indicators;
- create maps of the data gathered;
- make the above information available through a data bank to be regularly updated.

In order to perform these tasks it was necessary to:

- conduct a marine survey through dives along transects and on geo-referred points;
- analyze the coastline and main coastal habitats by means of biological and human activity related indicators;
- analyze the sea bottom habitats by means of naturalistic value indicators.

Existing scientific publications were provided by the Libyan National Laboratory of Marine Biology and were considered in elaborating this report.

2 Context

The Mediterranean coastal environment has undergone radical changes thus losing many of its natural characteristics. It is difficult to list all the mistakes made in the management of the Mediterranean coast. Examples include industrial plants, refineries and thermal power plants built near the sea or inside lagoons, natural environments that have been destroyed by the construction of ports and indiscriminate building, as well as mass tourist resorts spoiling wonderful coasts. These measures - somehow planned in advance - are coupled with phenomena such as subsidence, sea water penetration into aquifers, beach regression, irrational use of resources, sea water pollution and eutrophy, as well as the accidental introduction of alloctonous species the effects of which are as yet unknown. Consequently, Mediterranean coasts largely suffer from the conflict between economy, legislation and the environment and human activities such as tourism and industry. Coastal exploitation is usually connected to:

a) the setting up of tourist activities on sea, coasts and the neighboring hills;
b) the development of urban settlements along the coast;
c) fishing;
d) aquaculture;
e) the setting up of industrial facilities.

The use of coastal resources strongly impacts on the environment both in terms of costs-benefits and wildlife conservation or depletion. These concepts are usually taken into account only when they play an important economic or sanitary role, whereas they should always be assessed on the basis of units of measurement.

This is particularly the case for coasts in order to avoid their ongoing deterioration with a consequent loss of value. Tourism ranges from seaside tourism (use of beach and services connected to nautical tourism) to nature tourism (use of the natural areas along the coast, such as bird sanctuaries and marine parks), and tourism connected to archaeological sites.

Tourism is largely based on landscape quality, which is to be safeguarded not only by imposing restrictions to changes but - above all - by involving the local population. Using the landscape for tourist purposes overlaps with environmental needs and the needs concerning both visitors and the local population. They may clash and lead to real conflict, but in a global context it should always be possible to draw up plans which benefit everybody. Coastal ecosystems are also an important source of global food production and support different economic activities such as fishing, aquaculture, leisure and

transport causing different forms of pollution. The task today is to foster economic development whilst limiting its impact and providing a better quality of life within the integrated management of resources.

Coastal zones can be properly managed only through regulatory norms which safeguard the environment as a whole. Guiding management, protection and conservation principles cannot merely coincide with principles underlying the safeguarding of open-sea waters. Protection of the coastal strip is possible only if carried out in the framework of an integrated management strategy. Coastal protection has long been the main focus of the international political arena in a series of conferences held in Stockholm (1972), Barcelona (1976), Athens (1980), Montego Bay (1982) and Rio de Janeiro (1992). These events have witnessed the definition of the necessary guidelines for a new sea water management policy, where protected areas will play a fundamental role.

Table 1: Coastal strip and marine resources

Economic and trade resources	**Historical and archaeological resources**
- coastal urbanization and road networks - harbors, canal harbors and tourist harbors - dredging	- historic sites - wrecks
- navigation and shipbuilding industry	**Social resources**
- artificial islands and offshore terminals - pipelines, underwater cables and pipes - hotels and holiday villages	- tourism and leisure - swimming and diving - yachting and sailing
Economic, mineral and energy resources	**Landscape resources**
- hydrocarbon extraction and storage - refineries and chemical industry	- parks, reserves and sanctuaries
- heavy industry	**State and military areas**
- thermal power plant - waste processing plants and dumps - alternative energy production - quarries and mines - salt marshes	- naval ports - firing grounds (forbidden areas) - prisons
Biological resources	
- demersal and pelagic fishing - aquaculture and aquaculture - fish meal - marine pharmacology and biochemistry	

The Libyan coastline

Libya has a 1,970 km coastline in the southern-most part of the Mediterranean basin. Three-quarters of the coast is low-lying and corresponds to the maritime fringe of the Libyan desert; the rest is

mountainous, on the slopes of the Jebel Akhdar region, in the North eastern part of the Country. Human density and tourism on the Libyan coastal fringe is low. Apart from the areas around towns and industrial centers, most of the Libyan coast is still protected from deterioration and remains very wild.

In 1998, WWF conducted The Mediterranean Marine Gap Analysis (see Figure 2, Annex I), which helped identify key marine and coastal areas for biodiversity in the Mediterranean where there is an urgent need for new reserves and changes in coastal management practices. According to this study, the Eastern Region of Libya was listed among the 10 "last paradises" of the whole Mediterranean. An inventory of coastal and marine sites of conservation interest was crucial to developing a concrete proposal for the creation of new coastal and marine protected areas aimed at preserving such a global outstanding site for marine biodiversity.

3 Libya in the Mediterranean

Population annual growth rate

The annual growth rate of the population of Libya is 3%. Mediterranean countries have different demographic characteristics. Annual growth rates are close to 4% in some States, such as in Middle Eastern countries - Jordan with 3.8% and Palestinian Territories with 3.7% - or North African countries (3% in Algeria). In others growth rates are almost equal to zero, with Italy recording the lowest levels (0.1%).

Table 2: Population growth rate

POPULATION 2003	TOTAL (mln)	Growth rate 1975-2001
Jordan	5,5	3.8
Palestinian Territories	3,6	3.7
Syria	17,8	3.1
Libya	**5,6**	**3**
Algeria	31,8	2.5
Israel	6,4	2.3
Egypt	71,9	2.2
Morocco	30,6	2.1
Turkey	71,3	2
Tunisia	9,8	2
Malta	0,4	1
Albania	3,2	1
Cyprus	0,8	1
Lebanon	3,7	0.9
Greece	11	0.7
France	60,1	0.5
Slovenia	2	0.5
Spain	41,1	0.5
Bosnia H.	4,2	0.3
Croatia	4,4	0.2
Italy	57,4	0.1
Serbia M.	10,5	-

Source: UNDP, UNFPA

1. Table 3: Population age distribution

POPULATION, AGE	% under 15	% over 65	Density	Coastal density
Albania	51.9	6	113,1	146
Palestinian Terr.	46.3	3.4	518,9	2310
Syria	39.1	3	92,4	324
Jordan	38.5	2.9	58,5	
Egypt	35.7	4.5	69,4	209
Algeria	34.3	4.2	13,6	215
Morocco	32.3	4.3	66,3	87
Libya	**32**	**3.7**	**3,2**	**23**
Turkey	31.2	5.6	90,0	97
Lebanon	30.2	6.1	400,8	552
Tunisia	29.4	5.8	61,8	135
Israel	28.1	9.9	288,9	784
Cyprus	22.5	11.7	86,5	86
Malta	19.7	12.5	1250,0	1250
France	18.7	16.1	108,3	124
Bosnia H.	18.3	10.3	80,2	51
Croatia	17	15.9	77,8	59
Slovenia	15.4	14.2	98,8	57
Greece	14.9	17.8	83,3	97
Spain	14.4	16.9	81,9	167
Italy	14.2	18.4	195,5	197
Serbia M.	-	-	104	57
MED	-	-	45	132

Source: UNDP, IUCN

Urban population growth rate

Over the past few decades, Mediterranean Africa has recorded an outstanding growth in urban population which, however, has not reached the levels of the northern Mediterranean coast. Over the last 25 years, Libya's urban growth rate has passed from 61% to 88% (+27%). Morocco has seen an increase from 37.8 to 56% (+18%). In Algeria and Tunisia it has grown by 17.5% and 16% respectively, while at the same time the Italian urban population has risen by 1.5%. Such a leap has been coupled with the growth of large cities in many countries. Alexandria, Algiers, Cairo, Casablanca, Tunis and Tripoli already exceeded one million inhabitants in 1990. Now, 52% of the urban population in Syria and

Egypt live in cities of over 750,000 inhabitants (only 34% in Italy): the percentage amounts to 54% in Libya, 69% in Lebanon and 66% in Greece.

Table 4: Urban population trends

URBAN POPULATION					% growth, annual average		
	1975	2001	Trend '75-'01	% urban pop. in cities with over 750,000 inh. (1995)	1975-1980	1990-1995	1995-2000
Libya	60.9%	87.9%	+27.0%	54	6.97	3.19	2.94
Cyprus	45.2%	70.2%	+25.0%	-	1.24	2.8	2.06
Turkey	41.6%	66.2%	+24.6%	37	3.11	4.24	3.35
Lebanon	67.0%	90.0%	+23.0%	69	1.18	4.04	2.24
Jordan	57.8%	78.8%	+21.0%	31	3.95	5.29	3.8
Morocco	37.8%	56.1%	+18.3%	32	4	3.18	3.23
Algeria	40.3%	57.7%	+17.4%	24	4.67	3.88	3.57
Tunisia	49.9%	66.1%	+16.2%	31	3.25	3.18	2.51
Croatia	45.1%	58.1%	+13.0%	39	2.6	0.53	0.6
Bosnia H.	31.3%	43.4%	+12.1%	-	3.42	-3.8	3.98
Malta	80.4%	91.2%	+10.8%	-	1.93	1.51	0.99
Albania	32.7%	42.9%	+10.2%	-	2.55	0.7	1.01
Spain	69.9%	77.8%	+7.9%	25	1.97	0.43	0.33
Slovenia	42.4%	49.2%	+6.8%	-	3.52	0.63	0.05
Syria	45.1%	51.8%	+6.7%	52	3.86	3.52	3.38
Israel	86.6%	91.8%	+5.2%	39	2.76	3.65	2.31
Greece	55.3%	60.4%	+5.1%	66	2.13	0.66	0.58
France	73.0%	75.5%	+2.5%	30	0.52	0.63	0.6
Italy	65.6%	67.1%	+1.5%	34	0.66	0.08	0.1
Egypt	43.5%	42.7%	- 0.8%	52	2.56	2.13	2.28
Serbia M.	-	57.0%	-	-	2.43	1	0.44
High-income OECD countries	79.1%	73.7%	- 5.4%	45	-	-	-
Developing countries	26.3%	40.8%	+14.5%	41	-	-	-
The poorest dev. countries	14.7%	25.7%	+11.0%	40	-	-	-
Arabian countries	41.5%	53.9%	+12.4%	-	-	-	-
Sub-Saharan Africa	21.0%	34.8%	+13.8%	-	-	-	-
World	37.9%	47.7%	+9.8%	41	-	-	-

Source: UNDP

Soil conditions

Africa is severely threatened by desertification mainly because of its climatic conditions. According to UNEP estimates, soil degradation affects 550 million ha. of arable land accounting for 65% of the total arable land on the African continent. Northern Africa does not only suffer from climatic risks but also from risks connected to farming, rapid urbanization, tourism and industrial development, especially in the field of oil processing.

Biodiversity

According to the IUCN, 6% of living species on the Earth are located in the countries overlooking the Mediterranean basin, and 12% of threatened species are concentrated in the Mediterranean basin. The biological wealth of the Mediterranean basin is so high that IUCN has identified it as a global biodiversity hotspot. 56% of amphibians living in the Mediterranean are endemic species (35 species out of 62), as well as 62% of reptiles (111 species out of 179). The Mediterranean is also important for birds. Two billion birds belonging to 150 different species use Mediterranean wetlands during migration. Nearly 50% of the western Palaearctic wintering population of ducks and coots either cross or stop here. The basin, which accounts for 1% of the world's sea surface, hosts 6% of the world's marine species, of which 28% are endemic. The main repositories of Mediterranean biodiversity are Turkey (hosting more than 8,000 vegetable species) and Southern Europe (Italy with 5,600 species, Spain and Greece with nearly 5,000 and France with 4,600). These countries, however, are threatened by major risks. One plant species out of 5 is dying out in Turkey and Spain. The same occurs to more than 11% of species in Greece, with other countries recording lower levels in line with world trends (4%). The situation is much better in Tunisia (1.1%) and in the Middle East (Israel with 1.4%, Jordan, Syria and Lebanon with less than 0.5%). One of the main threats to the protection of animals is the introduction of non-indigenous species in the ecosystem. This is particularly true for the Mediterranean where such a phenomenon is huge and irreversible. According to estimates, there are about one thousand exotic species many of which are particularly invasive and detrimental to both the economy and ecosystems.

Table 5: Plants, threatened species

Country	Total species	Threatened	% Threatened
Turkey	8 650	1876	21.7
Spain	5 050	985	19.5
Greece	4 992	571	11.4
Italy	5 599	311	5.6
Morocco	3 675	186	5.1
Algeria	3 164	141	4.5
France	4 630	195	4.2
Egypt	2 076	82	3.9
Libya	**1 825**	**57**	**3.1**
Cyprus	1 682	51	3
Albania	3 031	79	2.6
Malta	915	15	1.6
Israel	2 317	32	1.4
Tunisia	2 196	24	1.1
Jordan	2 100	9	0.4
Syria	3 000	8	0.3
Lebanon	3 000	5	0.2

Country	Total species	Threatened	% Threatened
Bosnia H.	-	64	-
Croatia	-	6	-
Slovenia	-	13	-
Palestinian Terr.	-	-	-
Serbia M.	-	-	-
MEDITERRANEAN	57 902	4710	8.1
WORLD	907 915	37455	4.1
Australia	15 638	2245	14.4
USA	4 669	19473	24.0
Canada	3 270	278	8.5

Source: IUCN

The culture of protected areas is not evenly spread along the Mediterranean coasts. According to IUCN estimates, Israel is the nation with the largest protected surface - 15.2% - with respect to its total area (IUCN categories from I to VI have been taken into account). It is followed by France whose 8 million ha. (14%) represent the widest surface of protected areas. A lower percentage of protected areas is held by Spain (8.5%), Italy (8.3%) and Cyprus (8.5%), followed by two Balkan nations, Croatia (7.4%) and Slovenia (5.9%). All other nations do not exceed the 5% threshold. The situation is not very encouraging in most areas of Northern Africa, despite the lower variety of natural environments and fewer human-induced risks. In Tunisia and Libya, for example, protected areas account for less than 0.5% and 0.1% of the total surface.

Trends in the past thirty years have confirmed such disparities. A considerable increase in protected areas has been recorded in France, Spain and Italy. Along the same lines, Algeria has also witnessed a positive growth though protected areas still account for less than 2.5% of its total area. Morocco and Tunisia have recorded less favourable results.

