Regional Activity Centre for Specially Protected Areas (RAC/SPA)
Boulevard du Leader Yasser Arafat - B.P. 337 - 1080 Tunis Cedex - TUNISIA
Tel. : +216 71 206 649 / 485 / 851 - **Fax**: +216 71 206 490
E-mail: car-asp@rac-spa.org
www.rac-spa.org

made in www.igd-tunisie.com

United Nations Environment Programme
Mediterranean Action Plan
Regional Activity Center for Specially Protected Areas

Updating the Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region (SAP BIO) on Climate Change Issues

Sub-regional report on vulnerability and impacts of climate change on marine and coastal biological diversity in the North Mediterranean non-Adriatic countries and Israel

Note : The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of UNEP concerning the legal status of any State, Territory, city or area, or of its authorities, or concerning the delimitation of their frontiers or boundaries.

Mediterranean Action Plan
Regional Activity Centre for Specially Protected Areas (RAC/SPA)
Boulevard du Leader Yasser Arafat
BP 337 –1080 Tunis Cedex –TUNISIA
E-mail : car-asp@rac-spa.org

This report should be quoted as:

UNEP-MAP RAC/SPA 2009. Sub-regional report on vulnerability and impacts of climate change on marine and coastal biological diversity in the North Mediterranean non- Adriatic countries and Israel. By Charton-Garcia, J., Cebrian, D., Limam,A., Zenetos, A., Galil, B., Badalamenti, F., Ozturk, B., Marba Bordalba, N., Rizzo, M., Borg D., Saliba, S., Hajichristoforou M., Ed. RAC/SPA, Tunis; 44 pages.

Table of Contents

LIST OF ACRONYMS

AR4 :	Fourth Assessment Report to the IPCC
CAMP :	Coastal Area Management Programme
CC :	Climate Change
CEE :	Central and Eastern Europe
CEICAG :	Comité Español de Investigación en Cambio Global (Spanish Committee of Global Change Research)
CIRCLE :	FP6 project "Climate Impact Research Coordination for a Larger Europe"
CNR :	Consiglio Nazionale delle Ricerche
EIA :	Environmental Impact Assessment
ESSP :	Consortium for Earth System Science
EU :	European Union
EUROCEANS :	European Network of Excellence for Ocean Ecosystems Analysis
FNC :	Maltese First National Communication to the UNFCCC
FP6 :	6th Framework Programme
FP7 :	7th Framework Programme
GEF :	Global Environment Facility
GHG :	Green-House Gases
GOOS :	Global Ocean Observation System
ICAM :	Integrated Coastal Area Management
ICZM :	Integrated Coastal Zone Management
IGBP :	International Programme Geosphere – Biosphere
IHDP :	International Programme Human Dimension of Global Change
IMCAM :	Integrated Marine and Coastal Area Management
IMO :	International Maritime Organization
IPCC :	Intergovernmental Panel on Climate Change
ITF :	Italian Trust Fund
MAP :	Mediterranean Action Plan
MATTM :	Italian Ministry for the Environment, Land and Sea
Med-CLIVAR :	Mediterranean Climate Variability and Predictability Programme
MEDREP :	Mediterranean Renewable Energy Programme
MEPA :	Malta Environment and Planning Authority
MPA :	Marine protected area
NAP :	National Action Plan
NGO :	Non-Governmental Organisation
PAP/RAC :	MAP Priority Actions Programme/Regional Activity Centre
RAC-SPA :	MAP Regional Activity Center for Specially Protected Areas
REC :	Regional Environmental Centre for Central and Eastern Europe
SAC :	Special Area of Conservation (under the EU Habitats Directive)
SAP BIO :	Strategic Action Programme for the Conservation and Protection of Biological Diversity in the Mediterranean Region
SPA :	Special Protection Area (under the EU Birds Directive)
SST :	Surface Sea Temperature
UNFCCC :	United Nations Framework Convention on Climate Change
UNEP :	United Nations Environment Programme
UNDP :	United Nations Development Programme
WFD :	Water Framework Directive

EXECUTIVE SUMMARY

Data and information available, research, and actual knowledge

• The scientific and technical 'know-how' of the countries to deal with CC research issues appears to be high, as exemplified by the number of high-quality research papers published so far in scientific journals indexed in ISI.

• Research / monitoring actions in the sub-region are at present dealing with:

- Atmospheric changes and climate features
- Long-term marine hydrographical and hydrodynamic trends (including sea level)
- Hydro-geological changes and terrestrial implications on BD
- Coastal erosion and desertification
- Eco-physiological, behavioural and ecological response of marine organisms and populations to seawater temperature increase
- Geographical distribution shifts of native and alien species, including migration patterns
- Spatio-temporal changes in marine community structure
- Model development and forecasting projections
- Socio-economical impacts of CC (tourism, fisheries, aquaculture, etc.)
- Public health

• Despite that, however, the level of scientific knowledge of CC impacts on marine and coastal biodiversity is considered to be very low, due mainly to the lack of funding opportunities, as well as to unevenly distributed effort among countries.

National activities related to CC and biodiversity

• The national capabilities in CC-related research and/or monitoring issues are unequal among countries.

• Large gaps in knowledge exist on the effects of CC on biodiversity and their consequences for human populations, although some countries are more advanced in the pursuit of these subjects

• Participation in international coordination activities is not general in the sub-region

• Training and public awareness is identified as a priority, although its application is unequally distributed

Vulnerability and impacts

• Different national reports highlight the high level of uncertainty associated to the likely effects of CC on coastal and marine biodiversity in the medium-to-long term (i.e. several decades), linked to the degree of accomplishment of adequate mitigation measures in the countries concerned.

• All national reports agree in the idea that the effects CC on the physical environment are already being detected, especially related with increase in SST, hydrological and hydrodynamic changes, sea level rise, and increased frequency of extreme events –winds and storms.

• Expected physical and chemical damages of these effects are accelerated coastal erosion, seawater intrusion into coastal aquifers, threats to low-lying areas (deltas, coastal lagoons and other wetlands, beaches, supra- and midlittoral zones, etc.) – with particular emphasis on the threats to islands, and changes in the nutrient supply and dynamics of coastal and high-sea waters.

• Short-term effects on biodiversity are being already observed, such as spatio-temporal patterns of biodiversity, shifts in the abundance of particular species, and changes in eco-physiological processes of vulnerable species (reproduction, immunological response affecting the individual performance at various stages of their life history, and possible adaptive selection pressure on species traits).

• Special emphasis has been putted on the occurrence and spread of thermal species (both by colonisation of new species originating from the Atlantic through the Gibraltar strait and the Indo-Pacific through the Suez Canal, and by the invasion of allochtonous species via anthropogenic actions – e.g. shipping, aquariophilia, aquaculture,

and other sources of alien species. Other phenomena such as mucilage events, harmful algal blooms and mass occurrence of scyphomedusae are likely to be facilitated by CC in synergy with other anthropogenic impacts (e.g. overfishing, nutrient load and other sources of pollution, etc.). Another ongoing phenomenon, increasingly frequent in coastal waters of the countries, is the occurrence of mass mortality of structural species (e.g. gorgonians, octocoral colonies, sponges, etc.)

• At medium term, more complex phenomena are expected, such as changes in the life cycle of marine species, distributional range shifts of species and habitats, local extirpation of vulnerable species and, ultimately, decrease in the resilience (i.e. resistance and reversibility to disturbance) as well as profound changes in the functioning of marine ecosystems, which at present are difficult to forecast with the adequate level of accuracy.

• All these changes are likely to exert deep impacts on the economy of coastal populations, as well as on public health.

• In general, the countries highlight that despite the high effort devoted to now to investigate and assess these changes, much more is needed to be done at both research and monitoring levels.

Needs and urgent actions to be taken

• To improve the scientific understanding of CC and its impact on BD, by mean of adequate and internationally co-ordinated long-term monitoring and research initiatives. Topics highlighted are:

- hydrographic / hydrodynamic / climatic measurements to validate existing and forthcoming models
- monitoring of the coastline, assessment of erosion / desertification vulnerability and risks
- monitoring of selected benthic / nektonic / planktonic species / habitats
- special emphasis on the spread of alien species
- basic research on the biology of species vulnerable to CC
- studying non-linear responses of littoral ecosystems to CC, and population-to-ecosystem links (functional approach)

• Development of predictive modelling tools, under different mitigation, adaptation and population growth scenarios, including down-scaling of regional scenarios

• Enhance communication and exchange (among scientists, managers, stakeholders)

• Training and public awareness initiatives

• National strategies and initiatives to study CC-BD issues on a multidisciplinary basis and through regional cooperation

International co-operation, support and funding

• Regarding international cooperation, the national reports reflect a general lack of CC-related supporting activities to developing and emerging countries, with the exception of Italy, whose level of implication on this kind of activities is notable, in particular with the Mediterranean region, Central Eastern Europe, China, South America and the Caribbean. On the other hand, all countries reviewed in this report are signatories of CC-related international treaties and conventions, and most of them are involved in international initiatives, programmes and networks for the monitoring and assessment of CC.

• The problems related to funding CC-related initiatives, as identified by national experts, rely on:

- Too little national and regional funding to deal with the scientific questions regarding CC on the marine realm, as most CC-related initiatives are focused on terrestrial and inland aquatic environments
- Lack of regularity and/or stability in long-term funding, both at national and regional levels.
- For severe lack of funding, important issues are going unstudied, thus possibly endangering marine and coastal biodiversity.

General conclusions

1. Scientific consensus about CC and its effect on Mediterranean biodiversity

• National experts agree (in line with the international scientific consensus) on the importance and extent of risks of marine and coastal biodiversity in their countries due to CC, as a result of (and synergistic complex interactions between):

- changes in precipitation patterns
- increasing air and sea water temperature, enhanced UV radiation
- sea level raising, likely to accelerate coastal erosion, marine intrusion into coastal aquifers, and other effects
- acidification (decreasing pH)
- hydrodynamic and hydrological parameters (e.g. local and regional currents, upwellings, thermal stratification, frequency of storms and extreme events, salinity, turbidity, nutrient supply…)

• Expected effects of CC-driven stressors will affect marine / coastal biodiversity by producing shifts in the short-, medium- and long-term:

- Short-term (ongoing and next decade):
- spatio-temporal patterns of biodiversity
- abundance of species
- eco-physiological processes (reproduction, immunological response affecting the individual performance of sensible species, at various stages of their life history, and possible adaptive selection pressure on species traits)
- Medium-term (decades):
- larval dispersal and recruitment
- resource availability (food, habitat, etc.)
- primary and secondary production
- complex (non-linear, non-independent) responses at the community / ecosystem level, likely leading to catastrophic regime shifts and local extirpation of species and habitat losses
- synergistic effects of other human-driven stressors (e.g. overfishing, pollution, habitat degradation, alien species), and land-sea links (e.g. soil erosion and desertification, agricultural runoff, river regulation, etc.)

• These biodiversity changes are likely to have profound direct socio-economical effects, and affect public health.

2. Activities concerning vulnerability and impacts of CC on BD

• The national capabilities in CC-related research and/or monitoring issues are unequal among countries.

• Research / monitoring actions in the sub-region are at present dealing with:

- Atmospheric changes and climate features
- Long-term marine hydrographical and hydrodynamic trends (including sea level)
- Hydro-geological changes and terrestrial implications on BD
- Coastal erosion and desertification
- Eco-physiological, behavioural and ecological response of marine organisms and populations to seawater temperature increase
- Geographical distribution shifts of native and alien species, including migration patterns
- Spatio-temporal changes in marine community structure
- Model development and forecasting projections
- Socio-economical impacts of CC (tourism, fisheries, aquaculture, etc.)
- Public health

• Large gaps in knowledge exist on the effects of CC on biodiversity and their consequences for human populations,

although some countries are more advanced in the pursuit of these subjects
• Participation in international coordination activities is not general in the sub-region
• Training and public awareness is identified as a priority, although its application is unequally distributed

3. National needs

• To improve the scientific understanding of CC and its impact on BD, by mean of adequate and internationally co-ordinated long-term monitoring and research initiatives. Topics highlighted are:

- hydrographic / hydrodynamic / climatic measurements to validate existing and forthcoming models
- monitoring of the coastline, assessment of erosion / desertification vulnerability and risks
- monitoring of selected benthic / nektonic / planktonic species / habitats
- special emphasis on the spread of alien species
- basic research on the biology of species vulnerable to CC
- studying non-linear responses of littoral ecosystems to CC, and population-to-ecosystem links (functional approach)

• Development of predictive modelling tools, under different mitigation, adaptation and population growth scenarios, including down-scaling of regional scenarios
• Enhance communication and exchange (among scientists, managers, stakeholders)
• Training and public awareness initiatives
• National strategies and initiatives to study CC-BD issues on a multidisciplinary basis and through regional cooperation.

4. Funding problems and opportunities

The problems related to funding CC-related initiatives, as identified by National Expert, rely on:
• Too little national and regional funding to deal with the scientific questions regarding CC on the marine realm, as most CC-related initiatives are focused on terrestrial and inland aquatic environments
• Lack of regularity and/or stability in long-term funding, both at national and regional levels. For severe lack of funding, important issues are going unstudied, thus possibly endangering marine and coastal biodiversity.

5. General recommendations

The national experts gathered under 'Cluster B' group agreed in the need to launch the following activities regarding CC impacts on marine and coastal biodiversity:
• Open-access, regionally co-ordinated database housed in RAC/SPA on the occurrence, spread and shifts (e.g. bleaching, flowering, mass mortality…) of "thermal" marine species (both native and alien).
• Long-term monitoring programmes of biodiversity shifts in a comprehensive set of geo-referenced sampling sites.
• Assessment of the socio-economic risks and observed consequences of CC, and economic valuation of non-adapting to CC impacts on marine and coastal biodiversity in terms of ecosystem services and goods.
• Necessity to launch regionally co-ordinated / harmonised (and adequately financed) national plans for the adaptation to the impacts of CC, with focus on synergistic effects of CC with other anthropogenic sources.
• Research on eco-physiological / behavioural / ecological responses of vulnerable species (affecting different biological traits along their life cycle), including connectivity and adaptation issues. Focus on non-linear complex emergent responses of communities / ecosystems.

1. INTRODUCTION

The present document has been produced in the framework of the process promoted by RAC-SPA to update the "Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region" (SAP BIO), in particular with reference to expected impacts of climate change (hereafter CC), all in accordance with the Outline for the SAP BIO Operational programme for the 2008-09 period proposed for Parties' adoption by the 8th meeting of National Focal Points for Specially Protected Areas, held in Palermo on 6-9 June 2007. The action aims to contribute to the objectives Almería Declaration by providing an insight on state of knowledge and actions concerning impacts of CC on marine and coastal biodiversity, as well as to serve as input when defining future activities on CC with regard to the protection of biodiversity within SAP BIO, RAC-SPA and MAP.

