STATE OF THE MEDITERRANEAN MARINE AND COASTAL ENVIRONMENT

UNEP

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For bibliographic purposes this volume may be cited as:
UNEP/MAP: *State of the Mediterranean Marine and Coastal Environment*, UNEP/MAP – Barcelona Convention, Athens, 2012.

Publication design and layout: GRID-Arendal
Cartography: GRID-Arendal
Front cover photo: Angela Sorrentino/iStockphoto
Back cover photo: Atila Uras

UNEP/MAP – Barcelona Convention
48, Vassileos Konstantinou Ave.
11635 Athens
Greece
www.unepmap.org

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Acknowledgements

The State of the Mediterranean Marine and Coastal Environment Report was realized under the aegis of the United Nations Environment Programme / Mediterranean Action Plan (UNEP/MAP).

The Mediterranean Action Plan wishes to thank:

Joan Fabres (Editor), Tiina Kurvits, Rannveig Rivedal Nilsen and Riccardo Pravettoni (Cartography) from GRID-Arendal; and Tundi Agardy from Sound Seas.

The UNEP/MAP family and in particular: Michael Angelidis and Tatjana Hema from MEDPOL, Sophie Martin, Jonathan Pace and Frederic Hebert from REMPEC, Jean-Pierre Giraud and Didier Sauzade from Plan Bleu, Marko Prem from PAP/RAC, Abderrahmen Gannoun and Daniel Cebrian from SPA/RAC, Meryem Cherif from CP/RAC, Virginie Hart, Maria Luisa Silva Mejias, and Atila Uras from the Coordinating Unit, and also Matt Billot, Charles Davies, and Elina Rautalahti from DEWA/UNEP;

The Experts who contributed to the review of the report: Lucien Chabason, Ljubomir Jeftic, Ivica Trumbic and Ameer Abdulla.

Foreword

The Mediterranean Action Plan (MAP) was established in 1975 as a coherent legal and institutional framework for cooperation through which all Mediterranean countries decided to jointly address common challenges of environmental degradation while linking sustainable resource management with development. It was soon followed by the Barcelona Convention and seven Protocols addressing issues relevant to the conservation and sustainable use of marine and coastal resources as well as to many policies and measures aiming to improve its management.

Information is key to the UNEP/MAP-Barcelona Convention which is first and foremost a governance framework. It acts as a catalyst facilitating cooperation and decision-making in the Mediterranean region. As it is well-known, availability and accessibility to relevant information is a precondition for sound policymaking and good governance.

Actions towards generating information on a more systematic basis followed the first Rio Conference 20 years ago. The Mediterranean countries decided to strengthen their reporting of information on environmental trends, a necessary feedback to improve the effectiveness of measures undertaken. In 2008 the Contracting parties to the Convention went one step further mandating the UNEP/MAP-Barcelona Convention to prepare periodic State of the Environment reports.

This State of the Mediterranean Environment report sets a new course while building on our previous thematic reports. It provides information on the overall nature of the Mediterranean ecosystems and defines recurrent and new pressures – such as aquaculture and desalination – that affect the state of its environment. It also assesses the availability and quality of information and identifies knowledge gaps so as to provide guidance for scientific research and monitoring efforts undertaken by the Contracting Parties to the Barcelona Convention. Lastly, an important insight on vital services provided by marine and coastal ecosystems to their inhabitants is offered.

For the first time, the report is organised around the 11 Ecological Objectives agreed by the Contracting parties to the Barcelona Convention as a common strategy for the application of the Ecosystem Approach to the management of human activities. Biodiversity conservation, coastal dynamics, fisheries management, pollution reduction, marine litter and hydrography are now agreed and presented as part of an integrated analytical and implementation framework which will be periodically monitored and reviewed through a rigorous six year cycle.

By doing so, this report initiates the post Rio+20 in the UNEP/MAP-Barcelona Convention. It launches a process that addresses two main lessons outlined in the Fifth Global Environment Outlook (GEO-5) of UNEP launched at the Rio+20 Summit on Sustainable Development earlier this year. Namely, that international agreements are most successful when they tackle goals with specific targets on a reduced number of priority issues; and, that evidence-based policy-making requires more reliable data. Indeed, a striking finding from the report is the significant information gaps that still exist.

The knowledge and management agenda ahead of us is huge. I am confident, however, that over time we will be able to fulfill our ambition of building the body of knowledge and management necessary for understanding and more effectively addressing cumulative risks and effects. A necessity if we are to reach the good environmental status of our battered sea and coastal ecosystems.

The report is a collaborative effort comprising UNEP/MAP-Barcelona Convention components, parties and partners. Its main source of information is the Initial Integrated Assessment on the Ecosystems Approach which was peer-reviewed by GESAMP. The report was compiled by GRID/ARENDAL and independently reviewed by experts on a pro bono basis. The Secretariat is grateful to all contributors to this report and looks forward to feedback and comments that could further enrich future reports.

Maria Luisa Silva Mejias
Executive Secretary and Coordinator,
UNEP/MAP-Barcelona Convention

Preface

The Mediterranean Action Plan (MAP) is a cooperative initiative undertaken by countries bordering the Mediterranean Sea and the European Union. It was launched in 1975 when sixteen Mediterranean countries and the European Community completed the first version of the plan. The MAP was the first plan to become a Regional Seas Programme under the United Nations Environment Programme (UNEP).

The "Convention for the Protection of the Mediterranean Sea against Pollution" (Barcelona Convention) was adopted in 1976 by the Mediterranean coastal states and the European Community and came into force in 1978. The main objectives of the MAP were to assist the Mediterranean countries to assess and control marine pollution, to formulate their national environment policies, to improve the ability of governments to identify better options for alternative patterns of development, and to optimise the choices for allocation of resources. Although the initial focus of the MAP was on marine pollution control, experience confirmed that socio-economic trends, combined with inadequate development planning and management, are at the root of most environmental problems. Consequently, the focus of the MAP gradually shifted to include integrated coastal zone planning and management, biodiversity preservation and sustainable development dimensions as the key tools through which solutions are being sought.

Twenty years later, the "Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean" (MAP Phase II) was designed, taking into account the results of the first United Nations Conference on Environment and Development (UNCED), Rio 1992, as well as the achievements and shortcomings of the first MAP in the context of previous developments. At the same time, the Contracting Parties adopted an amended version of the Barcelona Convention, renamed the "Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean" in order to reflect the wider mandate. The amended version of the Barcelona Convention came into force in 2004. Seven Protocols addressing specific aspects of Mediterranean environmental protection and conservation complete the MAP legal framework.

Today 21 countries that border the Mediterranean Sea: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia, and Turkey, as well as the European Union are Contracting Parties to the Barcelona Convention. The countries participating in the Plan are determined to work together to meet the challenges of environmental degradation in the sea and coastal areas and to link sustainable resource management with development in order to protect the Mediterranean region and contribute to an improved Mediterranean quality of life.

The MAP Coordinating Unit is the Secretariat for the Mediterranean Action Plan – Barcelona Convention. It performs diplomatic, political, and communication roles, supervising the main MAP components (MED POL – the marine pollution assessment and control component of MAP – and the six Regional Activity Centres), as well as coordinating major programmes.

Under Article 26 of the Barcelona Convention, the Contracting Parties commit to transmit to the Secretariat reports on legal, administrative, and other measures undertaken to implement the Barcelona Convention and its Protocols. They also commit to transmit reports on the effectiveness of these measures and the problems encountered. Additionally, the Contracting Parties agree, under Article 15, to provide public access to information on the State of the Environment in the field of application of the Barcelona Convention and its Protocols. Publication of a report on the State and Evolution of the Mediterranean Environment at regular intervals has been reaffirmed as a priority objective by the Contracting Parties to the Barcelona Convention. In addition, in 2008 the Contracting Parties to the Barcelona Convention asked the Secretariat to report periodically on the state of the environment.

This State of the Mediterranean Marine and Coastal Environment Report (SoMMCER) synthesises available knowledge about major drivers and pressures affecting the sea and its coastal inhabitants, the Mediterranean environment's condition, the current and prospective impacts of collective human activity, and emerging issues in coastal and marine management. The SoMMCER is intended to meet the needs of decision-makers for a regionally integrated synthesis at this critical time in the application of the Ecosystem Approach to the management of human activities in the Mediterranean (see the 2008 Decision IG.17/6 and the 2012 Decision IG.20/4). The Contracting Parties have made substantive progress in implementing the Ecosystem Approach roadmap that was adopted in 2008. The latest milestone achieved is the agreement of the Ecological Objectives for the Ecosystem Approach, which were adopted by the Meeting of the Contracting Parties in February 2012. The Ecological Objectives describe, for each of the major environmental issue identified, the desired results pursued by the application of the Ecosystem Approach to the management of human activities. This report features information that will support future directions in the continued application of the Ecosystem Approach.

The geographical scope of this report is the whole Mediterranean Sea including its coastal zones. The framework used for the assessment of the state of the environment is the Driver-Pressure-State-Impact-Response (DPSIR) framework and this is reflected in the organisation of the report:

- Part I provides background information about the Mediterranean Basin, an overview of the major drivers in the Mediterranean region and an introduction on the interrelation between Mediterranean ecosystems and human drivers.

- Part II provides an analysis of the pressures, state and known impacts associated with each of the issues addressed by the Ecosystem Approach Ecological Objectives.

- Part III analyses the responses in terms of policy instruments to the issues analysed in Part II, highlights the major findings on the state of the marine and coastal environment as well as the major information gaps, and discusses future avenues for the continued application of the Ecosystem Approach.

While information exists on the environmental and socio-economic impacts of human activities in the Mediterranean Sea and a suite of responses to these have already been implemented, the report places its focus mostly on the drivers, pressures, state and known impacts in order to clearly lay out the ground for the discussion on the next steps of the Ecosystem Approach. These next steps are: defining Good Ecological Status, setting targets, and developing an integrated monitoring programme, all of which will require thorough consideration of the impacts from human activities. These forthcoming steps will ultimately lead to the revision and development of action plans and programmes of measures, which will require further analysis of previous responses. Overall, this process will allow complete implementation of the DPSIR framework in future iterations of the SoMMCER.

The guidance and recommendations provided in the discussion of avenues for furthering the Ecosystem Approach focus on policies that will establish a systematic, comprehensive, holistic, and efficient monitoring regime. The objective of this monitoring regime is to provide a rigorous scientific basis for periodically determining the state of the Mediterranean environment, as well as environmental trends, in order to support science-based decision-making. It is this monitoring regime that will move the region fully towards an Ecosystem Approach and allow future recommendations flowing from State of the Environment reports to be oriented towards management.

The main information source on which this report is based is the *Initial Integrated Assessment of the Mediterranean Sea* (UNEP/MAP 2012), prepared as part of the implementation of the roadmap for the application of the Ecosystem Approach. The report was produced following a participatory approach involving all the Mediterranean countries. It was revised by country-designated experts, commented on by country officials, and peer reviewed by GESAMP (the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Where information contained in the *Initial Integrated Assessment* was insufficient to illustrate the subjects included in this report, it was complemented with information from the UNEP/MAP *State of the Environment and Development in the Mediterranean Report 2009* (UNEP/MAP/BP/RAC 2009), the EEA-UNEP/MAP 2006 report *Priority Issues in the Mediterranean Environment* (EEA and UNEP 2006), the UNEP/MAP 2005 report *Transboundary Diagnostic Analysis for the Mediterranean Sea* (UNEP/MAP/MED POL 2005), and the EEA-UNEP/MAP 1999 report *State and Pressures of the Marine and Coastal Mediterranean Environment* (EEA and UNEP 1999) and peer-reviewed research publications. Prior reports on the state of marine and coastal environment in the Mediterranean were produced within the MAP system in 1996 and 1989 (UNEP/MAP/MED POL 1996 and UNEP/MAP/MED POL/WHO/FAO 1989).

Some of the topics covered in the report, such as pollution and biodiversity, have been a focus of research and monitoring for many years and a wealth of information is readily available. Less information is available for other topics, such as noise, marine litter, sea-floor integrity, and trophic levels and food webs. This has resulted in some chapters of the SoMMCER being fully supported by robust evidence while other chapters are by necessity more qualitative. This dichotomy provides clear evidence of the need for a more robust approach to deriving information to support the major issues outlined in the Ecosystem Approach Ecological Objectives. For some issues, the existing information base is adequate to support decisions for the next steps of the development of the Ecosystem Approach. For other identified major issues, information will need to be gathered through targeted monitoring programs to provide a scientific basis for decision-making.

The strategic approach followed in the preparation of the SoMMCER was to aim to bridge the reporting requirements of the Barcelona Convention and the intrinsic need for systematic compilation of information for the application of the Ecosystem Approach. The report aims to avoid duplication in reporting by the MAP Contracting Parties and to provide a robust template for future reports on the state of the Mediterranean marine and coastal environment.

Upon request by UNEP/MAP, the SoMMCER was produced by UNEP/GRID-Arendal in collaboration with Sound Seas. The authors received input, guidance, and review throughout the process from the UNEP/MAP Coordinating Unit and all of the components of the UNEP/MAP system, MED POL (The Mediterranean Pollution Assessment and Control Programme), REMPEC (Regional Marine Pollution Response Centre for the Mediterranean Sea), BP/RAC (Blue Plan Regional Activity Centre), PAP/RAC (Priority Actions Programme Regional Activity Centre), SPA/RAC (Specially Protected Areas Regional Activity Centre), INFO-RAC (Regional Activity Centre for Information and Communication), CP/RAC (Regional Activity Centre for Cleaner Production). The report was finally reviewed by several independent experts on a pro bono basis.

Summary for Policy Makers

Introduction

The Mediterranean Basin is one of the most highly valued seas in the world. The region comprises a vast set of coastal and marine ecosystems that deliver valuable benefits to all its coastal inhabitants, including brackish water lagoons, estuaries, or transitional areas; coastal plains; wetlands; rocky shores and nearshore coastal areas; sea grass meadows; coralligenous communities; frontal systems and upwellings; seamounts; and pelagic systems.

The Mediterranean is not only complex in ecology, but also sociopolitically – twenty-one countries border this heavily used sea. The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) embodies international partnership to protect the sea, its coasts, and the uses and livelihoods that it supports. The Barcelona Convention provides a critical framework for setting environmental standards and targets that are agreed to by all the Contracting Parties, as well as for sharing important information for management. The Barcelona Convention's main objectives – to assess and control marine pollution; to ensure sustainable management of natural marine and coastal resources; to integrate the environment in social and economic development; to protect the marine environment and coastal zones through prevention and reduction of pollution, and, as far as possible, elimination of pollution, whether land or sea-based; to protect the natural and cultural heritage; to strengthen solidarity among Mediterranean Coastal States; and to contribute to the improvement of the quality of life – have spurred much progress. As Contracting Parties to the Barcelona Convention, the Mediterranean countries, together with the European Union, are determined to meet the continuing and emerging challenges of protecting the marine and coastal environment of the Mediterranean while boosting regional and national plans to achieve sustainable development.

Human impacts on the Mediterranean marine and coastal environment

In addition to being heavily used and highly valued, the Mediterranean Sea is one of the most thoroughly monitored and best studied ocean areas. The Barcelona Convention framework allows the coordinated collection of information on levels of key contaminants, through MED POL, while the Regional Activity Centre (RAC/SPA) in Tunis coordinates the collection of information on biodiversity. Other Regional Activity Centres track coastal development, and coastal and maritime industries. This information is disseminated in a variety of ways. State of the Environment Reports are prepared periodically by MAP. While earlier reports have touched upon the most critical issues affecting the Mediterranean environment, including fisheries, pollution, and coastal habitat loss, this State of the Environment report differs from its predecessors by attempting to systematically look at the full array of pressures that human activities have on the coastal and marine environment of the Mediterranean, and the attendant loss in ecosystem services that those impacts cause.

The state of the Mediterranean coastal and marine environment varies from place to place, but all parts of the Mediterranean are subject to multiple pressures acting simultaneously and in many cases chronically. The State of the Mediterranean Marine and Coastal Environment Report 2012 highlights the following as the major issues requiring coordinated policy and management responses in the coming years in order to stem the tide of degradation of the Mediterranean ecosystems.

- **Coastal development and sprawl**, driven by urban and touristic development, leading to fragmentation, degradation and loss of habitats and landscapes, including the destabilisation and erosion of the shoreline. Special attention should be paid to the degradation of transitional areas, including deltas, estuaries, and coastal lagoons, which serve as critical nursery areas for commercial fisheries and support unique assemblages of species but also to the broader coastal zone.

- **Chemical contamination** of sediments and biota caused by pollution from urbanisation, industry, anti-foulants, and atmospheric transport. Although environmental conditions are improving in regard to certain pollutants in many Mediterranean areas, thanks to improved control of land based pollution releases, contamination linked to hazardous substances remains a problem in many areas.

- **Eutrophication** caused by human-mediated input of nutrients into marine waters is a source of concern, especially in coastal areas near large rivers and/or cities. Impacts of eutrophication include algal blooms, some of them harmful, and hypoxia. The direct socioeconomic impacts are related to toxicity or mortality of harvested fish and shellfish, loss of aesthetic value of coastal ecosystems, and reduced water quality impacting tourism.

- The impact of **marine litter**, concentrated especially in bays and shallow areas, is increasingly regarded as a matter of concern across the Mediterranean.

- The impact of **marine noise** on biota, especially marine mammals and fish, requires targeted research. Intense maritime traffic, particularly in the Western Mediterranean, and intense offshore exploration and military activities in specific locations, suggest potentially serious impacts.

- **Invasive non-indigenous species** have increased in recent years, particularly in the easternmost reaches of the Mediterranean. Documented impacts on natural diversity include predation, alteration of the food web, niche competition, and modification of habitats, leading to a variety of impacts on fishing, aquaculture, shipping, human health, and tourism.

- **Over-exploitation** beyond sustainable limits affects many of the commercially exploited fish stocks of the Mediterranean. The result is changes in species diversity, with some species regarded as Endangered, Vulnerable or Near-Threatened. Over-exploitation also leads to changes in community structure, the food web, and, ultimately, ecological processes and the delivery of ecosystem services. Other pressures brought by the intense fishing activity in the Mediterranean include by catch, non-selective fishing methods, and destructive fishing. Understanding how multiple pressures reduce sustainable limits of harvest is necessary for effective fisheries management, which is crucial in a part of the world where seafood is both culturally and economically vital. While touted as a means of reducing pressure on wild stocks, aquaculture has increased noticeably since the 1990s, adding new pressures. These include nutrient and organic matter pollution leading to eutrophication and eventual benthic anoxia, pollution through the release of antibiotics and biocides, and the introduction of non-indigenous species.

- **Sea-floor integrity** is affected mainly by bottom fishing, but also by dredging and offshore installations. Bottom fishing and dredging lead to the resuspension of sediment and organisms and to changes in the structure of benthic communities. The impact of offshore installations is not well researched.

- Changed **hydrographic conditions** caused by local disruption of circulation patterns by human-made structures, changes in freshwater fluxes to the sea, brine release from desalination plants, or climate change influence both nearshore and offshore areas. Changes in freshwater flows also affect sediment delivery to the coastal zone near river mouths, with impacts on coastline stability on key systems, such as dune-beach complexes.

- **Marine food webs** have been affected by fisheries pressures that led to the estimated reduction on average of one trophic level in the fisheries catches during the last half-century, increased jellyfish numbers, and reduced abundance of large predator species.

- Finally the state of **biodiversity** reflects the cumulative effects of the pressures affecting the Mediterranean coastal and marine environment. Although there is still high diversity in the Mediterranean, some species of reptiles, marine mammals, birds, and fish are reaching dangerously low abundance levels. The Mediterranean also hosts a diverse array of habitats of commercial, ecological, and cultural importance. Many are under a variety of pressures. Complicating the issue, many offshore areas, where upwellings develop and seamounts provide important habitat, are located beyond national jurisdiction.

This picture of multiple pressures acting simultaneously, and affecting different components of the Mediterranean marine and coastal environment, to undermine ecosystem health and resilience, and put certain species and habitats at high risk, is certainly complex. Future monitoring will allow for more robust and systematic analyses of precisely how these pressures and their impacts affect the Mediterranean as a whole, and the economies and well-being of coastal countries and communities. This information is more urgently needed than ever, as countries define top priorities for management with limited time and resources with which to implement plans. The Mediterranean continues to be a valuable, treasured region, yet one clearly under threat; the commitment of countries that border it remains the only hope that these coastal and marine ecosystems will thrive despite these growing pressures.

Response analysis and recommendations

As use of Mediterranean coastal and marine resources and space grows, the ability of these interconnected ecosystems to deliver goods and services is compromised. Yet there is every reason for hope, as individual countries have tackled marine issues admirably, and the region as a whole is moving towards a more effective and efficient Ecosystem Approach. Such an Ecosystem Approach recognizes the linkages between various habitats, and between the environment and the biota it supports, and the economies and human well-being of coastal communities. The Ecosystem Approach allows priorities for management to emerge, and at the same time, creates efficiency in addressing management and conservation needs.

Contracting Parties to the Barcelona Convention have committed to this Ecosystem Approach; they have dedicated time and resources, as well as data, to the effort to more systematically address threats, and the drivers behind those threats. Understanding of the myriad values that natural infrastructure and the Sea as a whole provide has helped raise awareness, and has made the push for more effective management ever more urgent.

At the moment the information on the human pressures and their impacts in the Mediterranean is unevenly distributed depending on the subject and also in terms of space and time. Yet it is indisputable that a regionally shared understanding of how human activities impact the Mediterranean coastal and marine environment, and how those impacts in turn affect industries, local livelihoods, and human well-being, is developing. More effective management responses at both the country level and through international cooperation can be expected to flow from coordinated monitoring and systematic understanding of these pressures, allowing for prioritisation of the many complicated management issues that require management responses. With this systematic and coordinated framework for prioritisation, the sectorial management responses will mitigate the most harmful impacts, leading to fulfilment of an effective Ecosystem Approach that safeguards the vital biodiversity and ecosystem services upon which Mediterranean countries depend.

The net cumulative impact of the myriad of pressures affecting different locations within the Mediterranean is difficult to accurately determine beyond modelling efforts based on expert judgement due to previous non-integrated monitoring that focuses on single species, sites, or sectors. This drives home the need for a systematic monitoring regime that will allow accurate assessments of the state of the Mediterranean coastal and marine environment. In addition to establishing a systematic monitoring regime to derive needed information on condition and trends, future research will have to elucidate cause-effect relationships, in order to support the establishment of management measures that lead to the desired outcomes.

The Ecosystem Approach provides an integrated and holistic framework to give a much-needed look at, for example, the influence that freshwater use in watersheds and land use in coastal areas, in relation to urbanisation, industrialisation, and increasing coastal tourism, has on coastal and marine ecosystem health, productivity, and the delivery of valuable ecosystem services.

The commitment of the Contracting Parties to an Ecosystem Approach signals the extent to which countries value the coastal and marine resources and environments of the Mediterranean. Tangible progress towards the vision of "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations" is in evidence after the extensive work undertaken four decades in the framework of the Barcelona Convention, its Protocols and the Mediterranean Strategy for Sustainable Development. The major issues described above are the base for the Ecological Objectives of the Ecosystem Approach that were endorsed by the Contracting Parties in February 2012.