Table 6: The Protected areas (categories I – VI, IUCN classification)

Protected areas (ha)			2002		Trend 1970-2002
	1970	1980	Surface	% of total	
Israel	25435	41472	315899	15.2	290464
France	1824089	4740562	7727645	14.0	5903556
Spain	896285	1559141	4232209	8.5	3335924
Cyprus	66668	66668	78232	8.5	11564
Italy	351228	730578	2436549	8.3	2085321
Croatia	66503	114692	421096	7.4	354593
Slovenia	85430	85755	120295	5.9	34865
Jordan	209900	213300	393000	4.4	183100
Albania	58027	58027	102862	3.8	44835
Greece	29072	133482	469630	3.6	440558
Serbia M.	94786	188274	338001	3.3	243215
Algeria	1030	1030	5864322	2.5	5863292
Turkey	280668	464231	1192976	1.6	912308

Protected areas (ha)	1970	1980	2002 Surface	2002 % of total	Trend 1970-2002
Malta	290	296	311	1.0	21
Egypt	0	0	960300	1.0	960300
Morocco	273430	283033	363833	0.8	90403
Bosnia H.	26947	27091	27091	0.5	144
Tunisia	2600	52941	79917	0.5	77317
Lebanon	-	-	4810	0.5	-
Libya	**-**	**157000**	**173000**	**0.1**	**-**
Palestinian Terr.	-	-	-	-	0
Syria	-	-	-	-	-

Source: UNEP

Marine Protected Areas (MPAs)

To date, only 39 MPAs have been established in the Mediterranean sea, covering a total surface of less than 1% of the total basin area. Most of the existing MPAs are too small in size and lack efficient management, thus, they do not ensure the protection of marine ecosystems, habitats or species of the Mediterranean. Libya ranks high among the Mediterranean countries for total area (km2) of sea surface protected. Nevertheless, the protection level is not sufficient to ensure the long standing conservation of its marine resources.

Table 7: Marine Protected Areas

	Surface (km2)	% of total marine surface	Tot. marine surface (1.000 km2)	Setting up
Albania	240	2.0	12	1955
Algeria	920	0.7	137	1983
Italy	2800	0.5	552	1934
Morocco	970	0.3	278	1946
Turkey	762	0.3	237	-
Libya	**970**	**0.3**	**338**	**1978**
Israel	66	0.3	23	1964
Greece	1300	0.3	505	1962
Tunisia	170	0.2	86	1973
Cyprus	100	0.1	99	1961
Spain	1100	0.1	1219	1969
Malta	0,1	0.0	1277	-
Croatia	2000	-	-	1949
Egypt	-	-	-	1982
France	-	-	-	-
Jordan	-	-	1	-
Lebanon	-	-	23	1993
Serbia M.	-	-	-	-
Syria	-	-	-	-
Slovenia	2	-	-	1990
Bosnia H.	-	-	-	-

Source: UNEP-WCMC

Present priorities concerning the protection of marine and coastal environment

Libya has developed three National Action Plans within the framework of the Strategic Action Programme for the Conservation of Marine and Coastal Biodiversity in the Mediterranean (SAP BIO) of the Barcelona Convention:

- National Action Plan for the Conservation of marine and coastal birds
- National Action Plan on proposed new marine and coastal protected areas and national parks
- National Action Plan for the Conservation of marine turtles and their habitats

In the National Action Plan on MPAs, the Libyan government recognizes that its coast has valuable sites in urgent need of protection, and considers the coastal lagoons and bays of Ain El-Gazalah Bay, Bumbah Bay, Ain Ziana lagoon, Farwa and the river mouths (Wadi) of Wadi Al-Hamsah, Wadi Al-Khabtah, Wadi Ka'am, and the Tawrurgha spring and salt marshes of the Eastern Region as priority areas for conservation. It also recognizes that the lack of scientific data on marine and coastal biodiversity, the little knowledge on existing and potential threats to this biodiversity, limited technical expertise in the field of MPAs establishment and management, as well as poor environmental awareness among local communities should be urgently addressed to ensure the protection of such valuable sites.

4 Methodology

Description of the coastline

Nearly 280 km of coast of the Eastern Region of Libya, stretching from Al Dressia (Tulmaythah) to Ra's at Tin, were covered to assess environmental features - species and biocoenoses - within the main morphological types ranging from sandy and pebbly beaches to high indented cliffs and low rocky coast. The coastline was divided into 15 parts, which were analyzed by divers and documented by digital pictures. The aim was primarily to gather uniform and comparable data on environmental quality of the coast. Scuba-diving equipment was not used as it would have required a more in-depth analysis of the distribution of species colonizing deeper and more sheltered infralittoral and circalittoral zones, increasing differences due to changes in sea bottoms thus impairing comparison between the several stations. Although strong hydrodynamism usually depletes the upper infralittoral area of species, biological elements can be compared at a large number of stations (66) through transects running parallel to the coast. Had scuba diving techniques been used it would have been difficult to achieve the same results in the 15 days available given time requirements for bottle recharge, decompression, equipment delivery/recovery and everything necessary to carry out operations in compliance with safety standards.

Research above sea level involved the area affected by its proximity to the sea, which was defined taking into account the land between the main road from Susah to Ra's al Hilal and the shoreline. The same distance from the sea was maintained in other coastal strips. The study has identified 3 natural or semi-natural vegetation types that are sometimes subject to strong coastal restructuring and suffer from the proximity of industrial plants and/or drainpipes. Differences in human presence, level of naturalness and morphological varieties were recorded during the survey. In general, the area is characterized by a low human impact if compared to the north-western shores of the Mediterranean sea. A specific human impact scale was therefore defined accordingly.

Main elements of human impact

Clearly, the consumption needs for a population of 10,000 people in Susah are considerably different from those of 10,000 inhabitants of any European town. The same holds true for their ecological footprint. Human impact is consequently lower, even though waste problems are first and foremost caused by the use of uncontrolled dumping sites. This practice together with total lack of waste disposal

services leads to dispersion of lighter plastic material, such as plastic bags and bottles that can be found very far from where they have been left. Torrential stream beds and even river mouths are often used to deposit waste from built-up areas nearby. Such a practice probably dates back to ancient pre-industrial traditions, when people believed that heavy seas and spring rains could regularly clean river beds. Even if sanitary and aesthetic factors are neglected, this can only be done for a certain type of waste when the problem is not as serious as in western European countries. What would happen if this area started to witness the circulation of "western" products with their packages, the use of disposable plastic materials, detergent consumption (hence water consumption), batteries for small household appliances etc.? A society that is unprepared to tackle the problem will go through the same mistakes compelling Europe to spend an enormous amount of money for those countries that are only partly reached by the problem. Consequently, strong preventive measures and far-reaching development policies may avoid previous mistakes while giving a real and useful example of eco-sustainable development. That would be very different from the expensive actions taken to solve critical situations in developed countries. Hence the need for planning the coastal area in order to establish priority criteria in development and use of resources.

In short, existing minor problems have been found on the Libyan coast, but potential major threats exist in the event of development and slight changes in urbanization (tourism) and/or consumption patterns. Planning also implies awareness-raising measures targeted to the local population on the value and uniqueness of landscape and natural resources. So far, more than 80% of the western Mediterranean coast has been deeply modified, whereas the need for nature and environmental conservation is on the increase. Warning signals were first launched along Italian coasts, which in the post-world war period were equipped with facilities to meet the needs of mass tourism. This is also the case for the Spanish coast, where the property speculation of the 1970s has made it impossible to offer alternative tourist services, except for rare and limited stretches of coast remaining unchanged. Signals are quite strong: demand is constantly decreasing as supply is less able to match modern needs for entertainment. The Libyan coast is therefore an important resource and a natural capital to be safeguarded. Furthermore, it should be managed by focusing on its small population that can easily be controlled in terms of consumption propensity and correct development. It is better to manage a population of 5,6 million inhabitants scattered along 1,000 km of coast, rather than thousands and thousands of people (dramatically increasing during the summer) provided with insufficient services and facilities.

The illegal use of practices such as sand extraction for building purposes has to be analyzed as soon as possible in the framework of development, urbanization and proper land management. The combination

of such bad practice and the increase in population or quick coastal urbanization may damage landscape, which already suffers from road connections and is surrounded by well-preserved dunes and maquis. Geographical proximity to Darnah may seem a favorable element to attract tourists or to start developing tourist activities, but in fact it is a serious problem. Indeed, sand extraction is made some 30 meters from the sea with lorries and bulldozers; that leads to poor quality material, quick wear and tear of the equipment used and ecological damage such as coastal erosion, changes in the shoreline serving as the habitat for several species, disappearance of dunes and the vegetation behind them. There is no advantage whatsoever in allowing such an activity. Finally, extracting sand a few kilometers away from the coast may reduce transport costs and meet the demand with better results for the building industry.

Comparison with scientific literature

The list of species that is presented in Chapter 4.1 has been drawn up by means of observation and is only a starting point. The survey has enabled us to assess the main elements of naturalness and environmental weaknesses. Further monitoring actions may investigate aspects that certainly have international relevance. The coast is a real ecological laboratory where human factors may gradually be integrated under suitable planning. Specific and concerted training actions would provide the National Laboratory of Marine Biology, the University Omar al Muktar in Al Bayda and the Government Environment Agency with considerable opportunities to address eco-sustainable development in the inspected sites. Reiterated observations and the criteria used - which do not require specific needs in logistics and organization - will monitor the coastal area in view of future constructions (e.g. the extension of the coastal road west of Susah). They will also help set up an environmental task force tackling and monitoring development processes which may otherwise alter the natural environment.

When drawing up the checklist, it was extremely difficult to adjust the information from literature (mainly on the western Mediterranean) to different species distribution patterns. In other words, the lack of suitable and regularly updated benchmark scientific evidence may slow down classification given considerable differences in biocoenosis distribution.

Substrate is generally rather poor in sessile invertebrates, and filter-feeders in particular. Some specimens of *Mytilus galloprovincialis* have been found in a small inlet only, while vegetation distribution - though not very rich - is very interesting and is characterized by different *Cystoseira* species in shallow waters, too. Indeed, these brown algae can resist wave motion and colonized substrates even in open areas.

Data Assessment Methodology

The analysis of marine components was carried out by means of sea and land inspections at 66 sampling stations. Five visual inspections were made by means of R.O.V. (Remotely Operated Vehicle) to cover the stretch of coast under consideration as uniformly as possible. Every single sampling station has been given a value of "naturalness" of marine components according to the following factors:

Table 8: Factors of marine components

1) Substrate type.	1a) Substrate type diversity.
2) Vegetation physiognomy.	2a) Vegetation diversity.
3) Sessile animal coverage.	3a) Diversity in sessile animal coverage.
4) Fish abundance.	4a) Fish diversity.

Every area has also been given a score on External vegetation coverage (5) and Human impact (6).

Data gathered for each factor are included in a table ("Station assessment report") and turned into numerical values ("Station value report") according to the conversion tables below.

Introduction to methodology on rating and conversion tables

1) Substrate type

With reference to seabed analysis, a maximum depth of 15m was reached wherever possible. If not, observations were made to the depth needed to understand local features.

This choice stems from the need to carry out quick observations in free diving.

Every type of substrate can potentially be colonized by animals and vegetation to a different extent. In particular, hard sea bottoms are more suitable for benthic species than mixed sea bottoms. Nevertheless, the former are not more natural than the latter. This is why the scale of values makes reference to human changes in substrate rather than to natural conditions in the area. Clearly, a fully-colonized artificial substrate cannot be seen as biologically negative, and it is important when considering biotic components.

Archaeological finds have been given the greatest score so as to highlight their historical importance. Furthermore, despite altering the natural environment they have undoubtedly become an integral part of their surroundings.

In the light of the above remarks, a score has been given according to the following table:

Table 9: Conversion table for substrate type

Value	Description
0	artificial substrate whose structure is different from the natural structure of the area

1	artificial substrate whose structure is the same as the structure of the area
2	mixed substrate whose artificial structure is different from the natural structure of the area
3	mixed substrate whose artificial structure is the same as the natural structure of the area
4	natural substrate and/or archaeological finds

2) Vegetation physiognomy

In the light of the above-mentioned logistic and sampling needs, a score has been given to vegetation physiognomy as it can indirectly indicate quality values.

Table 10: Value conversion table for vegetation physiognomy

Value	Description
0	no colonization;
1	encrusting algae;
2	mosaic thicket;
3	large thicket;
4	mosaic-stratified vegetation; sparse phanerogam meadow;
5	continuous stratified vegetation; pristine phanerogam meadow.

3) Sessile animal coverage

The score is connected to substrate covered with sessile organisms as shown in the following table (percentages have been used according to Zurich-Montpelier methodology (Pérès & Picard, 1964)).

Table 11: Value conversion table for sessile animal coverage

Value	Description
0	widely-dispersed organisms, <5% coverage
1	numerous organisms, coverage ranging from 5% to 25%
2	very numerous organisms, coverage ranging from 25% to 50%
3	very numerous organisms, coverage ranging from 50% to 75%
4	>75% coverage

4) Fish abundance

This parameter provides an estimate of fish abundance. As the sampling has been limited in space and time and analyses have not been reiterated, data purely serves as an indication. Its purpose is to provide a baseline for further samplings.

Table 12: Value conversion table for fish abundance

Value	Description
1	Number of specimens ranging from 0 to 50

2	Number of specimens ranging from 50 to 200
3	Number of specimens exceeding 200

1,2,3,4a) Diversity in substrate type, vegetation, animal coverage and fish abundance

Every factor taken into account (substrate type, vegetation, animal coverage and fish abundance) corresponds to a new column where diversity is considered.

The aim is to identify the different data in quantitative terms. Indeed, underwater surveys have shown that some areas have good vegetation coverage, but the number of species is quite limited. This new parameter gives further information to people interpreting results in the final table.

For example, with reference to substrate high diversity results from the diversification of different elements. Similar remarks can be made for animals and vegetation.

Table 13: Scoring table for diversity

Diversity	
Score	Description
0	low
1	medium
2	high

5) Substrate type

This parameter makes reference to vegetation physiognomy. Scores have been given according to the following table:

Table 14: Scoring table for external vegetation coverage

Value	Description
0	No vegetation
1	*Pulvinus* vegetation
2	Shrubby vegetation

6) Human impact

Human impact has also been considered. Its assessment is quite difficult as it can hardly be identified in space and time, particularly in the marine environment.

The choice of human disturbance typologies has been made according to direct observations during samplings, on-the-spot evidence and information and the list of human activities affecting coastal areas provided by the MarLIN report (see Bibliography).

Table 15: Maritime and coastal activities (as modified by Walters et al., 2001)

COASTAL PROTECTION FACILITIES
-Barriers
-Artificial feeder facilities
-Groynes

DEVELOPMENT
-Constructions
-Land use
-Lagoon canals
-Navigation and shipbuilding industry
-Port/basin facilities
-Marinas and tourist harbors
-Coast urbanization and road networks
-Pipelines, underwater cables and pipes
-Gas/oil offshore platforms, artificial islands and off-shore terminals
-Artificial barriers

DREDGING

ENERGY PRODUCTION
-Non-renewable energy
-Alternative energy prod. (wind, waves and tides)

EXTRACTION
-hydrocarbon extraction and storage
-sand/gravel
-rock/minerals
-Water resources

FISHING
-Trawling
-Pelagic fishing
-Pot and trap fishing
-Hydraulic dredge fishing

COLLECTION
-Baits
-Rarities
-Macroalgae and superior plants
-Pebble upsetting
-Molluscs

AQUACULTURE
-Fish
-Macroalgae
-Molluscs
-Controls on predators

LEISURE
-Line fishing
-Yachting
-Diving sites
-Public beaches - bathing
-Hotels and tourist resorts
-Water sports

USAGE
-State and military areas
-Moorings and slipways
-shipment, loading and unloading operations

WASTE
-Fishing and agricultural waste
-Industrial waste water drainpipes
-Particulate and inert material mines
-Wreckage and waste
-Ship waste
-Digging dumps
-Waste water dumps
-Hot water drainpipes (cooling waters)

OTHERS
-Substrate clearance
-Salt marshes

The analysis does not focus on the impact of activities on the coastal environment. However, it has identified specific damage to the area considered, the effects of which may be perceived by observers.