The aim of the present document is to synthesize at the sub-regional level the findings presented in National Overviews of the so-called 'Cluster B' of countries, constructed 'ad hoc' (so that there is not a geographical criterion to establish a homogeneous sub-group of countries), and including:

- Greece, prepared by Zenetos A. & N. Streftaris
- Israel, prepared by Bella Galil
- Italy (non-Adriatic coast), prepared by Fabio Badalamenti, Franco Andaloro, Giandomenico Ardizzone, Giorgio Bavestrello, Lisandro Benedetti-Cecchi, Carlo Nike Bianchi, Renato Chemello, Francesco Colloca, Marco Curini Galletti, Marco Milazzo, Carla Morri, Stefania Puce, Leonardo Tunesi
- Malta, prepared by M. Rizzo, D. Borg and S. Saliba
- Spain, prepared by Dr. N. Marba Bordalba
- Turkey, prepared by Dr. Ozturk B
- Cyprus, Contribution provided at the Cluster meeting by Ms. Myroula Hajichristoforou

It is noteworthy to point out that no national expert has been appointed for the cases of France and Monaco. During the preparation of National Overviews, the authors were in contact with the national responsible, and, in some cases, benefited of the input from a number of national experts (as specified in each National Overview). Nevertheless, all findings, critical comments, opinions and proposals presented in the National Overviews are entirely under the responsibility of the respective authors.

This document, authored by José A. García Charton (associate professor of Ecology at the University of Murcia, and presently hired as RAC-SPA international consultant for the Mediterranean 'cluster B' sub-region for biodiversity and CC issues), has been guided by Dr. Daniel Cebrián Menchero (Marine Biology Expert, RAC-SPA SAP BIO Programme Officer), and Mr. Atef Limam (Marine Biology Expert, RAC-SPA International Consultant for SAP BIO).

Further from the National Overviews, and in addition to the basic regional and national SAP BIO documents, a number of regional and international documents and scientific articles have been consulted by the author to complement the information provided by national experts (see references below).

2. DATA AND INFORMATION AVAILABLE, RESEARCH, ACTUAL KNOWLEDGE

2.1 International sources

2.1.1 Fourth IPCC assessment report

The most important source of scientific information on the causes, impacts and possible response strategies to climate change, as cited by the national experts, is the set of periodic assessments elaborated by the IPCC[1] , so that the Fourth Assessment Report (AR4) "Climate Change 2007" is recognized to constitute the most comprehensive and up-to-date document available[2] , as, through three working groups, many hundreds of international experts assess climate change. As acknowledged by the report itself, this set of documents forms the standard reference for all concerned with climate change in academia, government and industry worldwide.

The contribution of Working Group I to the AR4 ("The Physical Science Basis"[3]) provides an updated perspective on the expected effects of CC on atmosphere, land surface, oceans, and snow, ice and frozen ground, together with the first probabilistic assessment of climate model simulations and projections using detailed atmosphere-ocean coupled models, and a detailed assessment of climate change observations, modelling, and attribution for every continent. For the latter information, Section 11.3 ("Europe and the Mediterranean") within Chapter 11 ("Regional Climate Projections" [4]) is relevant here.

Interestingly for the present report, within the contribution of Working Group II to the AR4 ("Impacts, Adaptation and Vulnerability"[5]), several chapters are devoted to provide a global perspective on the impacts of CC and sea-level rise on coastal and adjoining low-lying areas (Chapter 6[6]), and to the European case (Chapter 12[7]). The case of small islands (Chapter 16[8]) is relevant for the case of Malta, Cyprus, and other Mediterranean island states / regions, as well as for the multitude of islets spread over the Mediterranean coast (many of them already constituting marine and/or coastal protected areas). Chapter 17 is devoted to "Assessment of adaptation practices, options, constraints and capacity" [9], while chapters 18 ("Inter-relationships between adaptation and mitigation"[10]), 19 ("Assessing key vulnerabilities and the risk from climate change"[11]), and 20 ("Perspectives on climate change and sustainability"[12]) approach issues that are also relevant in the context of the present synthesis.

Finally, the Working Group III contribution to the IPCC AR4 ("Mitigation of Climate Change" [13]) focuses on new literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change, published since the IPCC Third Assessment Report.

2.1.2 Other international sources

The national experts highlight the importance of a series of scientific papers and reports dealing with CC issues in the Mediterranean regions, which are to be taken into consideration when planning forthcoming actions. Among the cited reports, we can underline those by Brochier & Ramieri (2001), Giannakopoulos et al. (2005) and Pérez (2008) (the latter elaborated especially as an assignment to the author by RAC SPA in the framework of the present action).

The number of scientific papers dealing with CC-related issues on the marine and coastal environment is increasing exponentially, so that it is out of the scope of the present report to summarise the information they contain. Further from the comprehensive review performed by Pérez (2008), however, a series of recent papers can be cited (among many others), dealing with consequences of sea-water warming and/or sea-level rise for the Mediterranean (e.g. Danovaro et al. 2004, Díaz-Almela et al. 2007, Occhipinti-Ambrogi 2007), response of European

[1] *http://www.ipcc.ch/ipccreports/assessments-reports.htm*
[2] *See synthesis report at http://www.ipcc.ch/ipccreports/ar4-syr.htm*
[3] *http://www.ipcc.ch/ipccreports/ar4-wg1.htm*
[4] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter11.pdf*
[5] *http://www.ipcc.ch/ipccreports/ar4-wg2.htm*
[6] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter6.pdf*
[7] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter12.pdf*
[8] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter16.pdf*
[9] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter17.pdf*
[10] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter18.pdf*
[11] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter19.pdf*
[12] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter20.pdf*
[13] *http://www.ipcc.ch/ipccreports/ar4-wg3.htm*

biodiversity to CC (e.g. Schröter et al. 2005, Thuiller et al. 2005, Dormann et al. 2008), and the implications of CC for conservation (e.g. Root & Schneider 2006, Brooke 2008, McClanahan et al. 2008).

2.2 National sources

Cyprus:

Not available.

Greece:

• The Greek capacity to monitor CC and its impact on marine biodiversity, as well as to provide advice or even solution to the problem is considered to be adequate. A growing number of scientific publications issued from national research efforts are being published on CC issues, notably about:

- Long-term hydrographical (temperature, salinity, nutrients, oxygen, etc.) and hydrodynamic (marine circulation, sea level, etc.) trends.
- Colonization and dispersion of thermophilic marine species (both alien and lessepsian species), leading to a phenomenon of recent "tropicalization" of the marine biota
- Metabolic, physiological, behavioural and ecological response of marine organisms to increasing seawa ter temperature.
- Geographic changes in the abundance of commercially harvested species (both pelagic and demersal resources).

• Ongoing scientific research at the national and international level is related namely to climate issues (inclding oceanic observation and forecasting), and cataloguing and detecting changes in marine biodiversity likely to be directly or indirectly linked to CC. Also, the spread of alien species and the thermal tolerance of important marine species are topics approached through research coordinated projects.

Israel:

• Israel has produced an important amount of scientific and technical information at the national level about the likely effects of CC on biodiversity; focus on marine and coastal biodiversity, however, appears to be lower than terrestrial biodiversity. Exceptions to this trend are the National Report linked to the elaboration of SAP BIO and the CAMP-Israel document.

• Special attention is paid to the issue of thermophilic marine alien species (mainly those entering the Mediterranean through the Suez Canal – Eritrean aliens). The latter issue has merited a number of high-quality peer-reviewed scientific papers, but, however, did not deserve national plans to assess this phenomenon.

Other issues stressed by the National expert are water scarcity, coastal erosion, and public health.

Italy:

• There is a large amount of information and studies available on the effect of CC in Italy. Most of this information has been published in a recent publication by CNR which gives an updated idea of what Italian research has been carried out in the field of climate and climate change.

• Most of the work done so far is on modelling of chemical-physical processes of climate, palaeo- and polar research on climate, satellite observations, measuring networks and the data base on climate change, climate change impacts and mitigation, and adaptation to climate change.

• Specific work on the vulnerability and impacts of climate change on marine and coastal biodiversity are scanty. There is information on the effect of increasing surface water temperature of sessile organisms but overall an organic way to study these effects does not exist.

• Overall, the quality of information available is high. In particular UNEP-MAP-RAC/SPA helped in focusing the problem of the impact of climate change on biodiversity in the Mediterranean Sea while the Italian Ministry for the Environment, Land and Sea and CNR provided a unique synthesis on the National (Italian) activities concerning

vulnerability and impacts of climate change. What is lacking is concrete examples and case of study.

Malta:

• National information regarding the effects of CC is related to the national reports produced under the UN FCCC (Malta submitted its First National Communication – FNC to the convention in 2004), and as a result of UNEP activities designed to contribute to the assessment of CC and the identification of suitable policy options and response measures.

• While local data on climate change impacts is limited, information on the status of the coastal and marine areas was indirectly derived from other sources, including EU transnational projects.

• Research related to CC in Malta is still in its preliminary phases and is not guided by a specific research programme. However, albeit at this stage research may appear to be fragmented, the current and envisaged research will lead to an overall strategy on climate change. Current research and data compilation efforts are those developed by the Malta Environment and Planning Authority (MEPA) and the University of Malta, focusing on vulnerability and adaptation (e.g. inventory and potential measures to abate GHG emissions, potential impacts of CC on vulnerable areas, updated NAP to meet Maltese international obligations), regional climate modelling, coastal meteorology, hydrography and physical oceanography.

Spain:

.Spanish research on CC issues is relatively well developed, as exemplified by the number of scientific reports and papers published. The Spanish national expert identified a series of national reports to inform on the progresses and initiatives undertaken to reach the objectives of the Kyoto Protocol. In addition, other documents are reported to assess the expected impacts of CC on ecosystems and economic sectors.

• The documents available provide an overview of (1) the current knowledge on climate change and marine biodiversity, as well as on vulnerability of marine and coastal biodiversity to climate change, and (2) actions un dertaken towards climate change mitigation and biodiversity conservation at global, Mediterranean and Spanish scales.

• Despite the evidence of climate change impacts on biodiversity, the magnitude of Mediterranean marine biodiversity responses to climate change remain largely unknown. This is partially due to the lack of long-term monitoring of Mediterranean marine biota and ecosystem processes, and the scarce information available on climate change impacts on marine organism physiology, population demography, reproduction, species distribution and ecosystem function.

Turkey:

• Turkey's Climate Change Coordination Committee was established by the Turkish Government in 200. This Committee has 8 working groups composed of government Institutions, NGO representatives, and universities. Working Group's Reports include CC potential future effects on agriculture, ecosystems, fisheries, water resources, diseases (leptospirosis, malaria, etc.), forestry, and climate scenarios, mitigation and adaptation options, measures, etc.

• Also, a set of research projects have been developed, dealing with different aspects of CC, such as forecasting scenarios, effects on aquatic and marine environments, and interrelation with parasite incidence (e.g. malaria, leptospirosis).

2.3 Synthesis and critical comments on the state-of-the-art

• The scientific and technical 'know-how' to deal with CC research issues appears to be high, as exemplified by the number of high-quality research papers published so far in scientific journals indexed in ISI.

• Research / monitoring actions in the sub-region are at present dealing with:

- Atmospheric changes and climate features
- Long-term marine hydrographical and hydrodynamic trends (including sea level)
- Hydro-geological changes and terrestrial implications on BD

- Coastal erosion and desertification
- Eco-physiological, behavioural and ecological response of marine organisms and populations to seawater temperature increase
- Geographical distribution shifts of native and alien species, including migration patterns
- Spatio-temporal changes in marine community structure
- Model development and forecasting projections
- Socio-economical impacts of CC (tourism, fisheries, aquaculture, etc.)
- Public health

• Despite that, however, the level of scientific knowledge of CC impacts on marine and coastal biodiversity is considered to be very low, due mainly to the lack of funding opportunities, as well as to unevenly distributed effort among countries.

3. NATIONAL ACTIVITIES RELATED TO CLIMATE CHANGE AND BIODIVERSITY

3.1 International Conventions, National Actions Plans and Strategies

Cyprus:

• Cyprus has already elaborated a National Action Plan to combat desertification on terrestrial environment with particular emphasis on agriculture, suggesting, inter alia, preventive measurers.

• In the framework of the Coastal Area Management Programme (CAMP) of the Priority Actions Programme Regional Activity Centre (PAP/RAC) of MAP, a CAMP-Cyprus project has been conducted. Within this project, a particular attention was given to the protection of marine biodiversity and relevant proposals are made under an extension of the scope of ICAM to include marine biodiversity and therefore, the ICAM could be referred as Integrated Marine and Coastal Area Management (IMCAM). Furthermore, within the ICAM the issue of climatic changes and their impact on the marine and coastal biodiversity has been included in the ICAM Cyprus. The main core project activities which are being proposed are: i) ICZM and ii) Tools of ICZM comprising (a) Strategic Environmental Assessment, (b) Carrying Capacity Assessment and (c) Resource valuation. The CAMP aims to strengthen the integration of policies for the conservation and sustainable development of coastal resources, to increase collaboration among the competent

Departments / Ministries in the policy-making and implementation process, to improve public awareness and to harmonize national / local level development visions.

Greece:

• Few legal instruments dealing with CC issues have been developed at the national level, despite a growing expression of the scientific consensus on policies, and the ratification by Greece of international conventions and protocols.

• International cooperation actions are being developed on the establishment of European networks of infrastructures for marine observation and research (including coastal observatories and ships), and on the deve lopment of CC forecasting models

• Monitoring actions include:
  - Sea level and SST
  - Water quality
  - Response of marine organisms to sea temperature rise
  - Changes in commercial fish species and communities (through fisheries data)
  - Changes in coastal planktonic assemblages
  - Shifts in spatial distribution of marine habitats

• Training CC-related activities are scarce, further from a number of ongoing funded PhD and MSc theses

• Different awareness activities (conferences and meetings) have been recently organised for policy-makers and managers, researchers, university students, stakeholders, NGOs and the general public.

• In general, the involvement of the Greek scientific community is scarce at present and mostly funded through international programmes (i.e. very few by national funds). The situation of monitoring and forecasting capacity in the framework of international efforts to model and understand large-scale physical and ecosystem changes due to CC is better perceived by the National Expert.

Israel:

• Legal activities are scarce (further from the ratification of the international conventions on CC).

The Ministry for Environmental Protection intends to boost an inter-ministerial plan to prepare the country against foreseen CC impacts.

• Some research is being developed on CC issues, with funds from National sources, namely about coastal erosion and climatic change scenarios.

Italy:

• Italy has coped well with the issue of CC by ratifying important agreements and developing appropriate measures to reduce the emission of greenhouse gases. Several programs are ongoing and many others are planned.
• Italy is also active in the International cooperation on CC-linked projects. Although recognized as an im portant aspect, the vulnerability and impact of CC on marine and coastal biodiversity needs more attention and specific actions are needed for the future. These actions should be agreed at a national level and it is hoped across the whole Mediterranean by specific agreements with other Mediterranean countries.