Strong signals suggest steps towards better management have already been taken, for instance, the entry into force in 2011 of the 2008 Protocol on Integrated Coastal Zone Management (ICZM). Under this Protocol, Contracting Parties are committed to establish a common framework for the integrated management of the Mediterranean coastal zone and to take the necessary measures to strengthen regional cooperation for this purpose. Additional milestones in coastal and marine management include the ratification of the 1995 Dumping Protocol so it enters into force, the identification of Ecologically and Biologically Significant Areas (EBSAs) proposed by MAP and its RAC/SPA; the 2005 Decision by the GFCM to restrict bottom trawling in all waters below 1.000 meters; and the many bilateral and subregional agreements fostering improved understanding and harmonised management. The most important of all developments may well be the dedication shown to fostering the Ecosystem Approach. Under this available technology and tools can now be harnessed to better assess what changes are taking place, why, and how to craft effective management responses. This move towards a more ecosystem-based approach is timely, coming at a time when ecosystems, though facing multiple threats, are still healthy and productive enough to be able to respond positively to improved management.

PART 1

Introduction to the Mediterranean Basin

The Ecosystem Approach to the Management of Human Activities

The Mediterranean Basin and its Waters

The Human Mediterranean Basin

The region enclosing the Mediterranean Sea encompasses portions of three continents: Europe and its southern peninsulas to the north, southwestern Asia to the east, and the Maghreb region of northern Africa to the south. Overall, it is a densely populated region with an intricate political history involving many different ethnic groups. This has led to a complex and patchy political map. Today 21 countries, with surface areas from 2 km^2 to 2,4 million km^2, have coastlines on the Mediterranean Sea. They are Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia, and Turkey.

The Mediterranean region has historically been the scene of intense human activity. The Mediterranean Sea and its coasts are the source of many of the resources harvested in the region, but also the conveyor belt for trade, and often the sink for the cumulative impacts of these activities. The Mediterranean is a relatively small, enclosed sea with limited exchange with the oceanic basins, intense internal mesoscale circulation, and high diversity of sensitive ecosystems. These characteristics, combined with the political complexity of the region, mean the management and protection of the coastal and marine environment will require multilateral environmental agreements and regulations, abided by at a supranational level. This approach is essential to sustainable development in all nations bordering on bodies of water that extend beyond their boundaries.

In order to be able to analyse the different environmental problems and issues that affect the Mediterranean marine and coastal ecosystems it is important to be aware of the natural characteristics of the Mediterranean Basin and have an overview of the major drivers in the Mediterranean region, including all economic sectors within the Mediterranean basin and specially those devoted to the exploitation of the coastal and marine natural resources. This allows increased understanding of the overall interrelation between Mediterranean ecosystems and the human drivers.

The Ecosystem Approach to the Management of Human Activities

The Mediterranean coastal and marine ecosystems: productivity, diversity and services

In many ways, the Mediterranean Sea and its coastal fringes are unique. While the level of biological productivity is low, the Mediterranean Sea and surrounding lands are characterised by a relatively high degree of biological diversity. The fauna includes many endemic species and is considered richer than that of Atlantic coastal areas (Bianchi and Morri 2000). The continental shelf is generally very narrow, but the coastal marine area of the Mediterranean, which stretches from the shore to the outer extent of this continental shelf, shelters rich ecosystems and the sea's few areas of high productivity. Central zones of the Mediterranean are low in nutrients, but coastal zones benefit from nutrient inputs that support higher levels of productivity. Among the reasons for the high habitat diversity are the steep depth gradient in the basin and the latitudinal range causing climatic conditions to range from sub-tropical to temperate.

Both coastal and marine ecosystems in the Mediterranean deliver extremely valuable ecosystem services that benefit all of the region's inhabitants. They include fisheries resources and tourism values, for which economic values can be ascertained relatively easily, as well as waste assimilation, a transport medium, buffering from storms, and the means to maintain the ecological balances that make life on Earth possible.

Mediterranean countries recognise the value of these ecosystem services, but are only now beginning to quantify them. In 2010, the UNEP/MAP Blue Plan Regional Activity Centre produced a preliminary Mediterranean marine ecosystem services valuation report (UNEP/MAP/BP, 2010). The study concluded that, across the Mediterranean region, ecosystem service benefits may exceed 26.128 million Euros annually. More than two-thirds of the estimated economic benefits come from tourism and the value of nature supporting tourism. Other valuable ecosystem services include provisioning of seafood, waste assimilation, coastal stabilisation and erosion prevention, and carbon sequestration. While the findings of the study are under review, the magnitude of the estimates for the ecosystem services suggests the importance of certain types of habitats and resources in supporting human well-being throughout the basin. As countries discuss how to move forward together toward a more ecosystem-based approach to marine management, priorities may centre on those habitats that provide the bulk of these economically, ecologically, and culturally valuable services.

Coastal and marine ecosystems of the Mediterranean include:

- rocky shores and nearshore coastal areas (including karstic systems);
- coastal plains;
- brackish water lagoons, estuaries, or transitional areas;
- wetlands;
- sea grass meadows;
- coralligenous areas (calcareous formations produced by encrusting algae);
- frontal systems and upwellings;
- deep water benthic systems including seamounts and cold-water coral reefs; and,
- pelagic systems.

Understanding the economic and social value of Mediterranean ecosystem services helps in assessing the costs of inaction or of continuing sector-by-sector management. The current management regime generally does not take into account how multiple uses of the marine and coastal environment act in synergy to undermine the health and productivity of entire regions. The loss of ecosystem services can be very costly and the effects can linger over long time periods. Small investments in taking an ecosystem approach to management could prevent further degradation.

The Approach to the Management of Human Activities

The Mediterranean Sea and coasts are the lifeblood of the region, providing not only sustenance and space in which to live and practice commerce, but also a key cultural backdrop against which Mediterranean civilisations have flourished and continue to flourish. This is one of the most used and highly cherished marine areas in the world. The long history of settlement and use has undeniably altered the coastal and marine ecosystems of the Mediterranean Basin, yet they continue to support the countries and communities that line the sea's margins.

Previous reports on the Mediterranean marine and coastal environment (EEA and UNEP 1999; UNEP/MAP/MED POL 2005; EEA and UNEP 2006; UNEP/MAP/BP/RAC 2009) have highlighted the ways that development of coastal and marine areas has impacted the Mediterranean as a whole. The issues of the past remain relevant today:

- poorly planned coastal development with fragmentation and loss of the integrity of coastal habitats and landscapes;
- loss of marine habitats;
- pollution;
- unsustainable fisheries;
- spread of invasive species; and,
- climate change.

Past changes have ramifications for human well-being in the present. The loss of biodiversity, declines in productivity, and contamination by pollutants do not affect only the marine systems and how well they function. They also affect human health, human economies, and the very fabric of these coastal societies.

Today Mediterranean countries are taking a holistic look at the condition of the Mediterranean environment, with the goal of understanding how multiple and cumulative impacts affect the environment and how, in turn, continued degradation of the environment affects human well-being. This holistic approach will certainly build on the steps already covered by previous integrated management approaches as the Integrated Coastal Zone Management (ICZM), recently strengthened by the entry into force of its Protocol. The commitment by the Contracting Parties of the Barcelona Convention to an Ecosystem Approach signals recognition of the immense value of the region's seas and coasts, and the singular importance of promoting management that allows for sustainable use.

Growing coastal populations, urbanisation, ever-increasing maritime commerce, exploitation of natural resources, and coastal tourism are the drivers behind the chronic pressures that continue to degrade Mediterranean seas and coasts. However, these drivers and pressures are not uniform throughout the basin. Tailoring a management response that effectively ensures continued sustainable use requires solid understanding of the levels of pressure, the underlying condition of the ecosystems, how the ecology is affected, and how institutions are responding. The state of the Mediterranean environment is really the story of multiple states of the environment, varying from place to place, and of how this range of conditions affects the sea as a whole and the ability of its marine and coastal ecosystems to continue providing the goods and services people need.

Since the 2006 EEA-UNEP/MAP report on priority issues in the Mediterranean environment, some changes are apparent. Improvements in water quality are discernible in specific places, thanks to strategic efforts to reduce pollutant loading. Quantities of hazardous substances such as DDT and heavy metals are declining in some areas (UNEP/MAP/MED POL 2011). New issues, however, are emerging. Desalination and its effects, particularly with respect to brine release, needs further in depth investigation. The increasing use of coastal and ocean space for aquaculture, including grow-out operations for bluefin tuna, brings with it the threat of increased pollution, eutrophication, release of invasive species and pathogens, and growing conflict over reduced access and availability of space for other uses. And impacts on the region's ecology and economy from invasive species continue to grow, warranting more serious attempts to prevent new invasions and to control, where possible, damage caused by these species.

One reason that Mediterranean ecosystems continue to be threatened, despite ever-increasing recognition of their value, is the historic inability to conduct a uniform assessment of pressures and states in order to formulate responses. With the exceptions of localised pollutants and nutrient and organic matter enrichment, data for some countries are limited. Some countries though have begun to assess climate-change impacts and to study emerging issues, such as noise pollution and cumulative impacts assessment. Other countries, with more limited human and financial resources, are focusing on their obligations under the various Barcelona Convention Protocols. A future, rationalised monitoring programme, based on the selection of ecological and operational objectives, already underway by Contracting Parties to the Barcelona Convention, will overcome these barriers to understanding the Driver-Pressure-State-Impact-Response sequence across a wide span of impacts from human activity.

The Contracting Parties of the Barcelona Convention agreed during the meeting of Contracting Parties in February 2012 (Decision IG.20/4) to strive to meet a series of ecological and operational objectives (see Part 3) aimed at guaranteeing that the Mediterranean ecosystems keep providing valuable services and profitable resources for Mediterranean countries. These objectives can be summarised as follows:

- Coastal processes are not disrupted by urbanisation, coastal development, and inadequate protection of the integrity of coastal habitats, ecosystems and landscapes, with the result that shorelines remain stable, sea-level rise is accommodated as much as possible by natural adaptation, and habitat fragmentation is minimised.
- Pollution caused by contaminants is minimised so as to prevent disruption of ecology, loss of biodiversity, and negative human health impacts.
- Human-induced eutrophication and increasing hypoxia and anoxia are prevented or minimised through controls on nutrient inputs into coastal waters.
- Marine litter does not adversely affect the coastal and marine environment, including marine life.
- Marine noise from human activities causes no significant impact on marine and coastal ecosystems.
- Non-indigenous species introduced by humans are kept, to the maximum extent possible, from becoming invasive and disrupting natural productivity and balances.
- Fisheries exploitation (and harvesting of fish to support agricultural and aquaculture industries) does not exceed sustainable limits, leaving resources to support the complex of ecosystems and allowing for replenishment.
- Anthropogenic damage to the sea floor is avoided or minimised, such that the integrity of benthic systems is maintained and benthic/pelagic coupling can continue, as is necessary for healthy marine ecosystems.
- Hydrographic conditions are not unduly altered through poorly planned coastal construction, changes to river flows leading to estuaries, or other physical alterations to the coasts and seas.
- Where possible, food webs are not altered by resource exploitation and environmental change, so that balances and productivity are maintained.
- Marine and coastal biodiversity at all levels (genetic, species, and ecosystem) is kept from being irreversibly lost, so that the ecological roles of species can be supported and ecosystems can provide both cultural and amenity values to the maximum potential possible.

Until these conditions are met, the environment of the Mediterranean marine and coastal systems will continue to be threatened, and the delivery of important and valuable ecosystem services will be at risk. As a result, so will be the communities and countries that border the basin.

The Mediterranean Basin and its Waters

Geography, physiography and landscapes

A general overview of the Mediterranean region's physical geography reveals an irregular, deeply indented coastline, especially in the north, where the Iberian, Italian, and Balkan peninsulas jut southward from the main body of Europe. Numerous islands correspond to isolated tectonic blocks, the summits of submarine ridges, or the tips of undersea volcanoes. The largest islands are Sicily, Sardinia, Corsica, Cyprus, and Crete, and the major island groups include the Balearics off the coast of Spain and the Ionian, Cyclades, and Dodecanese islands off Greece. Apart from the coastal plains and the deltaic zones of large rivers (Ebro, Rhone, Po and Nile), the coastlines are mostly rimmed by mountain ranges. Only the coastal plains from eastern Tunisia to the Sinai Peninsula, bordered mainly by low-lying desert, are free of mountains. In fact, the highest reaches of the main mountain ranges generally mark the limit of the hydrographic basin that drains towards the Mediterranean Sea. These mountain ranges include the Atlas, the Rif, the Baetic Cordillera, the Iberian Cordillera, the Pyrenees, the Alps, the Dinaric Alps, the Hellenides, the Balkan, and the Taurus (Amblas *et al.* 2004).

The Mediterranean Sea occupies a basin of almost 2,6 million km^2. The coastline is 46.000 km long, and the basin itself about 3.800 km from east to west and 900 km from north to south at its maximum between France and Algeria. The average water depth is approximately 1.500 m with a maximum depth of 5.121 m off southwestern Greece. The shallowest part of the Mediterranean Sea is the northern Adriatic, where the average depth does not exceed 50 m. The Mediterranean Sea can be divided into two sub-basins, the Western and the Eastern Mediterranean, which in turn are composed of a series of varied small basins (Amblas *et al.* 2004).

The Western Mediterranean has an area of approximately 0,9 million km^2 and includes the Alboran Sea, the Algerian-Balearic Basin, the Catalano-Balearic Sea, the Gulf of Lions, the Ligurian Sea, and the Tyrrhenian Basin. The Straits of Gibraltar, located at the western end of the Western Mediterranean, provide the only natural connection between the Mediterranean Sea and the global ocean. This passage, only 14 km wide and 290 metres deep at its sill, exerts crucial control on water circulation with an inflow of ca. 35.000 km^3 per year. The continental shelves tend to be narrow off the southern and northern Iberian Peninsula, the Balearic Islands, Corsica, Sardinia, the western Italian coast, northern Africa, and the Maritime Alps, where mountain slopes drop almost straight into the sea. Larger continental shelves, more than 50 km wide, are present off the mouths of the Ebro and Rhone rivers, mainly due to the seaward extension of deltaic systems. The continental shelf off the north coast of Tunisia is also wide. Bathyal plains, the flat deepest areas of the basin, occupy the central portions of the Algerian-Balearic Basin, with depths reaching 2.800 m, and the Tyrrhenian Basin, with depths up to 3.430 m.

In contrast, the much-larger Eastern Mediterranean, with an area of approximately 1,7 million km^2, has a highly varied physiographic character. It includes the Strait of Sicily, the Adriatic Sea, the Ionian Sea, the Levantine Basin, and the Aegean Sea. The major structures in the bathymetry of the Eastern Mediterranean are the Hellenic Trench and the Mediterranean Ridge. The Hellenic Trench is a subduction zone (an area where the Earth's tectonic plates meet, with one plate sliding beneath another), reaching a maximum depth of 5.267 m off the Peloponnese, the deepest point in the Mediterranean. This trench confines the Aegean Sea to the north, arching from the western Peloponnese to southeast of the island of Rhodes. The Mediterranean Ridge runs parallel to this structure, from the Ionian Basin in the west to the Cyprus arch in the east (Amblas *et al.* 2004).

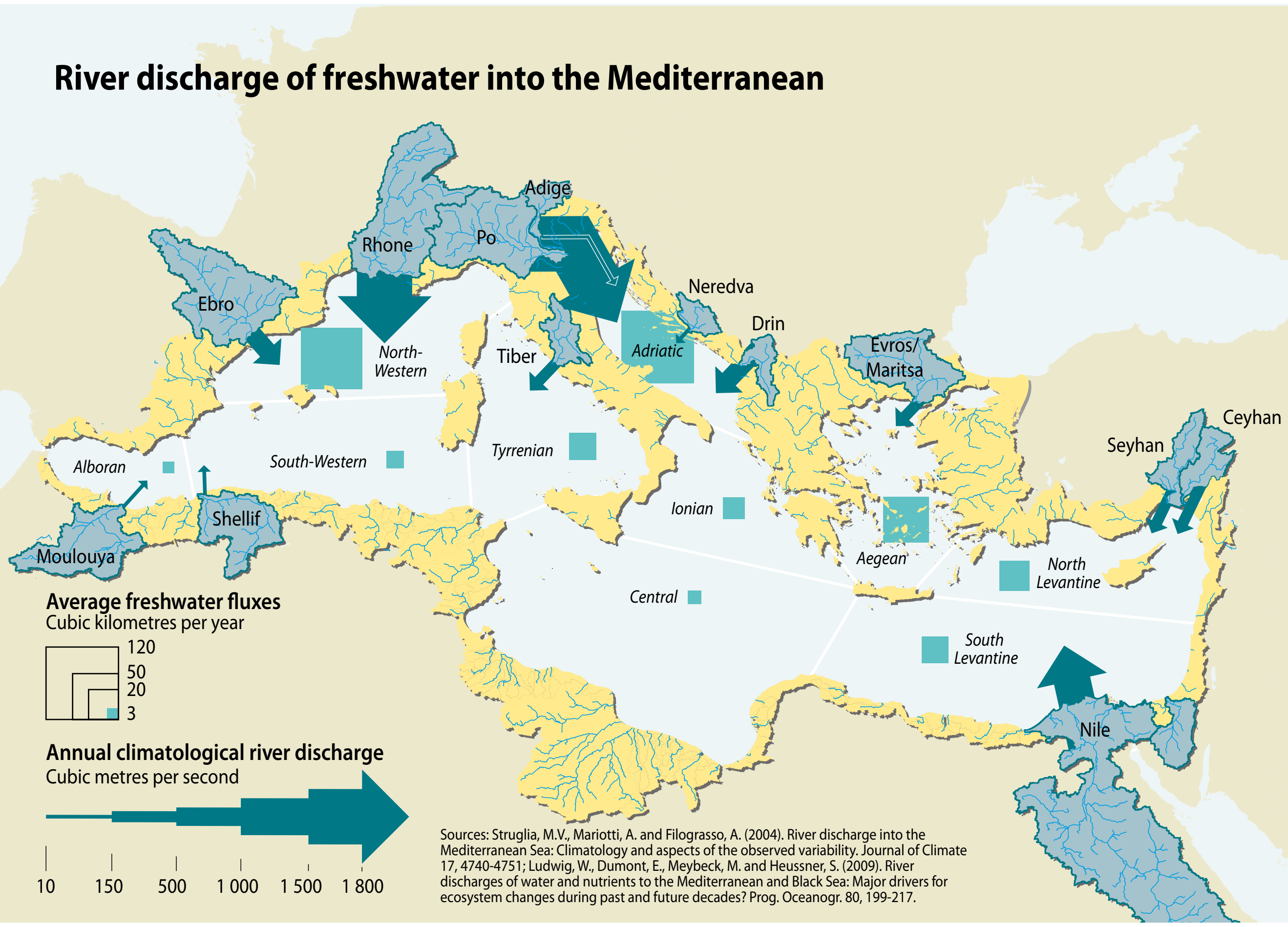
River	Drainage region	Outflow sub-basin	Drainage area
Ebro	Southern flanks of the Pyrenees and northern flanks of the Iberian Cordillera	Catalano-Balearic Sea	84.000 km^2
Rhone	Central Alps and flows through Lake Geneva and southeastern France	Gulf of Lion	96.000 km^2
Po	Southern flanks of the Alps and the northern part of the Apennine mountain range	Adriatic Sea	75.000 km^2
Nile	Northeastern part of the African craton	Levantine Sea	3.300.000 km^2

The Eastern Basin is connected to the Western Basin through the Strait of Sicily, with a maximum depth of about 400 m, and to the Black Sea by the Straits of the Dardanelles, with a maximum width of only 7 km and an average depth of 55 m. The inflow from the Black Sea is two orders of magnitude smaller than that from the Atlantic reaching ca. 200–300 km^3 per year. The connection on the southeastern end with the Red Sea occurs through the man-made Suez Canal. The continental shelves in the Eastern Basin are narrow off Peloponnesus, Crete, and southern and northern Turkey. However, they are particularly well developed east of Libya, in the area influenced by deposits from the Nile River delta, and in the Adriatic, where large areas are shallower than 100 m due to Po delta deposits. The Aegean Sea is also fairly shallow, a consequence of its relatively young crust rather than high sediment input. In the Eastern Basin, bathyal plains are deeper and smaller than those in the west. Maximum depths are up to 4.200 m in the Ionian Abyssal Plain and 3.200 m in the Herodotus Abyssal Plain (Amblas *et al.* 2004).

The Mediterranean drainage basin extends over an area of more than 5 million km^2. This includes the Nile and the Libyan coastal zone, neither of which are active parts of the drainage basin. Most of the water that drains to the Nile evaporates, particularly following construction of the Aswan High Dam, which increased the amount of water drawn from the system for agriculture. The drainage basin of the southern Eastern Mediterranean (including much of the Libyan coastal zone) is mostly desert with only small seasonal watercourses. Excluding these areas that have little riverine input, the drainage basin of the Mediterranean Sea measures less than 1,5 million km^2 (Ludwig *et al.* 2009). The major perennial rivers (Ebro, Rhone, Po, and Nile) are supplied by very large drainage basins that, in most cases, collect water beyond the boundaries of the Mediterranean climatic belt.

Smaller rivers, with drainage basins less than 10.000 km^2, cover nearly 60 % of the Mediterranean catchment area and play an important role. However, they are either ephemeral or carry small volumes of water due to relatively low annual rainfall (below 500 mm), high evaporation and infiltration, and the seasonal and sporadic nature of rainfall.

Sedimentary systems associated with the larger rivers have created large coastal plains, defining the characteristics of the



coastal zone and continental margin. Under the influence of the micro-tidal regime, these coastal plains have grown to form large deltaic systems, broad shelves formed by deltaic processes, and continental slopes incised by deep canyons hundreds of kilometres long (Canals *et al.* 2004). The Nile system is fed by sediments originating as far as 6.650 km from the coastline, creating an impressive onshore delta plain (formed before construction of the Aswan Dam) on the northeastern coast of Egypt. The offshore end of this sedimentary system is the Nile deep-sea fan, covering about 140.000 km^2, one of the largest submarine fan-shaped terrigenous deposits in the world.

The unique and recognizable Mediterranean coastal landscapes are the result of centuries of interplay among the diverse natural characteristics of the Mediterranean region and the equally diverse human activities, both past and present. The Mediterranean countryside is characterised by terraced slopes built for the mixed cultivation of vegetables, herbs, grains, grapes, olives, and fruit trees. Forests or small patches of forest also play an important visual, biological, and climatic role in the landscapes, even though forest is relatively scarce. Increasingly, mixed cultivation crops are being replaced by intensive plantations, and the traditional terrace pattern on the slopes is being displaced by the modern arrangement of large, dense farmlands in the flat areas. The terrace pattern remains, however, until natural vegetation gradually overgrows the terraces.

In the low-lying sectors of the coastal zone, large coastal plains occupy the areas near river mouths. Extensive saltpans were once located there. Nowadays, agricultural uses are taking over in some places, with salt produced in more restricted areas. In other places, the saltpans are abandoned and decaying.

Mediterranean cultural landscapes are also shaped by human activity, above all by architecture and urbanisation. The locations of traditional settlements were influenced mainly by climate and were largely contiguous along large parts of the Mediterranean coast. Currently, the settlement pattern is shifting from contiguous settlements to dispersed sprawl around major towns, resulting in landscape degradation.

Besides the characteristic landscapes described above, there is a multitude of other landscapes in the Mediterranean. So far, no Mediterranean-wide landscape classification system allows detailed mapping of landscapes for the entire basin. Nevertheless, the increased availability of spatial data in digital format and advances in Geographical Information Systems and related disciplines provide the opportunity for a more comprehensive, integrated and systematic assessment of the coastal environment (Vogiatzakis and Cassar 2007).