A list of human impacts in the area has been drawn up through observations in sampling stations. Human impacts have been divided into three different categories as shown in the table below:

Table 16: human impact scores

Score	Human impact
-1	low
-2	medium
-3	high

That results in a matrix ("Impacts on areas") with negative values. This has been done to give the idea of something "worsening" the situation. For example, a score cannot decrease in a marine reserve where all activities are monitored, while it can decrease in a dockland witnessing degradation.

Landscape quality and human impact classes

Landscape value has been estimated for each sampling station according to the method below. Sampling stations have been grouped into similar areas depending on their characteristics in order to make a comparison between different environments having the same features and resources.

1) Landscape value

The landscape value for each sampling station can range from 1 to 26. Five value classes have therefore been identified according to the following intervals:

Table 17: Landscape value

Interval	Landscape value	
1-5	1	Low significance
6-10	2	
11-15	3	
16-20	4	
21-26	5	High significance

It is possible to obtain value classes by area by averaging the values of the relevant stations (see table "Station total score").

2) Impact classes

Impact classes can be obtained by the "Impacts on areas" matrix, where local impacts have been divided into three different categories according to the above-mentioned methodology. The grand total is

calculated for each single area. Impact classes can be inferred by using the same logic as landscape value classes.

Table 18: Impact class

Interval	Impact class	
-27/-23	1	High impact
-22/-17	2	
-16/-11	3	
-10/-5	4	
-4/0	5	Low impact

3) Bioquality value

Different areas are also given a score on bioquality, which depends on the presence of algae, fish and other species (be they protected or locally important) that are found at the relevant sampling stations. Checklists have been drawn up by using different tools: direct observation, pictures and the comparison and contrast with local checklists. It is important to highlight that rare or protected species do not only take into account species included in official lists (e.g. NATURA 2000, Red Book "Gerard Vuigner", 1990, RAC-SPA Annexes, Bern Convention Annexes etc.). In fact, they also include species which can be regarded as important in that they characterize and enhance the local environment.

Some of the most important criteria used to establish the importance of species for nature conservation are the following (Walters et al, 2001):

- rare species have very limited distribution at local level;
- species reduction has exceeded 25% over the past 25 years;
- a large percentage of the species regional or world population can be found in the area considered;
- species play an important role for habitats (trophic role, structure etc.);
- species play an important economic, social and cultural role at local level.

4) Overall quality value

The overall value of each area considered results from the grand total of landscape values, impacts and bioquality. By means of the GIS, relevant layers have been overlapped and transposed onto the final map to provide a better and more detailed understanding of the area (see table “Station total score”).

It is therefore possible to identify the contribution made by each component, whilst highlighting the components with the highest impact on the area considered.

5 Results

The rapid biodiversity survey produced the following results, sorted by coastal stretches as per Figure 3 (Annex I).

A) Al Dressia (Tulmaythah)

(sampling station: 59)

Context

This station exemplifies an area under strong human impact in the Eastern Region of Libya. However, despite considerable impact on the coast, the situation is extremely different from on the Northern shore of the Mediterranean basin, although the town, the small harbor and its relevant activities decrease the values connected to impacts and bioquality (both class 2). Fishing, bathing, sea waste, military areas and former port facilities are generally present all over the area considered coupled by further negative elements decreasing the level of naturalness, such as urban waste and uncontrolled dumping grounds for urban solid waste. The problem does not lie so much in the impact of human activities (which are linked to a relatively low number of inhabitants totaling 10,000 people) as in the lack of facilities and procedures aimed at reducing their effects on the surrounding environment. This is also related to the population increase in the past few years with a 12% growth rate between 1973 and 1984, which is only second to Misurata (17%) as outlined in the First National Report on the state of the Environment of 2002. Development may also take place in fishing activities if spurred by changes in minimum requirements for modernization (transport, refrigeration and increase in fishing efficiency). From a natural viewpoint, the underwater environment is in good condition and is subject neither to considerable disturbance nor to the effects of subsistence fishing, except for changes shown in substrates near the built-up area. Hence its value is fairly good (class 3) thanks to good substrates and vegetation.

Fishing is carried out by half a dozen of small powered boats which, though not exceeding 25 Hp, concentrate their activities some fifteen miles from the port. Fishing is not typically commercial, and is mainly targeted to the local community. On the whole the area surrounding the town of Al Dressia (Tulmaythah) is included in class 3.

Noteworthy species and associations

The presence in the area of phanerogams (*Posidonia oceanica*), is witnessed by the considerable number of leaves washed ashore forming large banquettes and offering shelter to small fishing boats.

Corallum rubrum is also present: clearly, its exploitation has been limited by the lack of suitable collecting equipment.

Our team has been told that a license is about to be issued to an Italian company to exploit this resource, after specific surveys carried out in the past few years. The appropriate authorities should conduct an in-depth analysis of the possibility of allowing the exploitation of a very slow-growth biological resource, which can no longer be found anywhere else in the Mediterranean and should establish a suitable price for it. Coral is still present in Libya - and at this site especially - thanks to foreigners' limited access. Today, its commercial exploitation could endanger its survival. We do realize the costs and difficulties involved in launching a national campaign to take a census of coral sites and assess its overall stock. However, given the unmistakable economic interest, we recommend that a preliminary study on stocks be made at a local level by the license applicant, which can then be checked at random by national experts (at the applicant's expense). An annual exploitation rate could be established so as to guarantee stock maintenance on a precautionary basis. At the end of each year the licensee may report on the size of the resource and on what has actually been exploited, while results could be double checked at random by national experts. Participation of international experts, to be secretly appointed, may curb corruption. Obviously, the licensee shall pay all expenses.

Weak points and strong points

The coast could be impaired by the village structure as no organized management of human impacts has ever been taken into consideration. Should modernization commence, the effects of an increasingly larger community producing increasingly complex and dangerous waste will threaten the environment. Economic growth may also imply the onset of a license system to exploit coral reefs. Clearly, with respect to the application made by foreign companies, a policy envisaging royalties and reductions for local communities needs to be planned in order to give locals a suitable economic return.

B) Al Dressia (Tulmaythah) - Qasi ad Disah

(sampling stations: 39, 40, 49, 50, 51, 52, 53, 54, 55, 56 and 57)

Context

This area hosts a stretch of coast with very different morphological features. Very high jagged cliffs are interrupted by low rocky coast stretching into the sea. The area is also characterised by a large number of well-preserved beaches lying in a dune system, which sea turtles (the loggerhead sea turtle, *Caretta caretta,* and, reported by the representative of the national Marine Biology Research Centre, also the leatherback sea turtle, *Dermochelys coriacea*) use as a nesting site. The sea bed is extremely

diversified in terms of morphology and granulometry. A mixture of different rock types and sizes is very common, thus creating different environments and encouraging abundance of fish species both in terms of quantity and diversity. This is confirmed by the presence of several nursery areas hosting many minimum-size individuals (*Dicentrarchus labrax, Sphyraena sphyraena* and *Lithognathus mormyrus*), which have been observed during field inspections. Indeed, the considerable diversification of sea beds and streams presumably carrying larvae and eggs to the shore enable the various species to stay in safe areas before recruitment. The several shoals and islets overlooking the shoreline not only enhance the landscape, but are also a very important environmental reserve in terms of production.

The values of landscape and biological quality are therefore very high (both class 4), as diversity is significant.

Noteworthy species and associations

The sea bed near the coast is usually sandy under the rocks and cliffs, where vegetation colonies can hardly be seen. The area towards the mainland is made of shoals and islets, while seawards there are jagged eroded rocks awash and submerged embankments. The sandy area near the coast prevents algae from taking root, while further from the coast shoals and islets encourage the growth of reophil communities; indeed, this area hosts the largest number of representative macroalgal species. Subhorizontal levels host photophil communities such as *Cystoseira sp*. and its different species: *C. barbata, C. crinita.* Large coverings of *Sargassum vulgare* and *C. discors.* have been seen at deeper levels, especially in less narrow areas. Better-sheltered areas towards the shore host *Padina pavonia* and *Halopteris scoparia* marking transitional and, probably, less valuable areas. *Dendropoma petraeum* and its bioconcretions have been observed near the cliffs, especially where the shoreline is more irregular and has different wave exposures.

Weak points and strong points

It is extremely difficult to reach the area considered given the lack of coastal roads. Human impacts are therefore very limited (class 4), although cases of dynamite fishing and collection of turtle eggs have been reported.

The area is rated class 4 thanks to the lack of considerable impacts and the good quality of its landscape and biological features.

Industrial fishing (i.e. trawling) is almost impossible as the sea bed is extremely irregular. The local community may therefore be encouraged to (self)manage biologically protected areas where selective artisanal fishing could be carried out under regular monitoring.

The large size and beauty of sandy beaches and the limited human presence are a biological asset, as they enable marine turtles to nest in the area. At the same time, though, they jeopardize their conservation as they may be targeted by mass tourism speculations which are - sadly - overabundant in the Mediterranean.

C) Qasi ad Disah - Al Haniya

(sampling stations: 1, 2, 3, 4, 37 and 38)

Context

This area is characterized by fairly good qualitative values in terms of landscape and sea bed bioquality. However, the diversity of parameters only deserves a fair rating.

Noteworthy species and associations

Only one species of *Cystoseira* has been seen (*C. Spicata*), contrary to what was seen on the western coast where it was represented by 5 species. *Posidonia oceanica* grows in shallow waters in some sandy areas surrounded by rocks near the islets and isthmuses considered.

Weak points and strong points

Isthmuses, shoals and shallow waters promote the presence of very interesting vegetation colonies - though no significant species are represented - and non-migratory fish species. However, some specific impacts have been detected: if no control is envisaged, they may lead to permanent negative effects such as dumping grounds on the seashore, drainpipes into the sea, sand extraction from beaches, buildings, moorings etc. If combined to less serious though common problems (e.g. subsistence fishing, bathing and waste washed ashore), they decrease the overall value to class 3.

D) Al Haniya - Ra's Amir

(sampling stations: 5, 6, 7 and 10)

Context

The landscape has quite low values in terms of quality and diversity of vegetation and fish species. Only in some stations is the situation somewhat better. Generally speaking sea beds are covered with vegetation divided in thickets, but diversity values are always quite low. The same holds true for fish species, as shoals never exceed 50 individuals and are marked by poor diversity. This is why landscape quality has been rated class 2. The overall value of the area is the same as the previous one (class 3).

Noteworthy species and associations

No area is significantly covered with *Cystoseira*. The lack of sensitive species such as *C. mediterranea* or *C. Stricta* (which are present in neighboring sites) may be indicative of degradation by organic contamination, but no reasonable assumptions can be put forward due to insufficient data. The only evidence is that these species are present in other neighboring areas. Populations are sensitive to pollution and are progressively replaced by more common and resistant species such as *Padina pavonica, Stypocaulon scoparium*, etc.

Weak points and strong points

Only minor human impacts are present (subsistence fishing, bathing and waste washed ashore), while major ones only include recent buildings. Dynamite fishing is said to be quite common in the area. Moreover, works have begun to build a road connecting Darnah to Al Dressia (Tulmaythah), which will enable people to reach the coastal area now hardly accessible. Though considering the importance of transport and communication systems, this will inevitably increase human impacts and ensuing environmental degradation. If no land planning tools are set up (e.g. a detailed development plan marking the most vulnerable areas and those used for urbanisation, services, recreational purposes etc.), it is recommended to temporarily stop road works along this stretch of coast.

E) Ra's Amir - Susah

(sampling stations: 8, 9, 11 and 12)

Context

Underwater landscape quality does not exceed class 3 given the characteristics of underwater vegetation, which is quite unstructured and poor in species diversity. Biological quality is rated class 2. Impacts are included in class 4: even though the area hosts a desalinating plant and a holiday village, they do not seem to particularly affect the sea bed. Overall, the area is rated class 3.

Noteworthy species and associations

The area hosts islands, shoals and wide *Posidonia oceanica* meadows contributing to its functioning as a nursery area. Several dens of juvenile groupers (*Ephinephelus guaza*) have been observed: after their first nektonic phase, they usually choose some safe areas to settle.

Weak points and strong points

This area may be considered attractive due to the closeness of the port of Susah, thus spurring overexploitation - even by occasional fishermen - and reducing its potential production capacity. Some monitoring activities in the shoals and near the plant would therefore be desirable.

The road under construction referred to in the area “D” extends as far as here; the same remarks on future developments therefore apply.

F) Susah

(sampling stations: 26 and 60)

Context

This area sees the presence of the town of Susah and its very little port, hosting only some 20 fishing boats. The remarks on Al Dressia (Tulmaythah) may also apply to this stretch of coast, but in this case development is more remarkable as human activities and the local community are larger in number. The situation in Susah gives food for thought on human impacts, as they are definitely bigger in larger urban areas. Urban waste water is drained into the port (pending expansion) that is located near the hotel off the archaeological site, while several dumping grounds for urban waste are situated close by. As for the landscape, there is an interesting mix between natural and artificial (human modification) aspects. Some shoals and islets looking onto the coast have been reshaped over the centuries. Even external components have been so remodeled that they are now part of the attractive archaeological area. Vegetation and fish species have quite good values thanks to the reasonable structure of populations and their good diversity.

The archaeological value is combined to the fair value of the underwater landscape thus contributing to the final value of the area (class 3).

Noteworthy species and associations

Cymodocea nodosa has been seen in the internal stretch of water near the ancient port, while *Posidonia oceanica* meadows are located off the rocks marking the boundary of the stretch of water opposite the old town.

Weak points and strong points

Waste accumulation without treatment or aggregation leads to environmental degradation, not to mention the problems and danger associated with untreated waste. Such carelessness clashes with any development policy and undermines any tourist offer connected to the archaeological site and its attractive location. The area has great potential for development as it hosts the ruins of ancient Apollonia, with its partially-submerged port and countless underwater finds that are still visible and well-preserved. That could be a major engine of growth to solve those problems that might be insurmountable in a few years' time.

G) Susah - Ra's al Hilal

(sampling stations: 13, 24 and 25)

Context

This area is characterized by low landscape values with an overall class 2. As to sea-bed populations, no optimal values are reached as thickets have limited diversity with mostly mosaic coverage. There is a fairly good presence of fish species, though diversity is low. Some dumping grounds and extraction activities have been observed; the coastal road increases human presence but no specific emergencies have been recorded (class 3). The overall value of the area is class 3.

Noteworthy species and associations

No noteworthy species have been observed. Caves and hollows sometimes host *Vermetus* shelves, although they are not very large and can often be confused with the roughness of shallow hollows, whose inner and outer edges are usually not covered in vermetides.

Weak points and strong points

The hinterland is characterized by attractive inlets and gorges, but no outstanding areas have been seen.

H) Ra's al Hilal

(sampling stations: 22 and 23)

Context

As the area is quite small and is not within easy reach, no human impacts virtually exist (class 5). Caves and narrow gorges are a main feature of the promontory. The underwater landscape has good values: sea beds are completely natural and diversity is high. Populations are well-structured and diversified with abundance of both species and number of small-size fish. Algal coverage is quite poor probably due to sediments in the rocky substrate limiting colonization under hydrodynamism; algae grow on rocks that are more exposed to sunlight.