Malta:

• Legal activities related to CC in Malta are mainly associated with the relevant obligations arising from EU legislation (WFD, Bern Convention, Habitats Directive, Birds Directive, etc.), UNFCCC, and others (e.g. ICZM Protocol).
• To date, there is no overall national strategy or plan on adaptation and hence the only adaptation measures that may have been implemented in Malta (if any) have been on an ad hoc basis.
• There are no monitoring actions explicitly linked to CC, but data collection in the framework of research actions and international obligations are useful to provide data and assess CC-related trends.
• Malta is participating as observer through MEPA and the University of Malta, to the FP6 project CIRCLE (Climate Impact Research Coordination for a Larger Europe).
• Training programmes specifically related to CC impacts, vulnerability and adaptation are limited
• Public awareness on CC is mainly focused on mitigation (i.e. reduction of GHG emissions), including the use of alternative sources of energy.

Spain:

• Numerous activities addressing climate change and biodiversity are being conducted in Spain, encompassing legislation, elaboration of plans and programmes, participation in national and international committees, research and monitoring. Most these activities (except climatic monitoring) have been initiated during the current decade.
• Several legal activities are designed at European level and coordinated and implemented in Spain by the Spanish and autonomic governments concerning climate change and biodiversity. However, with the exception of the Water Frame Directive, legal actions concerning vulnerability and impacts of climate change on marine biodiversity are limited.
• Spain participates in international research programmes/committees concerning climate and global change and impacts on ecosystems. Research agencies at European, Spanish and autonomic levels promote research on climate and global change and their impacts on biodiversity through specific thematic areas.
Spanish researchers actively contribute to increase knowledge on these aspects by participating in international and national research projects as well by publishing the scientific results obtained. For instance, the number of scientific publications on global change by Spanish institutions has grown from less than 50 publications in 1990 to about 400 in year 2005. However a small proportion of publications on global change with participation of Spanish institutions concerned impacts on Mediterranean marine biodiversity.
• Atmospheric, meteorological and oceanographic parameters are being monitored along the Spanish Mediterranean by different agencies, in most cases, for more than 50 years. Most climatic time series are available and centralised by national agencies. Conversely, few monitoring networks of Spanish Mediterranean marine ecosystems are implemented so far. The Governments of three Spanish autonomies coordinate the monitoring of Posidonia oceanica meadows and one of them monitors invasive species along the Catalan coast. The few marine ecosystem monitoring networks existing along the Spanish coast have been initiated during the current decade.

Fisheries and chlorophyll a are being monitored by the Spanish Oceanographic Institute for several decades. Since the implementation of the Water Frame Directive, Posidonia oceanica meadows, phytoplankton, meiofauna and macroalgae within coastal and transitional waters are being monitored at different frequency, and for different time periods, depending on the region. Because the WFD monitoring of biological elements aims to assess the quality of the water masses instead of ecosystem conservation status, these monitoring programs might not be fully useful to detect ecosystem vulnerability and impacts of climate change.

• Training activities concerning biodiversity and climate change mostly apply to biodiversity on land and climate change.

• Spanish society is aware of climate and global change and, to some extent, vulnerability and impacts of climate and global change on marine biodiversity. The amount of news on climate and global change and impacts on biodiversity in Spanish media is rapidly growing.

Turkey:

• A series of initiatives have been launched, such as (i) a Conference on CC organised by the Ministry of Environment and Forestry (2004); (ii) a National report about CC in Turkey (2006), covering a wide array of CC-related issues (including e.g. vulnerability assessment, adaptation measures, impact assessment, mitigation scenarios, etc.); (iii) a Biodiversity Strategy and Action Plan Preparing project as prepared by the Ministry of Environment and Forestry, and an associated workshop (2007); (iv) a Fisheries Expert Group report (2007); and (v) a series of scientific and technical meetings dealing with CC in Turkey.

• No legal work is being developed at present specifically addressing CC issues.

• No monitoring initiatives specifically addressing CC issues have been launched, further from research programmes of university faculties, focusing on fisheries.

• Public awareness activities are still scarce but a growing interest has been detected by the national expert on CC issues.

3.2 Problems and constraints

• The national capabilities in CC-related research and/or monitoring issues are unequal among countries.

• Large gaps in knowledge exist on the effects of CC on biodiversity and their consequences for human populations, although some countries are more advanced in the pursuit of these subjects

• Participation in international coordination activities is not general in the sub-region

• Training and public awareness is identified as a priority, although its application is unequally distributed

4. VULNERABILITY AND IMPACTS

4.1 Vulnerability assessed and impacts identified

Cyprus:
Not available.

Greece:
• Recent research has detected important modifications of the thermohaline circulation in the Eastern Mediterranean, compared to early 1990s, as a result of changes in salinity and temperature of water masses, likely to be attributed to a climatic shift over the Aegean Sea, with the synergistic effect of runoff control of major rivers. These changes have initiated a series of modifications in the hydrology and dynamics of the entire Mediterranean, with possible influence on the Mediterranean outflow into the North Atlantic Ocean.
• In addition, increasing attention is recently being drawn to the atmospheric inputs of dust, containing nutrients and trace elements that are considered to affect the pelagic ecosystem.
• The Eastern Mediterranean is considered as an important source of sea water dimethylsulfide (DMS), so that climatic changes are going to be especially relevant to the regional atmospheric sulfur budget.
• Some studies give response to the concern about the behavioural, metabolic and molecular stress response of marine species (the national report cites the case of the bivalve Mytilus galloprovincialis) to elevated CO2 and temperature levels.
• Numerous studies focused on the detection and characterization of shifts in the geographical distribution or other changes in thermophilic organisms, as a likely result of (and/or a facilitating effect of) sea water warming, such as:

- Tropical / sub-tropical species originating from the western Atlantic (e.g. Percnon gibbesi, Oculina patagonica, etc.)
- Lessepsian migrants (from the Indo-Pacific through the Suez Canal) (more than 87 species recorded in Greek waters)
- Northern expansion of thermophilous fish (e.g. Lampris guttatus, Sardinella aurita)
- Mucilage events and harmful algae blooms (HABs) (e.g. Coolia monotis)
- Mass occurrence of scyphomedusae (e.g. Rhopilema nomadica)
- Increase in the abundance of certain zooplankton taxa (e.g. Oithona plumifera, Oncaea sp.)
- Change in marine resources –both pelagic (e.g. Sardinella aurita) and demersal (e.g. increased recruitment of commercial fishes in the Eastern Ionian Sea, first record of species of commercial interest such as the bathy-benthic octopus Bathypolypous sponsalis, or the increasing trend of abun dance and temporal shift in maturation of the squid Illex coindetii)
- Biological invasions, so that the number of known marine alien species in Greek waters (155 in December 2007) is sharply increasing.

Israel:
• As a first observation, the national reports highlight the significance of uncertainty of currently available CC scenarios, stressing the difficulties to accurately foresee what the impacts of CC are going to be.
• The physical impacts of CC are likely to be:

- Changes in precipitation (volume, predictability and spread), with the probable increase in frequency and intensity of flash floods, and the changes (probably decreases) in groundwater recharge
- Accelerated coastal erosion (beaches, cliffs, wetlands, and other riparian habitats), exacerbated by the changes suffered by the Nile delta as the main source of sand to the Israeli coast; concomitant economic impacts are to be expected
- Sea-water intrusion into the coastal aquifer, with associated losses of permanent reserves, also likely to

be affected by extreme events (such as tsunamis)

• The link between CC and public health has been stressed, with the example of the emergence of infections due to the free-living marine bacteria Vibrio vulnificus in Israel during the summer of 1996. Another example is the increase in vector-borne diseases (for instance carried by mosquitoes), such as the West Nile Fever, which caused a high human morbidity in the early 2000s.

• The national report describe the likely effects of CC and associated physical changes (temperature increase, sea level rise, shifts in marine circulation and frequency of extreme events – winds and storms) on marine and coastal biodiversity. The main response identified are:

- Changes in the life cycle of marine species: timing of ontogenetic stages (resulting in a temporal mismatch between larval production and food supply), spatio-temporal patterns of dispersion and settlement (likely altering the balance of larval recruitment to adult mortality, thus leading to local extinctions)
- Changes in distribution (horizontal, or vertical – zonation) or health of population of key structural (habitat-forming) marine and coastal species (e.g. macrophytes, vermetid platforms) and habitats (e.g. coastal wetlands, low-lying offshore islets)
- Decrease in marine ecosystems resilience (i.e. resistance and reversibility to disturbance)
- Biogeographical range shifts of native and allochtonous (including invasive) species, resulting in severe community and ecosystem changes due to local extinctions and introductions

Italy:

• The national expert highlights the difficulty to forecast effects of CC on Italian (non-Adriatic) marine and coastal biodiversity, although, due to geomorphological and biological features, this entire sector is likely to be affected.

• Greater impacts are expected in:

- Cold or cold-temperate parts of the Mediterranean, as well as the Black Sea
- Habitats situated at the level of the summer thermocline (e.g. coralligenous), and also in the shallower infralittoral zone (e.g. vermetid platforms), with gorgonians, sponges and octocorals being the most threatened species

• A particularly damaging effect is the spread of invasive species, both by the expansion of the geographic range of thermophilic species, and the facilitation of the installation of alien species

• The response of marine communities / ecosystems to the appearance of new (and probably competitively superior) species is difficult to predict, although changes in species dominance and biotic "homogenisation" have been hypothesised.

• Special focus is recommended on the numerical and evolutionary responses of meiofaunal species to CC, as well as on the eco-physiological response of seagrasses (namely Posidonia oceanica).

• The risks of sea level rise have been stressed, so that 27 areas have been identified as being at risk of resulting severely affected (namely sandy coastal areas and coastal lagoons).

• Socio-economic repercussions of CC effects on marine and coastal biodiversity have been studied for the case of fisheries, aquaculture, tourism, public health, and agriculture.

Malta:

• Local meteorological data (as showed in the FNC) indicates an increase in the mean annual air temperature of about 0.5° C in 77 years, which is in agreement with the regional values during the last century; such temperature increase is also reflected in the marine environment, with an increase in SST of 1.25° C at 1 m depth since 1978. FNC local data and projections indicate higher temperatures and a potential decrease in rainfall in the Maltese Islands by the end of the century, in accordance with the regional forecasting of AR4. These expected changes can have irreversible effects on coastal and marine biodiversity.

• Terrestrial coastal ecosystems (particularly plants) are expected to suffer most from drought, increased evapotranspiration and a decline in the availability and quality of freshwater, although no specific information is available

on the tolerance levels of coastal species to higher temperatures and reduced freshwater availability. The FNC identified the 6 habitats (among those listed in the Annex I of the EU Habitats Directive) more likely to be affected by drought, although the national report also emphasizes that all coastal ecosystems can be indirectly affected by the lack of freshwater resources, for instance through the expected environmental impacts of building new desalination plants.

• The increase in temperature, coupled to its effects on the marine physical environment, can have several repercussions on both benthic and pelagic biota. Among these, the Maltese national report highlights the following:

- Changes in abundance, distribution and migration patterns of marine species, including fish species of commercial importance (e.g. Coryphaena hippurus)
- Introduction of invasive species, such as Lessepsian migrants: molluscs (e.g. Atactodea striata, Brachidontes pharaonis, Cypraea pantherina, Natica gualteriana), fishes (e.g. Siganus spp., Sphyraena chysotaenia, Stephanolepis diaspros), algae (e.g. Acanthophora najadiformis, Botrycladia madagascariensis, Caulerpa racemosa, Halophila stipulacea, Lophocladia lallemandi)
- Outburst of diseases in marine benthic fauna (e.g. the Maltese document reports that 15 years ago, a spread of disease affecting sea-urchins nearly wiped out the populations in Maltese waters)
- Relocation of areas hosting primary productivity, with possible increase in HABs
- Changes in salinity, linked also to the increased use of desalination plants, and likely affecting Posidonia oceanica meadows
- Sea level rise threatening coastal habitats such as wetlands, and increasing coastal erosion of low-lying areas (this issue is of particularly critical importance for the North-eastern coast of the Maltese islands)
- Increased frequency of extreme weather events (cold days, heat waves, heavy precipitations, extreme high sea level and storm surges), likely to increase coastal erosion, and affect freshwater availability through increased runoff and reduced aquifer recharge, and affecting marine coastal areas by the increase in turbidity and pollution of coastal waters (benthic habitats identified to be affected by these phenomena are associations with Lithophyllum lichenoides, maërl facies, P. oceanica meadows, facies of Cladocora caespitosa, and Cystoseira spp. communities)
- Other potential impacts associated to CC include changes in water circulation, and changes in biogeo chemical properties, although no local data are available on the potential effects of such changes on marine biota

Spain:

• The Spanish report highlights that the magnitude of atmospheric temperature rise in Spain during the XXth century has been larger than that recorded globally, with a concomitant rise in sea water temperature.

• Global climate models forecast a relatively uniform increase of temperature in Spain of, on average, 0.4 °C per decade in winter and 0.6-0.7 °C per decade in summer (depending on the scenarios), but actual data are increasing even faster than that forecasted by the most unfavourable scenario.

• Other expected general effects of global warming are decline in precipitation, increase in the frequency of extreme events, and sea level rise (of about 50 cm, and perhaps up to 1 m by the end of XXI century).

• Present fingerprints of these changes on marine and coastal biodiversity are:

- Increased mortality of some species
- Changes in species reproductive biology
- Increase in the arrival of invasive species

• Expected impacts of CC on coastal areas are:

- Threats to low-lying coasts (deltas, coastal lagoons and other wetlands, beaches) and the habitats and species living on them (e.g. seagrass meadows)
- Eco-physiological response of marine phytoplankton to increasing CO2 and warming seawater, strengthened by synergies with other anthropogenic effects (e.g. increased nutrient availability), leading to changes in marine productivity.

- Produce mass mortality events of sessile (e.g. gorgonians, scleractinians, sponges) and benthic mobile (e.g. crustaceans) species, as well as increase the mortality rate of seagrass species (e.g. Posidonia oceanica).
- Produce the shift in geographical distribution range of marine species.
- Favour the settlement and spread of invasive species.
- Increase the risk of hypoxic events in coastal marine systems, particularly during calm periods.
- Increase seawater pH

• Expected impacts on socio-economic activities relies on:

- Modifying fish larvae and recruitment dynamics, as well as impact on the physiology of diadromous species and migratory routes and depth distribution of other species of commercial interest, hence affecting fishing stocks.
- Likely effects on aquaculture, by affecting local planktonic productivity and hydrological parameters, as well as favouring the arrival and spread of mariculture parasites.

Turkey:

• The three sub-regional seas surrounding the country (Aegean, Black, and Eastern Mediterranean Sea) experience different situations regarding the effects of CC, but, in general, the available information is fragmented, occasional, and usually local.