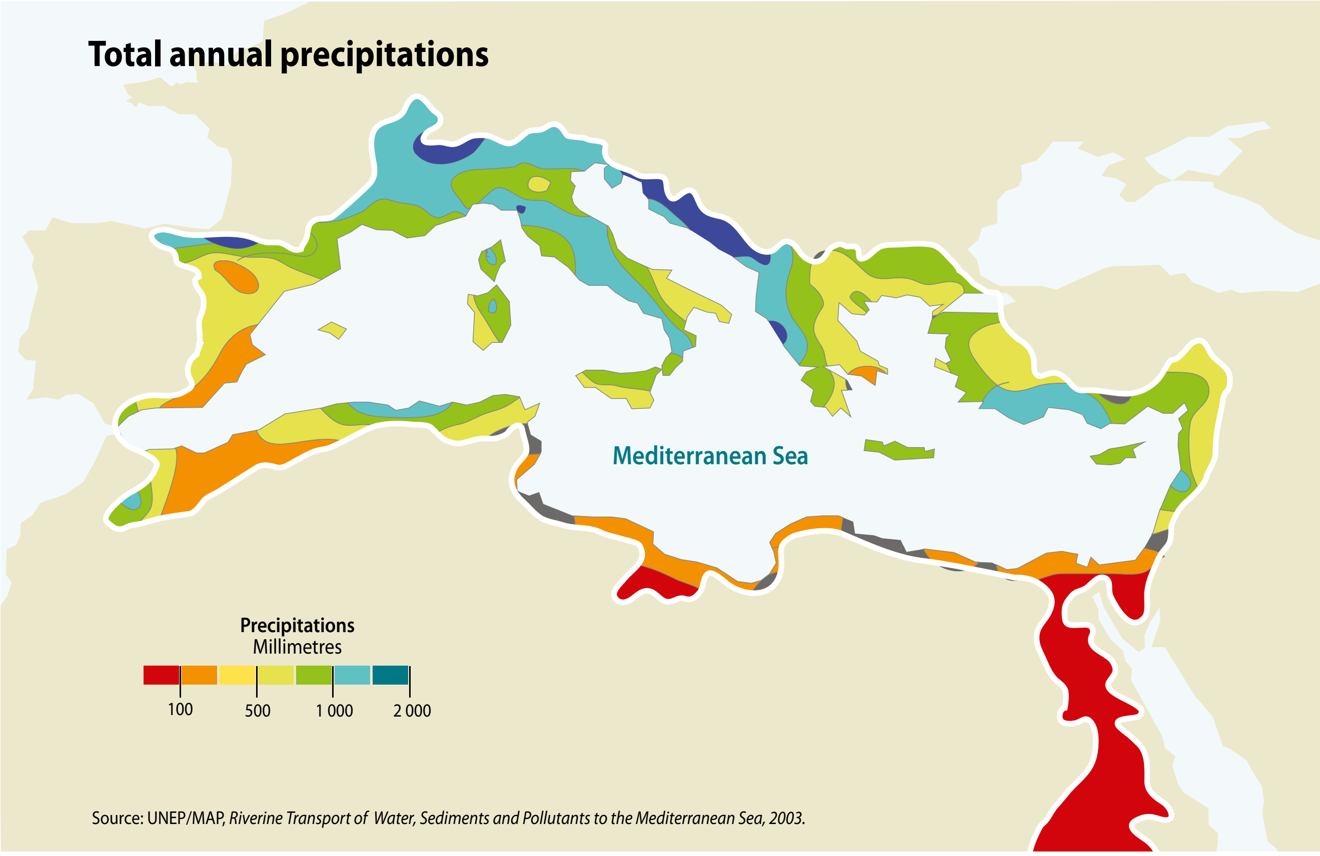
Hydrological and climatic setting

Rivers play a key role in the Mediterranean region's water circulation and geochemistry. Because the Mediterranean Sea is a semi-enclosed ocean basin receiving relatively large amounts of drainage, they also play a role in sustaining marine productivity. Changes in freshwater input due to natural variability or major river regulation lead to changes in the Mediterranean's surface-water salinity. These changes can have a basin-wide impact on the vertical circulation and mixing of water masses, with resulting impacts on surface water productivity and the characteristics and ventilation of deep-water masses (Rohling and Bryden 1992). The release of contaminants through the network of rivers will unavoidably have an impact on the levels of these contaminants in the marine basin. Finally, due to the oligotrophic – low in nutrients – character of the Mediterranean, changes in riverine nutrient inputs, whether natural or human-induced, are potential drivers for long-term changes in coastal and open-water marine productivity and in marine ecosystems (Ludwig *et al.* 2009).

The estimated mean annual river discharge into the Mediterranean for recent years is about 10.000 m^3/s, with a dry season in midsummer and a peak flow in early spring (Struglia *et al.* 2004). Ranked according to annual discharge, the ten largest rivers contributing to the Mediterranean Sea are the Rhone, Po, Drin-Bojana, Nile, Neretva, Ebro, Tiber, Adige, Seyhan, and Ceyhan. These rivers account for half of the mean annual discharge, with the Rhone and the Po alone accounting for already one-third of it (Ludwig *et al.* 2009). Of the three continents that discharge into the Mediterranean Sea, Europe dominates, with a climatological mean annual discharge that accounts for half of the total. The European discharge clearly determines the seasonal cycle for the Mediterranean. Discharge from Asia and Africa is considerably smaller. Discharge into the Adriatic Sea, the Northwestern Basin, and the Aegean Sea, combined, accounts for 76 % of the whole. About one-third of the total basin discharge flows into the Adriatic (3.700 m^3/s) (data from Ludwig *et al.* 2009). The Nile, with a catchment area an order of magnitude greater than any other Mediterranean river, has a mean annual discharge of 2.800 m^3/s to the Aswan Dam. The discharge is reduced to about 5 % of that amount (150 m^3/s) by the time it reaches the Mediterranean Sea.

Mediterranean river discharge patterns depend on properties of the atmospheric water budget as well as on the geographical characteristics of the Mediterranean catchment. A substantial latitudinal gradient characterises Mediterranean precipitation year-round, with dry areas along the African coast and significantly wetter ones north of the Mediterranean Sea (Struglia *et al.* 2004). Winter is the main rainy season for the European land regions, which contribute most of the discharge, while summers south of 40 degrees N are basically dry. Most of the water discharge in the northern region occurs during short floods associated with maximum river flow after heavy rainfall, which generally occurs between February and May. The strong summer-winter rainfall contrast, which increases from north to south and from west to east, is the major characteristic of the Mediterranean climate (UNEP/MAP/MED POL, 2003). In the large and medium-sized river basins in north and central Europe, wide-ranging and continuous precipitation is the most common cause of flooding. Floods also occur in association with snow melt in late spring and early summer. Intense short-lasting rainfall during spring and fall affecting small coastal catchments is the main cause of coastal floods in arid and semi-arid parts of the Mediterranean area.

Overall, freshwater discharge into the Mediterranean decreased by an estimated 20 % between 1960 and 2000, with no major differences between the Eastern and Western basins. This reduction results from large-scale changes in precipitation and temperature. It therefore reflects the potential impact of climate change on river freshwater discharge and represents a minimum estimate. In the drier parts of the Mediterranean drainage basin, anthropogenic water use can also reduce the long-term water



discharge, particularly to sub-basins such as the South Levantine, Alboran, Southwestern Basin, Aegean, Central, and North Levantine. Given the importance of water resources to local economies in this part of the world, a 20 % reduction in only 40 years is significant. Climate monitoring and modelling studies reveal a general trend toward drier and warmer conditions, which started in the last century and is expected to worsen in the future. The trend could have serious repercussions for riverine water discharges (Ludwig *et al.* 2009).

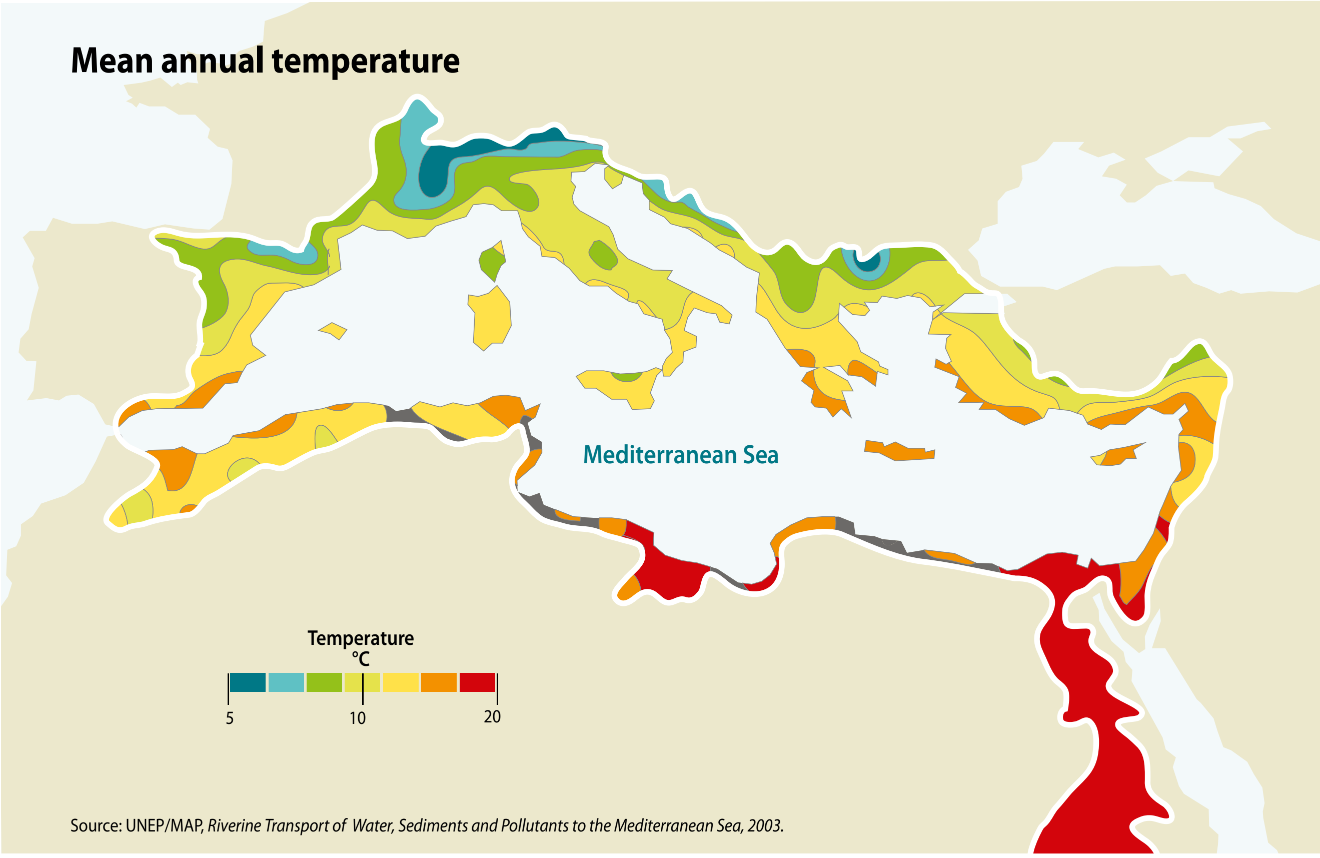
Due to damming, several major Mediterranean rivers, such as the Rhone and Ebro, have seen a reduction in freshwater discharge. River flow regulation for irrigation purposes is estimated to have caused a further reduction of up to 40 % in freshwater discharge to the Mediterranean Sea (Poulos 2011). In the case of the Ebro River in Spain, trend analysis shows a reduction of the river's discharge of about 50 % since the 1950s. This change is attributed to increased human water use (urban demand, agriculture, industry, and tourism) and regulation, but also to an increase in shrub and afforestation-related vegetation cover where grazing and traditional agriculture have disappeared (Lopez-Moreno *et al.* 2011). Similarly, Zahar and Albergel (1999) reported that the closure of the Sidi Salem Dam in Tunisia led to a reduction of the mean annual discharge of the Medjerdah River by 65 % due to diversion for irrigation and evaporative losses.

Coastal aquifers provide another source of freshwater discharge to the Mediterranean. The submarine groundwater discharge from the coastal aquifers, estimated at 2.200 m^3/s, accounts for almost one-fifth of the total freshwater inflow into the Mediterranean, with more than one-third of this discharge entering from the sea's European shores (Zektser *et al.* 2006). Seepage inflows are prevalent on the eastern coast of the Adriatic, dominated by karstic aquifer systems, as well as on the eastern and southern Mediterranean coast with semi-arid and arid conditions, limited precipitation and runoff, and limited surface watercourses and discharge points. Coastal seepage and submarine discharges are critical to the water balance and seawater quality in the marine sub-basins. They also support wetlands and brackish water habitats, important to biodiversity, and fishery nursery areas. The coastal aquifers are threatened by over-exploitation and consequent seawater intrusion and water and land salinisation, which will add to the deficit in recharge of the Mediterranean (UNEP/MAP/MED POL 2005). Submarine groundwater discharge is also a significant source of nutrient input in some regions and could provide pathways for pollutants to disperse into the sea (Lobkovsky *et al.* 2003).

Climatically, the Mediterranean is characterised by warm temperatures, winter-dominated rainfall, dry summers, and a profusion of microclimates (UNEP/MAP/MED POL 2003). Mean annual temperature follows a marked north-to-south gradient, with local variations superimposed by geography.

Mediterranean circulation and water masses

A large thermohaline cell (affected by both temperature and salinity) characterises the general circulation in the Mediterranean Sea. Circulation is driven by the water balance deficit and by the heat fluxes between the sea and the atmosphere. The water deficit, caused by greater evaporation than precipitation and river run-off, is mainly compensated for by the inflow of Atlantic water through the Straits of Gibraltar and by the water contribution from the Black Sea through the Straits of the Dardanelles. The exchange of heat with the atmosphere, leading to the cooling and subsequent sinking of surface waters, also contributes to the thermohaline circulation.

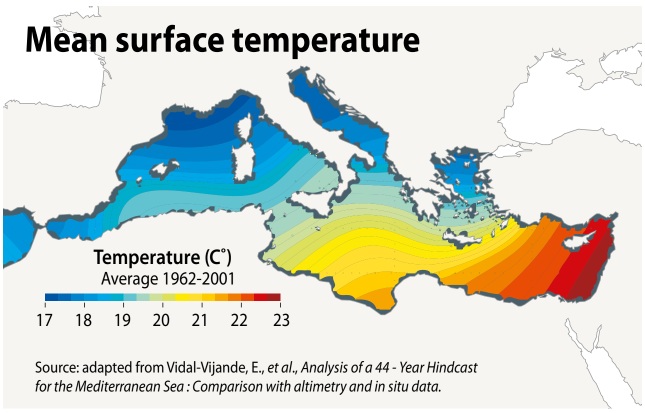


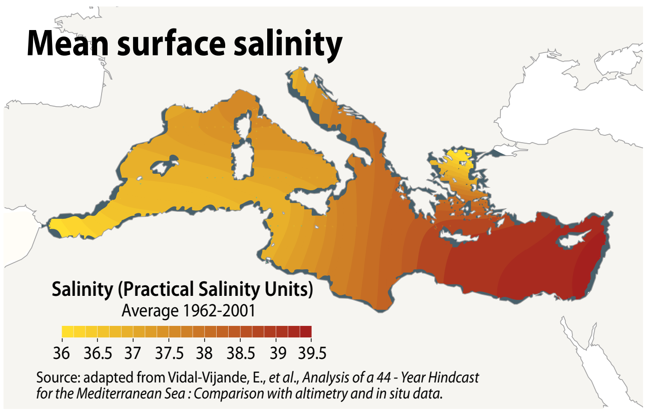
Schematically, the Mediterranean Sea comprises three main water masses (EEA and UNEP 1999):

- the Modified Atlantic Water (MAW), found in the surface layer, with a thickness of 50–200 m and characterised by a salinity of 36,2 psu (practical salinity units) near Gibraltar to 38,6 psu in the Levantine basin;
- the Levantine Intermediate Water (LIW), formed in the Levantine basin, lying in depth between 200 and 800 m, and characterised by temperatures of 13–15,5°C and salinity of 38,4–39,1 psu;
- the Mediterranean Deep Water (MDW), formed in both the Western and Eastern basins. The Western Mediterranean Deep Water (WMDW) is characterised by a temperature of 12,7°C and a salinity of 38,4 psu, while the Eastern Mediterranean Deep Water (EMDW) is characterised by a temperature of 13,6°C and a salinity of 38,7 psu.

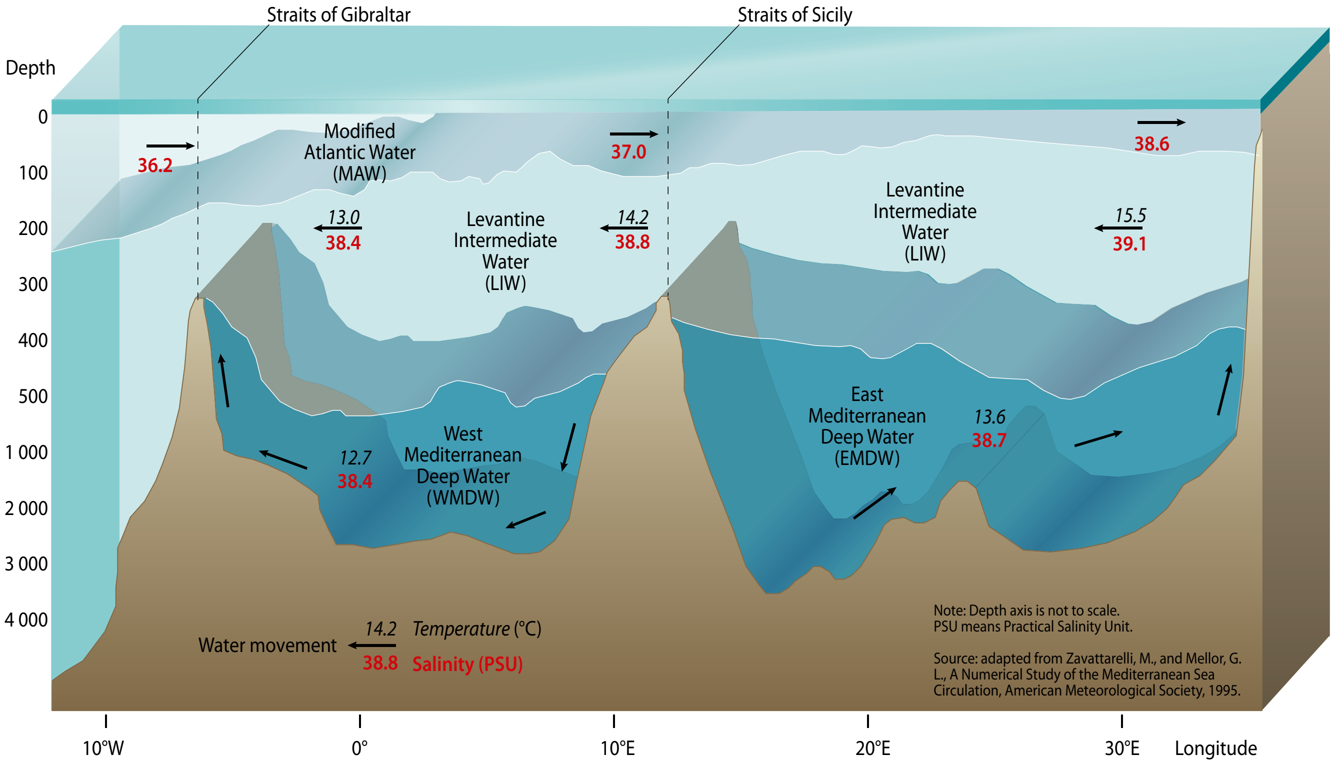
Within the sea, the incoming Atlantic water is continuously modified by interactions with the atmosphere and mixing with older surface waters and with the waters underneath. All along its course, MAW is seasonally warmed or cooled, but overall its salt content increases and it becomes denser. In autumn, in the northern parts of both basins, MAW remains at the surface. In winter, cold and dry air masses induce marked evaporation and direct cooling of MAW, resulting in a dramatic increase in its density, which makes it sink. This sinking occurs in a series of specific zones, generally located in the northern parts of the basins, and is responsible for the formation of the deeper waters in the Mediterranean.

Besides some secondary formation of deeper waters related to overcooling of shelf waters, the major deep water formation process occurs offshore in some sub-basins. Fundamentally, densified MAW sinks and mixes with the denser waters underneath. The mixture continues to increase in density. The resulting water masses will be either intermediate or deep. Deep vertical convection in the northern part of the Western Basin forms the WMDW.





Mediterranean Sea water masses: vertical distribution



Cold winter winds between Rhodes and Cyprus and on the northern and central Adriatic Sea are responsible for the formation of LIW. LIW is the warmest and saltiest intermediate water, and the largest in volume. Because of its characteristics and amount, LIW is recognizable more or less everywhere in the sea. Due to its relatively low density, it is found just below MAW, and it mixes with MAW as soon as MAW starts sinking.

The overall formation rate of intermediate and deep Mediterranean waters is estimated to be approximately 90 % of the Atlantic water inflow at Gibraltar (10 % being evaporated). About three-quarters of intermediate and deep waters are formed in the Eastern Basin. The estimated residence time of Mediterranean waters is quite high, around 50–100 years (Millot and Taupier-Letage 2005), which has important implications for the cycling and eventually export of contaminants.

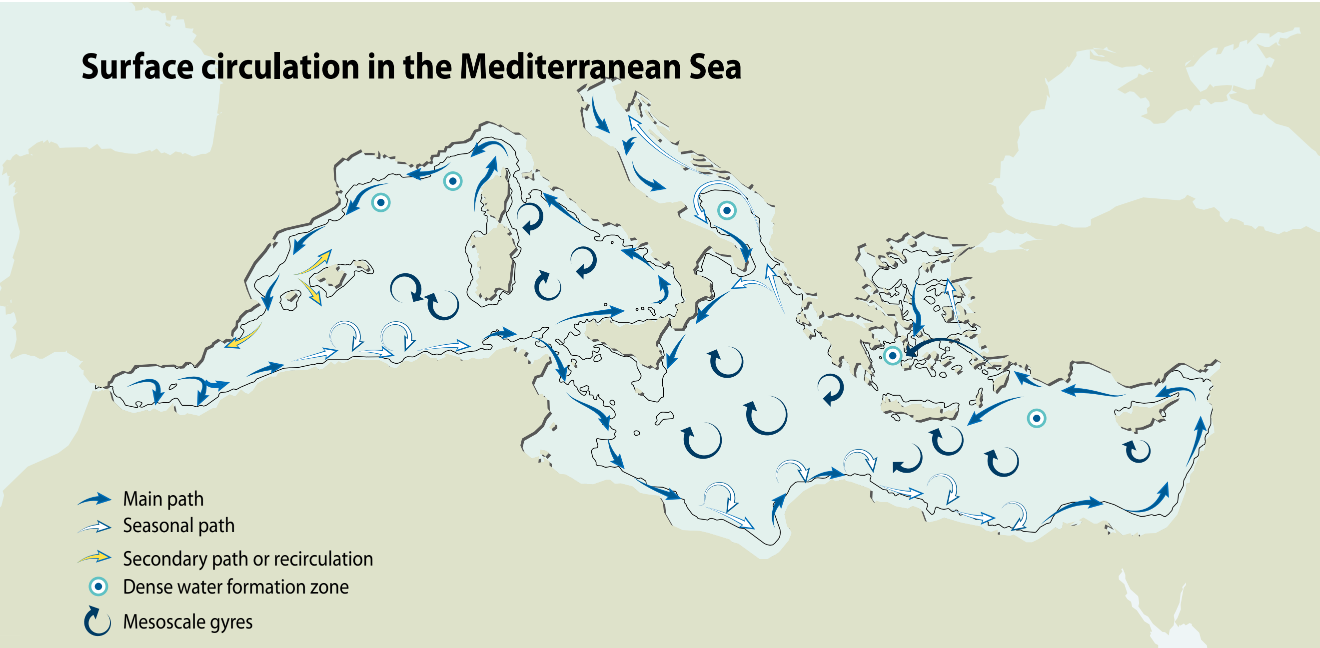
The large-scale circulation of the Mediterranean Sea has been described as sub-basin-scale and mesoscale gyres interconnected and bounded by currents and jets with strong seasonal and inter-annual variability (Millot and Taupier-Letage 2005). This general circulation flow impinges on the coastal regions and strongly influences the local dynamics of currents. Shelf areas in the Mediterranean are comparatively small and are separated from the deepest regions by steep continental shelf breaks. This configuration makes possible the intrusion of the large-scale flow field on the coastal/shelf areas and the direct influence of the large-scale currents on coastal flow. Transport of material from the coastal areas to the open ocean is enhanced by this mechanism, with important consequences for the maintenance of the ecological cycles in the basin (EEA and UNEP 1999) and for the potential for redistribution of pollution from land-based sources.