Bioquality (class 3) is not very high as the area could have higher species richness thanks to its discontinuities, as observed in some areas near the cave that has been visited. The overall value is class 4.

Noteworthy species and associations

A cave located near the military area hosts a *Lithophyllum trottoir* with bioconstructions under which a *Corallina elongata* covering has been observed. A big specimen of *Charonia nodifera* has been seen in narrow gorges: this species is usually protected by international regulations but can locally be collected, especially in the area closer to the promontory overlooking Ra's al Hilal. Several dens of groupers with - presumably - newly-settled juveniles can be found in open areas with submerged cliffs crossing the shoreline.

Weak points and strong points

The area has been accorded military status, which usually keeps human impact at bay. However, coastal management and its restrictions should not be interpreted as private concessions where a privileged few can collect what is forbidden by international regulations (e.g. *Charonia nodifera*) or concentrate their fishing effort in a restricted area where fishing should not even be allowed.

I) Ra's al Hilal - Springs

(sampling stations: 14, 18, 19, 20 and 21)

Context

This area suffers from considerable human impacts (class 2) such as dumping grounds, drainpipes into the sea and sand extraction from the beach. Minor impacts in the whole area are also present (e.g. professional fishing, subsistence fishing, bathing, sea waste, military areas, former port facilities and archaeological sites). The site also hosts a town (Hilal), a holiday village and fish farming.

Substrates are mostly natural. Vegetation is usually made of mosaic thickets and a fairly large number of fish were observed. The landscape value is overall quite low particularly due to poor diversity.

Low bioquality and landscape values (both class 2) give the area an overall class 2.

Noteworthy species and associations

In some stations *Posidonia oceanica* was located very near the coast.

Weak points and strong points

This area has - more than any other - different land uses and different entrepreneurial activities: tourist resorts, aquaculture and experimental tuna breeding among others. However, development is still at an early stage: this is why a costal zone management plan should be assessed in the shortest terms, in order to take clear decisions and, if possible, to make different entities coexist.

L) Springs - Ra's bin Jabar

(sampling stations: 15, 16, 61, 62, 63 and 64)

Context

The situation is similar to that in area “G”. Dumping grounds and extraction activities have been observed here, too. The coastal road leads to considerable human presence, though no specific emergencies have been recorded (class 3). Landscape value is reasonable (class 3). Sea beds have high naturalness and environments are fairly diversified. Vegetation is better structured than in the previous area and ranges from mosaic thickets to phanerogam meadows and *Cystoseira sp.*. Fish species are well represented in quantitative terms, but only in two cases have interesting values been

recorded for species diversity. Moreover, some external areas are particularly interesting as they host stacks, caves and beaches which are very impressive and not within easy reach.

The area is characterized by low bioquality (class 2). The overall value is class 3.

Noteworthy species and associations

Small specimens of *Mytilus galloprovincialis* have been seen in the inlets; the only specimens observed during the campaign. Given the presence of this species and the vegetation typical of eutrophic areas, this inlet - like other inlets - is likely to host organic matter concentrations and be subject to land washing away.

Weak points and strong points

Greater control of human impact should be granted by the environmental response capacity and the shoreline, which is easily accessible from urbanized areas. The implementation of development plans to regulate land use near the sea is desirable on a long-term basis.

M) Ra's bin Jabar

(sampling stations: 17, 43 and 44)

Context

The area is virtually not subject to any human impact (class 5). Bioquality is very high thanks to good fish species diversity. Landscape values are fair (class 3). Vegetal populations are well structured though distributed discontinuously and in mosaic thickets, but diversity values are very low. Apart from one case, no meaningful values have been recorded for fish populations in terms of number or species.

The overall value is class 4.

Noteworthy species and associations

The good value refers not so much to diversity as to the presence of some important species. Indeed, *Cystoseira* is coupled by *Laurencia papillosa,* a species of the lower mediolittoral zone colonizing substrates that are subject to strong hydrodynamism forming a belt over Cystoseira. It is an indicator of good water quality and, above all, the maturity of communities. This is why low diversity is thought to be physiological rather than connected to environmental degradation.

Weak points and strong points

The area is characterised by low human impact and the sea is not within easy reach. Families and visitors occasionally pass by, as witnessed by the rubbish piling up in the maquis nearby. The natural state of the environment should be safeguarded by setting up appropriate lay-bys equipped with the necessary facilities, at least with litter bins and/or instructions to keep the area clean.

N) Ra's Karsa - Darnah

(sampling stations: 27, 28, 29 and 30)

Context

The situation concerning human impact is similar to that of areas “G” and “L”. Even in this case some dumping grounds and extraction activities have been observed; the coastal road increases human presence but no specific emergencies have been recorded (class 3).

There is a high-quality underwater landscape thanks to good conservation conditions (class 4). Sea beds are natural and have high-level diversity. Vegetation is well structured: both *Cytoseira* and phanerogam meadows are present in large thickets though, unlike the previous area, high species diversity has been recorded. The same holds true for fish species, whose large number is combined with good species diversity. Finally, small islands are situated not far from the coast: as previously stated, they give an added value to the area with their morphological and biotic aspects, as they are both a biological reserve and an area for fish production and aggregation.

Bioquality is within the average (class 3).

Noteworthy species and associations

No noteworthy species have been found unless elsewhere mentioned.

Weak points and strong points

Although the closeness of the town poses a threat to the environment, it could boost awareness-raising activities of main coastal problems. Indeed, experimental educational and awareness-raising models could be implemented in the most crowded areas.

O) Darnah

(sampling stations: 41 and 42)

Context

The town of Darnah is the largest in the area and has more facilities than any other town or village nearby. Communication routes are efficient, different kinds of infrastructure are present, the dockland has good facilities and, although there are very few fishing boats, they are provided with powerful engines and equipment enabling them to cover long distances and have good fishing results.

Consequently, the area considered is subject to all the impacts recorded. They range from minor ones including fishing, bathing, sea waste, military areas and former port facilities to major ones, such as buildings on the seashore, dumping grounds, untreated urban waste. Impacts clearly increase in urban areas - a class 2 rating has been given.

The landscape is strongly influenced by the town. Indeed, the shoreline has been adjusted to the needs of port and communication facilities even in suburban areas, while beaches and dune systems have been affected by sand extraction for building purposes. Vegetation is increasingly concentrated in thickets thus losing diversity in areas that are closer to the town. The same holds true for fish species, whose small number is combined to low species diversity. The landscape value is also rated class 2.

The overall value for the whole area is class 2.

Noteworthy species and associations

No noteworthy species have been recorded.

Weak points and strong points

What has been said for N) also applies to O).

P) Sidi Awn

(sampling stations: 31, 32, 33, 65 and 66)

Context

Coastal morphology is completely different after the town of Darnah. It is a stretch of coast with stacks falling sheer to the sea, several caves, narrow gorges and almost no landings. The coastal road connecting this area to Darnah and Bumba bay is passing on the plateau, some 15 – 20 km more inland and away from the shore, which makes the whole coastline more inaccessible.

Wadi Khalis bay is the only exception, as its environment is quite peculiar due to the flow of a freshwater stream. It is the place where the only local human activities are concentrated, even though they do not affect the final score of impacts (class 4). Underwater landscape values are positive (class 4): all factors have good characteristics of naturalness (natural substrate, well-structured populations, well-represented fish species) and diversity. Bioquality is fair (class 3). The overall value is class 4.

Noteworthy species and associations

Interesting algal coverage has been observed under *Cystoseira* belts, which are less developed than in neighboring stations. Rocky sea beds are extremely diversified and offer the ideal substratum to wide facies of *Dictyopteris membranacea* that were blooming at the time of observation. The relevant flora is *Cystoseiretum crinitae*, such as *Padina Pavonia, Halopteris filicina, Dictyota dichotoma, Corallina sp.* and *Peyssonnelia sp.*. *Peyssonnelia* species - including *Udotea petiolata* and *Halimeda tuna* among the main ones - have been seen under the small hollows in the rocks and reefs.

Weak points and strong points

An increase in the size of fish has been observed: this is connected to the limited exploitation of the area, which is considered as important as a biological reserve. The peculiar sea bed morphology (lack of impediments such as outcrops and shallow waters) makes it vulnerable to trawling. However, hydrodynamism is particularly steady and strong: it is connected to thermal breeze blowing in the morning and hindering navigation near the shore as well as fishing activities. The port of Darnah hosts few (5) fishing boats (purse seiners and long-liners) that can navigate in rough sea thanks to their tonnage. Other types of fishing gear (rod and dynamite) are not possible for orographic reasons.

Many hollows and caves - some of which are wide - are particularly interesting. Two of them have been found in the sampling area, of which the one to the East has a Y-shaped mouth entering into the cliff for over 40 meters. In short, this site is quieter (lack of human disturbance) than many other places because of the small number of visitors, its hydrodynamism and its orography. This is confirmed by the larger size of fish fauna. The area should be environmentally safeguarded: this would not negatively affect the resident population, who do not, in general, use it.

Q) Wadi el Hamassah - Ra's at Tin

(sampling stations: 34, 35 and 36)

Context

The situation is very similar to that described in the previous area. Even in this case the stacks provide only one access to the sea (Wadi el Hamassah), and geomorphology is very similar to that of Sidi Awn.

The easternmost point of the area deserves mentioning. Near Ra's at Tin the above-mentioned stack morphology is replaced by well-preserved beaches and dune systems, which then give way to very peculiar wetlands and shallow waters. This area must be pointed out because it is used for *Anguilla anguilla* farming, which is quite common at a local level. As for underwater landscape and bioquality, the same remarks as those for the area “P” apply. The overall value is class 4.

Noteworthy species and associations

The environment is quite varied and considerable importance is attached to the fjord layout. Rock sides have different colonies according to resuspension and, consequently, the closeness of the beach and the sandy bottom. Further from the inlet sea bed, *Cystoseira* meadows are located closer to the surface thus diversifying vegetation.

Weak points and strong points

The area is extremely varied and has remarkable naturalistic features. For example, some impressive stretches of coast host fossils cropping out among sand lilies which should, somehow, be preserved. Similarly, a conservation and development plan should be promoted to fence the most vulnerable parts

and establish paths to be included in well-known tourist routes. Such a plan would follow a thorough administrative analysis and may lead, for example, to the setting up of a small visitor centre.

6 The species observed

Macroalgae observations

The analysis of macroalgal coverage focused on a set of samplings of high-coverage species (more than 90%) witnessing considerable density. Attention was given to strongly discontinuous species which could provide useful indications of changes in morphology, exposure and substrate. Cosmopolitan macroalgae species are quite common in the Mediterranean and were often found in the surveys: as a biological resource, they are therefore independent of variations in environmental conditions - just like several invertebrate sessile species. This is why the checklist is a selection of species whose importance is connected either to their low density at all stations or - in the event of large coverage - to their representativeness. This is the case for *Dictyota dicothoma*, a brown alga that is usually associated to *Cystoseira* and is an indicator of anomalies if found on its own, especially when similar stations have different algal coverage. *Cystoseira* meadows along surface slabs are of the utmost importance. Coverage allows for the sheltering of fish species and other marine organisms, which would otherwise be at the mercy of surges. However, strong mechanical resistance of species where *C. amentacea* is dominant - and *C. mediterranea, C. compressa*, *C. crinita* and others are also present - is not enough to withstand strong environmental changes due to an increase in sedimentation and/or physical and chemical alterations of water characteristics. Consequently Cystoseira is often a good indicator, especially when it is present in several varieties or a sudden decrease is recorded.

Fish observations

Surveys have been made on the coastal area (50-80m off the coast) and have enabled us to establish health conditions of fish species in order to gather indirect information about the human impact of coastal activities and the detection of nursery areas. They have also been useful in assessing biodiversity in stations and/or stretches of coast that can be compared in terms of geomorphology, hydrology and other elements marking their differences. Beside the coast and fish species that are typical of rocky and sandy shorelines, surveys have also been made on shoals and islets with a view to identifying useful standards and assessing any differences. The checklist produced is by no means exhaustive on the presence of fish species in the area considered. Some remarks have also been made on fishing and fish quality, even to complement the checklist with pelagic species passing unnoticed.

However, the tables used to assess coastal characteristics do not take into account the list of fish caught in order to avoid any confusion in data interpretation.

Sixty species have been surveyed thanks to visual census techniques. Twenty seven of them are either commercial species or species for which subsistence fishing is justified. A dozen species belong to the eastern Mediterranean sea, the majority of which are Lessepsian species. Their distribution is often wider than that stated in recent literature, while distributional areas are expanding westwards in terms of permanence - which is never occasional - and presence. Finally, their consumption is regular. In this regard it would be useful to set up a monitoring centre on population dynamics since literature is largely extemporary and distribution data given by non-local experts may be unreliable as they are based on sporadic observations.

Some observation sites have been chosen as they are close to ports and landings used for professional fishing. It must be noticed that local fishing activities can be compared to European recreational fishing in terms of effort and products, although the term “recreational fishing” is not properly used as it usually refers to line fishing for private consumption and limited distribution within the local community. No specific signals of environmental stress have been noticed in the area considered. Large diversity includes commercial species, while the poor presence of large-size fish is due to the limited range of observations (near the coast), where nursery areas are mostly concentrated. 66 surveys have shown the relatively common presence of small-size groupers *Ephinepelus guaza* (5-6 specimens on 100 m^2) near shoals and isthmuses.

Areas near the beaches, particularly Wadi El Hamassah and Wadi Kalji to the west of Ra's at Tin, as well as sandy areas alternating the rock off Qasr ad Disah host a concentration of juveniles smaller than 4 cm in inlets or shallow waters. They often belong to commercial species such as *Lithognathus mormyrus, Maena sp., Dicentrarchus labrax, Sparus sp.* etc. that are present in the area. Dead fish have sometimes been found near human settlements. In some cases they were clearly daily discards (e.g. Maria gulf), while in others (Ra's Amir) they were clear evidence of dynamite fishing which is strongly affecting the sea bed.

The fish population is dominated by Lessepsian species and/or eastern Mediterranean species. Data have been gathered from surveys, contact with fishermen and analyses of fish caught. It is witnessed by traces on beaches sometimes reaching considerable extent (e.g. piers in the small harbour of Tolmeita).

Environments and communities

Surveys were restricted to the shoreline within the tidal and infralittoral zones that could be reached by free diving. Considering the environment as a whole, the main focus was on the vulnerability of areas suffering from environmental disturbance on a short-term basis.

In tidal communities the number of species and their coverage change according to sea-level proximity and, above all, the impact of coastal pollutants. For example, a large coastal area stretching from Sousa to Ras al Ilal was totally covered in tar, and tidal communities had been considerably reduced and were confined to hydrocarbon-free areas. It was impossible to establish community renovation and re-colonization rates due to lack of information on polluting events. Studying such trends would be interesting as the increase in oil transport will lead to an increase in pollution, thus becoming an international problem, and more difficult to address.