• The increase in sea water temperature around Turkey over the past 20-25 years is a fact, causing effects and threats to marine organisms in recent years, such as:

- Episodes of mass mortality and bleaching of gorgonians
- Effect on larval and juvenile fish stages
- Damage to migratory movements of anadromous and catadromous fish species
- Possible loss of low-lying areas (e.g. beaches, supra- and midlittoral zones, islets) likely to affect sensitive species (e.g. nesting of sea turtles, vermetids)
- Distributional shifts of some species (e.g. sardine, bogue, salema, peacock wrasse, sea urchins, etc.), including invasive species, with first records in the Black Sea as early warning signals

• Special emphasis has been made in the national report on the following topics:

- Impact of invasive species on native fauna and flora
- Changes in fish composition and catches of the commercial fisheries
- Harmful effects of venomous or toxic species (e.g. Lagocephalus sceleratus, Pelagia noctiula, Rhopilema nomadica)
- Effects of CC on populations of marine mammals (9 cetacean species and one pinniped – Monachus monachus, are known to occur in Turkish waters), due to shifts in distribution of the cetaceans themselves or their preys (small pelagic fish, demersal fish, squids, etc.)

4.2 Synthesis and critical comments

• Different national reports highlight the high level of uncertainty associated to the likely effects of CC on coastal and marine biodiversity in the medium-to-long term (i.e. several decades), linked to the degree of accomplishment of adequate mitigation measures in the countries concerned.

• All national reports agree in the idea that the effects CC on the physical environment are already being detected, especially related with increase in SST, hydrological and hydrodynamic changes, sea level rise, and increased frequency of extreme events – precipitations, winds and storms.

• Expected physical and chemical damages of these effects are accelerated coastal erosion, seawater intrusion into coastal aquifers, threats to low-lying areas (deltas, coastal lagoons and other wetlands, beaches and dunes, supra- and midlittoral zones, etc.) – with particular emphasis on the threats to islands, and changes in the nutrient supply and dynamics of coastal and high-sea waters.

• Short-term effects on biodiversity are being already observed, such as spatio-temporal patterns of biodiversity,

shifts in the abundance of particular species, and changes in eco-physiological processes of vulnerable species (reproduction, immunological response affecting the individual performance at various stages of their life history, and possible adaptive selection pressure on species traits).

• Special emphasis has been putted on the occurrence and spread of thermal species (both by colonisation of new species originating from the Atlantic through the Gibraltar strait and the Indo-Pacific through the Suez Canal, and by the invasion of allochtonous species via anthropogenic actions – e.g. shipping,

• Aquariophilia, aquaculture, and other sources of alien species. Other phenomena such as mucilage events, harmful

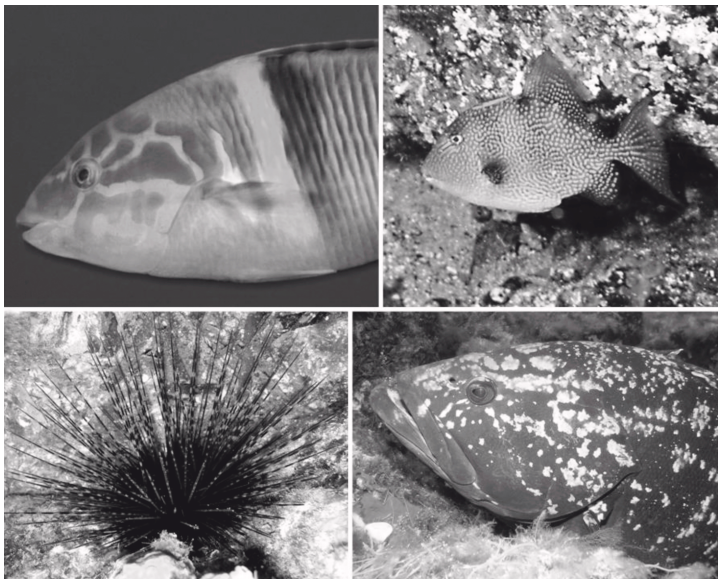
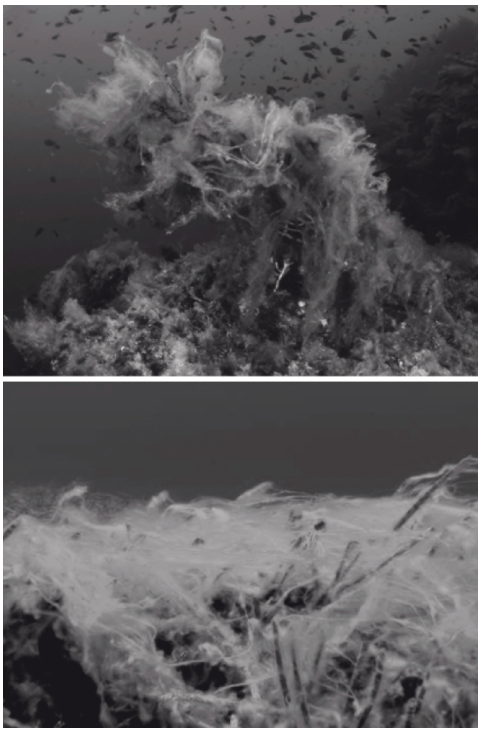


Figure 1 : Indicator species of the southernizing of the north-western Mediterranean. A) the ornate wrasse Thalassoma pavo; B) the grey trigger fish Balistes carolinensis; C) the sea-urchin Centrostephanus longispinus; D) the dusky grouper Epinephelus marginatus. Photos R. Graille (A), J.G. Harmelin (B) and T. Pérez (C,D)

(please refer to colour figure 1 on page 21).

algal blooms and mass occurrence of scyphomedusae are likely to be facilitated by CC in synergy with other anthropogenic impacts (e.g. overfishing, nutrient load and other sources of pollution, etc.).

Another ongoing phenomenon, increasingly frequent in coastal waters of the countries, is the occurrence of mass mortality of structural species (e.g. gorgonians, octocoral colonies, sponges, etc.)



• At medium term, more complex phenomena are expected, such as changes in the life cycle of marine species, distributional range shifts of species and habitats, local extirpation of vulnerable species and, ultimately, decrease in the resilience (i.e. resistance and reversibility to disturbance) as well as profound changes in the functioning of marine ecosystems, which at present are difficult to forecast with the adequate level of accuracy.

Figure 2: Proliferation of filamentary algae on the seabed in the north-western Mediterranean. Here, two events observed in the water of Port-Cros National Park in 2003 (A) and in 2007 (B). The mucilages covered the epigaeal fauna in the coralligenous droops (A) and the Posidonia meadows (B). Photo by R. Graille (A) and T. Pérez (B).

(please refer to colour figure 2 on page 21).

Color plates

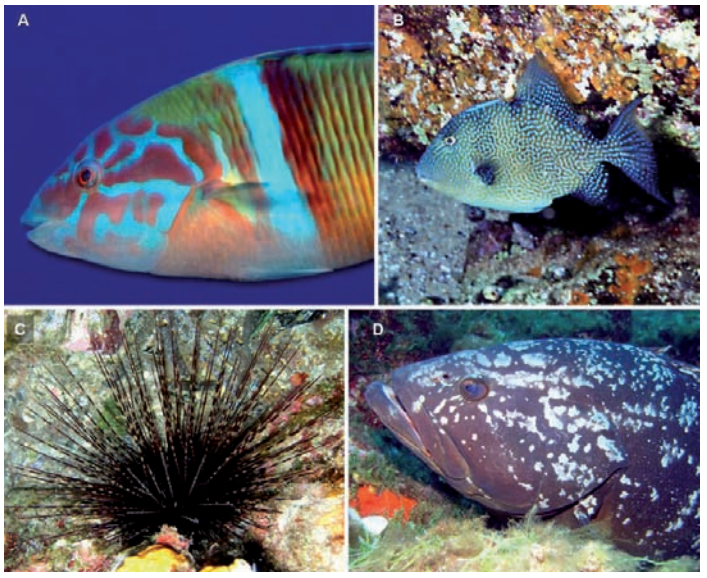


Figure 1 (Page 20) :
Indicator species of the southernizing of the north-western Mediterranean. A) the ornate wrasse Thalassoma pavo; B) the grey trigger fish Balistes carolinensis; C) the sea-urchin Centrostephanus longispinus; D) the dusky grouper Epinephelus marginatus.
Photos R. Graille (A), J.G. Harmelin (B) and T. Pérez (C,D)

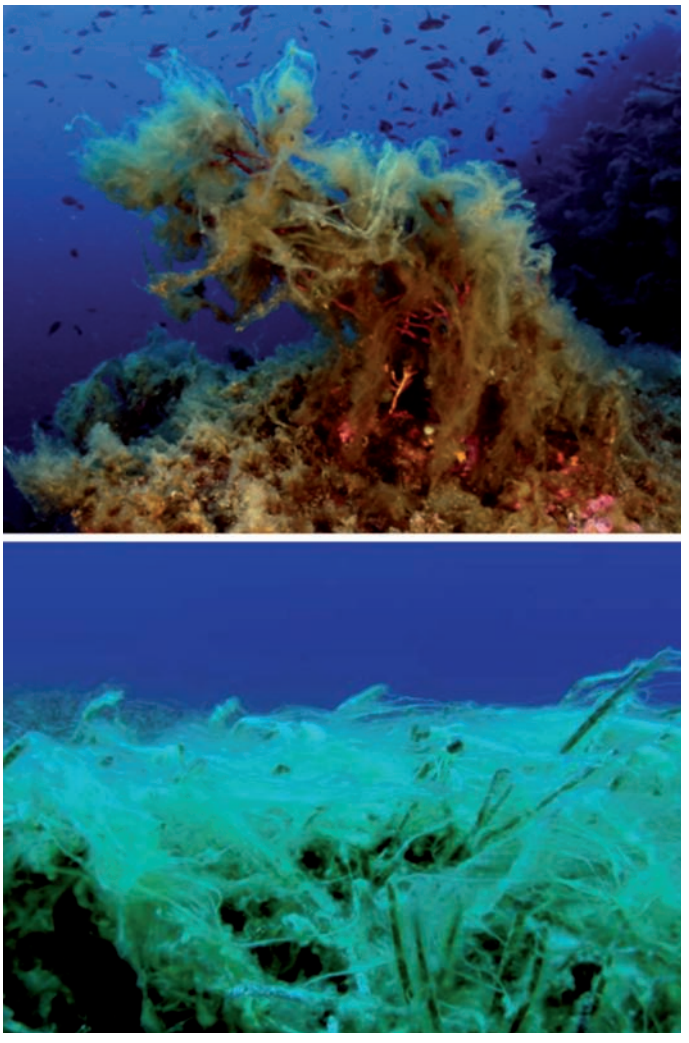


Figure 2 (Page 20) :
Proliferation of filamentary algae on the seabed in the north-western Mediterranean. Here, two events observed in the water of Port-Cros National Park in 2003 (A) and in 2007 (B). The mucilages covered the epigaeal fauna in the coralligenous droops (A) and the Posidonia meadows (B).
Photo by R. Graille (A) and T. Pérez (B).

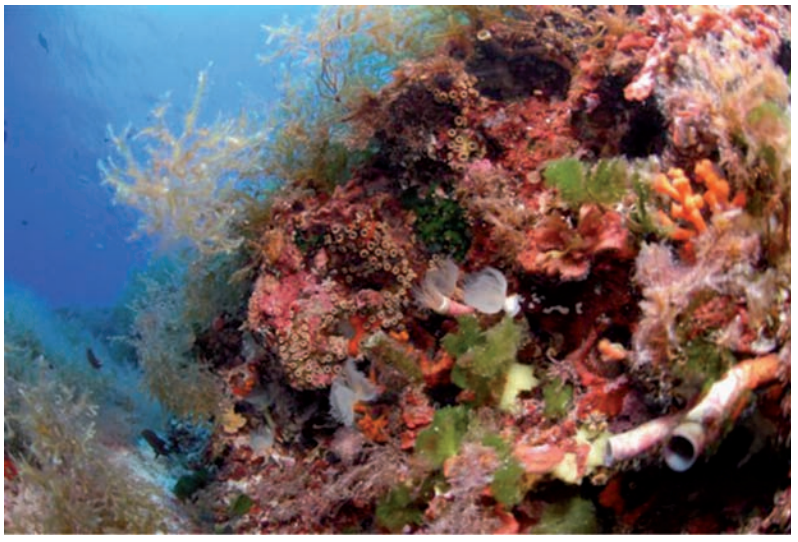


Figure 3 (Page 25) :
The most threatened habitats, are those most particular to the Mediterranean, such as A) coralligenous assemblages, or B) structures at the sea surface such as the "encourbellement" of Lithophyllum lichenoides while C) the general regression of the Posidonia oceanica meadows at Mediterranean level seems to be ascribed with difficulty to the warming phenomenon affecting this sea during the last 30 years.
Photos by F. Badalamenti.