Chemical characteristics of the Mediterranean waters

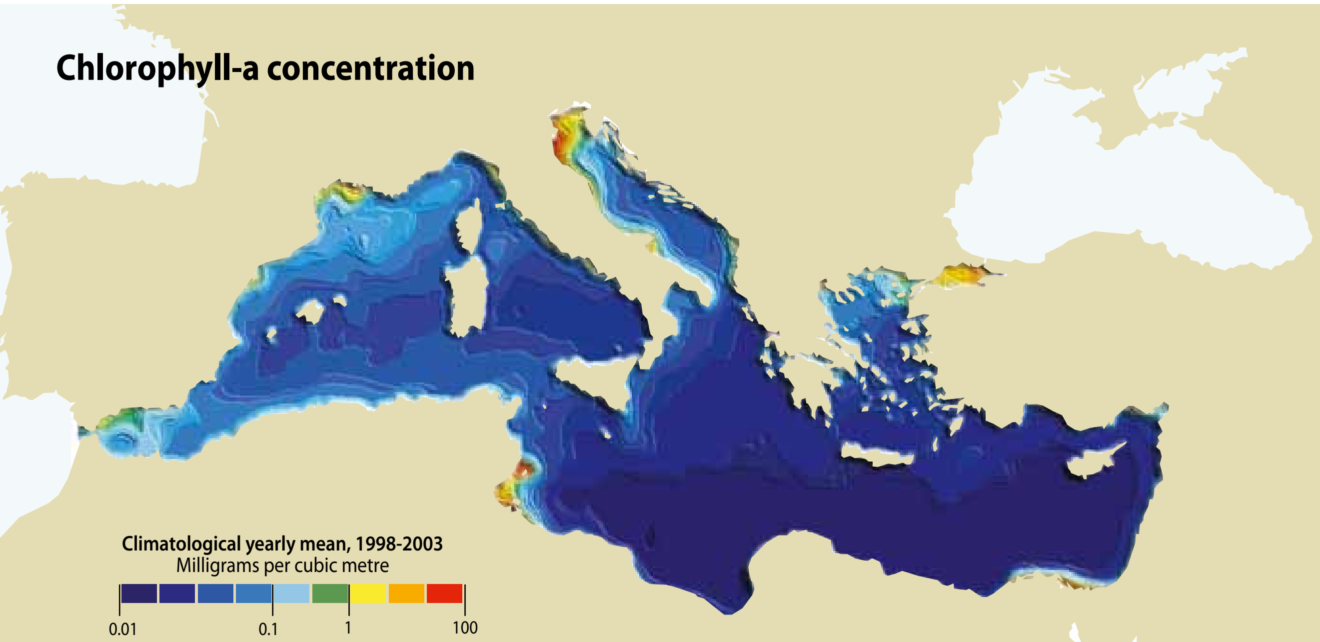
The Mediterranean Sea is an impoverished area with surface nutrient concentrations too low to support a large biomass (McGill 1961). Because of its negative water balance and the resulting water circulation, Mediterranean deep waters export large amounts of nutrients to the Atlantic Ocean (Hopkins 1985), where they are lost to the basin for internal primary production. The limited supply of nutrients to the surface waters of the Mediterranean Sea, both from its lower layers and from external sources, does not compensate for the export at depth. Zones of high productivity are therefore mainly restricted to areas in the vicinity of major freshwater inputs and/or with intensified mesoscale circulation.

Phosphorus is the most important limiting nutrient in the Mediterranean (Margalef 1963; Berland *et al.* 1980), closely followed by nitrogen. Inflowing Atlantic water carries nutrients needed for photosynthesis, but overall this water is low in nutrients. Estimates of inorganic forms of nutrients in the inflowing waters range from 0,05 to 0,20 µM (µmol/L) for phosphate-phosphorus, 1 to 4 µM for nitrate-nitrogen and nearly 1,2 µM for silicate-silicon (Coste *et al.* 1988). Density gradients develop in the lower part of the inflowing Atlantic waters, preventing the exchange with deeper, nutrient-rich basin waters. The nutrient content of the surface water is reduced as it moves through the Mediterranean Sea and encounters nutrient-poor basin water and biological activity. The nutrient concentration in the Aegean Sea is twelve times lower than in the Atlantic Ocean and eight times lower than in the Alboran Sea (McGill 1969), explaining the lower production in the Eastern Mediterranean. Coste *et al.* (1988) calculated a nutrient deficit of about 10 % for the total nitrogen and phosphorus outflow and about 50 % for the total silicon outflow. Bethoux *et al.* (1992) proposed that, at a basin scale, the phosphorus deficit would be balanced by runoff from land and atmospheric deposition, while nitrogen losses might be balanced by additional fixation by sea grass epiphytes and pelagic bacterioplankton.

Mean annual gross primary production (PP) in the Mediterranean Sea is estimated at about 110–120 g C/m^2 for the Eastern Basin and about 120–160 g C/m^2 for the Western Basin (Bethoux *et al.* 1998; Crispi *et al.* 2002; Bosc *et al.* 2004). According to recent estimates by Ludwig *et al.* (2009) the maximum primary production that can be supported by the riverine nutrient inputs is only about 1–2 % of the total primary production in the Mediterranean. In coastal areas with large rivers, however, this contribution can be much more important. Changing river nutrient loads may therefore have a substantial impact on biological productivity in the more productive river-dominated coastal systems, such as the Adriatic Sea.



Sources: C. Millott and Taupier-Letage, I. (2005). Circulation in theMediterranean Sea. Hdb Env Chem Vol. 5, Part K, 29–66



Source: adapted fromV. Barale, Jaquet J. and M. Ndiaye (2008). Algal blooming patterns and anomalies in the Mediterranean Sea as derived from the SeaWiFS data set (1998–2003). Remote Sensing of Environment 112, 3300–3313.

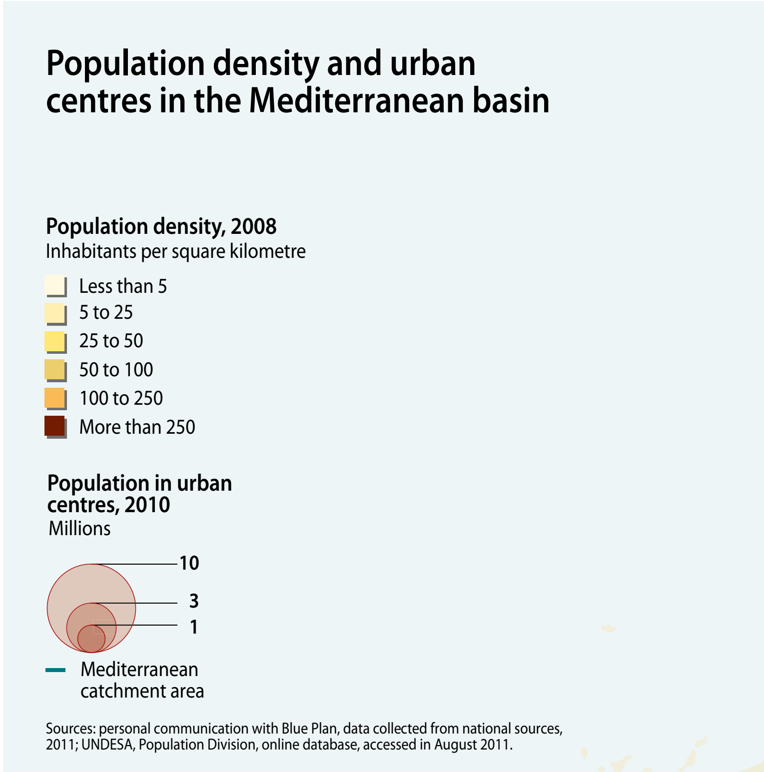
The Human Mediterranean Basin

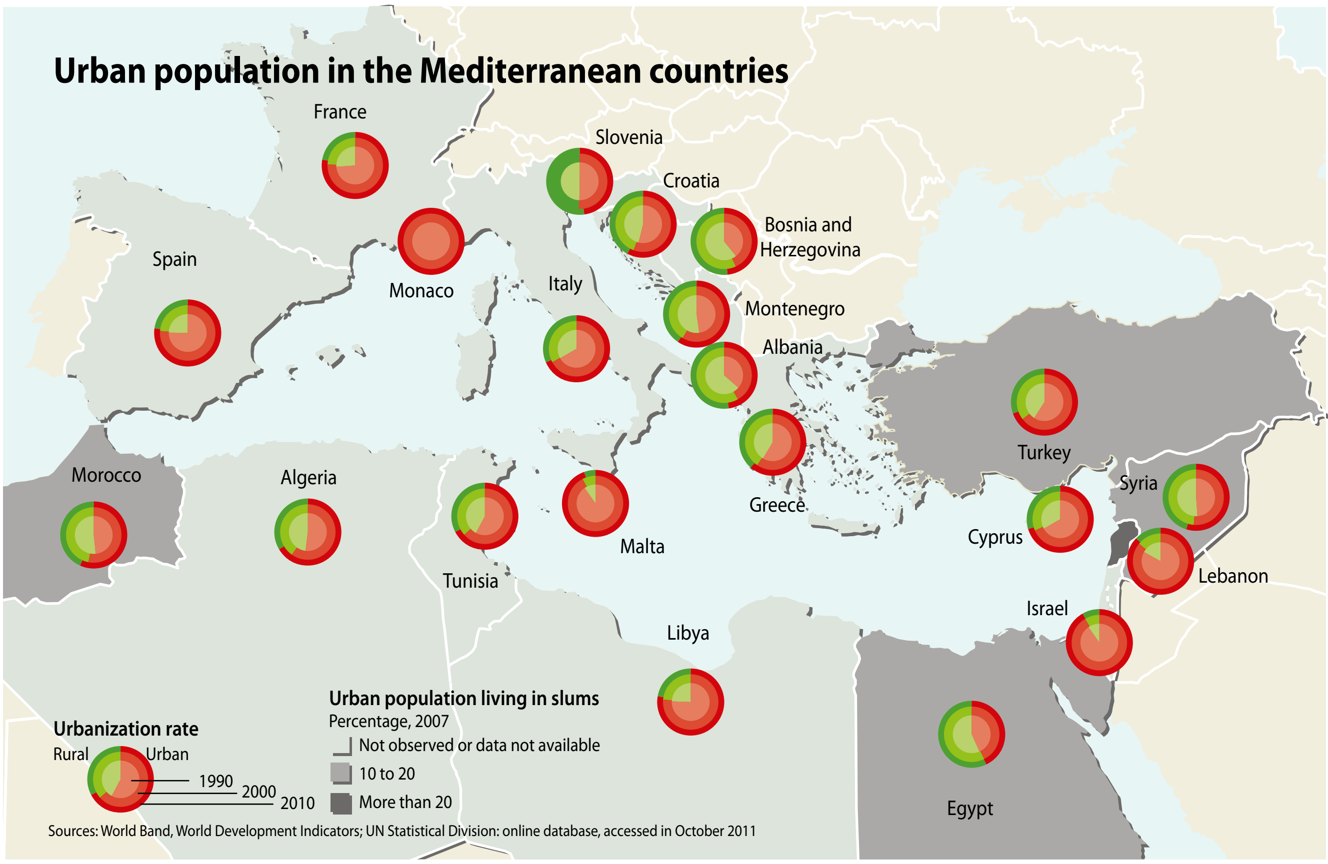
Human population and development

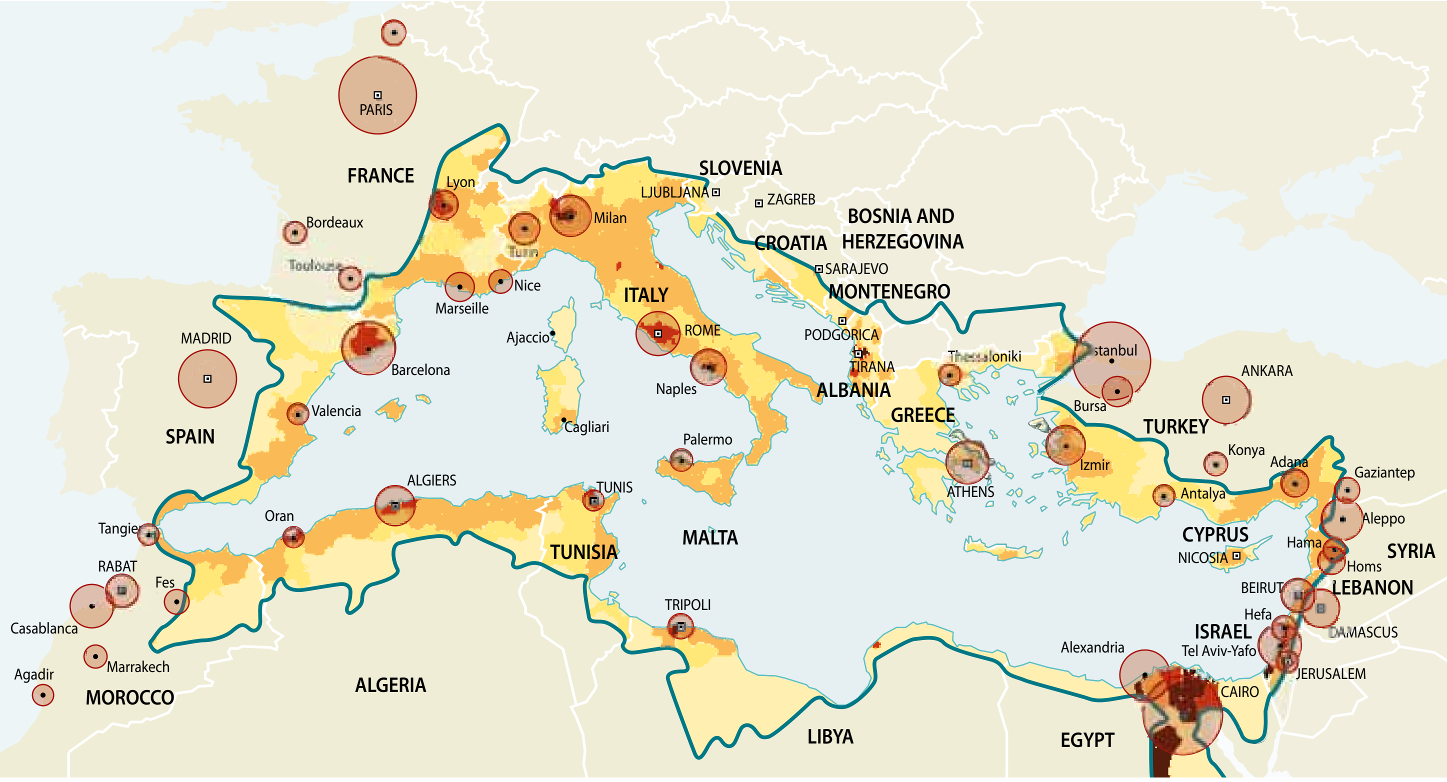
The total population of the Mediterranean countries grew from 276 million in 1970 to 412 million in 2000 (a 1,35 % increase per year) and to 466 million in 2010. The population is predicted to reach 529 million by 2025. Four countries account for about 60 % of the total population: Turkey (81 million), Egypt (72 million), France (62 million), and Italy (60 million) (Plan Bleu computations based on UNDESA 2011). Overall, more than half the population lives in countries on the southern shores of the Mediterranean, and this proportion is expected to grow to three-quarters by 2025 (UNEP/MAP/MED POL 2005).

The Mediterranean region's population is concentrated near the coasts. More than a third live in coastal administrative entities totalling less than 12 % of the surface area of the Mediterranean countries. The population of the coastal regions grew from 95 million in 1979 to 143 million in 2000. It could reach 174 million by 2025 (UN/MAP/BP/RAC 2005). The concentration of population in coastal zones is heaviest in the western Mediterranean, the western shore of the Adriatic Sea, the eastern shore of the Aegean-Levantine region, and the Nile Delta. Overall, the concentration of population in the coastal zone is higher in the southern Mediterranean countries. This is also where the variability of the population density in the coastal zone is highest, ranging from more than 1000 people/km^2 in the Nile Delta to fewer than 20 people/km^2 along parts of coastal Libya.

Urban development in the Mediterranean has been very rapid. Of the 190 million people added to the population between 1970 and 2010, 163 million live in towns. Urban population (towns with more than 10.000 inhabitants) increased 1,9 % per year during that period, from 152 million to 315 million. The total could reach 385 million by 2025. More than 74 % of this growth

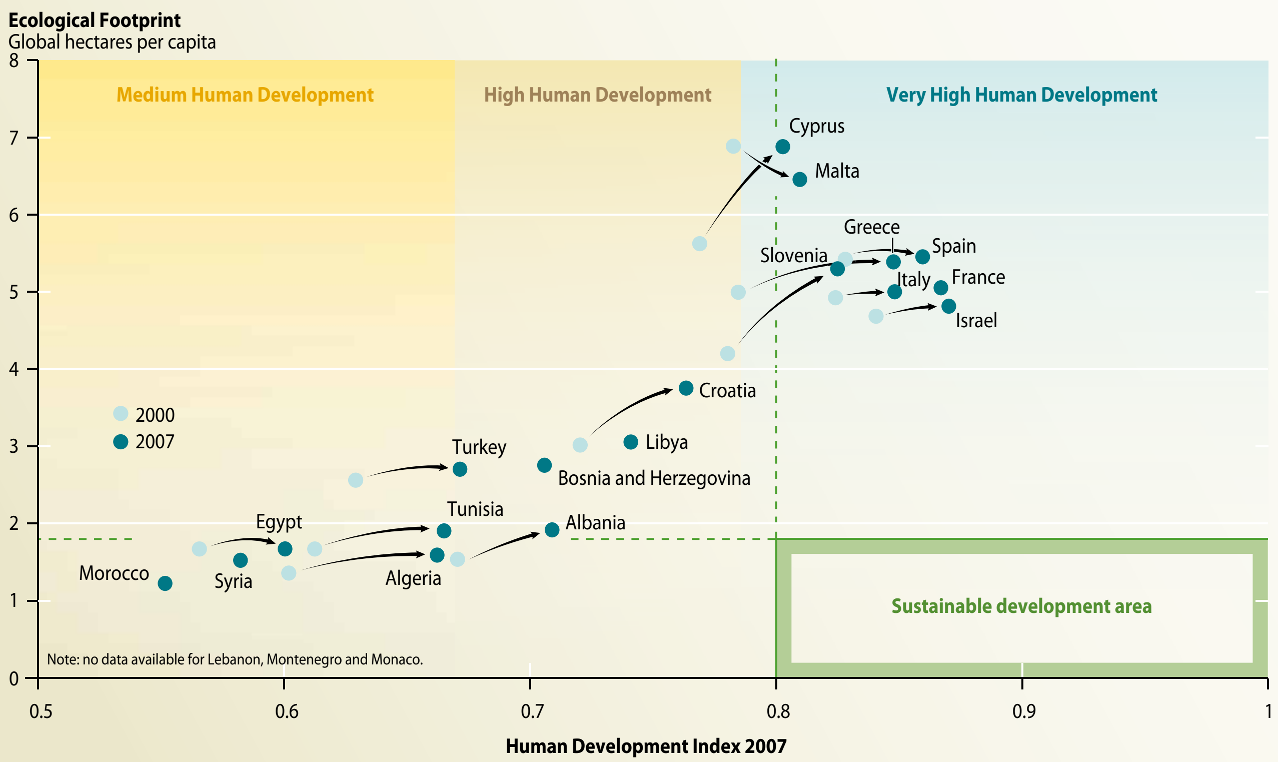






took place in the south and east, where urban growth from 1970 to 2010 averaged 3,1 % a year, and about 4 % a year in Libya, Syria and Turkey. Urbanisation around the Mediterranean increased from 54 to 66 % over the same period. The south and east Mediterranean is urbanising more rapidly than the rest of the world. Projections indicate a drastic shift in the south and east Mediterranean. What were essentially rural countries, with an average urbanisation of 41 % in 1970, will become urban countries with

Human development and ecological footprint in Mediterranean countries



Sources: Ecological Footprint Network; UNDP; online databases

66 % urbanisation by 2025. (Plan Bleu computations based on UNDESA 2010). In coastal regions, where the urbanisation process results in over-development, the urban population could increase by 33 million (30 million of that increase in the south and east) between 2000 and 2025.

As for the overall distribution of population the number of coastal cities with more than one million inhabitants is largest in the western Mediterranean on the eastern coast of the Levantine basin, and in the Nile Delta region. In absolute terms, population growth remains high, and its impacts on the environment are likely to increase because of the greater number of people in cities and on the coasts.

The long history of the Mediterranean has led to a diversification of political and governance approaches, a broad range in economic development, and a diversity of social systems, all of which is reflected in the levels of development and the ecological footprints of the Mediterranean states. The ecological footprint is a measure of human demand on the Earth's ecosystems and it represents the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate associated waste.

Mediterranean countries can be separated into two groups:

1. middle-income countries, with low Human Development Indices (HDIs) and small ecological footprints plus substantial progress in HDI, concentrated in the southern and eastern Mediterranean and on the eastern shore of the Adriatic Sea; and
2. high-income countries, with high HDIs and large ecological footprints. These are the EU Mediterranean countries and Israel.

Between 2000 and 2007, all Mediterranean countries both improved their HDIs and increased the size of their ecological footprints, with the exception of Malta, which managed to decrease its ecological footprint (UNEP/MAP/BP 2011).

Human economic activities have an impact on the structure and function of natural ecosystems and on the many services provided by these ecosystems such as recreation, climate regulation and provision of natural resources, either living, such as fish and molluscs, or non-renewable, such as oil and gas and minerals. Coastal areas and their landscapes, in particular, face significant pressures from heavy concentrations of population and economic activities. As the coastal population grows and urbanises, natural coastal habitats and landscapes get further fragmented, the land use changes towards more anthropogenic with the corresponding change in the landscapes leading to decreasing integrity of coastal landscapes and ecosystems.

Economic sectors

Agriculture and forestry

Agriculture in the Mediterranean Basin, despite many different sub-climates, is mainly rain-fed. Cereals, vegetables, and citrus fruits account for over 85 % of the Mediterranean's total agricultural production (UNEP/MAP/BP/RAC 2009). Cultivation of other products, such as olives for olive oil and grapes for wine, also occupies a significant amount of agricultural land (Leff *et al.* 2004).

Production of vegetables, cereals, and citrus fruits has increased to between 2,5 and 5 times the production levels of the 1960s. The total surface area of cultivated land in the Mediterranean Basin, however, has remained approximately stable over this period. The increase results from intensified production through greater use of irrigation (approximately 20 million hectares in 1960, rising to 38 million hectares in 1999). Despite higher production, countries on the eastern and southern shores of the Mediterranean still depend on food imports to meet the requirements of an increasing population (UNEP/MAP/BP/RAC 2009).