Communities are usually characterized by marked seasonal cycles, with maximum development taking place in winter and at the beginning of spring. Indeed, greater hydrodynamism in autumn and winter, greater input of nutrients and fewer hours of sun allow for better growth. On the contrary, in summer most algae disappear or strongly revert, in so far as their renewal cannot meet herbivores' consumption needs.

a. Upper mesolittoral rock community

This community is usually represented by the following species:

Nemalion helmintoides

Rissoella verruculosa

Patella vulgata

Patella tarentina

Patella mammillaria

Littorina punctata

Shiphonaria pectinata

Chtamalus stellatus

Pachygrapsus marmoratus

Its degradation is caused by organic and industrial pollution. It starts with the progressive disappearance of *Nemalion helmintoides* and *Rissoella verruculosa*, followed by the appearance of *Bangia atropurpurea* and *porphyra leucosticta* leading to the demise of Patella vulgata, Patella tarentina, Patella

mammillaria and Siphonaria pectinata. Finally, *Bangia atropurpurea* and *porphyra leucosticta* also disappear to be replaced by cyanophytes.

b. Lower mesolittoral rock community

This community is constantly under wave motion (emergence/submergence) and precedes perennially submerged communities. It is represented by the following species:

Laurecia papillosa

Lithophyllum lichenoides

Ceramium ciliatum

Gelidium latifolium

Nemalion helminthoides

Chaethomorpha aerea

In vertical rocky areas under wave motion, *Lithophyllum lichenoides* stands on lower mesolittoral rocks shaping what is known as trottoir. Such a formation is actually quite rare in the area considered, as it has only been found near caves and in near-vertical substrates.

Laurecia papillosa is located in horizontal substrates under strong hydrodynamism. This species is not only an important indicator of vegetation maturity, but also a link with the infralittoral zone because of its connection to *Cystoseira mediterranea*.

The lower mesolittoral community is quite developed and is made up of different species, such as:

Actinia equina

Dentropoma petreum

Patella caerulea

Monodonta turbinata

Chiton olivaceus

Thais haemastoma

Mytilus galloprovincialis

Pachigrapsus marmoratus

Eriphia verrucosa which is often replaced by yellow-legged spider-like crabs.

c. Infralittoral zone

Continuous submergence in this area - reaching over 50 meters of depth in the Eastern Region - allows for steady environmental conditions thus leading to highly diversified and rich life.

Algal dominance is so complex that different layers can be identified. The first layer is made of calcareous encrusting algae covered by a layer of small algae divided into thickets, whose thallus may be calcified. They are sciophilous species, which are sheltered from the covering of the following "shrubby" layer, where algae are lower than the following "arboreal" layer with large red and brown algae.

This model is gradually being simplified by the progressive loss of the above-mentioned layers. The arboreal layer is the first one to disappear, followed by shrubby layers and thickets. Well-structured communities are generally made of species belonging to stable environments with no physical or biotic tension, which is the case for most stations observed. On the contrary, when such tension exists simple communities are present, sometimes represented by pioneer species.

d. Infralittoral rock photophil community under wave motion

This community is located in the first centimetres below sea level in limestone rocky areas with strong hydrodynamism and clean water.

Though connected to mesolittoral communities, its most representative species could be distinguished. A larger number of species has been found where abrasion shelf was wider. Species in this biocoenosis include:

Cystoseira mediterranea	*Aiptasia diaphana*
Anadiome stellata	*Clavularia ochracea*
Hypnea musciformis	*Sertularella ellisi*
Jania rubens	*Mytilus galloprovincialis*
Spongites notarisii	*Dendropoma petreum*
Laurencia obtusa	*Thais haemastoma*
Lithophyllum incrustans	*Balanus perforatus*
Fauna includes:	*Eriphia verrucosa*
Clathrina coriacea	*Pachigrapsus marmoratus*
Sycon raphanus	

This biocoenosis is very sensitive to disturbance and its absence or presence is an indicator of water quality. Its degradation by organic or industrial pollution implies the disappearance of most distinctive species and the appearance of *Corallina elongata, Mytilus galloprovincialis* and *Balanus perforatus*.

e. Vermetid communities

These are organogenic structures made of calcareous tubes belonging to sessile mollusks - *Dendropoma petreum (=Vermetus (=Spiroglyphus) cristatus)* -, which are consolidated by thalluses of encrusting red algae, mainly *Spongites notarisii* and *Miniacina miniacea* (a foraminifer) playing an important gap-filling role. They are located on the rocks under wave motion at almost 0-level in non-contaminated areas.

Organisms settling on these formations come from both the lower mesolittoral rock and the infralittoral rock photophil community under wave motion, while fauna is mostly made of polychaetes, that is small-size mollusks. This community is actually quite common in the western Mediterranean, but it has only been observed at some stations and could often be confused with shallow hollows, where typical vermetids were not present.

f. Infralittoral sciaphilous algae community under wave motion

This community is located in surface hollows and narrow gorges under wave motion and protected from direct sunlight. Species include:

Flora:	Fauna:
Cladophora pellucida	*Sertularella ellisi*
Valonia utricularis	*Clavularia ochracea*
Palmophyllum crassum	*Actinia equina*
Corallina elongata	*Lithophaga lithophaga*
Gelidium latifolium	*Mytilus galloprovincialis*
Plocamium cartilagineum	*Balanus perforatus*
Peyssonnelia rosa-marina	*Turbicellepora magnicostata*
	Pseudodistoma cyrnusense

Its degradation by organic or industrial pollution implies the disappearance of algal communities - except for *Gelidium latifolium* and *Corallina elongata* - the proliferation of bryozoans and the appearance of mollusks that are usually found in contaminated areas, such as *Watersiphora subovoidea*, *Schizoporella errata*, and of resistant species such as *Mytilus galloprovincialis, Balanus perforatus, Tubicellepora magnicostata, Diplosoma spongiforme* and *Diplosoma listerianum*.

g. Infralittoral photophil algae community in calm areas

This community settles on consolidated rocks - which here are limestone - and sediments, and protected from strong hydrodynamism due to peculiar littoral geomorphology and depth. Although the need for light makes it typical of shallow water communities, it exceeds 30 meters in depth thanks to considerable water transparency.

It is one of the most important landscape units, where vegetation is highly developed in sessile species and fish species are strongly represented.

Flora

Acetabularia acetabulum
Anadyomene stellata
Cladostephus hirsutus
Cystoseira compressa
Dictyota dichotoma
Dilophus fasciola
Halopteris scoparia
Laurencia obtusa
Sargassum vulgare
Padinia pavonica
Lithophillum incrustans
Caulerpa prolifera
Taonia atomaria
Amphiroa rigida
Dasycladus vermicularis
Dyctiopteris membranacea
Halopteris filicina
Jania rubens
Ligora viscida
Cystoseira ercegovicii
Halimeda tuna
Corallina elongata

The community may include facies of *Dictyopteris membranacea* and *Dictyota linearis* after a certain depth, while *Acetabularia acetabulum, Dasycladus vermicularis* and *Liagora viscida* can be found in very calm sea areas.

7 Major pressures on marine biodiversity in the Eastern region of Libya

Introduction

The Mediterranean Region includes the marine and coastal waters of 21 countries. An estimated 60 percent of the population of such countries lives within roughly 100 kilometers of the shore and in certain countries, for example Libya and other African countries, this value rises up to 80%. This means that people rely heavily on marine habitats and resources for food, building materials, building sites, and agricultural and recreational areas and use coastal areas as a dumping ground for sewage, garbage, and toxic wastes.

As a consequence, pressures on marine ecosystems include coastal population density and continued population growth, which are accompanied by increased consumer demand for marine products, increased waste disposal, rapid alteration of coastal habitats, uncontrolled industrial pollution, inadequate institutional structures for managing marine resources, lack of property rights and management regimes within international waters, and lack of understanding and awareness of marine ecosystem processes and the effects of human actions on marine biodiversity. Moreover, much of the remaining in land population is concentrated along rivers and other waterways. Pollution and poor land use practices within these watersheds affect downstream marine habitats because sediments and pollutants are ultimately washed into coastal waters. Among this pressures, much of the deterioration of the Mediterranean marine environment can be attributed to pollution from land-based sources, supplemented by oil from heavy tanker traffic and ill-managed coastal development. Due to the diversity of culture and pleasant climate in the regions bordering the Mediterranean sea, the number of tourists and settlers will continue to increase yearly. In Libya the tourism sector, especially the foreign one, is not developed at the moment, but is expected to increase, thanks to the wealth of natural beauty, coastal ecosystems and archeological sites. This will also increase stress on the marine environment, so urgent attention should be paid to the development of sustainable tourism structures.

Pressure on the marine biodiversity of the Eastern Region of Libya

The coastal environment of the Eastern Region at the moment is not seriously in danger. Local pollution is associated with the larger cities of the region (Banghazi and Darnah) and major industrial sites. Untreated solid wastes are dispersed along the coastline underlining a chronic lack of waste

management system, particularly near the major urban settlements, whereas untreated waste discharges in the sea is the major land-borne pollution concern in the area. Despite no serious oil contamination, cases have been observed between Al Dressia (Tulmaythah) and Darnah, with the exception of limited deposits of hydrocarbons on rocks and on beaches observed in other areas, the development of the petroleum industry in Libya and the presence of various refineries, terminals and other installations, constitute a serious potential hazard to the environment.

More in detail the principal pressures and potential environmental marine hazards observed in the surveyed coastal zone are:

- Water Pollution from land-based sources;
- Solid Waste;
- Crude Oil and petroleum derivates spill.

1. Water Pollution from land-based sources

General consideration

The main sources of marine pollution is from land-based activities, including urbanization and coastal development, industries including power and desalination plants, refineries, recreation and tourism, wastewater, coastal mining and quarrying activities, and oil bunkering. The major pollutants found in runoff from urban areas include sediment, chemicals, nutrients, oxygen-demanding substances, road salts, heavy metals, petroleum hydrocarbons, pathogenic bacteria, and viruses. Suspended sediments constitute the largest mass of pollutant loadings to receiving waters from urban areas. Construction is a major source of sediment erosion. Nutrient and bacterial sources of contamination include fertilizers, pet wastes, and faulty septic tanks. Petroleum hydrocarbons result mostly from automobile sources.

If pollutants are discharged from a fixed point such as a municipal or industrial plant effluent pipe, the pollution is referred to as *point source pollution*. If the pollutants do not enter the watercourse at a fixed point, such as surface runoff from precipitation, the pollution is referred to as a *nonpoint source*. *Point source pollution* is most evident and easier to control. Industrial and municipal point sources in many cities today represent a small component of water pollution. The large percentage of coastal pollution is *nonpoint*. *Nonpoint pollution* is widespread because of the distribution of activities that add polluting substances to the land. In coastal areas, *nonpoint* pollution is generated by:

- Urban/suburban areas (oil, grease, lead, chromium, bacteria, and sediments);
- Agriculture (sediments, fertilizers, nutrients, and pesticides);
- Sewage discharges from faulty septic tanks and their discharge fields;

- Construction sites and mining operations;
- Marinas (boat storage and service facilities);
- Hydromodification (construction of dams and canalization);
- Contaminated groundwater (septic systems).

Sites affected by water pollution in the coast of the Eastern Region of Libya

The situations and sources of water pollution have been observed mainly in the urban and suburban areas and are constituted by urban waste water drain off, and open field refused solid wastes disposals, located close to the shoreline or river beds. The impacts are caused by the direct release of pollutants (organic and inorganic, and microbiological contamination), into seawater and potential drainage of pollutants from solid wastes in ground waters and in the sea.

These cases are located in the following zones:

Zone A **Al Dressia (Tulmaythah)** - (urban waste water drain off – open field solid wastes);

Zone C **Qasi ad Disah-Al Haniya** - (urban waste water drain off - open land fill solid wastes);

Zone F **Susah** - (urban waste water drain off - open land fill solid wastes);

Zone G **Susah-Ra's al Hilal** - (open land field solid wastes);

Zone I **Ra's al Hilal-Sorgenti** - (urban waste water drain off - open land solid wastes);

Zone L **Sorgenti-Ra's bin Jabar** - (open land field solid wastes);

Zone N **Ra's Karsa-Darnah-** (open land field solid wastes);

Zone O **Darnah** - (urban waste water drain off - open land field solid wastes);

Zone Q **Wadi el Hamassah-Ra's at Tin** - (open land field solid wastes);

Water Pollution Management

Nonpoint source pollution presents a large threat to coastal water quality and because of its diffuse nature, is much more difficult to control than single source pollution. While there have been recent improvements in curbing point sources of pollution, nonpoint pollution control has presented a more difficult challenge to coastal managers. Progress in reducing nonpoint pollution can be slow because there are many more nonpoint sources and they are sometimes difficult to identify. Moreover, traditional regulatory controls used for direct discharges are not easily applied to nonpoint sources of pollution and uniform regulations are often too expensive to be feasible. Because sources of nonpoint pollution can be hundreds of kilometers from the coast, management must also incorporate approaches for influencing water quality far inland from the coastal zone.

Strategies and Measures

To control nonpoint pollution, two basic methods can be employed:

- managing land to reduce runoff by maintaining or increasing the ability of the land to retain water;
- minimizing the use of contaminating pollutants.

To reduce runoff and limit nonpoint pollution coastal managers have found that maintaining the natural capacities of the coastal ecosystem greatly helps. For example, preserving naturally forested lands along shorelines helps to filter pollutants and to remove excess nutrients. Increasing vegetation within a watershed helps, as well as protecting or restoring wetlands, and using natural channels and sedimentation ponds. Another strategy used to reduce runoff is maintaining as much unpaved land as possible, and restricting the percentage of developed land.

Additionally, strategies known as Best Management Practices (BMPs) are often adopted by regional and local municipalities. BMPs are designed to help reduce the amount of pollution in runoff and the amount of runoff itself. BMPs address agricultural, urban and construction impacts on coastal water quality.

In urban environments, construction of wetlands and multiple-pond systems remove pollutants by impounding runoff from stormwater or construction activities to control runoff rates and settle and retain suspended solids and associated pollutants. Use of porous asphalt and restricting the amount of impervious surfaces also helps to reduce runoff. Storm drain stenciling programs (whereby storm sewers along walks and roads are plainly marked to indicate that they feed directly into coastal waters) can be effective tools to reduce illegal dumping of litter, oil, pesticides and other toxic substances down urban runoff drainage systems.

These programs serve as educational reminders to the public that storm drains often discharge untreated runoff directly into coastal waters. Adopting certain construction techniques (such as filter fencing, phased land clearance, protection of trees and vegetation) and grading restrictions may also help to reduce the amount of runoff and its toxicity.

Another useful approach in understanding the impacts of nonpoint pollution of coastal waters is to view whole watersheds when drawing management plans. By examining the watersheds that drain into coastal waters, communities can gain a better perception of what is affecting their coasts Public involvement and education is vital to solving the nonpoint problem. Major issues include convincing coastal and upland populations to reduce waste, recycle solid wastes, prevent littering, recycle used motor oil, and to stop disposal of waste in storm drains or waterways.

2. Solid Waste

General consideration

One of the major problems associated with urbanization is the disposal of solid waste, the management of which is an integral part of public health and environmental control. The situation currently observed in Libya is that waste management is at an early stage of development - most solid waste is disposed of in open fields or in river beds - needing a gradual evolution towards "modern" standards.

Rivers are an important conduit for the transport of waste to the sea; direct dumping of urban and industrial waste is also an important source. Waste disposal near coastal cities is sufficiently large to modify shorelines, and it covers adjacent sea bottoms with characteristic deposits on a scale large enough to be geologically significant. Not only are the rates of sedimentation high, but the waste tends to contain a high level of such substances as carbon and heavy metals.