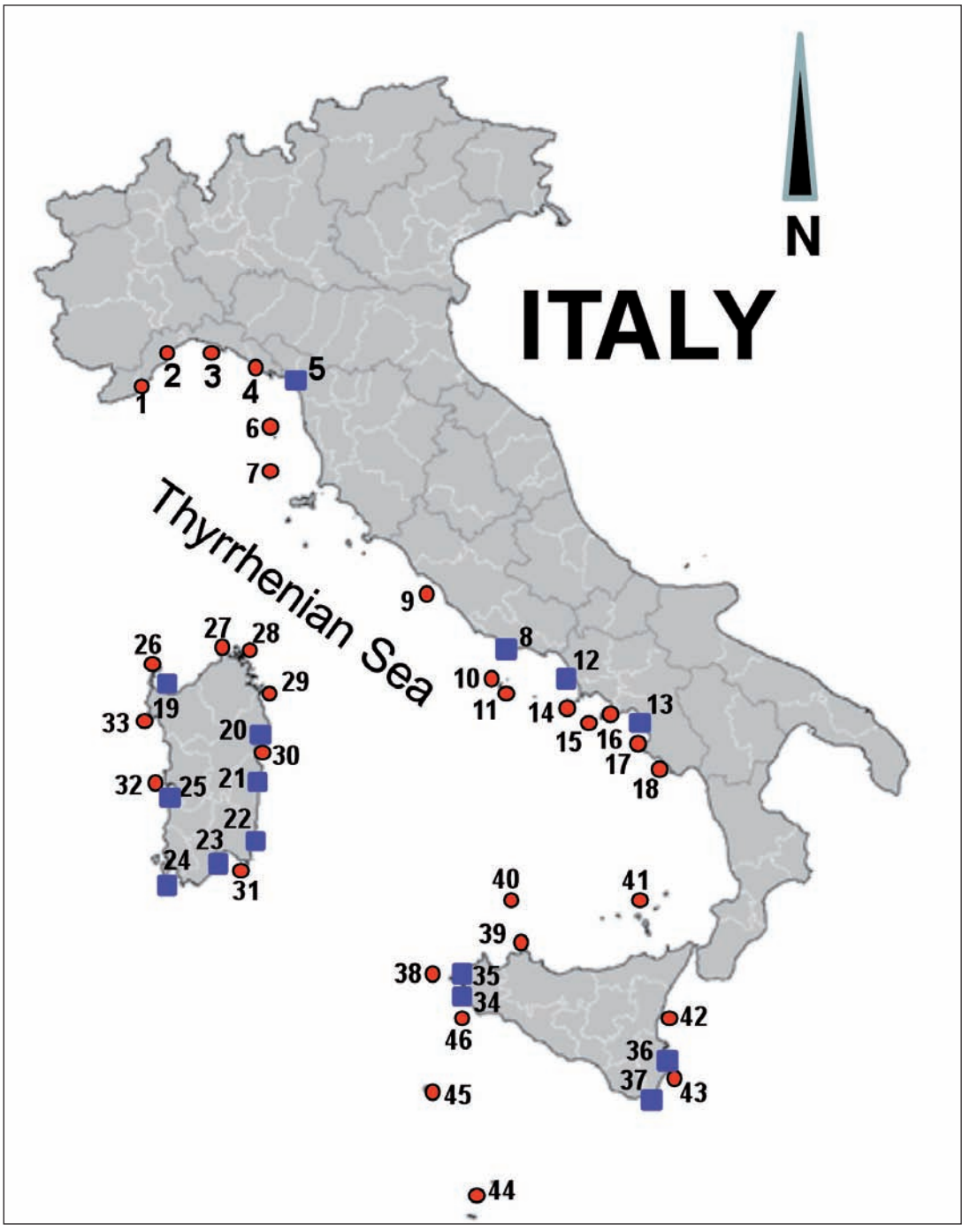


Figure 4 (Page 41) :
List of marine and coastal sites considered to be especially at risk (or endangered) in the short term by the effects of climate change in Italy (Adriatic excluded). Squares refer to Areas at risk from rises in sea level and circles refer to areas at risk of impact on biodiversity.

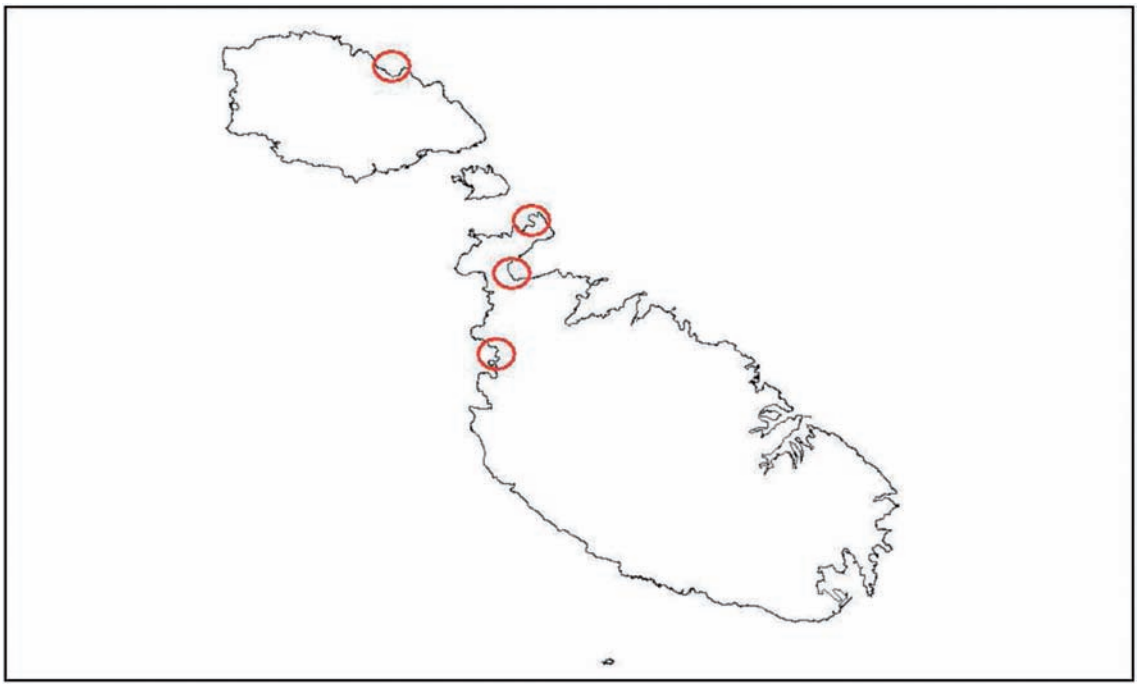


Figure 6 (Page 43) :
Location of the extant sand dunes in the Maltese Islands (Source: MEPA)

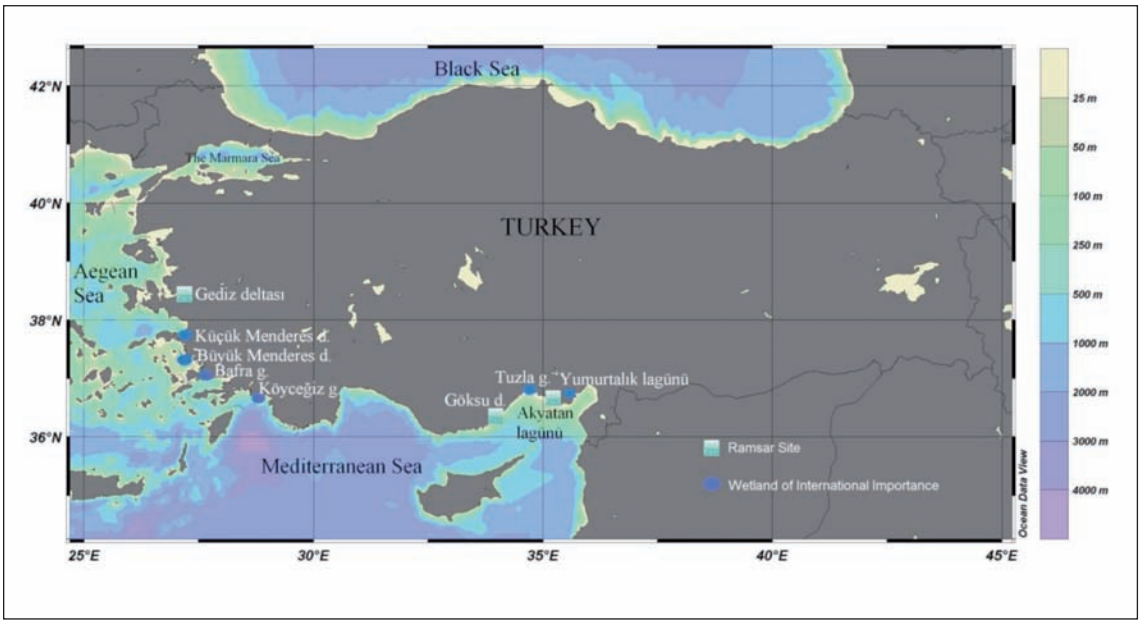


Figure 7 (Page 44) :
Wetlands and lagoons possibly affected by CC

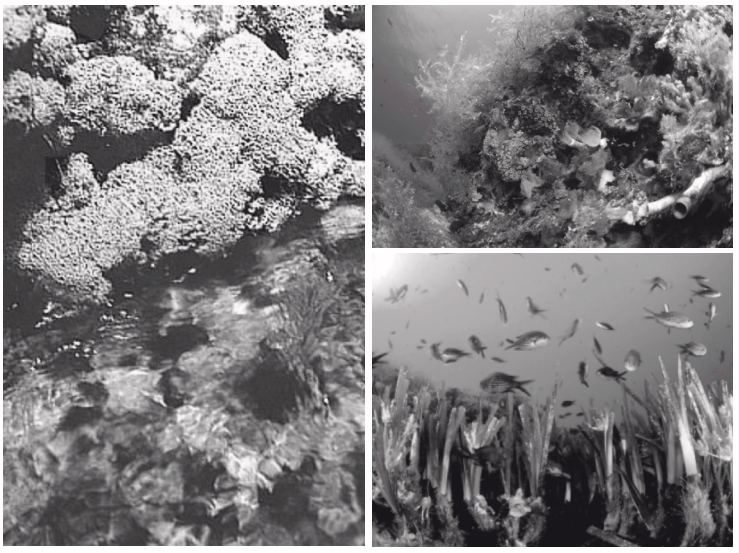


Figure 3 : The most threatened habitats, are those most particular to the Mediterranean, such as A) coralligenous assemblages, or B) structures at the sea surface such as the "encourbellement" of Lithophyllum lichenoides while C) the general regression of the Posidonia oceanica meadows at Mediterranean level seems to be ascribed with difficulty to the warming phenomenon affecting this sea during the last 30 years. Photos by F. Badalamenti.

(please refer to colour figure 3 on page 22).

• All these changes are likely to exert deep impacts on the economy of coastal populations, as well as on public health.

• In general, the countries highlight that despite the high effort devoted to now to investigate and assess these changes, much more is needed to be done at both research and monitoring levels.

5. NEEDS AND URGENT ACTIONS PROPOSED

5.1 Needs and urgent actions

Cyprus:
Not available.

Greece:
The improvement of the scientific understanding of CC and its impact on biodiversity gives raise in parallel to new questions about the implications of changes in the water mass characteristics and the redistribution of the modified water masses to the biology of the Greek Seas. Detected gaps in knowledge and associated needs have been stressed, regarding:

- Local measurements of air-sea exchanges, as well as studies on changes in the extremes in sea level, in order to validate existing global models and data banks
- Monitoring actions, taken in a systematic basis, to collect data on spatial and temporal shifts in fisheries, benthic communities, the spread of alien species, and geographical and long-term trends in plankton communities (specially jellyfish and red-tide species); in particular, the promotion and consolidation of data derived in the framework of EU directives as well coordination of observations gathered from various sources is suggested.
- Developing programmes for data collection and monitoring on the presence of non-indigenous marine species and their population trends (including those used in aquaculture), the impact of such alien species on the indigenous biodiversity, and the origin of ballast water discharged into territorial waters; this monitoring effort is suggested to focus particularly on 'hotspots' (ports, coastal lagoons, aquaculture sites, sensitive areas, etc.), by developing a alien-specific indicator, and through adequate training programmes; the need is highlighted to launch legal improvements at the national and international level.
- Immediately initiating a study to assess the vulnerability of Greek coastline to erosion, and formulating a National Adaptation Strategy to mitigate the impact of CC, based on (i) encouraging research into new technologies for managing coastal areas without disturbing natural processes, and (ii) public education and awareness on CC issues and their consequences.
- Preparing National Reports aiming at assessing the situation as regards the impact of CC on biodiversity.

Israel:
The national report stress the fundamental need for more research, as no policies, plans or actions are valid or useful as long as we lack a solid understanding of the possible impacts of climate change on marine and coastal biodiversity. Research gaps, as identified in this report, relies on:

- Understanding non-linear responses of littoral systems to CC, likely leading to catastrophic regime shifts; special emphasis is to be done on synergistic effects of multiple stressors linked to CC (e.g. temperature, UV, CO2, etc.) or not (e.g. overfishing, agricultural runoff, alien species).
- Linking individuals and populations to communities and ecosystems dynamics.
- Development of predictive modelling tools.
- Multidisciplinary studies (gathering biological, physical and humanistic research practitioners); this would require training and capacity building within Israel coupled with international cooperation and assistance.

Italy:

Priority needs are:

• Well directed funding for monitoring and research (both multidisciplinary and on an international scale), to understand and predict the effects of climate change on marine ecosystem structure (e.g. species composition, food web lengths, size distribution) and functioning (e.g. biomass, production and decomposition processes, predator-prey interactions); assess the relative role and or synergism of fishing, eutrophication and climate change on variation of fish stocks

• Developing the right tools for implementing dialogue between politicians and researchers

• The creation of a network of sampling sites, preferably within the system of Italian (and European – Mediterranean) marine protected areas, to measure biodiversity variables to relate to climate change.

Malta:

Priority national needs regarding CC include:

• Filling gaps in data and information through more research, particularly on:
  - Projections of climate parameters at local scale by downscaling of regional scenarios
  - Biology (e.g. life and reproductive cycles, genetics) of key, sensitive species and ecosystems, including to lerance levels, ensuring also the availability of data on the distribution of marine habitats and of endemic or rare species
  - Monitoring schemes to assess changes in species population dynamics and habitats, and the likely effects
  - f CC on them

• Training and capacity building, in particular in analysis of CC impacts, vulnerability and risk assessments, and assessment of adaptation options and costs of adaptation (also in terms of ecosystem services)

• International cooperation with / assistance to or from other countries within the same biogeographical area, in order to ensure a collective effort to address CC impacts and deal with the transboundary nature of such impacts.

• The most urgent needs are related to the current gaps in data and information on CC impacts and the vulnerability of coastal and marine biodiversity, and, in general, to put CC top on the agenda, to recognize need for action at a national level.

Spain:

• The Spanish national report highlight the need for:
  - Increase the number of marine protected areas.
  - More information on the distribution and conservation status of vulnerable ecosystems.
  - A planned retreat from vulnerable coastal areas.
  - Long-term monitoring of ecosystems and habitats vulnerable to CC.
  - Increased participation of Spanish research and management institutions in international programmes
  - Promotion of research on CC issues and their synergies with other global change impacts to marine and coastal biodiversity
  - Increase the dissemination and training activities.

• Identified gaps in knowledge are the following:
  - Time series on climate parameters (seawater temperature, sea level rise) are lacking for most of the Mediterranean regions, particularly Eastern and Southern Mediterranean
  - Long term monitoring of marine biota and ecosystem processes is lacking for most of coastal Mediterranean regions
  - Impacts of changes in rainfall (increased flood/drought events) on marine biodiversity are poorly known
  - Identification of climatic threshold values for shifts in coastal ecosystems
  - Need of more information on invertebrate populations life-cycle (reproductive efforts, successful reproduction and recruitment of larvae, the contribution made by asexual reproduction and

regeneration in maintaining populations), gene flow between populations and dispersion of propagules, adaptation capacity to stress
- Availability of very few eco-physiological studies on Mediterranean species affected by climate change
- Little knowledge on impacts of climate change on ecosystem function
- So far, no model has tried to assess the future of Mediterranean biodiversity under climate change scenarios

Turkey:

National needs involve:

• Legal support to CC issues at national and international levels.

• Increasing research efforts devoted to understand and asses CC effects on marine and coastal biodiversity

• Launching a monitoring programme to assess impacts of CC to the seas and coastal areas, and support long-term faculty initiatives concerning especially the study of fisheries shifts, risks to coastal habitats (wet lands, beaches, rivers, etc.), benthic habitats, distribution shifts of invasive species, impacts on marine mammals.