Besides rain-fed or irrigated cultivation, other common agricultural land uses in the Mediterranean Basin are pasture, animal feedlots, dairy farming, and orchards. Aquaculture is also practised. All of these activities have environmental implications. Fertilising, tillage, application of pesticides, manure spreading, and cattle breeding feed nutrients (nitrates and phosphates), pesticides, and pathogens into the system (EEA and UNEP 1999). Surficial run-off, sediment transport, and leaching carry them into rivers, ground water, lakes, wetlands, and, ultimately, into the sea.

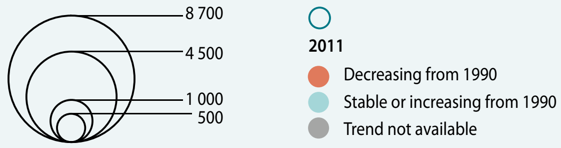
Especially in the drier parts of the Mediterranean Basin, agricultural production relies on the use, and sometimes over-use, of areas with good soil and adequate rainfall or irrigation water. The need to produce enough food drives over-extension of crops onto marginal land, easily degraded due to irregular rainfall and fragile soils on erosion-prone slopes. This leads to soil erosion, destruction of the woody and herbaceous cover, and a reduction in optimal grazing areas. Animal grazing is displaced, in turn, to poorer grazing areas and forests. The result is over-grazing, with the inevitable degradation of vegetation and soil, aggravating the process of desertification. According to the Intergovernmental Panel on Climate Change (IPCC), the southern shores of the Mediterranean will be strongly affected by climate change, placing an additional burden on agricultural production, which is already limited by constrained natural resources.

The Mediterranean forests even if characterised by low productivity provide several important ecosystem services (carbon sequestration, biodiversity, landscape quality, preservation of water

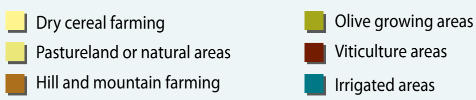
Agriculture and population in the Mediterranean basin

People employed in agriculture

Per 10 000 people living in rural areas

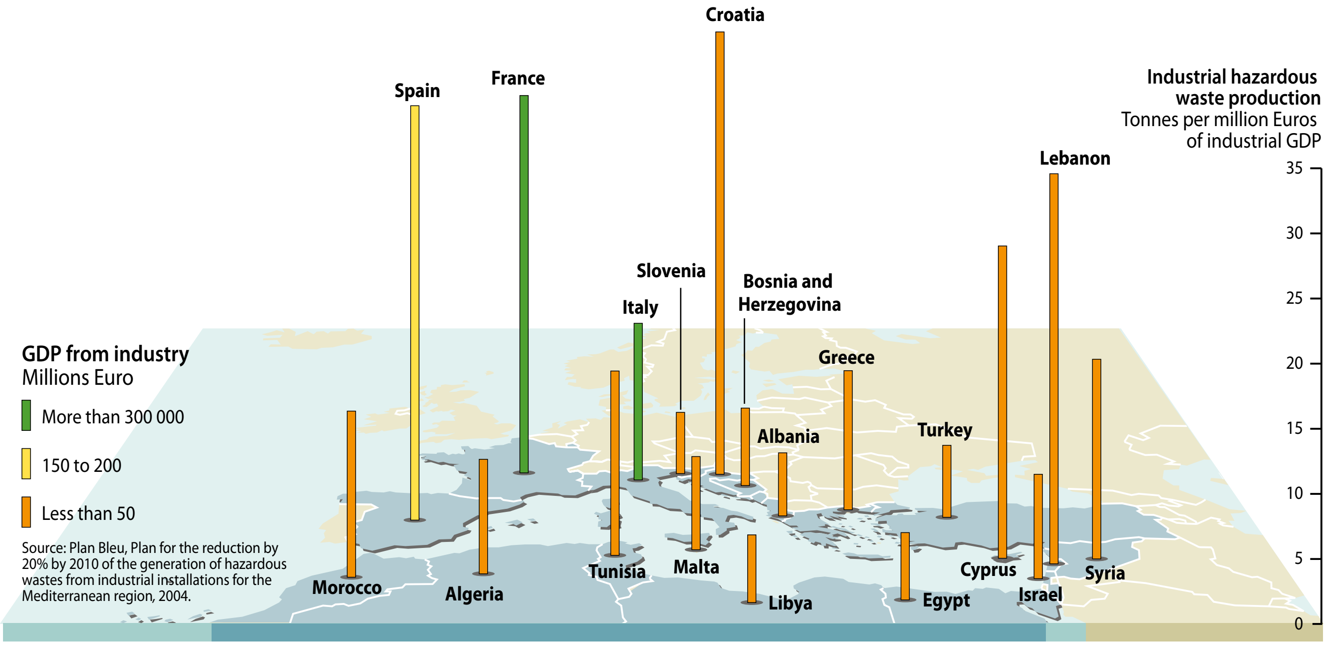


Agricultural land



Sources: World Band, World Development Indicators, on line database, accessed October 2011; Beilstein, M;, Bournay, E., Environment and Security in the Mediterranean: Desertification, ENVSEC, 2009.

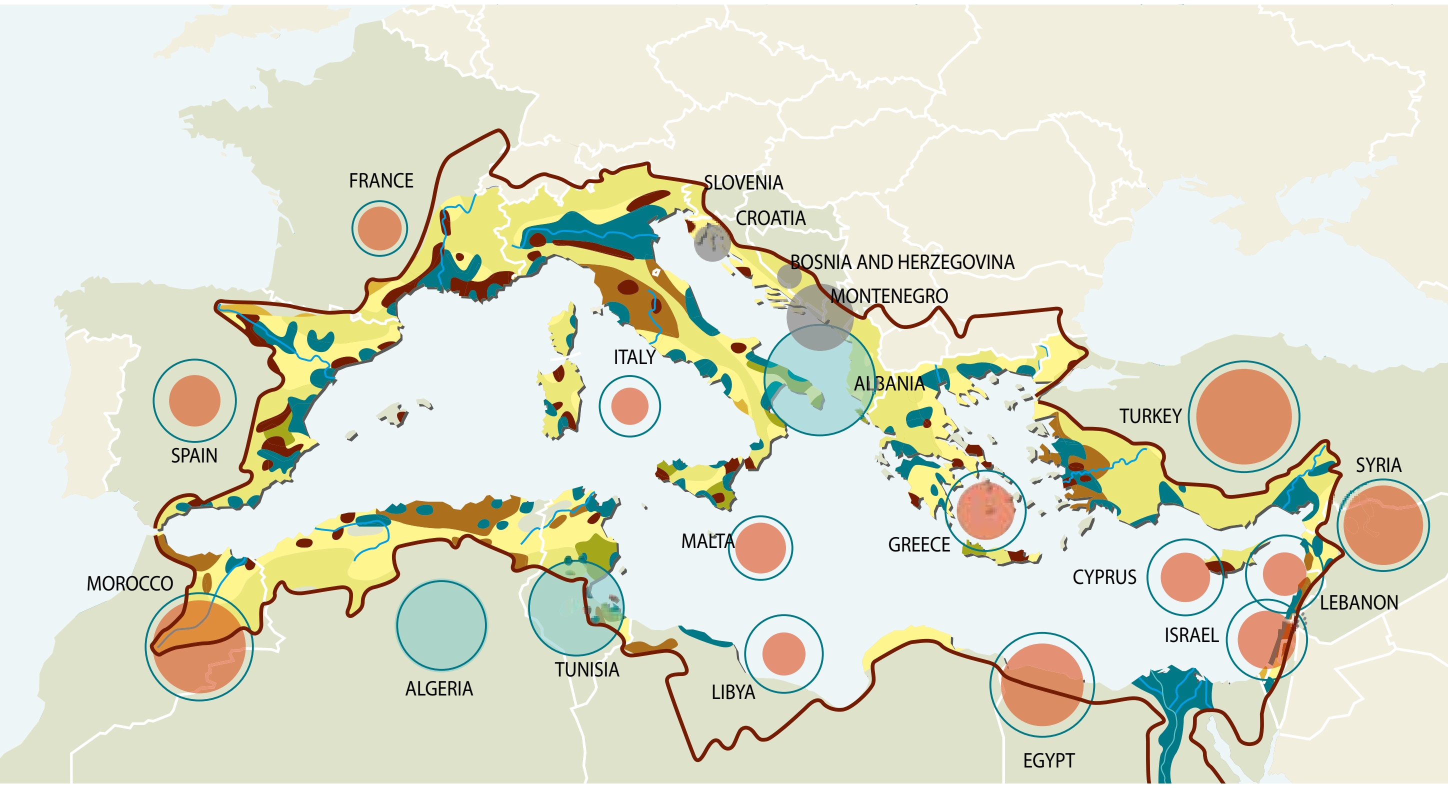
Industrial hazardous waste in the Mediterranean countries



resources and fight against land degradation). Despite their apparent fragility, Mediterranean forest landscapes have been shaped by human activities and have demonstrated for several centuries their strong resilience to changes of anthropogenic origins. However, today they are facing a threat of unprecedented magnitude dominated by climate change and the increase in population that they will have to adapt to in the coming decades. More than a third of the economic value of Mediterranean forests is linked to the production of wood forest products followed by recreation services, watershed regulation, grazing by cattle and the production of non-wood forest products altogether accounting in similar proportions for half of the remaining economic value (FAO/FD 2011).

Mining and manufacturing

The lack of major iron and, especially, coal reserves within the Mediterranean Basin influenced the industrial development path of the countries surrounding the Mediterranean Sea. Steel production has been concentrated in the north (Italy, France, Spain, Turkey and Greece), with a few producers in the south (Egypt, Algeria and Tunisia). Other mining activity in the Mediterranean has focused on mercury (Spain), phosphates (Morocco, and Tunisia), chromite (Albania and Turkey), lead, salt, bauxite (Bosnia and Herzegovina, Croatia, France, Greece, Slovenia and Montenegro) and zinc (Spain and Morocco) (EEA and UNEP 1999).



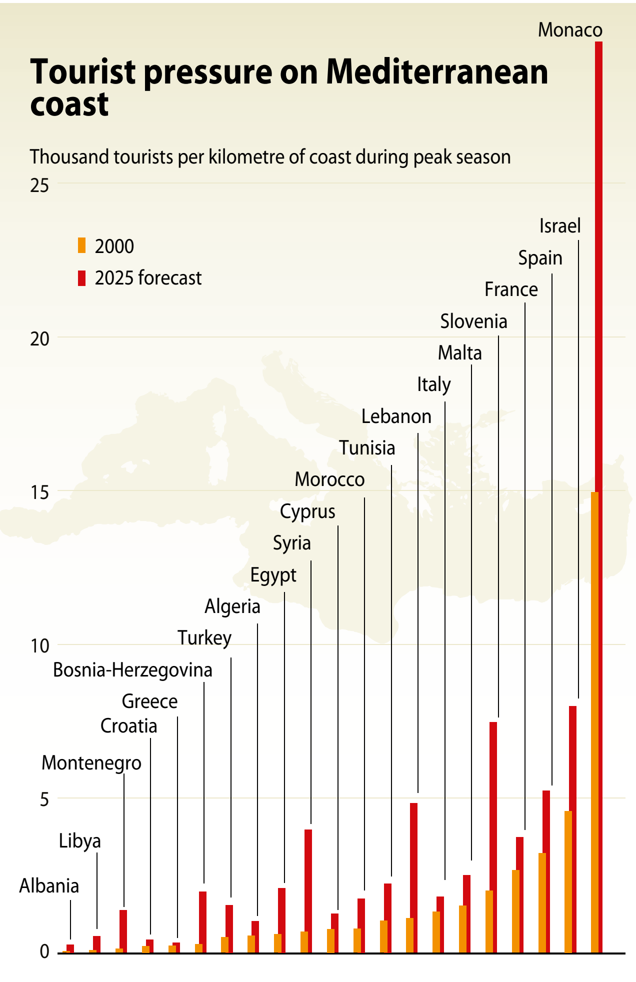
The existence of oil and gas reserves located in Algeria, Cyprus, Egypt, Israel, Italy, Lebanon, Libya and Syria motivate the presence of more than 40 refineries and petrochemical installations around the Mediterranean that produce ammonia, methanol, urea, ethylene, naphtha, propylene, butane, butadiene, aromatics, and other industrial chemicals. In addition to the mining, petrochemical, and metallurgy sectors, a highly diverse industrial manufacturing sector includes the manufacture of foods, textiles, leather, paper, cement, and chemicals, including fertilisers. However, the geographical distribution of industrial activities in the Mediterranean Basin is uneven, with most industry concentrated in the northwest, particularly in Italy, France, and Spain.

The study of the substances released by the different industrial sectors together with their hazardous nature allowed identifying the following as the most polluting types of industry (UNEP/MAP/MED POL 2012):

- Energy production
- Metal industry
- Manufacture of cement
- Oil refining
- Treatment of urban wastewater
- Chemical industry
- Manufacture of fertilizers

Industry is frequently located along the region's coasts in areas with high population density, sometimes within urban centres, and often in close proximity to other economic activities like agriculture and tourism. This means that pressures brought by industry to coastal and marine environments add to and interact with other types of pressures.

The environmental pressures on the Mediterranean coastal marine environment generated by this broad range of industrial activities are multiple and varied, including the use of territory and natural resources (both marine and non-marine), the generation of waste and the release of pollutants into the atmosphere and water bodies.



Source: WTO; Plan Bleu, 2003; Attané and Courbage, 2001; Géopolis.

Tourism

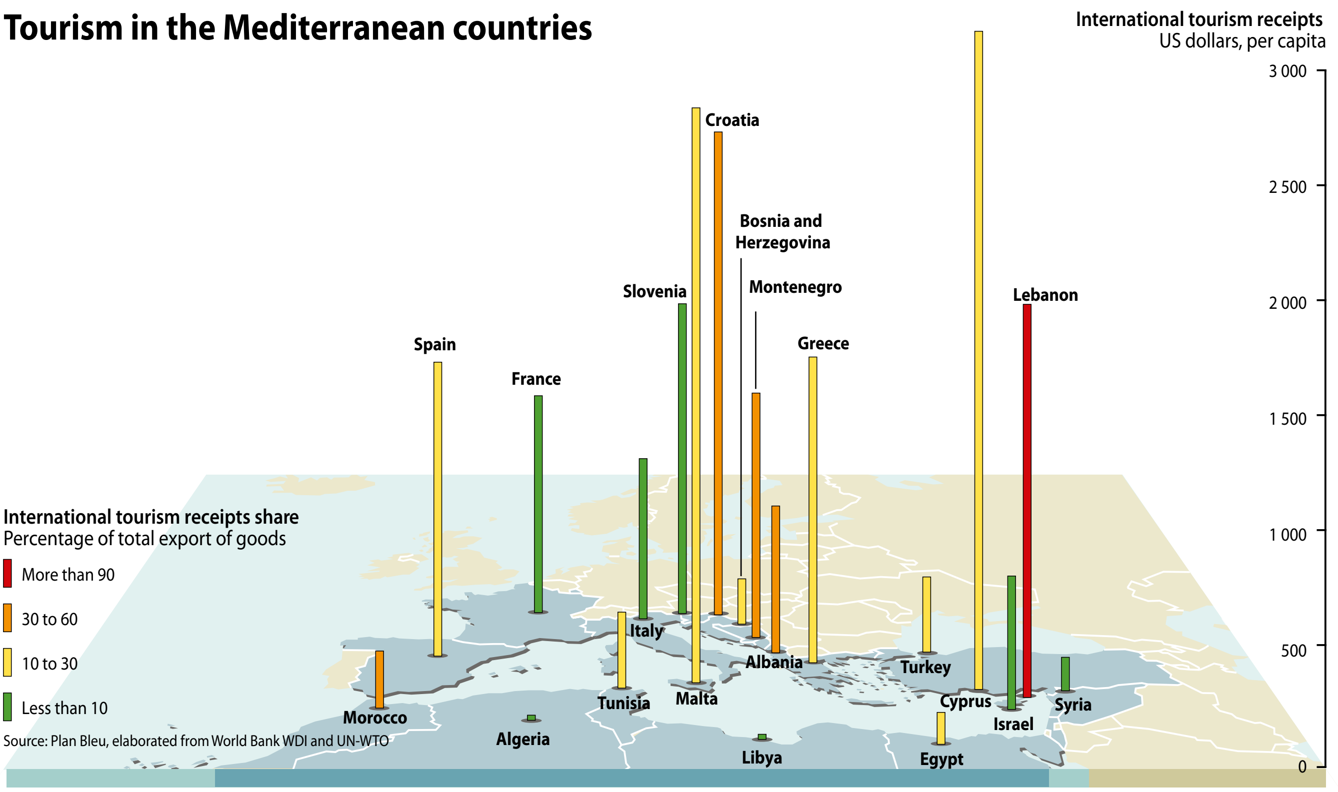
The Mediterranean basin, if considered as a single area, is by far the largest global tourism destination, attracting almost a third of the world's international tourists (306 million out of 980 million worldwide) and generating more than a quarter of international tourism receipts (190 out of 738 billion Euro worldwide). It is forecasted that the Mediterranean region will reach 500 million of international tourist arrivals by 2030 (UNWTO 2012). The bulk of the tourists are of European origin (81,1 % in 2010) followed by Middle East tourists (6,4 %) that recently have outnumbered those coming from the Americas (5,7 %). Domestic tourism is also significant in the region. Of a total of 450 million visitors each year, including both domestic and international tourists, 100 million stay on the Mediterranean coast of their own host country, considerably increasing human concentration there (UNEP/MAP/MED POL 2005).

Mediterranean tourism includes emigrants returning to their homelands during the summer holiday period, which produces a noticeable flow of visitors over a short period of time. This kind of tourism is not always focused on the coast. In Israel, for example, tourism is mostly related to pilgrimage and family visits. Fewer than a quarter of such visitors stay on the Israeli coast. Still, tourism in the Mediterranean Basin is strongly coastal, with more than half of all visitors (and as high as 90 % of visitors to some countries) visiting coastal areas. Tourism is heavily seasonal, peaking in July and August.

The tourism sector is more developed in the advanced economies of Europe, with more than two thirds of international tourism arrivals concentrated there. Still emerging economy destinations in the Eastern Mediterranean, North Africa and the Middle East experienced above average growth (9 % a year), with international arrivals more than tripling between 1995 and 2010. Average growth in this period was 12 % a year in the Middle East, 6 % in North Africa, and 9 % in emerging Europe. 2011-2012 were particularly challenging years for North Africa and the Middle East destinations in terms of international tourist arrivals with a drop of 31 % in the Middle East and 10 % in North Africa. Long-term forecasts still show that emerging country destinations are expected to grow faster than mature destinations. For the period 2010–2030, Mediterranean Africa (4,6 % a year), the Middle East (4,5 %) and the emerging economies of Europe (4,1 %) are expected to significantly outgrow the advanced economies of Europe (1,6 %) (UNWTO, 2012).

Tourism is a vital part of the Mediterranean economy and an extremely important source of employment and foreign currency for all the states bordering the Mediterranean Sea. The amenities and recreational opportunities for tourism provided by the Mediterranean's marine and coastal ecosystems form the foundation for more than 68 % of the total value of economic benefits provided by these ecosystems and about 17 % of total international tourist spending (UNEP/MAP/BP 2010).

Tourism in the Mediterranean countries



Tourism contributes CO_2 emissions, mostly through increased use of air and road transportation. Beyond that, the major direct pressure from coastal tourism on the marine and coastal environment is the demand for space, both in the coastal zone, resulting mainly in urbanisation, and on the coastline itself, through construction of marinas and other infrastructure that leads to concretisation of the shores. The concentration of tourism within specific geographical areas and limited time periods increases pressure on natural resources such as fresh water and leads to higher rates of sewage and solid waste production. Coastal tourism is, by definition, located in sensitive habitats within the coastal zone, such as beaches, sand dunes, and wetlands. The unavoidable result is change in the state of these habitats and their associated ecosystems, as well as economic impacts on other activities that benefit from coastal ecosystem services. Unsustainable development of mass tourism will result in the rapid degradation of fragile natural habitats (EEA and UNEP 1999, UNEP/MAP/MED POL 2005).

Marine transport

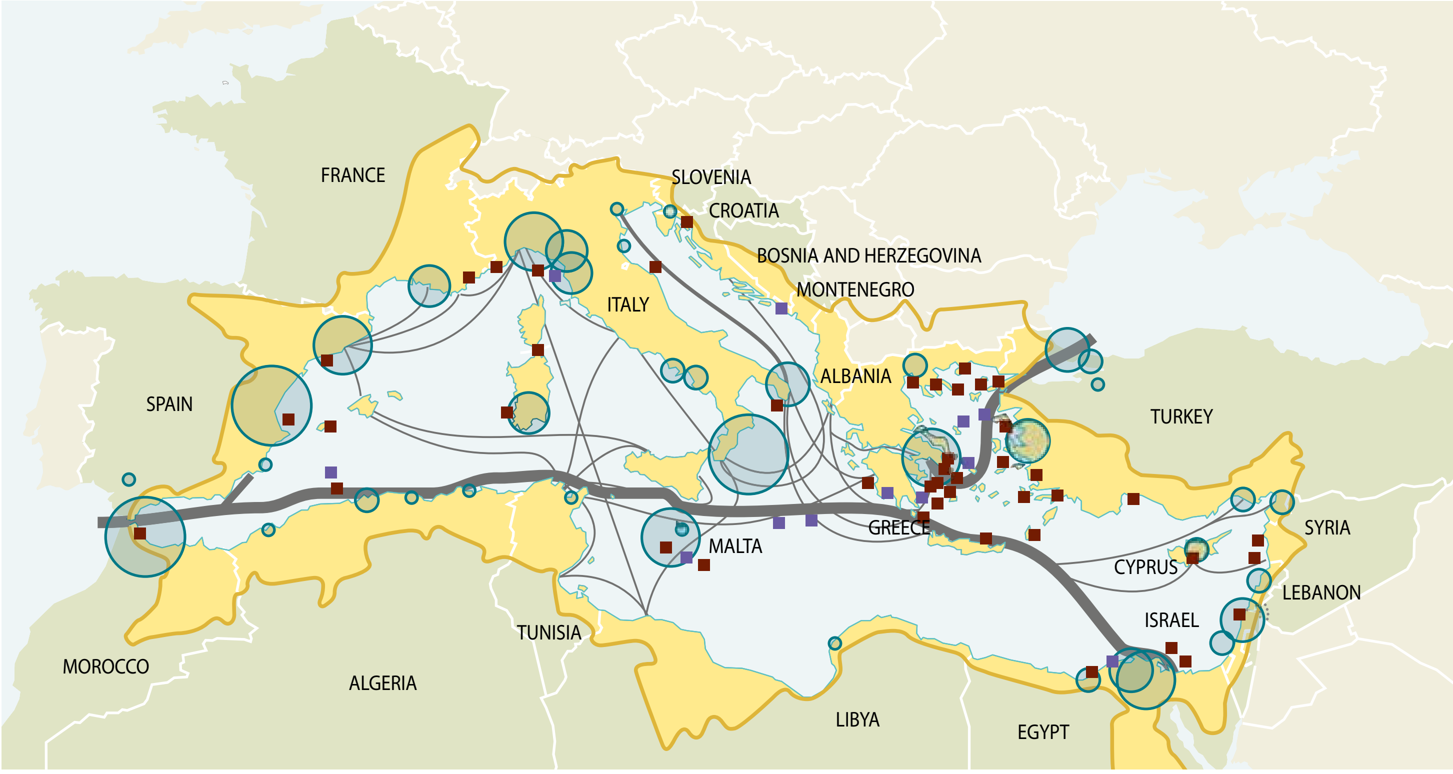
Another strong traditional economic sector in the Mediterranean is transport, specifically maritime transport. The Mediterranean Sea is among the world's busiest waterways, accounting for 15 % of global shipping activity by number of calls and 10 % by vessel deadweight tonnes (dwt). More than 325.000 voyages occurred in the Mediterranean Sea in 2007, representing a capacity of 3.800 million tonnes. Almost two-thirds of the traffic was internal (Mediterranean to Mediterranean), one-quarter was semi-transit voyages of ships mainly of small size, while the remainder was transit voyages, mainly by large vessels travelling between non-Mediterranean ports through the Mediterranean's various straits: the Straits of Gibraltar, the Straits of the Dardanelles, and the Suez Canal (data provided by REMPEC).