Nontoxic solid wastes and marine debris cause significant mortality among marine species. For example, plastic bags, fishing lines, and other debris can entangle seals, seabirds, and other organisms, causing slow but sure deaths. Bits of plastic and other man-made materials are regularly ingested by sea turtles and other species, often with fatal consequences.

Over the last twenty years, waste management has begun to emerge in developed countries as a scientific and engineering profession in its own right.

Environmental standards of refuse incineration and land filling have gradually improved, and new methods of refuse sorting and resource recovery have begun to emerge. Research has been directed, for example, at waste in landfill sites focusing particularly on the production of leachate and its potential for water pollution. Industrial, and in particular hazardous wastes, have emerged as a priority concern. Complex legislation and control systems, and networks of sophisticated treatment and disposal facilities are being developed in parallel. The political priority given to waste management has increased sharply, largely due to public concern over well-publicized incidents.

Sites with presence of impacts from solid wastes in the Coastal Zone

Solid waste disposal is perhaps the most important impact observed in the studied area. Urban garbage is widespread along the coast, increasing close to the urban and suburban areas. This situation causes deterioration of the environment, both for the release of pollutants in the ground water and seawater and from an aesthetic point of view. Sites with presence of impacts from solid wastes have been noticed in the following zones:

Zone A	**Al Dressia (Tulmaythah)** - (open field solid wastes);
Zone C	**Qasi ad Disah-Al Haniya** - (open field solid wastes);
Zone D	**Al Haniya-Ra's Amir** - (open field solid wastes);
Zone F	**Susah** - (open field solid wastes);
Zone G	**Susah-Ra's al Hilal** - (open field solid wastes – open land fill in river bed);
Zone I	**Ra's al Hilal-Sorgenti** - (open field solid wastes);
Zone L	**Sorgenti-Ra's bin Jabar** - (open field solid wastes);
Zone N	**Ra's Karsa-Darnah**- (open field solid wastes);
Zone O	**Darnah** - (open field solid wastes);
Zone Q	**Wadi el Hamassah-Ra's at Tin** - (open field solid wastes).

Solid and Toxic Waste Management

Waste disposal will remain a problem until a better disposal service is implemented. Essential prerequisites for any successful programme to improve solid waste management (collection, treatment, disposal) is to establish it as a political priority for adequate management practices, good planning and educational programs.

Considerable weight should be given to the cleaning of coastal areas and swimming sites.

Specific actions

- Development of an integrated national programme for waste management
- Restoration of abandoned landfill sites
- Construction of new landfills
- Extended recycling programme
- Construction of composting plant
- Implementation of innovative techniques for the collection, treatment and disposal of waste
- Study for the implementation of packaging directive
- Coastal zone cleaning, with emphasis on tourist sites

Strategies and Measures

Technologies and management systems need to be appropriate to the specific problems of the local situation, and need to consider:

- the nature of the solid waste (Waste Generation Rates, Waste Density and Composition, Moisture Content);
- the climate and geographic situation;
- Institutional constraints;
- the presence of industries and other issues specific to hazardous wastes.

Solid Waste Storage and Collection

The question of the selection of appropriate technology and management systems for refuse storage and collection is an important one. The factors which must be taken into account include the following:

- The need in many countries for *daily collection* due to the hot climate;
- Perhaps the most important single factor in improving the efficiency of public cleansing services is to introduce a primary storage and collection system which results in *single handling* of wastes. Collection systems often involve double handling or, when non-tipping trucks, trailers or trolleys are in use, even triple handling of all wastes.
- Improving the effectiveness of primary collection in slum and shanty neighborhoods;
- Providing, appropriate vehicles workshop facilities for routine servicing, and the management structure to ensure that the vehicles can be repaired rapidly, are essential.

Solid Waste Treatment and Disposal

The strategies to manage this problem generally fall into two categories:

(a) throwaway methods, like incineration, land filling, and sea dumping, and

(b) low-waste methods, like recycling and composting.

Incineration produces air pollution, while landfills give off gases that contribute to global warming, and pollute underground water supplies. Landfills provide a ready dumping ground for non-hazardous waste, but these spaces are running out. Some landfills create their own problems; for example, older ones have no lining and wastes can filter down through the soil and into the water supply. In most landfills little air is available to decompose the waste, and items buried 20 years ago have been dug up intact.

These considerations point out the great importance of a good planning of this type of structures in order to avoid the problems above mentioned. Other considerations concerning the planning of such plants are regarding the site location and the management of land filling plants, in terms of avoiding waste percolate and possible underground water contamination (remark that in desertic countries such problems are easily handled and less expensive than in rainy countries such as North Europe).

New landfills or expansions to existing landfills must have a clay and plastic underlines and a mechanism to collect and treat "leachate", i.e. rainfall or groundwater which becomes polluted after leaching through garbage. Closed landfills must be retrofitted with a four foot soil, clay and synthetic impervious "cap" and incorporate landfill gas control measures.

According to that, a developing country like Libya, that is for a great part a dry land and has extended availability of spaces, could implement as first step the land filling technique for solid waste management, but providing for careful environment assessment and projects of the plants, and looking for the modern alternative trends for solid waste disposal.

The strategy of land filling for waste disposal has been widely used in high urbanized and industrialized countries, but actually the modern concepts and programs for waste management, are directed toward different integrated techniques and intermediate technology approaches to refuse treatment and disposal. A typical strategy could be the collection of wastes separately (glass, paper, metals, plastic) and the recycling of part of them, composting, incineration with energy cogeneration and land filling for the residual treated fractions of wastes.

It is projected that by the year 2025 quantities of urban waste will increase four to five fold. The large volume of waste, and its ecological and health hazards, demands cost effective strategies in urban waste system. As concerns about discarding valuable materials grows, and space for landfills runs out, support for low-waste methods is growing.

The rapid population growth also demands increased efficiencies in agricultural productivity, distribution and marketing. Present problems in agriculture include competition for water and soil degradation due to erosion, leaching and poor cultivation practices in many regions of the world.

There is a solution available to the urban waste problem, which is also agreeable to the problems encountered in agriculture: intermediate technologies which reformat urban waste for agricultural application to increase soil fertility. This is possible because more than half of urban waste consists of soiled paper, degradable sludge, and yard and food wastes. By changing the composition of waste input, (sorting the input waste and processing of the resultant materials) rich compost can be made available for improving soil fertility and biological activity. Waste water can also be properly processed for irrigation and aquaculture.

The urban/agricultural interface has, not only environmental, but also social and economic benefits. For example, it provides economic savings to farmers and urban residents and provides new opportunities for privatization in waste transformation and marketing

3. Hazardous and Other Special Wastes

General consideration

Hazardous waste management has received increasing attention from international and other organizations over the last ten years, but it is still not high on the political agenda in many countries.

Developing countries can learn much from the experience and mistakes of industrialized countries in controlling hazardous wastes. Cleaning up pollution caused by past dumping of hazardous waste is much more expensive than correct management in the first place

Hazardous or prescribed wastes may originate from all sectors, but the majority are generated by the commercial, industrial and trade sectors. Sources of prescribed industrial wastes include hospitals; food outlets; chemical, paint and plastic manufacturers; and food processing plants. Potentially hazardous wastes of domestic origin include paints, solvents, used car batteries and motor oils, televisions, computer. Other hazardous wastes coming from various activities are biomedical waste, fuel tanks, used motor oil, motor vehicles and vehicles parts, propane tanks, chemicals.

Hazardous or prescribed wastes require careful management and/or treatment due to their potential to harm the environment and the community. To ensure that hazardous wastes are managed appropriately, specific regulations and permitted treatment, storage, and disposal facilities should be established.

Crude Oil and petroleum derivates spill

Libya is the greatest producer and exporter of crude oil in the Mediterranean sea (1,29 million bbl/d*) and this fact involves special consideration and attention to possible accidental or deliberate oil spills in the marine environment. The number of accidents is increasing in the Mediterranean Sea and oil spills can occur at any time especially along the major sea routes and in or around the more important oil loading and unloading terminals. An oil spill is the release of crude oil which consists of a mixture of petroleum liquids and gases (together with associated impurities) pumped out of the ground through oil wells. Accidental or deliberate, operational discharges and spills of oil from ships, especially tankers, offshore platforms and pipelines, are the most obvious and visible cause of oil pollution of the marine environment. Other examples can be well blowouts, pipeline breaks, ship collisions or groundings, overfilling of gas tanks and bilge pumping from ships, leaking underground storage tanks, and oil-contaminated water runoff from streets and parking lots during rain storms.

Sources of oil input to the marine environment are often divided into natural, sea-based and land-based sources. In the NRC report, the perspective of "following the oil" is used, with four main categories of

sources: discharges through natural seeps, discharges during the extraction of oil, discharges during the transportation of oil, and discharges during the consumption of oil (including both sea-based and land-based sources). There are also other ways of placing accidental or operational/deliberate discharges of oils into main categories.

a) Natural

- Natural seeps

b) Sea – based

- Accidental oil spills from tankers; other commercial vessels; grounded and abandoned vessels; oil platforms (blowouts); pipelines.
- Deliberate, operational discharges of oil from all kinds of commercial vessels (ship- or cargo-related discharges);oil platforms; pipelines.
- Emissions of nmVOCs and PAHs from tankers and pleasure craft, and from oil extraction.
- Other ship-related activities (dry docking, scrapping).
- Other activities (dumping of oily waste, etc.)

c) Land-based

- Discharges of untreated or insufficiently treated municipal sewage and storm water (urban runoff).
- Discharges with rivers.
- Discharges of untreated or insufficiently treated waste water from coastal industries.
- Accidental or operational discharges of oil from coastal refineries, oil storage facilities, oil terminals, and reception facilities.
- Emissions of gaseous hydrocarbons from oil-handling onshore facilities (terminals, refineries, filling stations) and from vehicles exhausts (traffic).
- The effects of oil spills can be far-reaching, from an environmental as well as a socio-economic perspective. Marine and coastal habitats, wildlife species, recreational activities, local industry, and fisheries, are among the resources and sectors that can be negatively affected by oil spills.

Sites with presence of impacts from oil spill and petroleum products in the Coastal Zone

Limited areas of petroleum products impacts have been observed in the studied area. Local points of consistent crude oil spills stuck on the rocks, are present only in few zones, but several cases of diffused traces of crude oil and petroleum products have been surveyed on beaches. The observed sites are located in the following zones:

Zone C **Qasi ad Disah-Al Haniya** - (traces of oil products on beaches);

Zone D **Al Haniya-Ra's Amir** - (traces of oil products on beaches and rocks);

Zone F **Susah** - (traces of crude oil stuck on rocks);

Zone G **Susah-Ra's al Hilal** - (local point of crude oil stuck on rocks);

Zone O **Darnah** - (traces of oil products on beaches and rocks);

Oil spill management

Natural processes of oil transformation start developing from the first seconds of oil's contact with seawater. These complex mechanisms include *weathering, evaporation, oxidation, biodegradation*, and *emulsification,* and may act to reduce the severity of an oil spill or accelerate the decomposition of spilled oil. The progression, duration, and result of these transformations depend on the properties and composition of the oil itself, parameters of the actual oil spill, and environmental conditions. The main characteristics of oil transformations are their dynamism, especially at the first stages, and the close interaction of physical, chemical, and biological mechanisms of dispersion and degradation of oil components up to their complete disappearance as original substances. Similar to an intoxicated living organism, a marine ecosystem destroys, metabolizes, and deposits the excessive amounts of hydrocarbons, transforming them into more common and safer substances.

Over these considerations, specific actions should be taken for controlling oil spills and minimizing their impacts on human health and the environment.

These response measures and arrangements can be programmed at various levels:

Contingency plans

A contingency plan is a plan for action prepared in anticipation of an oil spill. At present in Libya there is no National contingency plan for oil spill even if the National Oil Corporation is preparing a plan for response to this type of marine pollution.

Contingency plans are essential because they establish practical plans of action for all types of oil spills so that, when spills do occur, a quick response can minimize the damage. The first step in developing a plan is to learn as much about the area as possible. Regardless of the geography or the size of an area, contingency plans normally include:

- identification of authority and a chain of command;
- a list of persons and organizations that must be immediately informed of a spill;
- an inventory of available trained spill personnel and spill response equipment;

- a list of actions that must be done (in order of priority);
- a communication network to coordinate response;
- probable oil movement patterns under different weather conditions; and
- sensitivity maps and other technical data.
- Planners need to know about:
- important or sensitive physical and biological resources within or near the area, such as marshes, unusual flora (plant life) and wildlife resources such as fish, shellfish, marine mammals and birds;
- important habitat areas required by particular species for spawning, feeding or migration;
- tides, currents and local climatic conditions, such as wind and severe weather patterns;
- shoreline characteristics; and
- proximity to roads, airports, trained response personnel, oil spill clean-up equipment, etc.

Libya has ratified the Barcelona Regional and Bilateral Agreement with states bordering the Mediterranean in August 2004 and the OPRC Convention (International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990).

Prevention measures

The measures that can be taken to avoid oils from being discharged into the marine environment can be divided into sea and land actions:

Prevention at sea:

Measures and actions that can be taken to make extraction and transportation of oil at sea safer are:

- Surveillance
- Inspections
- Reception facilities
- Ship's design
- Maintenance and owner responsibility
- Navigational aids and onboard equipment

Prevention on land:

The first step is to locate and identify the many sources on land. The main sources of input of oil from land-based sources to the marine environment are:

a. untreated or insufficiently treated municipal sewage and stormwater — urban runoff — from cars, machinery, spills at filling stations and garages, flushed-out residues of lubricants, etc.

The stormwater contains waterborne and airborne pollutants; everything that is flushed onto or falls down upon the hard surface will become constituents of the contaminated stormwater: car exhausts, particles from worn tires, small spills of oil from engines of different vehicles, small oil spills from garages, workshops, residues of oils and lubricants that we want to get rid of.

b. untreated or insufficiently treated waste water or stormwater from various coastal facilities: coastal industries, coastal refineries, coastal oil storage facilities, oil terminals, and reception facilities. Untreated stormwater from ports, refineries, oil storage facilities, oil terminals etc. especially oil terminals, has a high oil content that originates from valves, pumps, loading ramps for vehicles, quays, etc.
c. untreated waste water and residues discharged directly into rivers and with the rivers to the sea.
d. The second step is to close those sources and thus prevent oils (hydrocarbons) to reach the marine environment through sewage, storm water, industrial waste water, exhaust gases and rivers

Response techniques

- Controlling at sea: Response techniques when the oil is still in the water and has not yet reached the shoreline.
- Controlling on land: Response techniques when the oil is very close to the shoreline or has already stranded.

The oil which reaches the coast generally has the greatest environmental and economic impact. It is important to start removing oil promptly from contaminated shorelines, because oil will stick more and more firmly to rocks and sea walls, and may become mixed with sediments, as time passes. A number of advanced response mechanisms are available for controlling oil spills and minimizing their impacts on human health and the environment. The key to effectively combat spills is careful selection and proper use of the equipment and materials best suited to the type of oil and the conditions at the spill site. Most spill response equipment and materials are greatly affected by such factors as conditions at sea, water currents, and wind. Damage to spill-contaminated shorelines and dangers to other threatened areas can be reduced by timely and proper use of containment and recovery equipment.