• Undertake special training and awareness programmes, according to stakeholders' demands and priorities 5.2

5.2 Synthesis of national needs

• To improve the scientific understanding of CC and its impact on BD, by mean of adequate and internationally co-ordinated long-term monitoring and research initiatives. Topics highlighted are:
- hydrographic / hydrodynamic / climatic measurements to validate existing and forthcoming models
- monitoring of the coastline, assessment of erosion / desertification vulnerability and risks
- monitoring of selected benthic / nektonic / planktonic species / habitats
- special emphasis on the spread of alien species
- basic research on the biology of species vulnerable to CC
- studying non-linear responses of littoral ecosystems to CC, and population-to-ecosystem links (functional approach)

• Development of predictive modelling tools, under different mitigation, adaptation and population growth scenarios, including down-scaling of regional scenarios

• Enhance communication and exchange (among scientists, managers, stakeholders)

• Training and public awareness initiatives

• National strategies and initiatives to study CC-BD issues on a multidisciplinary basis and through regional cooperation

6. INTERNATIONAL CO-OPERATION, SUPPORT AND FUNDING

6.1 Co-operation and support: needs and opportunities

Cyprus:
Not available.

Greece:
• No contribution of the country to cooperation initiatives with developing or emerging countries have been identified by the national report.
• The country is participating in international committees and networks (e.g. EUROCEANS, Med-CLIVAR, etc.), as well as in international projects to develop CC models (e.g. collaboration between the Aristotle University of Thessaloniki and the Alfred Wegener Institut für Polar und Meeresforschung).

Israel:
• No contribution of the country to cooperation initiatives with developing or emerging countries have been identified by the national report further from the signature and ratification of CC-related international conventions

Italy:
• Italy promotes bilateral cooperation programmes on CC with developing countries (237 projects with more than 45 countries in the years 2001-2006), with diverse and ambitious objectives (e.g. efficient use of energy and water resources, promotion of renewable resources, training and exchange, promotion of eco-efficient technology). The Mediterranean region is targeted through the MEDREP (Mediterranean Renewable Energy Programme). Other regions receiving particular attention are China, South America and the Caribbean.
• Central Eastern Europe (CEE) is receiving particular support through the Task Force established for this region in Belgrade in 2004 by the Italian Ministry for the Environment, Land and Sea (MATTM) (53 projects in 13 countries, with special emphasis on Serbia), focused on strengthening local and national capacities on environmental governance, transferring know-how and technology to prevent and control pollution and water management, and promoting renewable energy and energy efficiency. Also, the MATTM organised a training course on the Kyoto Protocol for 500 experts from CEE. Furthermore, this area receive particular attention after the establishment in 2001 of the Italian Trust Fund (ITF) as a targeted contribution of the MATTM to the Regional Environmental Centre for CEE (REC).
• Italy cooperates (contributing with substantial amounts of money) with various multilateral partners such as UNEP, UNDP, the World Bank and the GEF.

Malta:
• No contribution of the country to cooperation initiatives with developing or emerging countries have been identified by the national report.

Spain:
• The national report does not identify specific cooperation actions with third countries in CC issues, further from the signature and ratification of international conventions (UNFCCC, Barcelona, etc.).
• Spain supports and participates in a series of international research programmes and committees on CC, such as the International Programmes Geosphere – Biosphere (IGBP), Diversitas, Human Dimension of Global Change (IHDP), the Consortium for Earth System Science (ESSP), and the Spanish Committee of Global Change Research (CEICAG).
• The country is also contributing to the international systems and networks for CC monitoring.

Turkey:

• Turkey is a party to both the Bucharest and Barcelona Conventions and to other related protocols as well. Besides, Turkey has signed UNFCCC and participated in some preparatory meetings with UNDP, World Bank and EU for international cooperation. Turkey, however, needs more stringent cooperation on CC issues.

6.2 Funding: problems and opportunities

Cyprus:

Not available.

Greece:

• The main message is that more national funds should be allocated to study the impact of CC on marine biodiversity: National Report stressed the need to devote resources coming from the Greek ministries to marine CC-related issues, as at present none of the Greek funded research projects is so far focused on CC. Interestingly, the opportunity to use private funds currently allocated to EIAs of local or particular projects to provide useful data has been proposed, in particular when monitoring schemes are required. Also, private funds could be allocated to CC concerns through projects co-funded by the EU, such as LIFE+. Some expectation is raised among the scientific community about the funding possibilities derived from the increased concern of EU about CC issues, given the long experience and track record of Greek researchers on this topic; nevertheless, EU research programmes cannot be considered as a regular source of funding, and then financing lines should be opened to make this research interest more constant.

Israel:

• The national report underline that no funding is available for the study of marine/coastal biodiversity vulne rability to climate change in the budgets of national ministries.

Italy:

• As a general rule funding is not regular (i.e. the same agencies/institutions do not fund regularly) or stable (different agencies/institution may fund research on climate change through years). In addition, funding to research on marine and coastal biodiversity is pretty limited, and access to funding opportunities not that easy.

Malta:

• At present, there are no regular national funding sources targeted specifically at CC issues

• Malta has embarked on private-public partnerships on various environmental issues (such as management of protected areas); however none of these were related to CC. Nevertheless, opportunities of such partnerships in the future are not being discounted.

• While several international funding opportunities may be tapped for CC-related projects, there are no specific instruments dealing exclusively with CC. Notwithstanding this, several EU and international mechanisms directly address CC amongst other priorities (such as structural and cohesion funds, LIFE+, FP7, or GEF). Each funding programme or mechanism is bound by its own rules, and eligibility criteria vary for different programmes.

Spain:

• Funding sources for research projects include national and regional public administrations (Ministry of Science and Innovation; Ministry of Environment, Agriculture and Fisheries; Autonomic Governments), private organisms (e.g. Biodiversity Foundation, AXA foundation), and EU research calls (FP7, LIFE, INTER REG, etc.).

• All these institutions have programmes for funding research on CC issues; however, the fraction of funding

allocated to marine biodiversity is small. In addition, it is stressed that activities to promote collaborative research across north and southern Mediterranean countries should increase.

• Importantly, it is highlighted that current research projects span a maximum of 5 years, which is considered to be insufficient to support long-term monitoring programmes.

Turkey:

• There is no regular national source yet for the climate change and impacts of this phenomenon. However, Turkish National Research Council already allocated some fund for researches on some topics such as natural hazards.

• As for private or public funds, some universities such as Middle East Technical University, Institute of Marine Science, and Istanbul University has granted some researches for the sea level oscillation, acidification, sea current monitoring and global ocean observation systems.

• Internationally, GEF allocated some fund for developing countries. The Turkish Ministry of Environment and Forestry has some initiative to be involved in international projects and programmes.

6.3 Synthesis regarding co-operation and funding

• Regarding international cooperation, the national reports reflect a general lack of CC-related supporting activities to developing and emerging countries, with the exception of Italy, whose level of implication on this kind of activities is notable, in particular with the Mediterranean region, Central Eastern Europe, China, South America and the Caribbean. On the other hand, all countries reviewed in this report are signatories of CC-related international treaties and conventions, and most of them are involved in international initiatives, programmes and networks for the monitoring and assessment of CC.

• The problems related to funding CC-related initiatives, as identified by national experts, rely on:

- Too little national and regional funding to deal with the scientific questions regarding CC on the marine realm, as most CC-related initiatives are focused on terrestrial and inland aquatic environments
- Lack of regularity and/or stability in long-term funding, both at national and regional levels.
- For severe lack of funding, important issues are going unstudied, thus possibly endangering marine and coastal biodiversity.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Inputs provided by national experts

Cyprus:

• A monitoring program should be set as a priority on a national level in order to trace the link between CC and changes to coastal/marine biodiversity and ecosystem functioning.

• The increasingly water-deficit problems, which are prominent over the recent years in the Mediterranean, and particularly in the eastern region, resulted in the need of augmentation of waters sources through constructions of sea water desalination plants. Therefore, a long-term monitoring and assessment of the impact of desalination on coastal/marine biodiversity is needed to be undertaken.

• A pan-Mediterranean network of National Institutions should be established for exchange scientific information to deepen the knowledge on the impact of CC on marine biodiversity and to initiate cooperation in relevant research programs.

• Assessment the socio-economic consequences of biodiversity changes due to CC on a national and regional level including possible mitigation measures.

• Public awareness and strengthening the education aspects.

Greece:

An adaptation plan in Greece should include the establishment of a Working Group / Task Force / National Committee, authorized by the Ministry for the Environment, Physical planning and Public Works, in collaboration with the competent ministries that will interactively plan the national actions concerning the impacts of CC. A clear legislation covering its spectrum of activities and authorities is considered crucial. The scheme will:

• Launch the procedures for enacting or strengthening EU or national legislation relevant to impacts of CC e.g.

• Set up and co-ordinate a group of experts who will be responsible for analysing long-term biological data and correlate them with hydrographical data/ and analyse risks and possible consequences, in close consultation with the other Parties and relevant International Organisations

• Develop/promote monitoring programmes for data collection in hotspots (ports, coastal lagoons, aquaculture sites, sensitive areas, etc.). Incorporation of data collection in existing EU directives should be promoted.

• Develop programmes to raise the awareness of the general public and target groups, including decision-makers, concerning the risks associated with CC e.g. marine non-indigenous species introduction, sea level rise and, generally, natural phenomena and the economic consequences of beach management

• Strengthen, and where necessary, set up systems to control the intentional import and export of non-indigenous marine species

• Develop and implementing risk-assessment techniques

• Validate the conclusions and the measures respectively and prepare on a regular basis a national report on biodiversity changes on the marine ecosystem.

Israel:

The following actions should be taken in collaboration, or at least coordination, with neighbouring countries:

• Survey of the infralittoral biota along the Mediterranean coast (with emphasis on the commercially valuable species), in order to identify communities spatially or physiologically vulnerable to climate change. Identification of "thermal indicator species".

• Survey of marine and coastal thermophilic opportunistic and invasive alien species (including pathogens and disease vectors) and their impacts on the native biota*.

• Estimation of the impact of sea level rise and accelerated coastal erosion on the supratidal populations (shorebirds, marine turtles, endemic fauna and flora), and the midlittoral vermetid reefs.

• Establishment and protection of coastal and marine nature reserves and establishing corridors between

reserves.
• Perfection of transplantation and reintroduction techniques of species considered most endangered.
• Preparing an all-Mediterranean open-access dynamic data base of the temporal and geographical distribution of "thermal indicator species" and thermophilic opportunistic and invasive alien species.

Italy:
• Multidisciplinary monitoring and research on CC issues are urgently needed.
• Monitoring and updating of distribution and abundance maps of species sensitive to variations in temperature, e.g. Thalassoma pavo, Ophidiaster ophidianus, Astroides calycularis and/or important for the fishing industry such as Engraulis encrasicholus, Sardina pilchardus, Seriola dumerili, Thunnus thynnus, etc.
• Monitoring of habitat-former species in danger from increases in surface temperatures and from rises in sea level such as Dendropoma petraeum and Posidonia oceanica through checking density, distribution and relationships with other species.
• Selection of specific cases for evaluating the effects of competition between native and exotic species and to understand the changes to the functioning of ecosystems with particular reference to the trophic food web;
• Selection of variables for the study and comprehension of changes to the biology of species, to be related to changes in climate.
• Monitoring, preparation and updating of distribution and abundance maps of species sensitive to variations in temperature
• The creation of a network of sampling sites, preferably within the system of Italian marine protected areas, to measure biodiversity variables to relate to climate change.

Malta:
• At present, most of the information available on the impacts of CC on Maltese coastal and marine biodiversity is qualitative in nature and is mainly based on regional scenarios, which do not allow an adequate interpretation of CC impacts at a local scale, and, furthermore, do not take into consideration issues associated with small islands.
• Due to the lack of resources associated with a small island state, Malta should focus its resources on adaptation measures, which implies the need of a realistic indication of the extent and significance of CC impacts.
• There is a lack of information on the biology and requirements of species and habitats, necessary to assess the vulnerability of species and habitats to CC impacts that would be predicted through climate projections. Furthermore, adaptation options for vulnerable species and habitats should be based on knowledge on the biology/requirements in order to avoid maladaptation.
• Terrestrial coastal biodiversity (particularly in the north-eastern coast of the Maltese Islands) is vulnerable to drought, deterioration of freshwater quality and availability, as well as inundation and coastal erosion that may be caused by both sea-level rise and increased frequency of storm surges. Other coastal ecosystems host rare or endemic species which in view of their limited distribution in the Maltese Islands or their restriction within one or two coastal areas, are considered to be highly vulnerable to CC impacts.
• There is an urgent need for the collection of information and further studies on the Maltese marine environment as well as the need for designation of MPAs.
• Gaps in data and information on the biology, distribution and population dynamics of species and habitats need to be addressed and knowledge of their current conservation status must be ensured.
• Malta should explore options for adaptation of terrestrial coastal ecosystems beyond connectivity to other natural areas.
• Malta must seek to cooperate with other countries in the region, to tackle CC impacts on marine biodiversity, particularly in monitoring trends in the physico-chemical parameters of the Mediterranean sea and trends in species distribution.
• In general, Malta should ensure that current policies and legislation are addressing non-climatic impacts that are

reducing the resilience of ecosystems to CC. In particular, spatial planning should take into consideration the effects of CC on biodiversity and enhance their adaptive capacity.

• Rather than focusing solely on adaptation for biodiversity, it is deemed to be important for Malta to develop a national strategy on adaptation that would cover all sectors and ensure coherence between different adaptation measures identified for different sectors.

Spain:

The following actions towards decreasing impacts of climate and global change to vulnerable Spanish marine and coastal biodiversity are recommended:

• Initiation of long-term monitoring programmes of key ecosystems, habitats and species.

• Creation of a data centre that compiles, and makes available to public, data from monitoring programmes of key ecosystems, habitats and species.

• Increase the number of marine protected areas, particularly along the peninsular Spanish Mediterranean.

• Increase research activities addressed to understand and forecast climate dynamics, interactions between atmospheric climate and oceanography and marine biodiversity responses to climate (and global) change.

• Increase dissemination and training actions on climate change impacts and vulnerability of coastal and marine biodiversity.

• Implement existing legislation to decrease and mitigate direct and diffusive impacts of human population to coastal and marine ecosystems

• Design and implementation of a Retreat Plan from vulnerable coastal ecosystems

• Promote adaptive management of coastal ecosystems and marine biodiversity, adjusting to their responses to the evolving impacts of climate change, as opposed to static regulation and management approaches that are not flexible enough to accommodate the dynamic situation of the Mediterranean marine ecosystem.

These actions could be implemented by national or autonomic community governments, but they should be coordinated and homogenously designed at national, and when possible, Mediterranean scale.

Turkey:

Urgent actions proposed are:

• Review and integrate existing information on past and current status of selected taxa in Turkish waters.