During the last ten years, merchant vessels operating within and through the Mediterranean have been getting larger and carrying more trade in larger parcels. Vessels transiting the Mediterranean average 50.000 dwt and are, on average, more than three times larger than those operating within the Mediterranean. Transit densities, measured in terms of ship voyages, are dominated by high-frequency, small-size intra-Mediterranean passenger traffic. However, the majority of trade, including petroleum oils and gases, is concentrated in larger vessels sailing less frequently (data provided by REMPEC).

The major axis, which sees 90 % of total oil traffic, is from east to west, connecting the eastern passages of the Straits of the Dardanelles and the Suez Canal with the Straits of Gibraltar. This axis passes between Sicily and Malta and closely follows the coasts of Tunisia, Algeria and Morocco. Traffic branches off as it moves westward to unloading terminals in Greece, the northern Adriatic, the Gulf of Genoa and near Marseilles. It is intersected by tanker routes connecting Algerian and Libyan loading terminals with the northern Mediterranean oil ports. From the eastern Mediterranean another important route links crude oil terminals in the Gulf of Iskenderun and on the Syrian coast with the main axis (EEA and UNEP 1999).

Passenger ships (34 % and concentrated in the western Mediterranean) and dry cargo ships (31 %) make up the majority of ships calling at Mediterranean ports. Ships transiting through the Mediterranean without stops are dominated by dry cargo ships, which account for nearly two-thirds (61 %) of the voyages. Other transiting ships are container ships (13 %), tankers (chemical tankers 8 %, product tankers 5 %, crude oil tankers 4 %), and passenger ships (4 %). Container ships and tanker ships, however, represent an important part of the tonnage.

The Mediterranean is a major load and discharge centre for crude oil. Approximately 18 % of global seaborne crude oil shipments take place within or through the Mediterranean, even if only 2 % of the ship calls are crude oil tankers. The major traffic lanes are dominated by crude oil shipments from Novorossiysk (in the Black Sea) through the Straits of the Dardanelles to Mediterranean destinations, as well as exports from the Persian Gulf



through the Suez Canal and the Sumed pipeline (ending at Sidi Kerir, close to Alexandria), both to Mediterranean destinations and to ports west of Gibraltar. Transit voyages in 2006 accounted for only 15 % of the crude oil voyages. The remainder of the voyages either originated from or ended at Mediterranean ports.

Liquefied natural gas (LNG) and liquefied petroleum gas (LPG) shipments also make up a considerable proportion of the energy-related shipments in the Mediterranean. The vast majority are intra-Mediterranean exports from North Africa to other ports in the Mediterranean, mostly in Europe.

The forecast for maritime transport in the Mediterranean points to an increase in traffic, linked in part to increased exports of crude oil from the Caspian region and the Black Sea. Another factor is improved infrastructure in Central and Eastern Europe, which could lead to an increase in bulk cargo through the Adriatic ports, rather than through Northern European ports, which is the current practice.

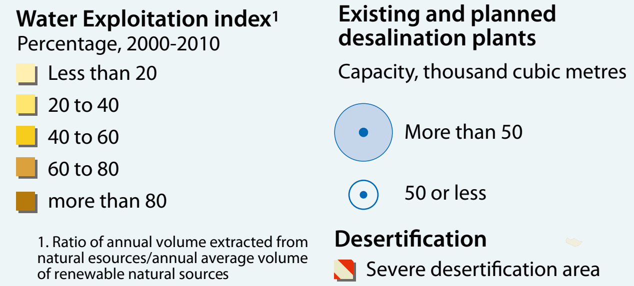
The major maritime-transport-related impacts that affect marine environment are pollution from marine accidents and from antifouling-paint biocides, the introduction of pathogens and invasive species, ship-strike mortality of cetaceans and sea turtles, and underwater noise. Despite the regulation and eventual banning of the discharge of waste at sea, the practice of dumping waste and other harmful substances continues to occur. Ongoing marine dumping, plus the legacy from past dumping, continues to subject the marine environment to considerable pressure.

With regards to the coastal zone the development of maritime transport is inherently linked to the development of coastal infrastructures such as ports and motorways and railways connecting inland areas to the ports. The development of large logistic coastal infrastructures brings, amongst others, fragmentation of coastal landscapes and habitats, changes in the land use and increased pollution loads.

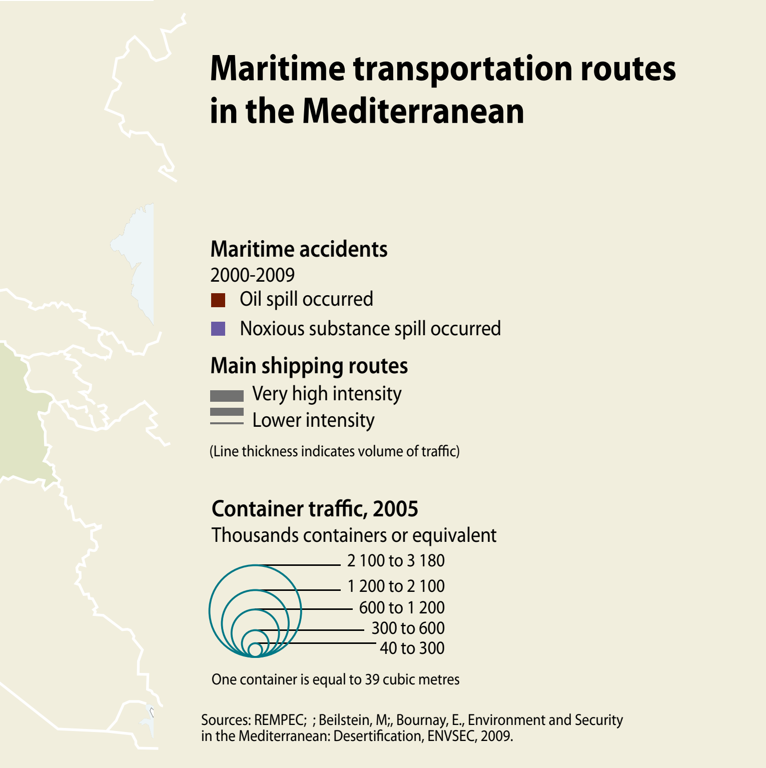
Coastal and marine natural resources

Coastal and marine resources include both non-living resources, such as fertile soil, fresh water, and fossil fuels, and living resources, such as fish. The availability of these resources is a precondition for sustainable economic development in the region. The Mediterranean Basin faces growing problems with degradation of land resources and water scarcity as a result of human activity. Fisheries, also vital to Mediterranean economies, are threatened by over-exploitation and unsustainable practices (UNEP/MAP/MED POL 2005).

Water stress in the Mediterranean basin



Sources: Blue Plan, informations based on national sources; *Water, energy, desalination & climate change in the Mediterranean*, 2008; IDA Worldwide Desalting Plants Inventory; Beilstein, M;, Bournay, E., Environment and Security in the Mediterranean: Desertification, ENVSEC, 2009.



Soil and freshwater

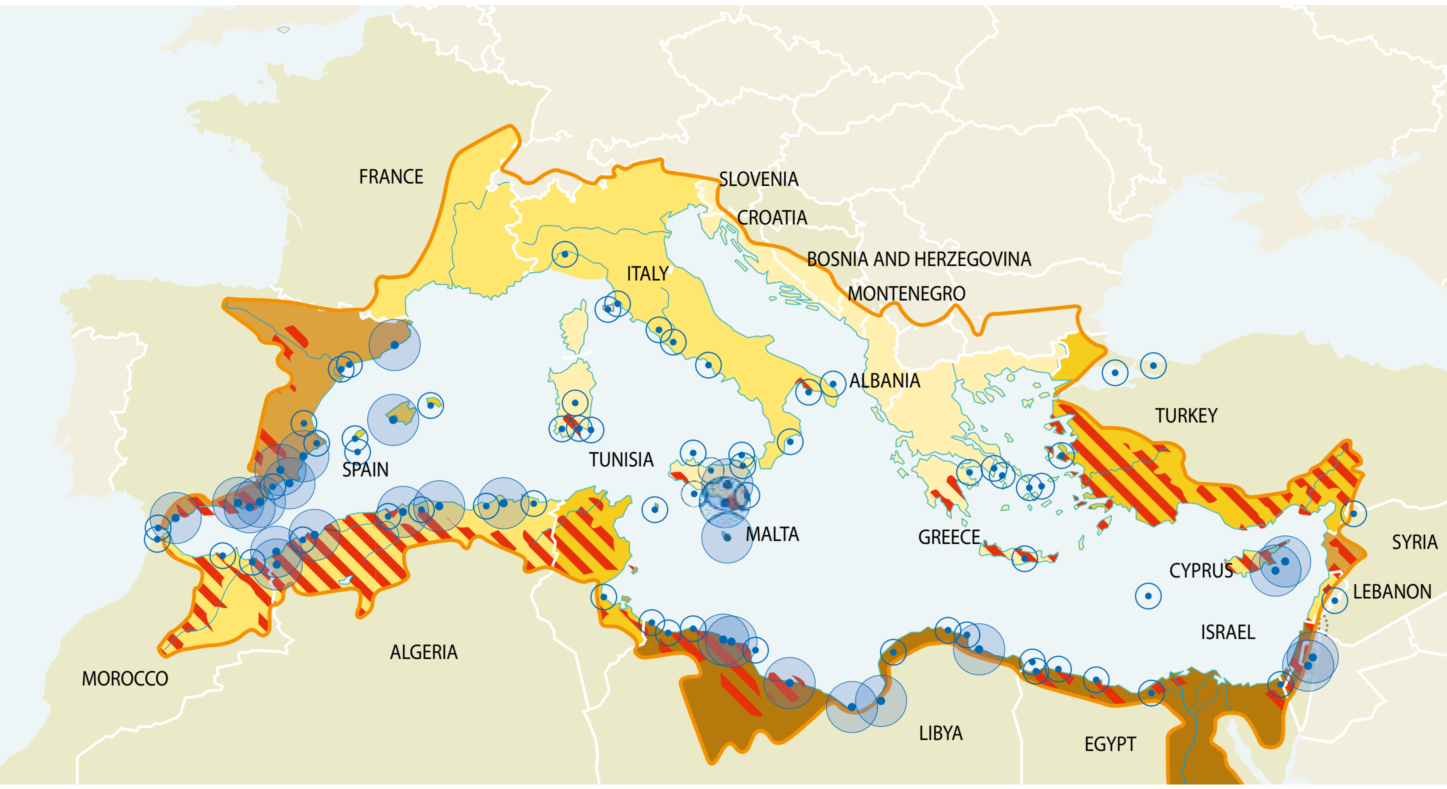
Around the Mediterranean Sea, alluvial and coastal plains are few and not extensive, the Nile Delta being by far the largest. The coastal lowlands are particularly vulnerable to climate change, which can affect hydrology, sea levels and ecosystems. They are also threatened by the results of human activity, such as pollution and sediment flow from intensive agriculture and industrial development, both local and upstream. The intensification of agriculture, in particular, has reinforced a long-term trend toward desertification in the region. About half of Mediterranean lands are subject to the risk of erosion (UNEP/MAP/MED POL 2005) and therefore of soil loss.

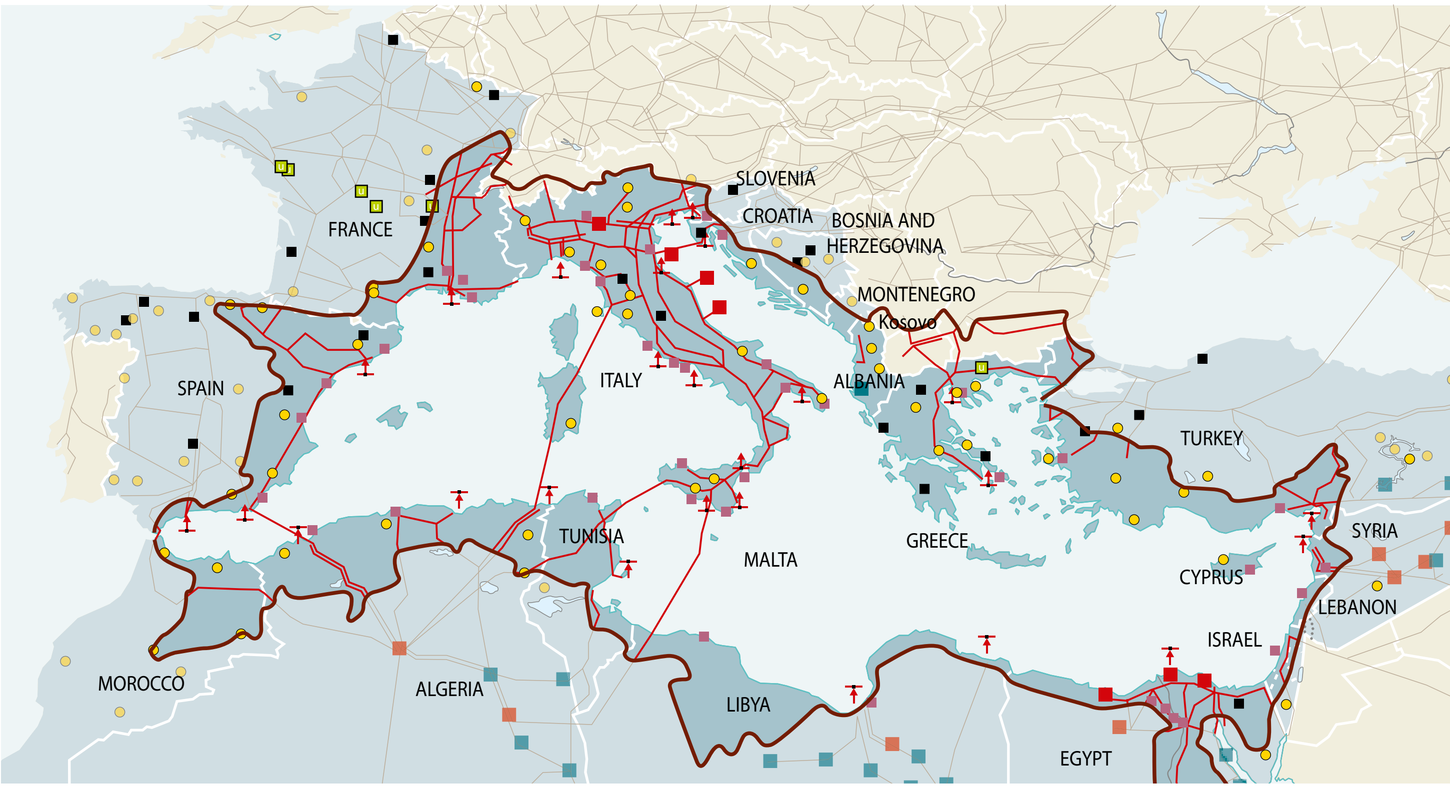
Agricultural irrigation and population growth are also reducing the flow of fresh water in the rivers that feed the Mediterranean's alluvial plains. In most Mediterranean countries with an erratic rainfall pattern, many of the available sources of water have already been developed or are currently being developed. Estimates by Blue Plan conclude that by the year 2025, eight of the twelve southern and eastern Mediterranean countries could be consuming more than the total of their renewable water sources (UNEP/MAP/MED POL 2005). Already, all major rivers flowing into the Mediterranean have had much of their flows diverted to agriculture and other uses over the past 40 years, resulting in a 20 % reduction in freshwater inflow into the Mediterranean (Ludwig *et al.* 2009).

Oil and gas

The oil industry is extremely active in the Mediterranean Basin, with Libya, Algeria and Egypt considered moderate-sized petroleum producers and refineries distributed all around the basin. In some countries, such as Greece, Italy, Cyprus, Israel, Lebanon and Turkey, domestic oil and gas production is relatively small, but exploration is very active especially since the recent vast discoveries and assessment of undiscovered reserves in the Levantine Basin Province in the eastern Mediterranean (EEA and UNEP 1999, Schenk *et al.* 2010). Complex geology and large, unexplored regions contribute to the uncertainty in determining the size of hydrocarbon resources in the Mediterranean region. The total known oil reserves are estimated at more than 45.000 million barrels. Exploration is the focus of most companies operating in the area and the most attractive exploration regions are located in both onshore and offshore areas.

Among the better prospects are four in Algeria (at Ghadamis and Illizi basins near the Algeria-Tunisia-Libyan borders), three in Libya (at Sirte, Ghadamis and Murzuq basins), six in Egypt (at Ashrafi in the Gulf of Suez, East Tanka offshore, Western Desert, Meleiha, Qarum and Abu Gharadiq), four in Greece (north-west Peloponnesus, Ioannina, Aitoloakrnania and the Gulf of Patraikos



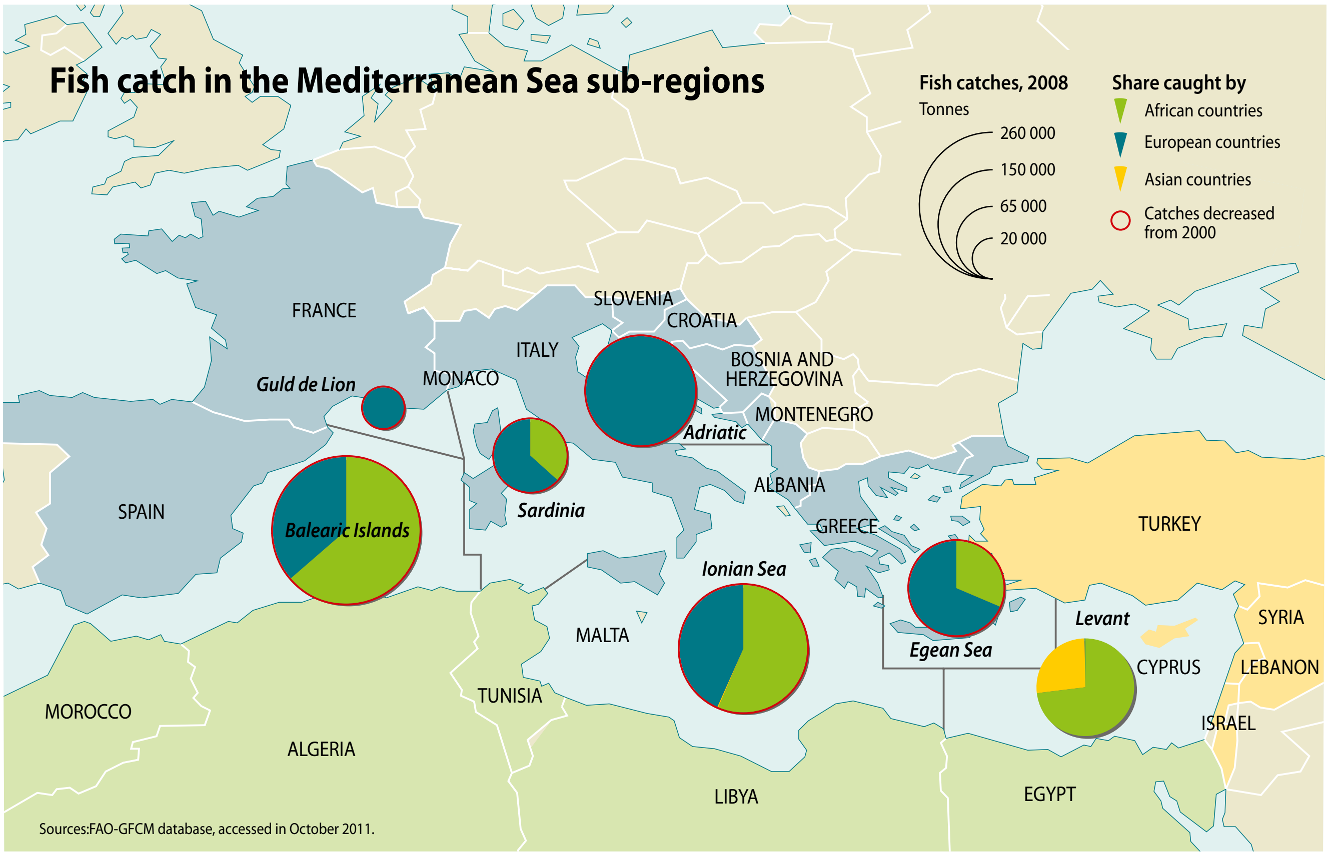


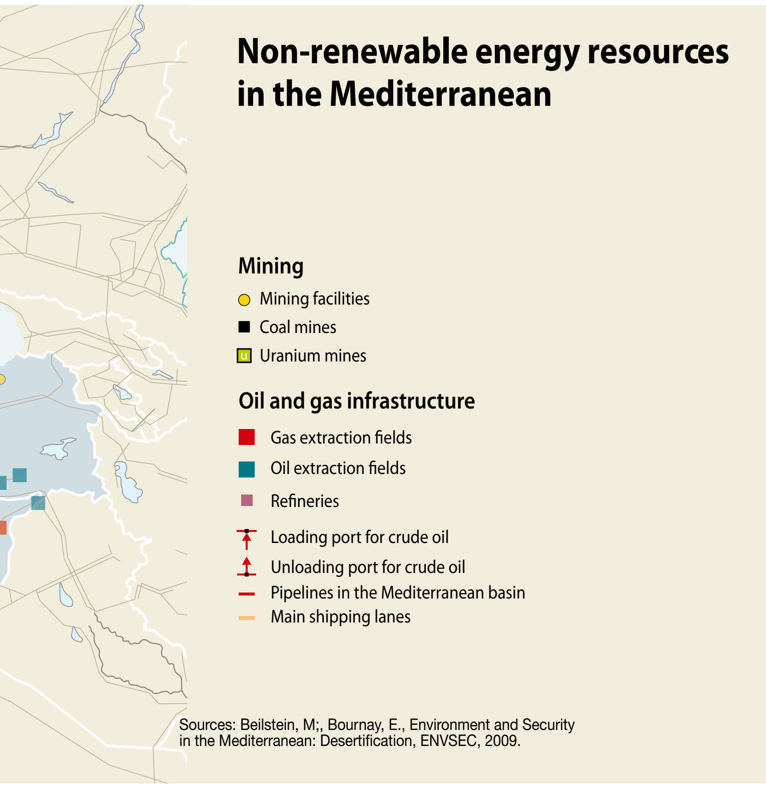
offshore), three in Italy (Val d'Agri in the southern region of Basilicata, Abruzzo, offshore, and in the lower Adriatic Sea off Brindisi) (EEA and UNEP 1999), and very considerable reserves in the Levantine Basin Province (Schenk *et al.* 2010).

The active trade and distribution of oil and gas in the Mediterranean Basin, both on land and at sea, involves an extensive network of crude oil pipelines and gas line systems, mainly in the countries of production, linking their oilfields to their refineries and port terminals or to other countries.