- Mechanical containment or recovery is the primary line of defense against oil spills. Containment and recovery equipment includes a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials. Mechanical containment is used to capture and store the spilled oil until it can be properly disposed.

- Chemical and biological methods can be used in conjunction or alternatively with mechanical means for containing and cleaning up oil spills. Dispersants and gelling agents are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Biological agents and bio surfactants agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands. Research into these technologies continues to improve oil spill cleanup.
- Physical methods are used to clean up shorelines. Natural processes such as evaporation, oxidation, and biodegradation can start the cleanup process, but are generally too slow to provide adequate environmental recovery. Physical methods, such as wiping with sorbent materials, pressure washing, and raking and bulldozing can be used to assist these natural processes.
- Scare tactics are used to protect birds and animals by keeping them away from oil spill areas. Devices such as propane scare-cans, floating dummies, and helium-filled balloons are often used particularly to keep away birds.

8 Conclusions

Two sites of special environmental interest in the area have been identified and should be considered priorities for protection:

1. **Al Dressia (Tulmaythah) - Qasi ad Disah**
2. **Darnah - Sidi Awn**

Both areas are granted with particularly outstanding marine and coastal biodiversity and sea/landscapes in need of urgent conservation actions. The unique conservation status of such coastal stretches justify further study and the development and implementation of *ad hoc* conservation measures, specifically the establishment of a network of Marine Protected Areas (MPAs), built-in into a broader Integrated Coastal Area Management Plan (ICAM) for the region. The central area of the coast, from Qasi ad Disah to Al Haniya to Darnah, provides excellent opportunities to develop sustainable tourism initiatives connected to the protected areas and the archeological sites, and - with the necessary precautions - aquaculture. The coastal areas between Al Dressia (Tulmaythah), Qasi ad Disah, Sidi Awn, Wadi el Hamassah and Ra's at Tin are particularly underexploited and rich in environmental resources, which can be easily protected with little impact on the livelihood of local communities.

1. Coastal Area of Al Dressia (Tulmaythah) - Qasi ad Disah

The coastal area stretching from Al Dressia to Qasi ad Disah represents one of the few examples in the Mediterranean of a large sand dune system (60 km of coast) where human impact is still very limited. Indeed, in other Mediterranean countries it would have already been highly exploited for tourism purposes. The supralittoral environment encompasses the biocenosis of supralittoral sands and some of its facies:

- facies of sands without vegetation, with scattered debris;
- facies of tree trunks which have been washed ashore;
- facies of phanerogams which have been washed ashore (upper part).

Human presence near Al Dressia is scarce due to the local communities' infrequent use of the coastal environment for leisure activities. The Libyan Marine Biology Laboratory has long been operating in this area as the nearby sand dune system is an important nesting site for sea turtles. So far, sea turtle monitoring activities have been carefully designed and are regularly carried out by the centre. Historical data sets have been published and have been made available to the public. There is an important

opportunity to collaborate with the scientific institutes involved and further strengthen their expertise and capacities. The protection of this area should include both the system of coastal dunes and the beaches, islets and rocks (intertidal area).

2. Coastal Area of Darnah - Sidi Awn

The western part of the coastal area stretching between Darnah to Sidi Awn (about 61 km) is characterized by unique geomorphologic and biocenotic features, typically made of rocky substrate. Up to date, disturbance of these biocenoses has been minimal, due to scarce human presence all year round. The coastal area characterized indeed by high cliffs not easily accessible from the road, which runs landwards about ten kilometers away from the seashore, nor from the few urban settlements to the east of Darnah. Access from the sea is also quite limited. The steep and indented cliffs and the choppy sea below prevent fishermen from approaching the coastline (max. 100/200 meters), thus benefiting nursery areas and infralittoral biocenoses. The port of Darnah (which is the only landing site before Sidi Awn) hosts only 5 fishing boats of high tonnage. The strong hydrodynamism of the sea area near the port of Darnah contributes to contain the polluting effect of the main sewer of the city, which is located on the eastern side of the port. For all these reasons, environmental protection would be easier to be imposed as it would have limited impact on the economic interests of the local community. This coastal area is also important because it hosts important underwater nursery areas and several caves and hollows scattered along the cliff (“Semi-dark caves” biocenoses) that may still host the Monk seal.

Conservation work to preserve the Eastern Region of Libya.

The Eastern Region of Libya has been identified as a priority for the second stage of the Action Plan on Marine Protected Areas of the Strategic Action Programme for the Conservation of Biological Diversity (SAP BIO) in the Mediterranean Region. In the “National Action Plan on proposed new marine and coastal protected areas and national parks” of SAP BIO, Libya has committed to develop a national legal framework to enhance the establishment of new MPAs and promote their sustainable management. However, MPAs should be developed within a broader management framework to ensure not only the long standing ecological integrity of the marine and coastal resources, but also the sustainable development of local communities.

This requires:

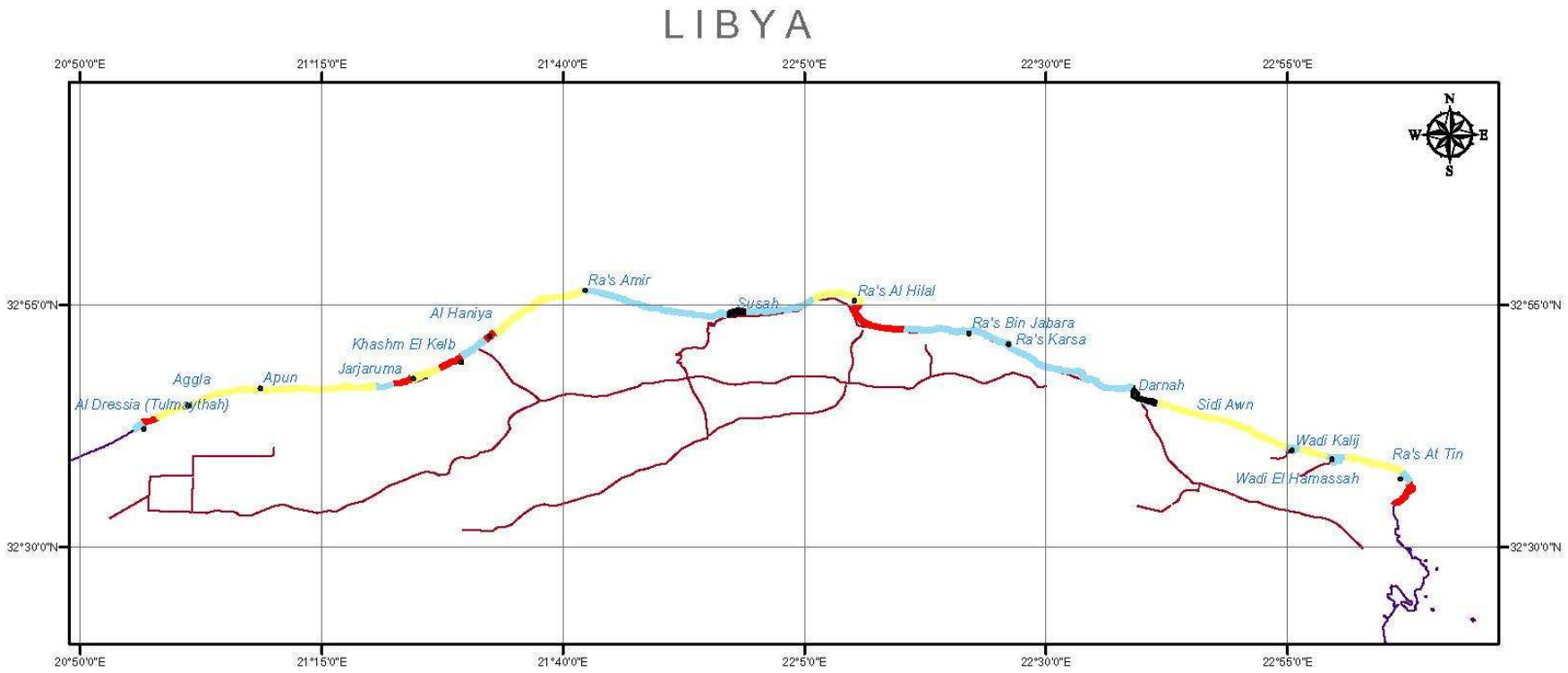
- an in-depth analysis of the social, biophysical, institutional and organizational characteristics of the area (baseline data) highlighting the problems and causes for concern in the coastal area,

to facilitate an understanding of the relationships between key factors and prioritize management issues properly;

- the strengthening of public awareness of environmental issues and the need to take action;
- the strengthening of local capacity in the fields of land planning, waste management (solid urban and sewer waste) and environmental monitoring through international cooperation programs in specific fields of action;
- the identification of priorities and goals for local communities to better orient the planning process.

International cooperation may help local experts and institutions in the planning, design and management of the new MPAs and the establishment of such an integrated coastal area management framework.

This report is the starting point for the development of the conservation work necessary to preserve this unique region and prevent the extinction of key species and ecosystems, whose value is priceless, and whose loss would be unforgivable. The GIS image, and related tables, below graphically highlight the richness of the coastal area of the Eastern Region, its natural and cultural biodiversity and the economic potential it can offer to local and foreign investors.

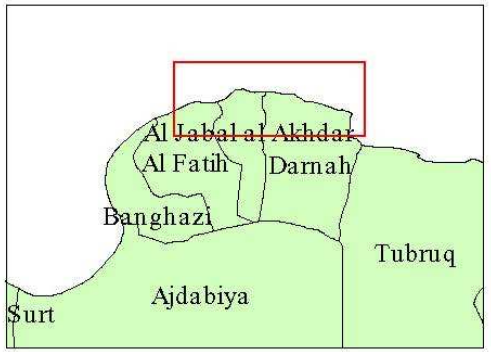


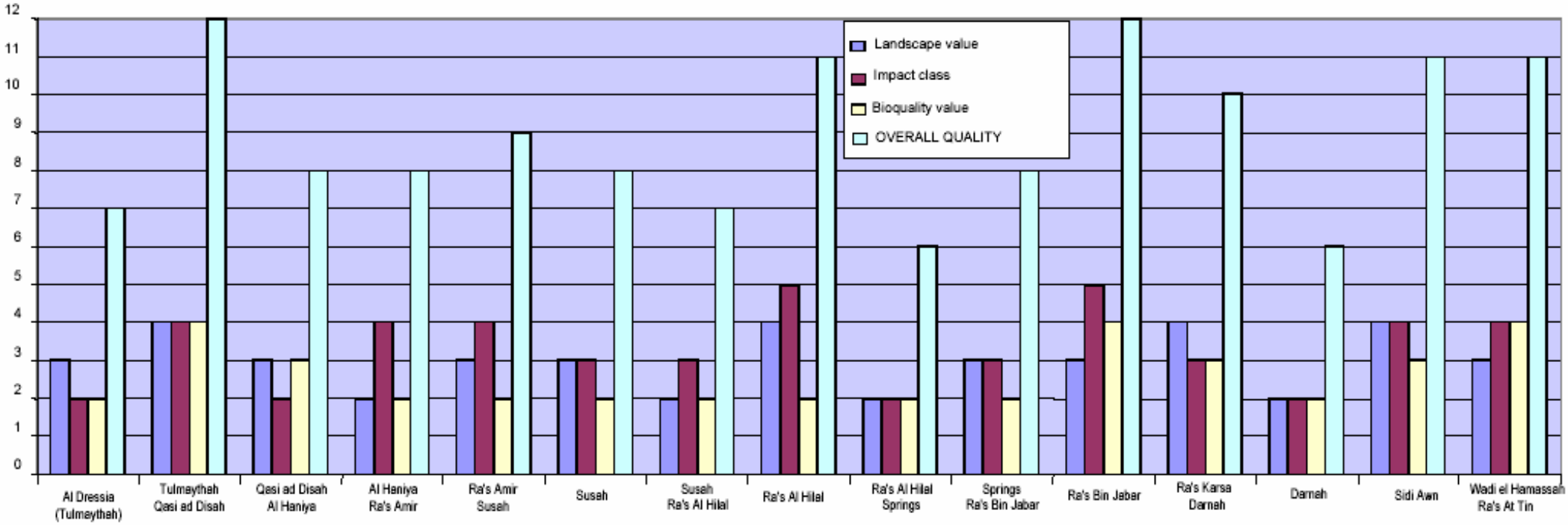
Legend

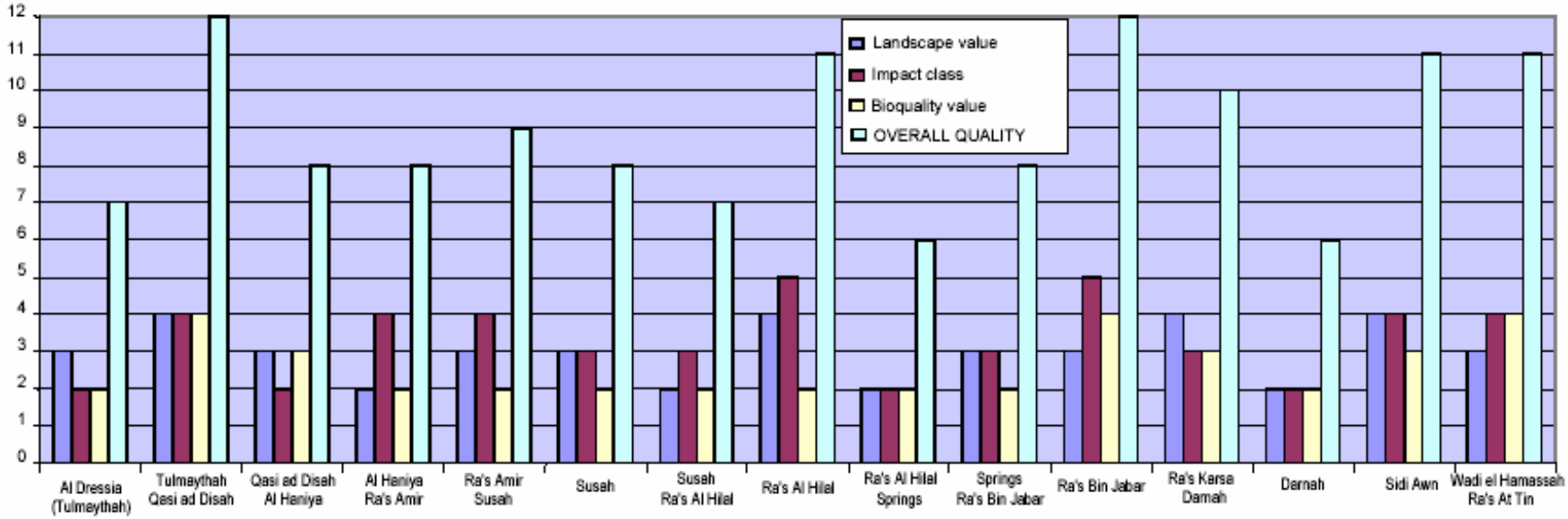
- Site names

Total lenght of coastline: 278 Km

- Stretch of coast suitable for the devlopment of sustainable tourism (cultural and environmental): 109 Km
- Stretch of coast suitable for the protection of marine and coastal environment: 125 Km
- Stretch of coast exposed to the risk of pollution: 11 Km
- Stretch of coast suitable for artisanal fishing and mariculture: 33 Km




Landscape value
Impact class
Bioquality value
OVERALL QUALITY
0
1
2
3
4
5
6
7
8
9
10
11
12
Al Dressia (Tulmaythah)
Tulmaythah Qasi ad Disah
Qasi ad Disah Al Haniya
Al Haniya Ra's Amir
Ra's Amir Susah
Susah
Susah Ra's Al Hilal
Ra's Al Hilal
Ra's Al Hilal Springs
Springs Ra's Bin Jabar
Ra's Bin Jabar
Ra's Karsa Darnah
Darnah
Sidi Awn
Wadi el Hamassah Ra's At Tin


Landscape value
Impact class
Bioquality value
OVERALL QUALITY
0
1
2
3
4
5
6
7
8
9
10
11
12
Al Dressia (Tulmaythah)
Tulmaythah Qasi ad Disah
Qasi ad Disah Al Haniya
Al Haniya Ra's Amir
Ra's Amir Susah
Susah
Susah Ra's Al Hilal
Ra's Al Hilal
Ra's Al Hilal Springs
Springs Ra's Bin Jabar
Ra's Bin Jabar
Ra's Karsa Darnah
Darnah
Sidi Awn
Wadi el Hamassah Ra's At Tin

Bibliography

BOCA D., ONETO G., 1990, *Analisi paesaggistica: manuale per la preparazione dei piani paesaggistici e altre operazioni di architettura del paesaggio*. Pirola, Milano.