• Establish Turkish "biodiversity warning system", based on climate-indicator species, to detect and monitor major changes in marine biodiversity mostly for the toxic Lessepsian species for human health; identify a set of "sentinel species" which can reliably represent indicators of climate change; these species may be Litho phyllum lichenoides an indicator of the sea level variations, Eunicella singularis and Paramuricea clavata which are likely to suffer from the mass mortality due to turbidity and rise of water temperature.

• Identify a list of species or taxa that will be mostly threatened by increasing warming of waters and climate-related events and thus in need of special protection.

• Track the geographic expansion of "warm-water" species and the retreat of "cold-water" species. Monitor the relations between global warming, ballast waters and harmful aquatic organisms in Turkey. Assess tropicalization impacts on species commercially important for fisheries, for example, by providing information on geographic shifts as a consequence of warming of waters and/or competition with fast advancing species of low economic value.

• Record mass events (invasions, blooms, mass mortalities) around Turkey.

• Relate changes in abundance and distribution ranges of Mediterranean species to the variability and trends of the hydro-climatic environment.

• Develop dynamic, web-interfaced, interactive distribution maps providing information on taxonomy, ecological traits and geographic trends of climate-indicator species.

• Actively participate GOOS (Global Ocean Observation System) in the Mediterranean Sea and deploy new buoys to the Mediterranean coast of Turkey. At the moment only 6 real time sea level observation systems exist in the Turkish Mediterranean Sea.

• Investigate global warming and acidification process.

• Develop more public awareness campaigns to distribute all relevant information to the large public for the impacts and basic knowledge of the climate changes in the Turkish coastline. This kind of campaign is also important for the tourism as well as for local people in such case as venomous jellyfish species Pelagia noctulica and R. nomadica or poisonous fish like Legocephalus sceleratus.
• Integrate all actions to the related Turkish national legislation.
• Develop new strategies in the framework of the Barcelona Convention, EU Habitat and Water Framework Directives, and help forge conservation strategies for biodiversity.

7.2 General conclusions

7.2.1 Scientific consensus about CC and its effect on Mediterranean biodiversity

• National experts agree (in line with the international scientific consensus) on the importance and extent of risks of marine and coastal biodiversity in their countries due to CC, as a result of (and synergistic complex interactions between):

- changes in precipitation patterns
- increasing air and sea water temperature, enhanced UV radiation
- sea level raising, likely to accelerate coastal erosion, marine intrusion into coastal aquifers, and other effects
- acidification (decreasing pH)
- hydrodynamic and hydrological parameters (e.g. local and regional currents, upwellings, thermal stratification, frequency of storms and extreme events, salinity, turbidity, nutrient supply…)

• Expected effects of CC-driven stressors will affect marine / coastal biodiversity by producing shifts in the short-, medium- and long-term:

> Short-term (ongoing and next decade):
- spatio-temporal patterns of biodiversity
- abundance of species
- eco-physiological processes (reproduction, immunological response affecting the individual performance of sensible species, at various stages of their life history, and possible adaptive selection pressure on species traits)

> Medium-term (decades):
- larval dispersal and recruitment
- resource availability (food, habitat, etc.)
- primary and secondary production
- complex (non-linear, non-independent) responses at the community / ecosystem level, likely leading to catastrophic regime shifts and local extirpation of species and habitat losses
- synergistic effects of other human-driven stressors (e.g. overfishing, pollution, habitat degradation, alien species), and land-sea links (e.g. soil erosion and desertification, agricultural runoff, river regulation, etc.)

• These biodiversity changes are likely to have profound direct socio-economical effects, and affect public health

7.2.2 Activities concerning vulnerability and impacts of CC on BD

• The national capabilities in CC-related research and/or monitoring issues are unequal among countries.
• Research / monitoring actions in the sub-region are at present dealing with:

- Atmospheric changes and climate features
- Long-term marine hydrographical and hydrodynamic trends (including sea level)
- Hydro-geological changes and terrestrial implications on BD
- Coastal erosion and desertification
- Eco-physiological, behavioural and ecological response of marine organisms and populations to seawater temperature increase

- Geographical distribution shifts of native and alien species, including migration patterns
- Spatio-temporal changes in marine community structure
- Model development and forecasting projections
- Socio-economical impacts of CC (tourism, fisheries, aquaculture, etc.)
- Public health

• Large gaps in knowledge exist on the effects of CC on biodiversity and their consequences for human populations, although some countries are more advanced in the pursuit of these subjects
• Participation in international coordination activities is not general in the sub-region
• Training and public awareness is identified as a priority, although its application is unequally distributed

7.2.3 National needs

• To improve the scientific understanding of CC and its impact on BD, by mean of adequate and internationally co-ordinated long-term monitoring and research initiatives. Topics highlighted are:

- hydrographic / hydrodynamic / climatic measurements to validate existing and forthcoming models
- monitoring of the coastline, assessment of erosion / desertification vulnerability and risks
- monitoring of selected benthic / nektonic / planktonic species / habitats
- special emphasis on the spread of alien species
- basic research on the biology of species vulnerable to CC
- studying non-linear responses of littoral ecosystems to CC, and population-to-ecosystem links (functional approach)

• Development of predictive modelling tools, under different mitigation, adaptation and population growth scenarios, including down-scaling of regional scenarios, and a special focus on the projections on small-island countries
• Enhance communication and exchange (among scientists, managers, stakeholders)
• Training and public awareness initiatives
• National strategies and initiatives to study CC-BD issues on a multidisciplinary basis and through regional cooperation

7.2.4 Funding problems and opportunities

The problems related to funding CC-related initiatives, as identified by National Expert, rely on:
• Too little national and regional funding to deal with the scientific questions regarding CC on the marine realm, as most CC-related initiatives are focused on terrestrial and inland aquatic environments
• Lack of regularity and/or stability in long-term funding, both at national and regional levels.
For severe lack of funding, important issues are going unstudied, thus possibly endangering marine and coastal biodiversity.

7.3 General recommendations

The national experts gathered under 'Cluster B' group agreed in the need to launch the following activities regarding CC impacts on marine and coastal biodiversity:
• Open-access, regionally co-ordinated database housed in RAC/SPA on the occurrence, spread and shifts (e.g. bleaching, flowering, mass mortality…) of "thermal" marine species (both native and alien).
• Long-term monitoring programmes of biodiversity shifts in a comprehensive set of geo-referenced sampling sites.
• Assessment of the socio-economic risks and observed consequences of CC, and economic valuation of non-adapting to CC impacts on marine and coastal biodiversity in terms of ecosystem services and goods.
• Necessity to launch regionally co-ordinated / harmonised (and adequately financed) national plans for the adaptation to the impacts of CC, with focus on synergistic effects of CC with other anthropogenic sources.

• Research on eco-physiological / behavioural / ecological responses of vulnerable species (affecting different biological traits along their life cycle), including connectivity and adaptation issues. Focus on non-linear complex emergent responses of communities / ecosystems.

8. LITERATURE CITED

Brochier F & Ramieri E (2001) Climate change impacts on the Mediterranean coastal zones. Fondazione Eni Enrico Mattei. 82 pp.

Brooke C (2008) Conservation and adaptation to climate change. Conservation Biology 22: 1471-1476.

Danovaro R, Dell'Anno A & Pusceddu A (2004) Biodiversity response to climate change in a warm deep sea. Ecology Letters 7: 821-828.

Díaz-Almela E, Marbà N & Duarte CM (2007) Consequences of Mediterranean warming events in seagrass (Posidonia oceanica) flowering records. Global Change Biology 13: 224-235.

Dormann CF, Schweiger O, Arens P, Augenstein I, Aviron St, Bailey D, Baudry J, Billeter R, Bugter R, Bukácek R, Burel F, Cerny M, De Cock R, De Blust G, DeFilippi R, Dieköter T, Dirksen J, Durka W, Edwards PJ, Frenzel M, Hamersky R, Hendrickx F, Herzog F, Klotz St, Koolstra B, Lausch A, Le Coeur D, Liira J, Maelfait JP, Opdam P, Roubalova M, Schermann-Legionet A, Schermann N, Schmidt T, Smulders MJM, Speelmans M, Simova P, Verboom J, van Wingerden W & Zobel M (2008) Prediction uncertainty of environmental change effects on temperate European biodiversity. Ecology Letters 11: 235-244.

Giannakopoulos C, Bindi M, Moriondo M, LeSager P & Tin T (2005) Climate change impacts in the Mediterranean resulting from a 2°C global temperature rise. WWF. 66 pp,

McClanahan TR, Cinner JE, Maina J, Graham NAJ, Daw TM, Stead SM, Wamukota A, Ateweberhan M, Venus V & Polunin NVC (2008) Conservation action in a changing climate. Conservation Letters 1: 53-59.

Occhipinti-Ambrogi A (2007) Global change and marine communities: Alien species and climate change. Marine Pollution Bulletin 55: 342-352.

Pérez T (2008) Impact of climate change on biodiversity in the Mediterranean Sea. UNEP-MAP RAC/SPA. 61 pp.

Root TL & Schneider SH (2006) Conservation and climate change: The challenges ahead. Conservation Biology 20: 706-708.

Schröter D, Cramer W, Leemans R, Prentice IC, Araújo MB, Arnell NW, Bondeau A, Bugmann H, Carter TR, Gracia CA, de la Vega-Leinert A, Erhard M, Ewert F, Glendining M, House JI, Kankaanpää S, Klein RJT, Lavorel S, Lindner M, Metzger MJ, Meyer J, Mitchell TD, Reginster I, Rounsevell M, Sabaté S, Sitch S, Smith B, Smith J, Smith P, Sykes MT, Thonicke K, Thuiller W, Tuck G, Zaehle S & Zierl B (2005) Ecosystem service supply and vulnerability to global change in Europe. Science 310: 1333-1337.

Thuiller W, Lavorel S, Araújo MB, Sykes MT & Prentice IC (2005) Climate change threats to plan diversity in Europe. Proceedings of the National Academy of Sciences of the United States of America 102: 8245-8250.

9. ANNEX: LIST OF MARINE AND COASTAL SITES OR HABITATS CONSIDERED TO BE ESPECIALLY AT RISK (OR ENDANGERED) IN THE SHORT-TERM BY THE EFFECTS OF CLIMATE CHANGE

Cyprus:
Not available.

Greece:
Not available.

Israel:
• Sea level rise will accelerate coastal erosion - a rise of 1 m will lead to loss of coastal strip of:
- 50-100 m wide along the sandy beaches which make up more than half the Mediterranean coastline of srael and accelerate erosion of the Eolianite sandstone cliffs
- 30-40 m high, that makes up 70 km of the Israeli Mediterranean coastline.

• It is estimated that SLR of 1 m will double the present erosion rate.
• The entire Israeli coast is VULNERABLE - both low-lying sandy beaches and the coastal sandstone ridges.
• Coastal installations (ports, power stations, desalination plants) may be vulnerable as well - especially in case of predicted "extreme events".
Vulnerability to biodiversity aspects of CC:
• Sea level rise may cause extinction of slow-growing, long-lived species such as the unique, Mediterranean-endemic vermetid reefs, or impact low-lying off-shore islets serving as nesting sites for water fowl, and the area of sandy shore available for nesting of marine turtles. Vermetid reefs are present in several areas along the northern half of the Israeli coastline; several off shore islets are located along the central and northern coast as well.
• Changing climatic conditions may bring about biogeographical range shifts, both latitudinal range shifts of native species, and the establishment and spread of alien species, along the entire Israeli littoral.

Italy (Adriatic excluded) (Fig. 1):
Liguria
Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of:
1. Isola di Gallinara
2. Isola Bergeggi
3. Portofino
4. Cinque Terre

Tuscany
Areas at risk from rises in sea level:
5. Verisilia Riviera

Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of:
6. Arcipelago Toscano
7. Secche della Meloria

Latium
Areas at risk from rises in sea level:
8. Fondi and Pontina plains

Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of:

9. Secche di Tor Paterno
10. Isole Pontine di Ponza, Palmarola and Zannone
11. Isole di Ventotene e Santo Stefano

Campania

Areas at risk from rises in sea level:

12. delta of Volturno in the Gulf of Gaeta
13. delta of Sele in the Gulf of Salerno

Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of:

14. Regno di Nettuno (Isole di Ischia, Vivara and Procida)
15. Isola di Capri
16. Punta Campanella
17. Santa Maria di Castellabate
18. Costa degli Infreschi

Sardinia

Areas at risk from rises in sea level:

19. Pilo lagoon
20. Tortolì lagoon
21. Gulf of Orosei (beach and lagoon)
22. Murtas Beach
23. Porto Pino and Palmas (Sardinia)
24. Gulf of Cagliari
25. Gulf of Oristano

Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of:

26. Asinara
27. Capo Testa - Punta Falcone
28. Arcipelago della Maddalena
29. Tavolara - Punta Coda Cavallo
30. Golfo di Orosei - Capo Monte Sannu
31. Capo Carbonara
32. Penisola del Sinis - Isola di Mal di Ventre
33. Capo Caccia – Isola Piana

Sicily

Areas at risk from rises in sea level:

34. Stagnone di Marsala
35. Trapani and Paceco saltmarshes
36. Noto and the Vendicari lagoon
37. Pantani Cuba and Longarini

Vermetid platform within the Marine Protected Areas of:

38. Egadi and
39. Capo Gallo - Isola delle Femmine

Coralligenous assemblages and/or "encourbellement" of Lithophyllum lichenoides within the Marine Protected Areas of :