Fisheries

Fishing is an important issue for the Mediterranean. Although it puts only a relatively small quantity of produce on the market compared with the demand, it is a significant source of employment and an important component of the Mediterranean cultural identity. It ac-





Non-renewable energy resources in the Mediterranean

Sources: Beilstein, M;, Bournay, E., Environment and Security in the Mediterranean: Desertification, ENVSEC, 2009.

counts for 420.000 jobs, 280.000 of which are fishermen, and the average prices of landed produce are much higher than world prices.

The sustainability of fish resources (and, consequently, of fishing) is favoured by the diversity of water depths and by the presence of many refuge zones for spawning, two factors that can increase the resilience of fish populations to pressures. The exceptionally high proportion of small-scale operators engaged in commercial fishing is also an advantage in terms of sustainability. Small-scale inshore fishing operations target commercially valuable fish, have a high ratio of jobs created to the quantity of fish landed and are much more selective in their catch than large-scale industrial fishing (trawl nets in particular). Over 85 % of the boats in the Mediterranean fishing fleet (71.800 out of a total of 84.100) are involved in small-scale fisheries. These boats are sometimes not motorised (for example, 4.000 of the 13.700 fishing boats in Tunisia are not motorised).

Many fishermen have several jobs (for example, 80 % of fishermen in Malta and 92 % in Syria). The percentage of the total catch that is from inshore fishing varies among countries (87 % for Syria, 58 % for Cyprus, 56 % for Greece, 44 % for Tunisia, 41 % for Italy, 39 % for Israel and 10 % for Slovenia). The industrial fleet is concentrated mainly in the EU-Mediterranean countries (57 % of the total fleet). Recreational fishing accounts for 10 % of the total catch, which is substantial (UNEP/MAP/BP 2005).

Mediterranean fish landings represent a small fraction of the worldwide total – just over 1 % of the total landings, by volume. This is a significant level of fishing pressure, however, given that the Mediterranean Sea represents less than 0,8 % of the global ocean surface. Moreover, fishing in the Mediterranean tends to be concentrated in the in-shore areas, with some boats fishing on the continental slope for prized species such as the pink shrimp (*Aristeus antermarus*), the deepwater rose shrimp (*Parapenaeus longirostris*), and hake (*Merluccius merluccius*). Deep-water areas are currently not exploited and are highly unlikely to be exploited in the short term. Mediterranean fish production currently ranges from 1,5 million t/year to 1,7 million t/year. 85 % of production is attributable to six countries (Italy, Turkey, Greece, Spain, Tunisia and Algeria). Mediterranean fishing no longer satisfies demand in the coastal nations, supplying, on average, one-third of the demand for fish (UNEP/MAP 2012).

PART 2

Human Pressure, State and Impacts on Mediterranean Ecosystems

The ability to suggest measures in order to reach the objectives agreed within the framework of the Ecosystem Approach is grounded on the systematic analysis of the major issues identified. The following chapters include information on the pressures, state and impacts associated with each of the major issues, moving progressively from pressure dominated to state dominated and from coastal to offshore focussed issues. The amount of information related to each of the issues varies depending on how much focus has been placed in the past on that specific issue and it does provide an initial indication of where further work is needed if the objectives related to them are to be fulfilled.

Coastal Ecosystems and Landscapes

Coastal landscapes

Many centuries of interactions between natural and human-induced processes have created a complex landscape mosaic in the Mediterranean Basin (Bratina-Jurkovič 2011). This evolution has been shaped by major historical developments. In recent times, the period of population growth, industrialisation and technical and technological advances following the Second World War precipitated major land-use changes, especially increased urbanisation and agricultural intensification. New pressures on Mediterranean ecosystems came with these changes, including increased need for arable land and fresh water and increased demand for land and sea transportation. The expansion of urbanised and cultivated land and marine traffic caused multiple impacts, including habitat loss, reductions in freshwater and sediment discharges by rivers, salinisation of coastal aquifers, soil and coastline erosion and eutrophication of some coastal waters. These continuing pressures and their associated impacts now threaten natural and cultural landscape integrity and diversity in the region, altering the fine-grained and multifunctional landscape and limiting options for sustainable development.

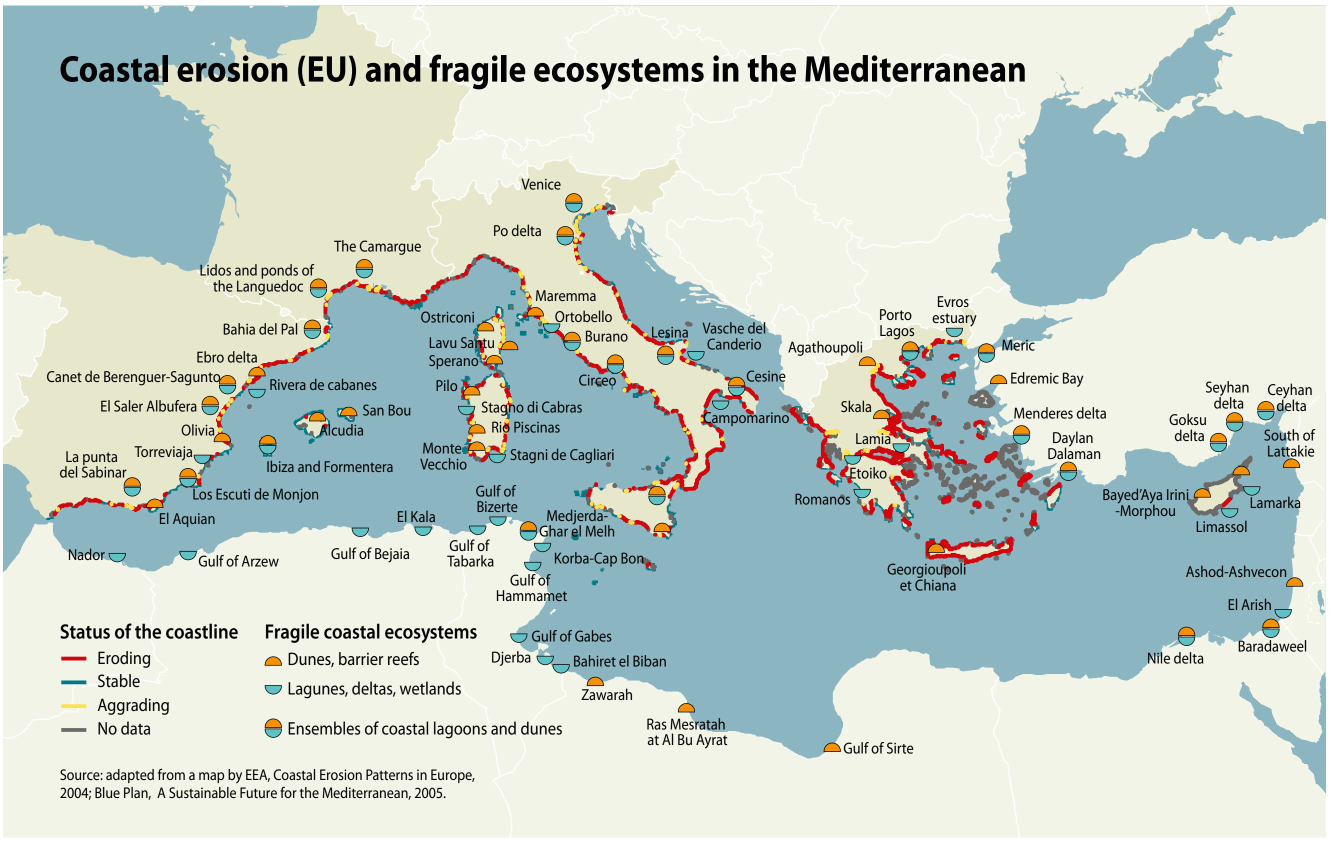
In the Mediterranean Basin, the areas that have experienced the most human-induced change are those most intensively exploited due to ready availability of the natural resources needed for settlement. Deltas are good examples, with low-lying terrain suitable for construction of dwellings, arable land, freshwater resources and easy access to the sea.

Coastline stability and erosion

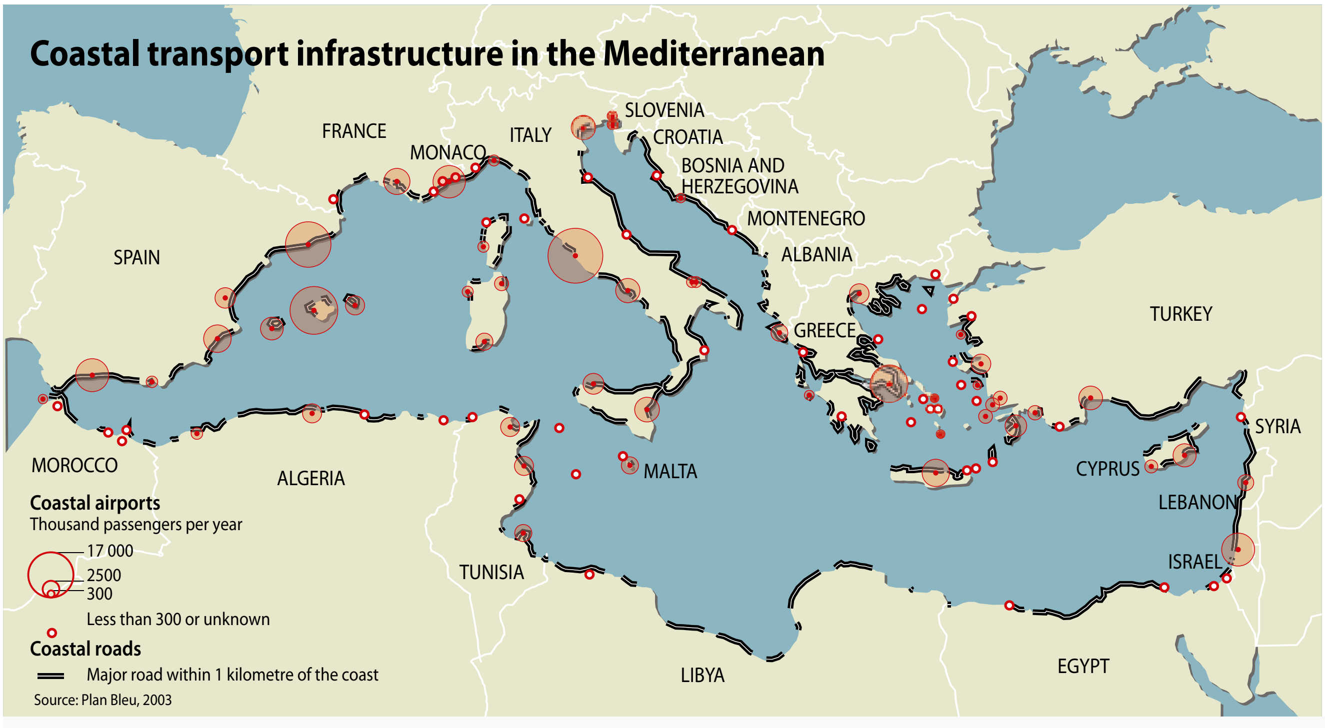
The Mediterranean coastline is approximately 46.000 km long, with nearly 19.000 km of island coastline. 54 % of the coastline is rocky and 46 % is sandy coast that includes important and fragile habitats and ecosystems such as beaches, dunes, reefs, lagoons, swamps, estuaries and deltas. Low-lying sedimentary coasts are more dynamic than rocky coasts. The balance between sea-level rise, sediment supply and wave and coastal current regimes will determine whether the coastline advances (accretes), remains stable, or retreats (erodes).

Model predictions for the extent of sea-level increase in the Mediterranean for the 21st century range up to 61 cm (in a worst-case scenario) for the Eastern Mediterranean (Marcos and Tsimplis 2008). Satellite altimetry data on variations in the level of the Mediterranean Sea between January 1993 and June 2006 indicate that sea level will rise more in the Eastern Mediterranean than in the Western Mediterranean. Delta areas, due to their topography and sensitive dynamics, are most vulnerable to impacts from sea-level rise.

Coastline stability is also affected by the increase in artificial structures, both within the drainage basin (especially reservoirs) and along the coastline (the proliferation of marinas and other urban and tourist-industry infrastructure). About 45 % of the sediments that would be delivered by rivers to the Mediterranean annually are either retained behind dams or extracted from river beds for sand and gravel, leading to an overall deficit



Source: adapted from a map by EEA, Coastal Erosion Patterns in Europe, 2004; Blue Plan, A Sustainable Future for the Mediterranean, 2005.



of sediments on the coast (UNEP/MAP 2009). Artificial structures associated with beach-dune complexes and waterfronts, the destruction or degradation of sea grass beds and dune vegetation, and the extraction of gas, water and sand may also affect the cycling and redistribution of sediment in neighbouring coastal areas, especially if modifications to the coastline have not been properly planned and designed (EEA and UNEP 1999).

Systematic research and documentation of coastline erosion has been carried out only on the Mediterranean states that are members of the EU, as part of the LaCoast, CORINE (Coordination of Information on the Environment), and Eurosion projects. Approximately one-fourth of the EU Mediterranean coastline suffers from erosion, with variation among countries. Sea defences to control erosion have been constructed along 10 % of the European coastline. These defences, however, often cause undesirable impacts, including increased erosion in other areas.

CORINE coastal data showed that, by the last years of the 20th century, 1.500 km of the EU Mediterranean coast had been transformed to "artificial coast" (mostly concentrated in the Balearic Islands, Gulf of Lion, Sardinia, and the Adriatic, Ionian, and Aegean seas). European harbours accounted for 1.237 km of this total (EC 1998). Even for EU states, the lack of information and the difficulty in accessing dispersed data have been obstacles to assessing the status and trends in erosion. This has hampered implementation of policies for the protection and management of the coastal environment at local, national and regional levels (CORINE 1995).

Among the many impacts erosion has on coastal ecosystems are the destruction of soil surface layers, leading to groundwater pollution and to reduction of water resources; degradation of dunes, leading to desertification; reduction of biological diversity; adverse effects on beach dynamics; reduction of sedimentary resources; and disappearance of the sandy littoral lanes that protect agricultural land from the intrusion of seawater, resulting in soil and groundwater salinisation (EEA and UNEP 2006).

CORINE data were used to produce an inventory of natural sites of high ecological value that are affected by coastal erosion. The Gulf of Lion, the Ligurian Sea, the Tyrrhenian coast of Italy, and the Po Delta all contain many such sites. One of the major findings of the CORINE project was that coastal erosion management practices often indirectly use protected natural areas established under Natura 2000 (an EU network of protected areas) as sources of sediment. As Natura 2000 sites were selected because they are considered critical to the survival of Europe's most threatened habitats and species, these practices have significant implications for long-term coastal biodiversity and ecosystem resilience (Salman *et al.* 2004).

Pollution

Marine and coastal pollution affects water, sediments, and biota. It can be related to oxygen-depleting substances, heavy metals, persistent organic pollutants (POPs), hydrocarbons, microorganisms, nutrients introduced by human activities or debris. The latter two sources of pollution are discussed in the chapters on Eutrophication and Marine Litter respectively. Many different kinds of pollutants enter the Mediterranean Sea from its shores (land-based sources) either via discharge points and dumping grounds (point-source pollution) or from surface fluvial run-off (non-point-source pollution). Pollutants also enter the marine and coastal environments through atmospheric deposition, while others are introduced directly by marine activities such as shipping, fishing, mining, and oil and gas exploration.

Research on the impacts of pollutants on the environment has tended to focus on pollutants known to be most harmful to human health (for example, mercury). The geographical distribution of studies is poor, with little known about impacts from contaminants in many regions of the Mediterranean.

Concentration, distribution and potential impacts of priority contaminants

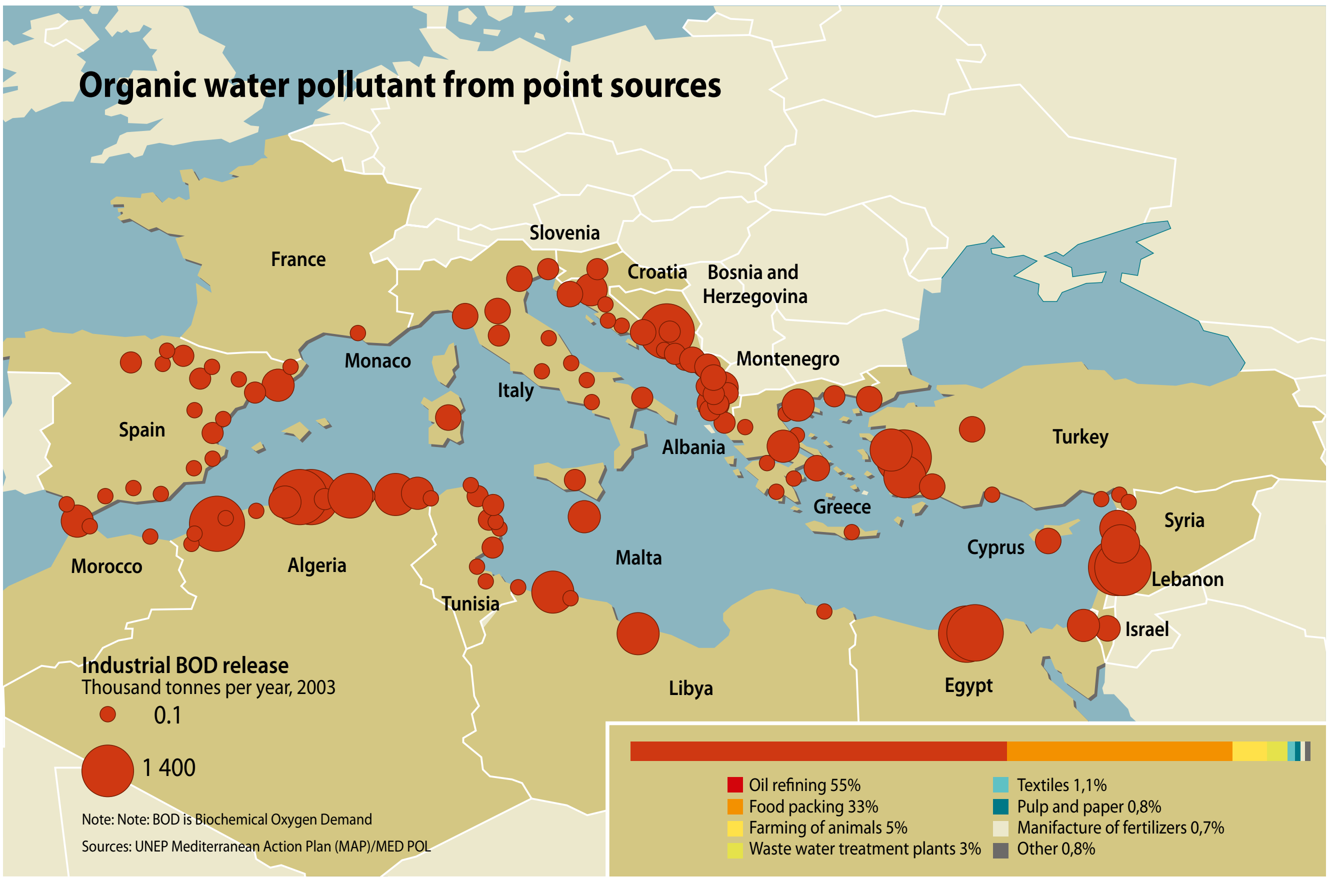
Wastewater organic matter

Organic matter in coastal and marine waters originates mostly from urban/domestic and industrial wastewater entering marine waters through direct point-source discharges or through rivers. The extent of organic matter pollution is measured as the Biochemical Oxygen Demand (BOD), the amount of oxygen needed by microorganisms to oxidise organic matter in the water.

The distribution of coastal cities that either lack wastewater treatment facilities or have inadequate treatment facilities (defined as those removing less than 70 to 90 % of the BOD) can be used as a proxy to identify areas where potentially deleterious amounts of organic matter are being added to the marine environment. Effective removal of pollutants from wastewater is achieved through secondary treatment that removes, through physical and biochemical processes, organic matter responsible for 70 to 90 % of the BOD. About half of organic-matter pollution from sewage originates from direct, untreated discharges, while less than one-third is in discharges of inadequately treated sewage.

63 % of coastal settlements with more than 2.000 inhabitants operate a wastewater treatment plant, while 37 % do not. Secondary treatment is mostly used (67 %) in Mediterranean treatment plants, while 18 % of the plants have only primary treatment (UNEP/MAP/MED POL and WHO 2010). The distribution of treatment plants is not uniform across the Mediterranean region, with no sewage treatment in many cities on the southern shore of the Western Basin, in coastal Sicily, the Eastern coast of the Adriatic, the Aegean, and the northeastern corner of the Levantine Basin.

Organic-matter pollution in industrial wastewater was documented by MED POL through an inventory of industrial point

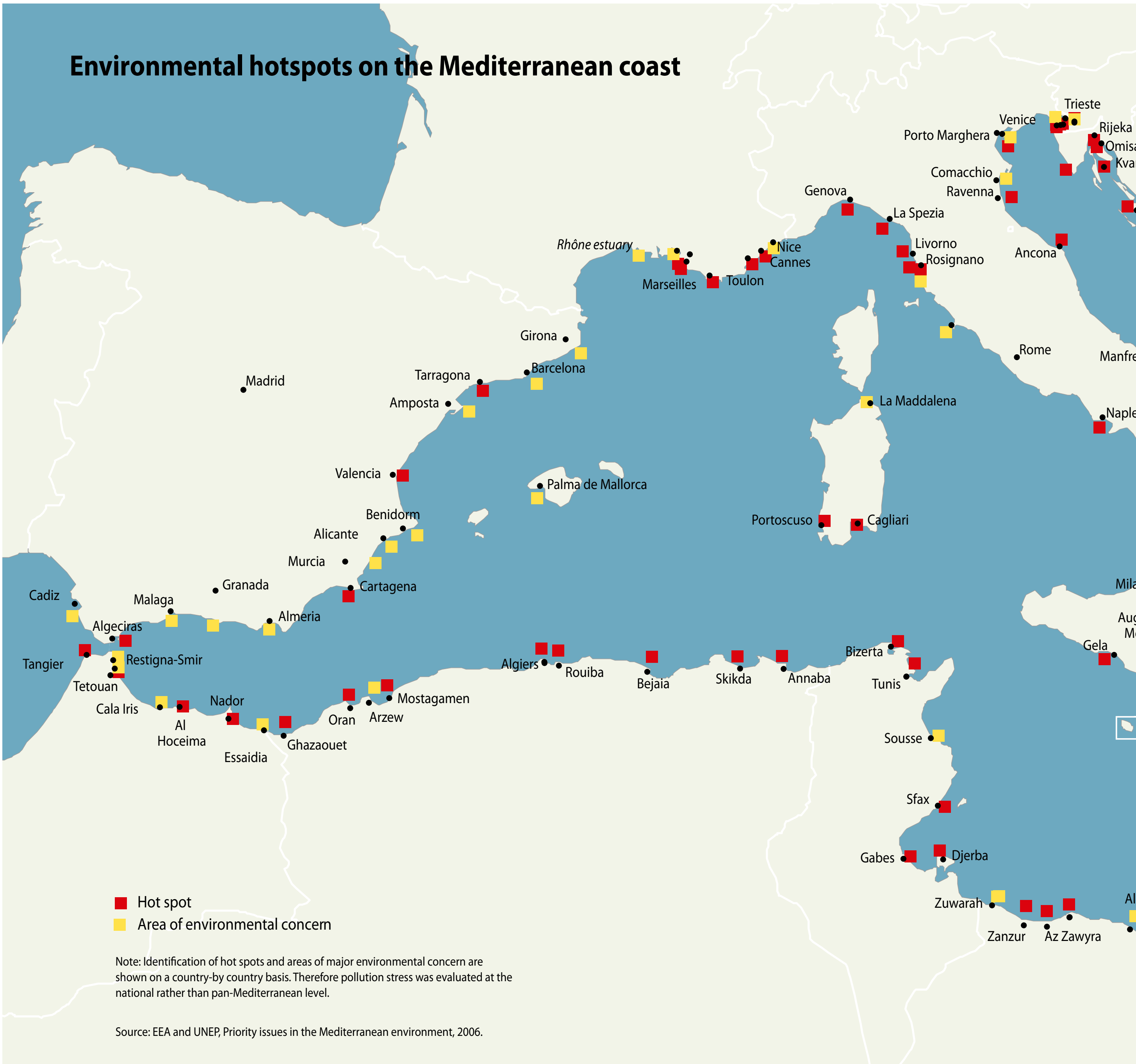


sources of pollution in 2003. The areas with the highest BOD are the southern shore of the Western Basin, the eastern coast of the Adriatic, the Aegean and the northeastern sector of the Levantine Basin. These regions, in general, also have insufficient sewage wastewater treatment facilities. This indicates that there is likely a cumulative effect of elevated organic matter in coastal waters from a combination of domestic and industrial sources (UNEP/MAP 2012). In the northern Mediterranean BOD is mainly released by wastewater treatment plants and the food industry, while in south and eastern Mediterranean other sectors like oil refining, farming of animals, textiles, paper or fertilisers are important emitters (UNEP/MAP/MED POL 2012).