DELLA CROCE N., CATTANEO VIETTI R., DANOVARO R., 1997, *Ecologia e protezione dell'ambiente marino costiero*. Utet Libreria s.r.l.

FERRARI M., 2000, *Ecologia del paesaggio ed ecologia applicata*. Calderini Ed agricole, Bologna.

LANDELL-MILLS N. AND PORRAS I. T., 2001, *Markets for Environmental Services and the Rural Poor - Silver Bullet or Fool's Gold: A Global Review of Markets for Forest Environmental Services and their Impact on the Poor.* ISBN 1 89982 592 4

ROMANI V., 1994, *Il paesaggio: teoria e pianificazione*. F.Angeli, MIlano.

Resources

NOAA - National Oceanic & Atmospheric Administration

NRC - National Research Council Canada

Annex I
Figures

Figure 1 The study area: the coastline of the Eastern Region of Libya from Benghazi to the east of Darnah.

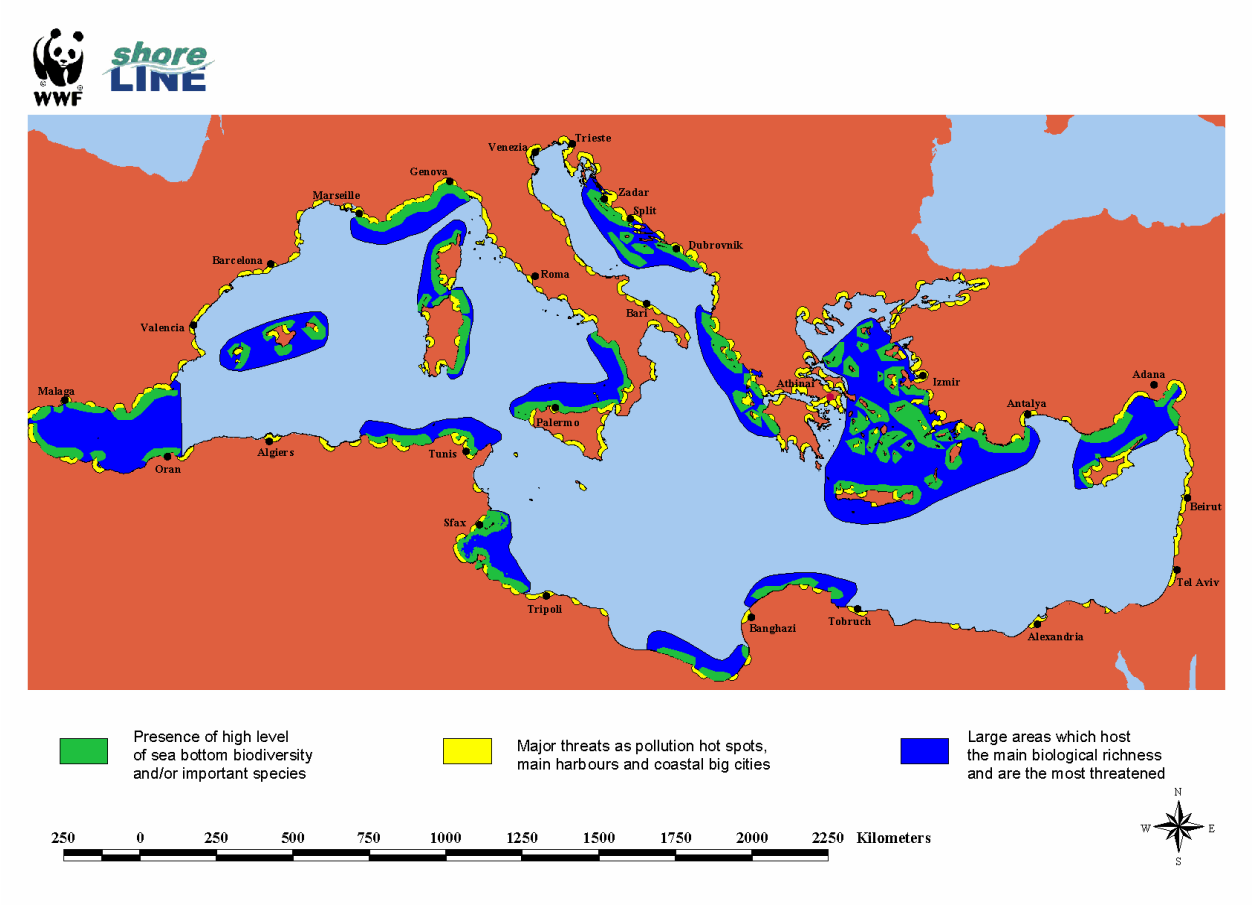


Figure 2 The Mediterranean Marine Gap Analysis (WWF MedPO, 1998).

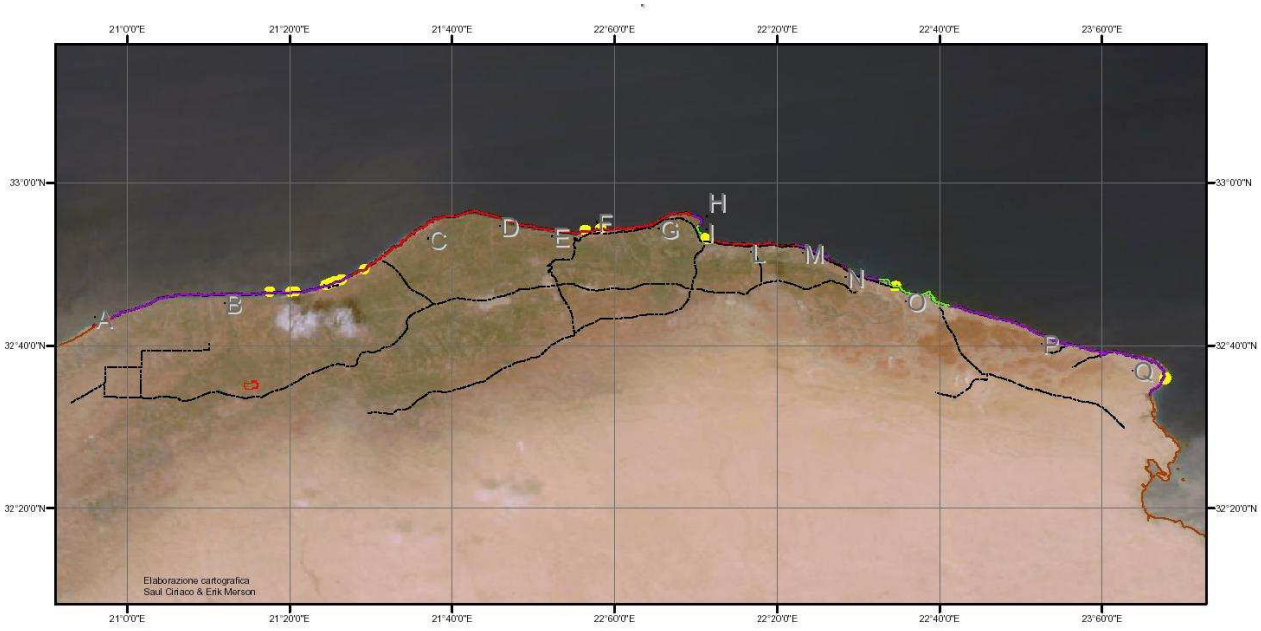


Figure 3 Sampled sites in the Eastern Region of Libya (A to Q).

Annex II
Selection of photographs from the coastal area of the Eastern Region of Libya

Figure 1 The coastline near the sample station of Fanal is marked by caves, a perfect habitat for the Mediterranean monk seal (WWF - Shoreline)

Figure 2 Typical rock in Haniya Bay (WWF - Shoreline)

Figure 3 Greek amphitheatre of Apollonia, Susah (WWF - Shoreline)

Figure 4 Ruins of Susah (WWF - Shoreline)

Figure 5 Columns in the sea at Susah (WWF - Shoreline)

Figure 6 Ra's al Hilal - white cliffs (WWF - Shoreline)

Figure 7 The entrance of the big cave of Ra's al Hilal (WWF - Shoreline)

Figure 8 The big cave of Ra's al Hilal (WWF - Shoreline)

Figure 9 Exploring the Ra's al Hilal cave (WWF - Shoreline)

Figure 10 Ra's Bin Jabar – coastline (WWF - Shoreline)

Figure 11 Small platform in Maria Gulf (WWF - Shoreline)

Figure 12 The coast of Maria Gulf (WWF - Shoreline)

Figure 13 The coastline in Maria Gulf (WWF - Shoreline)

Figure 14 Rocks of Darnah (WWF - Shoreline)

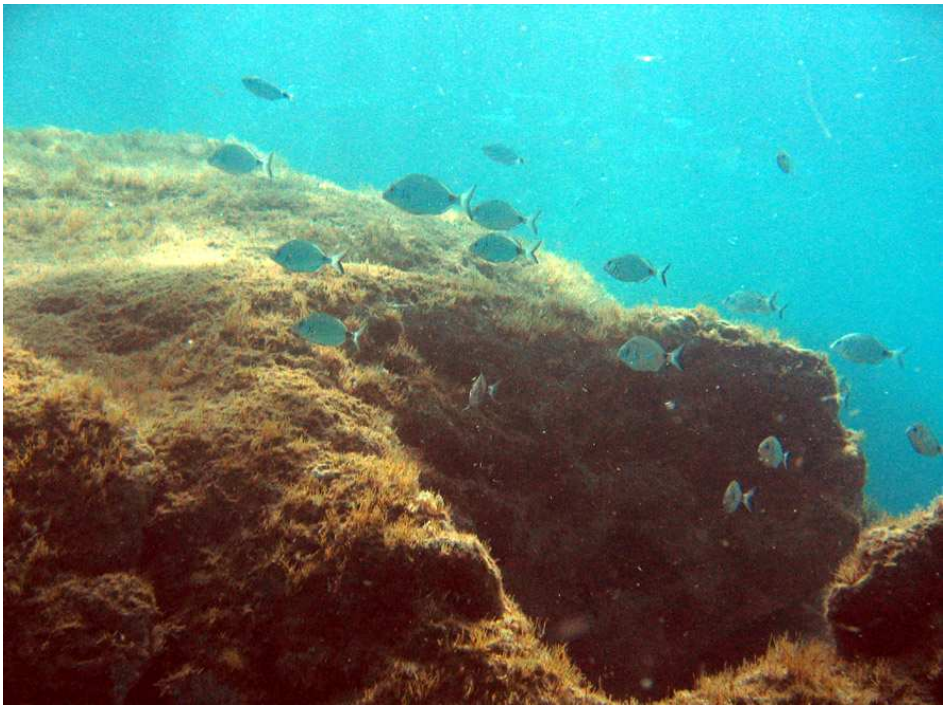


Figure 15 The submerged platform of Ra's Karsa (WWF - Shoreline)

Figure 16 Bay and white dunes in Wadi El Hamassah (WWF - Shoreline)

Figure 17 Wadi El Hamassah river mouth (WWF - Shoreline)

Figure 18 The wetland of Ra's At Tin (WWF - Shoreline)

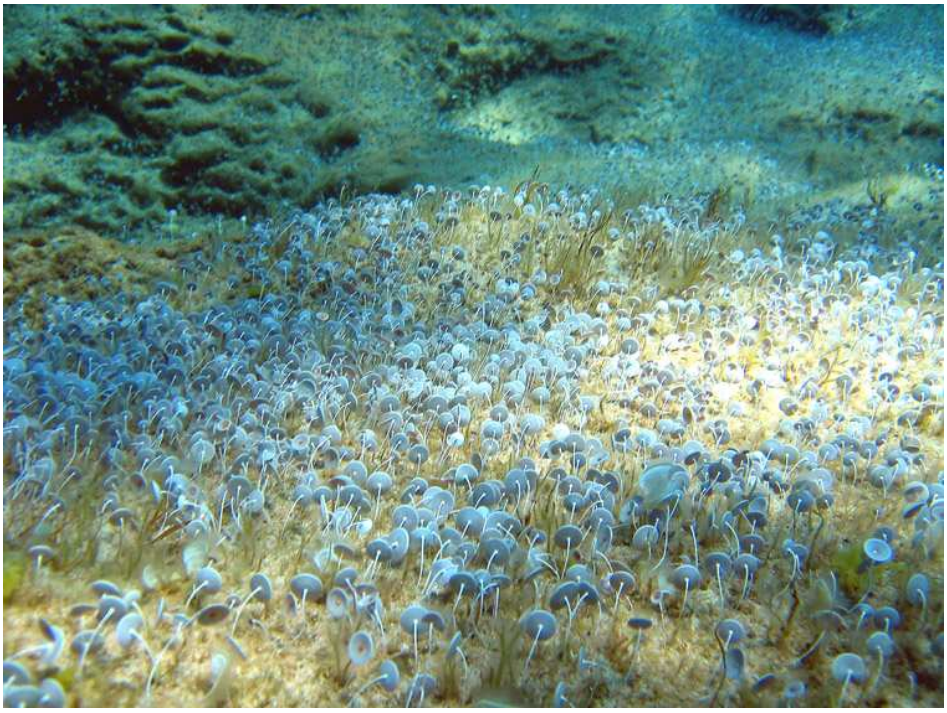


Figure 19 Vegetal cover of *Acetabularia* sp. (WWF - Shoreline)

Figure 20 The *Cystoseiretum* biocoenoses (WWF - Shoreline)

Figure 21 Young plants of *Posidonia oceanica* (WWF - Shoreline)

Figure 22 Marbled spinefoot (*Siganus rivulatus)* (WWF - Shoreline)

Figure 23 Marine turtle (*Caretta caretta)* (WWF Shoreline)

Figure 24 Triton shellfish *(Charonia nodifera)* (WWF - Shoreline)

Figure 25 Vanikoro sweeper *(Pempheris vanicolensis):* an invasive species from the Indian ocean (WWF - Shoreline)

Figure 26 Guitarfish *(Rhinobatos* sp.) - a rare Mediterranean species (WWF - Shoreline)