38. Isole Egadi
39. Capo Gallo e Isola delle Femmine
40. Isola di Ustica

41. Isole Eolie
42. Isole Ciclopi
43. Plemmirio
44. Isole Pelagie
45. Isola di Pantelleria

Posidonia recife barriere

46. Capo Feto SCI (Site of Community Interest)

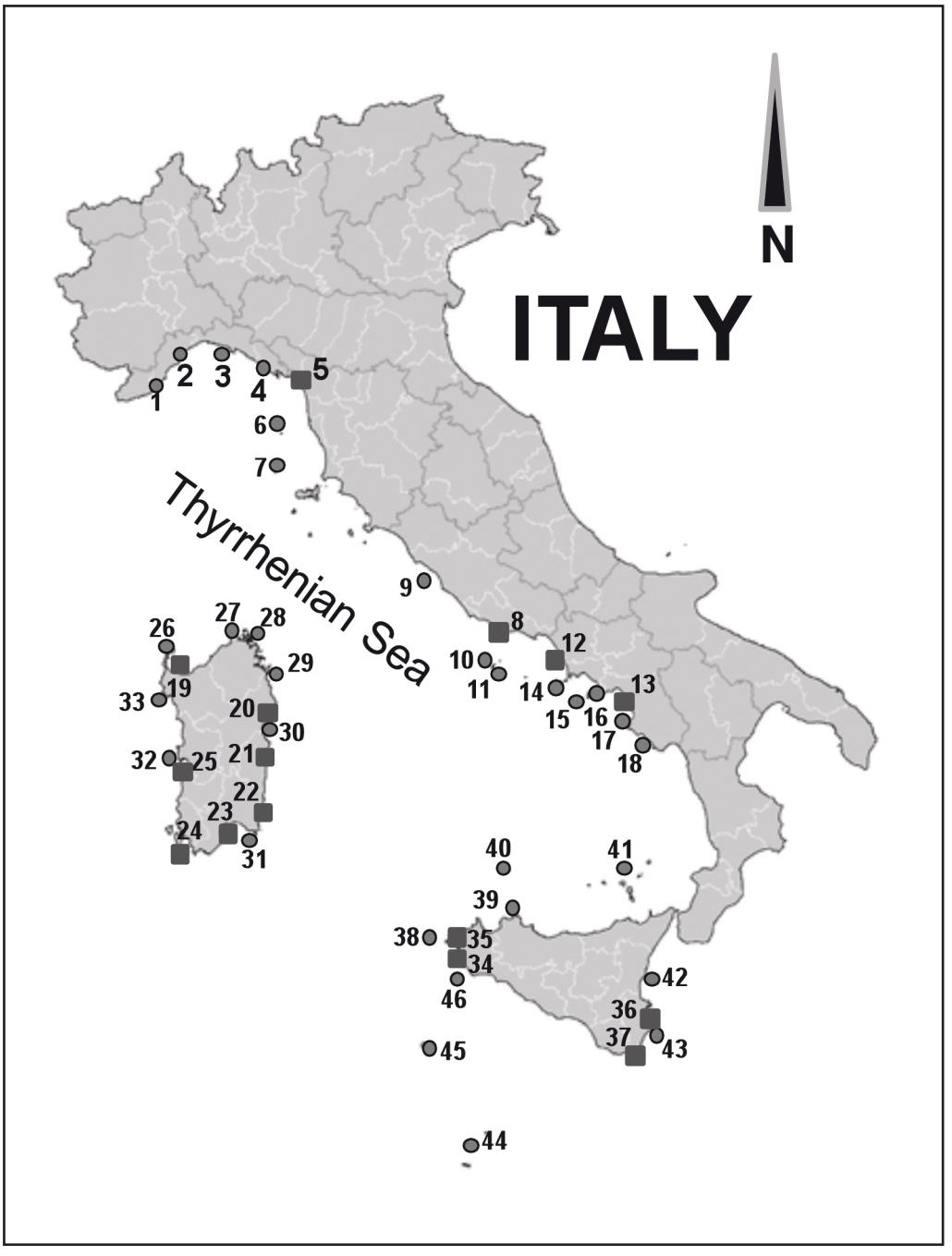


Figure 4 List of marine and coastal sites considered to be especially at risk (or endangered) in the short term by the effects of climate change in Italy (Adriatic excluded). Squares refer to Areas at risk from rises in sea level and circles refer to areas at risk of impact on biodiversity.

(please refer to colour figure 4 on page 23).

Malta:

The impact of CC is particularly critical for coastal habitats that depend on the availability of freshwater such as coastal wetlands (Fig. 2). The Maltese national report, based on Anderson & Schembri (1989) , identified 25 localities in the Maltese islands which at the time supported this type of habitat (19 in Malta, 5 in Gozo and 1 in Comino).

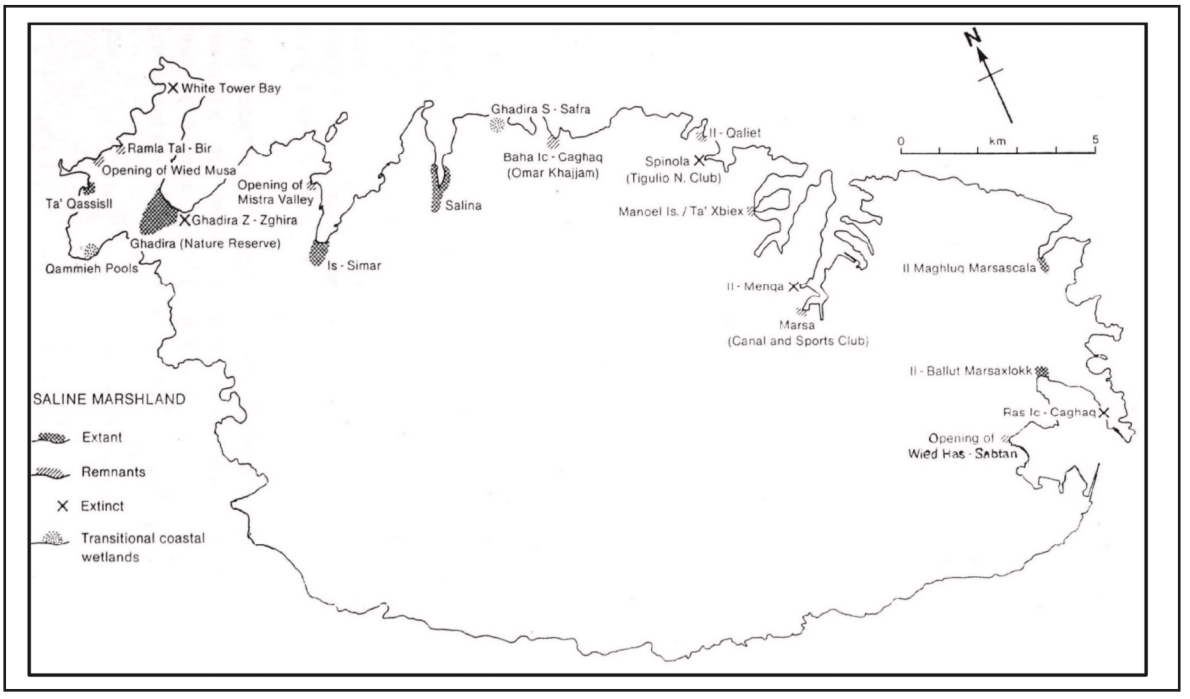


Figure 5 Location of current and former coastal wetlands on mainland Malta and their status as reported by Anderson & Schembri (1989)

• Six of these had already been obliterated by 1989, 13 were heavily degraded and only 6 sites were considered to be in good condition. At present, relatively preserved coastal wetlands are restricted to Ghadira (Mellieha Bay), is-Simar (Xemxija), il-Maghluq (Marsascala), il-Ballut (Marsaxlokk Bay) and Salina (Salina Bay).

• The most critical impact of sea-level rise and associated coastal erosion is envisaged to be on the low-lying Northeastern coast of the Maltese Islands, particularly on coastal habitats that are currently enclosed by development or otherwise disconnected from natural areas and hence do not have the possibility to shift inland. Attard et al. (1996) quotes several localities in the Maltese Islands that are vulnerable to inundation and shoreline recession. It should be noted that most of the protected areas within the Maltese Islands, including SACs and SPAs designated in terms of the Habitats and Birds Directive respectively, have a coastal location and are thus at risk from such impacts.

• Sandy beaches and associated sand dunes are very vulnerable to coastal inundation and erosion (Fig. 3).

These sand dunes support a number of rare, threatened and/or endemic species and their loss will be highly significant to the overall biodiversity.

[14] *Anderson EW & Schembri PJ (1989) Coastal Zone Survey of the Maltese Islands report. Beltissebh, Malta: Planning Services Division, Works Department; xii + 121pp + 100 hand-drawn colour maps and 19 synoptic maps.*

[15] *Attard DJ, Axiak V, Borg S, Borg SF, Cachia J, De Bono G, Lanfranco E, Micallef RE & Mifsud J (1996) Implications of expected climate changes for Malta. In: Leftic L, Keckes S & Pernetta JC (Eds.) United Nations Environment Programme - Climate Change and the Mediterranean: Environmental and societal impacts of climate change and sea level rise in the Mediterranean region – Volume 2.*

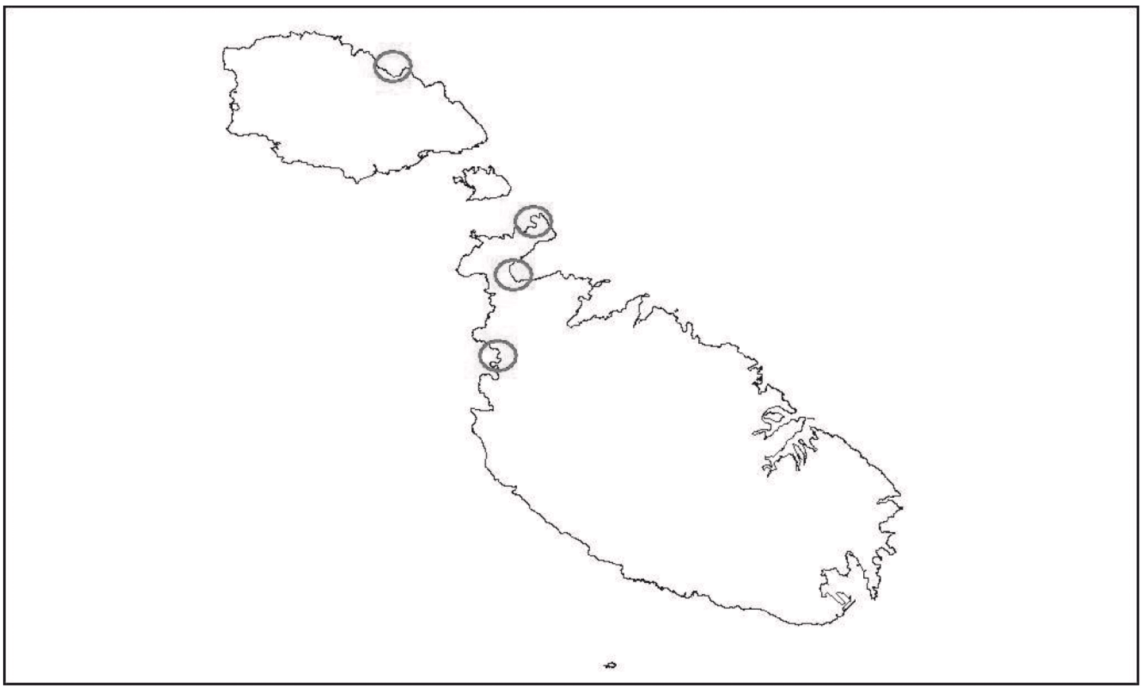


Figure 6 Location of the extant sand dunes in the Maltese Islands (Source: MEPA)
(please refer to colour figure 6 on page 24).

Spain:

• The most vulnerable ecosystems to climate change impacts are wetlands and ecosystems dominated by sessile organisms (e.g. red coral, gorgonians, sponges, Posidonia oceanica)

• The critical impacts of climate change on low land areas are related with increased frequency and/or intensity of storms, sea-level rise and, to some extend, changes in river (sediment and water) flow.

• Deltas rank amongst the most vulnerable coastal areas to sea level rise, especially:

- Ebro Delta
- Llobregat Delta
- Albufera de Valencia coastal lagoon
- Mar Menor coastal lagoon
- coastal lagoons at Cabo de Gata

• Sea level rise is the major climate change threat for beaches. However, very few Mediterranean Spanish beaches preserve the associated dune systems intact, mostly because they have been destroyed and urbanised. In some areas (e.g. La Manga del Mar Menor, Almería), the sand from dune systems has been extracted or occupied with urbanisation. An acceleration of beach erosion due to human pressure is evident along the entire Mediterranean coast of the Iberian Peninsula, as, for example:

- Puçol and Massalfasar, Castellón
- Albufera de Valencia, Valencia
- Santa Pola, Alicante
- La Manga del Mar Menor, Murcia
- Mazarrón, Murcia
- Carboneras, Almería

• The losses of Posidonia oceanica meadows along the Spanish Mediterranean mostly occurred during the last 3 decades as a consequence of antropogenic impacts, contributed to accelerate coastal erosion.

Turkey:

1. Specially protected areas: Belek, Kas-Kekova, Patara, Fethiye-Göcek, Köycegiz-Dalyan, Gökova Bay, Datça-Bozburun, and Foca.
2. Major rivers on the Aegean and Mediterranean coasts; Gediz and Menderes (see Fig. 4).
3. Wetlands of internationally importance: Gediz Delta, Küçük Menderes Delta, Büyük Menderes Delta, Bafa Lake, Koycegiz Lake, Göksu Delta, Tuzla Lake, Yumurtalik Lagoon, and Akyatak Lagoon (see Map 2).
4. Unique vermetid reefs on the eastern Mediterranean coasts of Turkey: **Datça, Gazipaşa, and Çevlik.**

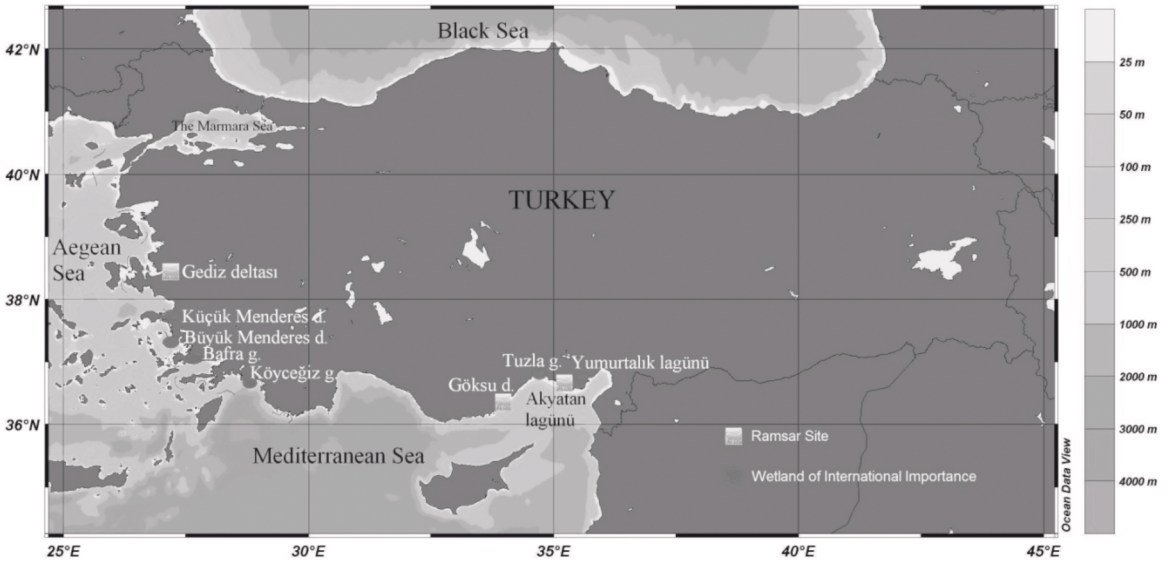


Figure 7 : Wetlands and lagoons possibly affected by CC
(please refer to colour figure 7 on page 24).