For marine animal and plant communities, oxygen depletion caused by either human-induced eutrophication or by input of organic matter in wastewater may be fatal. Addition of organic matter and eutrophication (resulting from productivity increasing because of the extra supply of nutrients) often stem from the same sources and act together to deplete oxygen. See the Eutrophication chapter for further discussion.

Oxygen is reduced by organic matter carried by wastewater through two processes. First, the increase in particle concentration reduces light penetration in water, reducing the depth of the zone in which photosynthesis occurs. The net effect is a reduction in the release of oxygen from the water column. Secondly, introduced organic matter uses up oxygen as it decomposes, especially near the bottom where particulate organic matter settles. In the Mediterranean, many instances of fish and shellfish kills have been recorded, as these species are the first to be affected by oxygen limitation.

Benthic communities are among the first to disappear under conditions of heavy stress. Benthic organisms play an important ecological role by reworking the sediments, which affects the flux of nutrients across the sediment-water interface. Thus

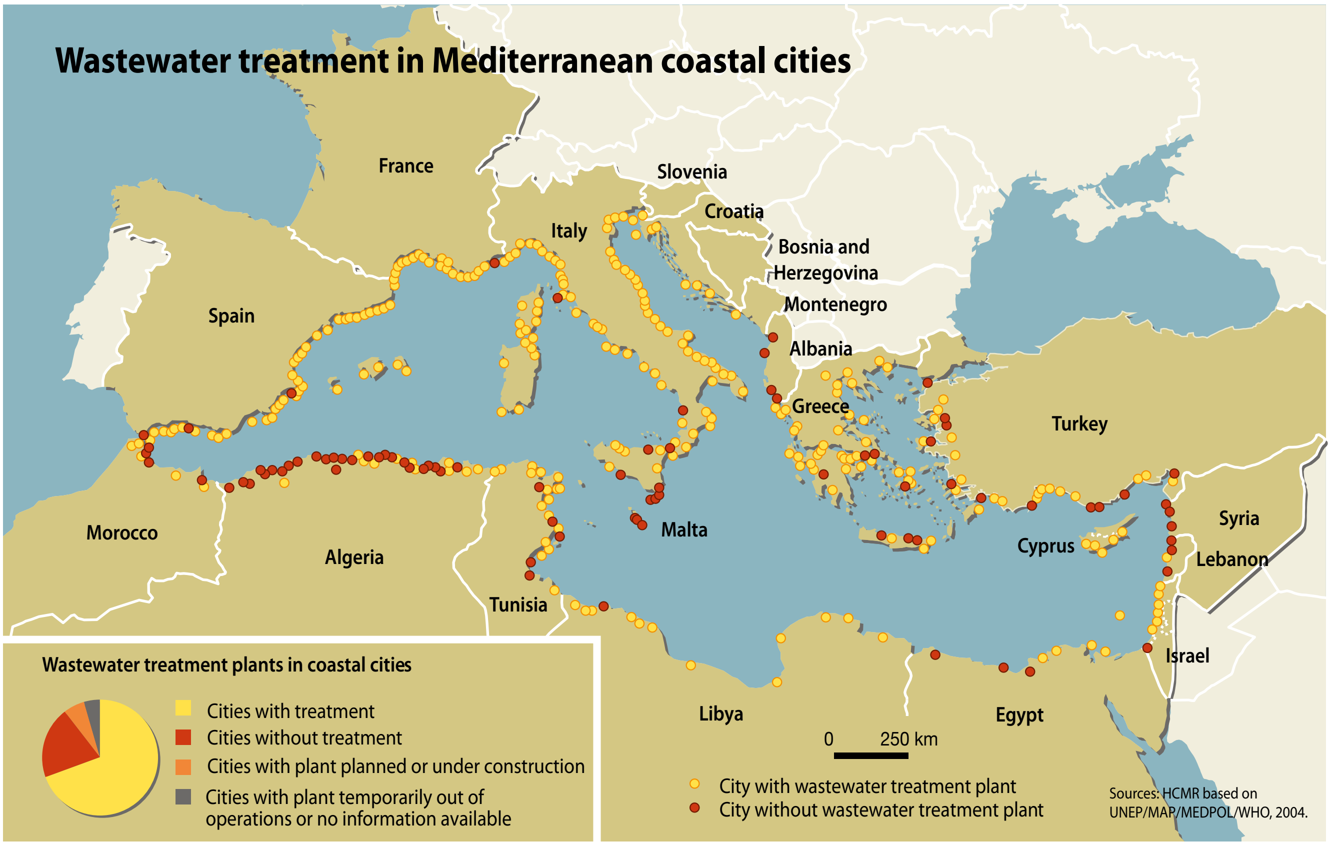


Environmental hotspots on the Mediterranean coast

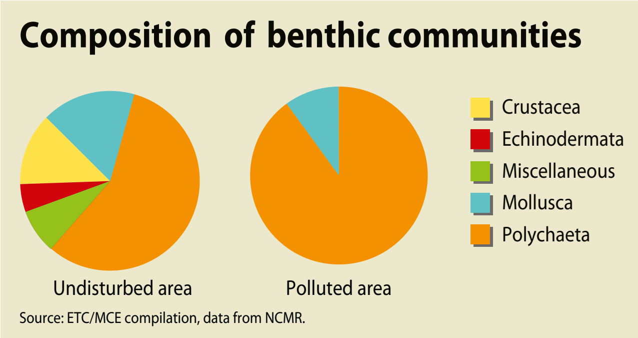
Hot spot
Area of environmental concern

Note: Identification of hot spots and areas of major environmental concern are shown on a country-by country basis. Therefore pollution stress was evaluated at the national rather than pan-Mediterranean level.

Source: EEA and UNEP, Priority issues in the Mediterranean environment, 2006.


Wastewater treatment in Mediterranean coastal cities
France
Slovenia
Croatia
Bosnia and Herzegovina
Montenegro
Albania
Italy
Spain
Greece
Turkey
Syria
Lebanon
Cyprus
Israel
Malta
Morocco
Algeria
Tunisia
Libya
Egypt
Wastewater treatment plants in coastal cities
Cities with treatment
Cities without treatment
Cities with plant planned or under construction
Cities with plant temporarily out of operations or no information available
0 250 km
City with wastewater treatment plant
City without wastewater treatment plant
Sources: HCMR based on UNEP/MAP/MEDPOL/WHO, 2004.


Zadar
Sibenik
Split
Sarajevo
Konjic
Mostar
Ploce
Bileca
Dubrovnik
Lezhe
Tirana
Durres
Karayasta
Vlora
Saranda
Barletta
Bari
Taranto
Brindisi
Kavala
Tessaloniki
Volos
Preveza
Messolongi
Patra
Elefsis
Athens
Argos
Aliaga
Foca
Izmir
Cesme
Aydin
Bodrum
Marmaris
Datca
Antalya
Side
Alanya
Silifke
Erdemli
Mersin
Tarsus
Antakya
Lattakia
Banias
Tartous
Morphou
Chirisochou
Paphos
Akrotiri
Vassilikos
Liopetri
Ayia Napa
Larnaca
Beirut
Sidon
Irakleio
Nahariyya
Haifa
Netania
Tel Aviv-Yaffo
Ashkelon
Khan Younis
Manzala Wetland
Burullus Wetland
Bardawi Wetland
Port Said
Rosetta
Maryut Wetland
Alexandria
Ras-il-Hobz
Il Cumnija
Marsascla
Marsaxlokk
Khums
Misratah
Sirt
Benghazi
Darnah
Tobruk



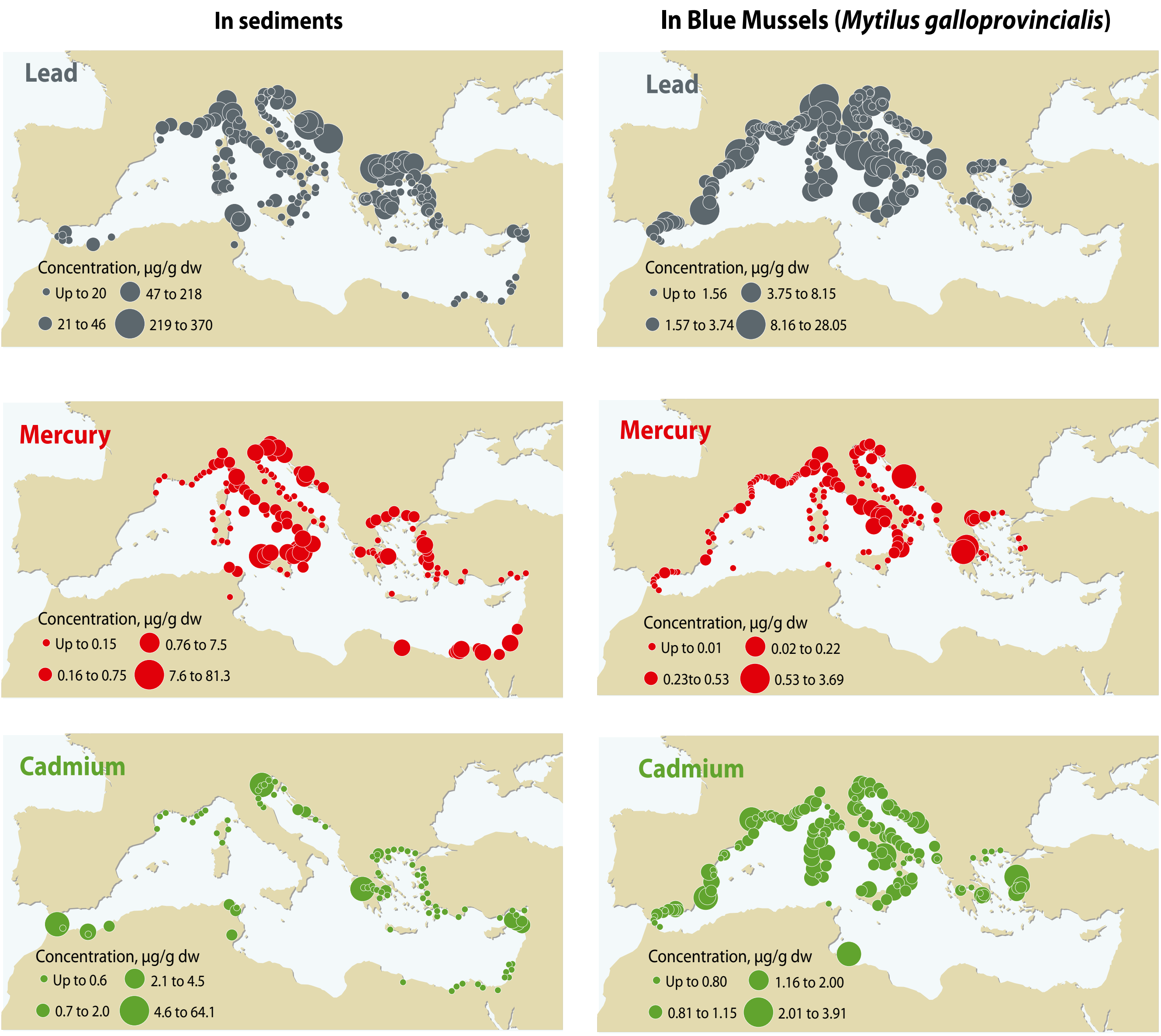
their loss is a liability to the ecosystem as a whole. In undisturbed areas in the eastern Mediterranean, benthic communities have a high diversity of species, consisting of polychaetes (50–65%), molluscs (15–25 %), crustaceans (10–20 %), echinoderms (5–8 %) and miscellaneous taxa. By contrast, in areas ranging from heavily disturbed (e.g., sewage outfall vicinity) to polluted (e.g., urbanised bay), echinoderms, crustaceans and miscellaneous taxa largely disappear, while a small number of polychaete species account for 70–90 % of the total abundance (Stergiou *et al.* 1997). The same applies to the Western Mediterranean benthic communities, where increasing disturbance also leads to reduction in species richness.

When the effects from organic enrichment exceed the potential for remineralisation (transforming the organic matter into inorganic matter) by benthic organisms, anoxic zones are created and bacterial mats cover the seabed. Although this type of ecosystem change is in general reversible, there could be severe and long-lasting consequences when the affected seabed is a critical habitat like the meadows of the sea grass *Posidonia oceanica* (UNEP/MAP/MED POL 2005).

Heavy metals

The term *heavy metal* is used here for potentially toxic metals that persist in the environment, bioaccumulate in human and animal tissues, and biomagnify in food chains. Metals and organometallic compounds are commonly included in emission inventories and monitoring networks, specially mercury, cadmium

Mean concentrations of trace metals



and lead. Urban and industrial wastewaters, atmospheric deposition and run-off from metal contaminated sites constitute the major sources of toxic metals.

In the Mediterranean countries, according to the National Baseline Budget (NBB) inventory, atmospheric emissions of metals are mostly related to the cement industry (Hg, Cu), production of energy (As, Cd, Ni) and the metal industry (Pb, Zn). Water releases appear to be mostly related to the fertiliser industry (Hg, As, Pb), metal industry (Ni, Zn) and wastewater treatment plants (Cd, Cu), with important contributions also from the energy sector and the chemical industry. Oil refining is the main source of chrome releases, both to air and water (UNEP/MAP/MED POL, 2012).

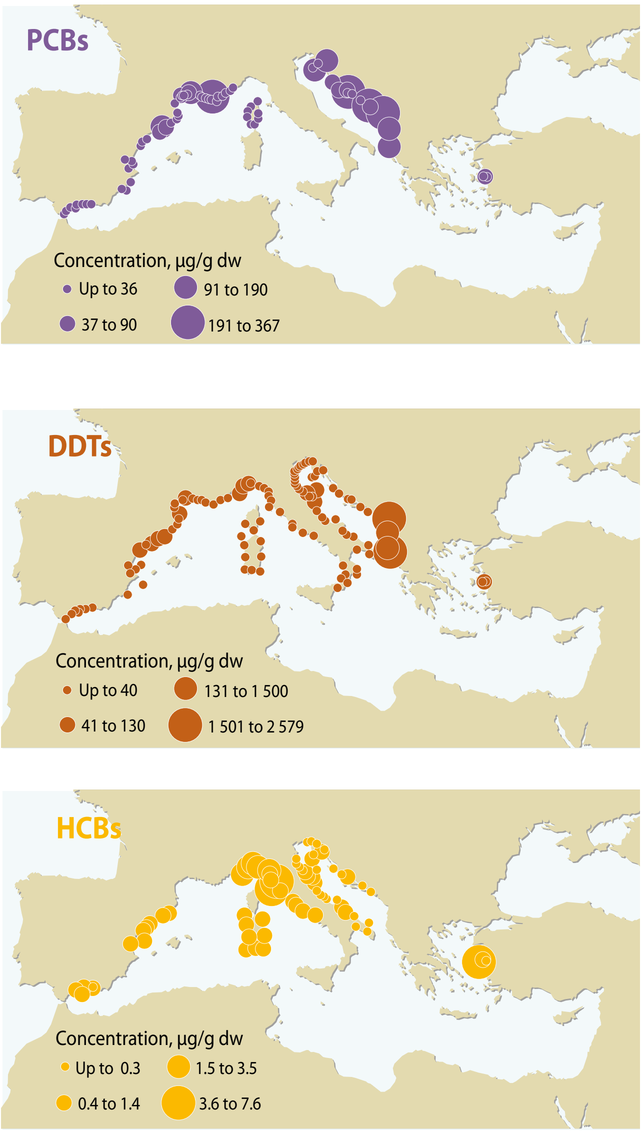
Aside from direct discharges from urban and industrial sources, rivers and streams are the major contributors of metals of anthropogenic and natural origin to coastal areas, although metal enhancements in local geology may also influence sediment metal content. Heavy metals from land-based sources may not only accumulate in the coastal zone but may also move into the deeper areas of the continental margin through advection, and even into the deep basin through downslope transfer processes. Atmospheric deposition is the main pathway for heavy metals to enter open-water regions. Metals entering the sea through air-sea exchange may accumulate through the food web, becoming concentrated in higher marine organisms, or they may adhere to particles and sink to the seafloor where they accumulate in the sediments.

A recent study (UNEP/MAP/MED POL 2011) provides an overview based on the MED POL database and recent publications on the distribution and trends of heavy metals (lead, mercury, cadmium, zinc and copper) in coastal sediments and biota (mainly in blue mussel, *Mytilus galloprovincialis*, and red mullet, *Mullus barbatus*). The distribution of information is not ideal as the southern Ionian, Aegean, and the Levantine Basin are underrepresented. Nonetheless, the results can be used for comparative purposes, especially results for cadmium, mercury and lead, for which the spatial sampling coverage is slightly better.

Lead levels are high in sediments in the area of Marseille-Fos and Toulon (France), Cartagena (Spain), along the western Italian coast, around Naples and in the Gulf of Genoa. Lead levels are also elevated in sediments in the Gulf of Trieste, along the southern coast of Croatia, in the Aegean Sea (especially the northern coast near Thessaloniki and Kavala and the region around Athens), along the Aegean coast of Turkey (Izmir Bay) and in Tunis and Bizerta lakes in northeastern Tunisia. These sites with high levels of lead in sediments are correlated with locations of industrial and domestic waste discharges and harbour activities. In biota (blue mussel), lead concentration is consistently high at locations with Pb-contaminated sediments: the western coast of Italy from the Gulf of Genoa to Naples, at locations in the Tyrrhenian Sea, along the Italian west coast, along the coast of northern Sicily (Palermo) and in the southern part of Sardinia (Portoscuso). Also, elevated levels of lead in biota have been detected at some locations along the southern coast of France (Marseille Gulf and Hyeres Bay) and the coast of Spain

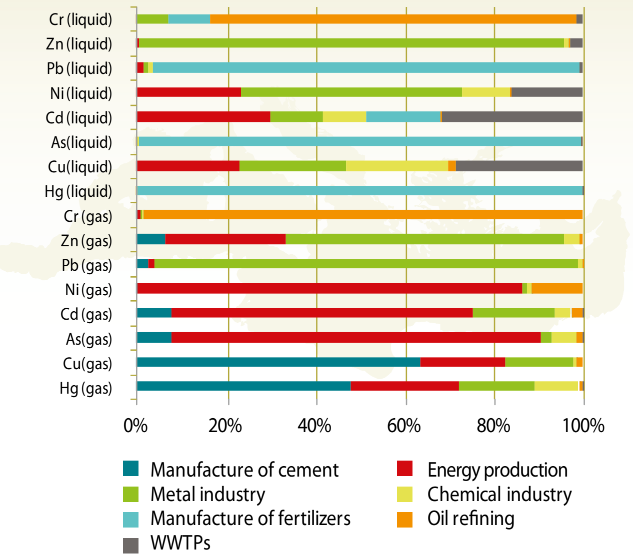
Mean concentrations of Persistent Organic Pollutants (POPs)

In Blue Mussels (*Mytilus galloprovincialis*)



Source: UNEP/MAP, Hazardous Substances in the Mediterranean: A Spatial and Temporal Assessment, 2011

Major industrial sectors emitting metals in the Mediterranean region



Source: MEDPOL; Releases, emissions and sources of pollutants in the Mediterranean region. An assessment of 2003-2008 trends; 2012.

(Barcelona, Cartagena and Malaga). In the Adriatic Sea, high levels of lead have been recorded in biota in the Venice lagoon and in the areas affected by the Po River discharges (consistent with the distribution pattern of urban and industrial discharges), the Gulf of Trieste, Vlora Bay and close to Durres. In general, the distribution of elevated lead levels in biota is correlated with the distribution of discharges and non-point sources of pollution from mining, industry and sewage.

Mercury levels are high in sediments around Messina, Palermo and Reggio Calabria in Sicily, potentially influenced by natural contributions from volcanic and geothermal sources of the southern Tyrrhenian Sea. Mercury sediment anomalies in some islands of this region may also be explained by proximity to volcanic and geothermal sources of mercury. Elevated levels of mercury have also been recorded in sediments in the Po Delta region, the Gulf of Trieste, the Aegean Turkish coast and Israel (e.g., Haifa Bay). High mercury concentrations were measured in biota along the northwest Italian coast (Gulf of Genoa, Portoscuso, Palermo), the coastal waters of the Tyrrhenian Sea (especially between Fiumicino and Naples and around Messina), Skikda (Algeria), Cartagena (Spain) and at Kastela Bay (near Split) on the western Adriatic coast. Significant concentrations of cadmium have been reported in sediments along the coast of France (Marseille-Fos), Spain (Cartagena), Morocco (Tangier-Martil and Nador), in the northeastern corner of the Levantine Basin between Cyprus and Turkey (including Iskenderun Bay) and the northern coast of Syria. In biota, relatively high levels of cadmium were recorded in biota at sites along the southern and southeastern coasts of Spain (Cabo de Gata, Almeria, and Cartagena), an intensely mined region, and at a few sites along the western coast of Italy (Naples), the southern shores of the Tyrrhenian Sea (Messina and Palermo), western Sardinia and France (Sete and Nice). In the Adriatic, high levels of cadmium are found in biota in the Po Delta and in Kastela and Rijeka bays (Croatia), due to the discharge of untreated urban and industrial wastewaters. Scattered samples of organisms in the Central and Eastern Levantine basins allow identification of some sites with high concentrations of cadmium in biota. Cadmium is also elevated in biota along the western coast of Turkey (Izmir Bay), Piraeus (near Athens) in the Aegean Sea and in Vlora Bay (Albania) in the Adriatic.

Despite the work of the MED POL programme, short time series and differences among sampling conditions mean that most available pollution data for the Mediterranean are not yet adequate for robust trend analysis (UNEP/MAP/MED POL 2011). Preliminary analyses show mixed trends. For example, data from Haifa (Israel) and the Gulf of Lions (France) indicate that heavy metals in sediments are declining, while no change is observed in mercury concentrations in the Gulf of Trieste, despite the closure of mining in Idrija (Slovenia).

Trends in heavy metals in biota were examined at sites with data for periods of at least five years starting in the late 1990s. These analyses showed that, while trends at individual sites tended not to be significant, there was a general pattern of stable to declining trends. A few stations with high levels of metals in biota in the Western Mediterranean (e.g., Marseille, Fos and Pombino) and in the Adriatic (e.g., Rijeka and Kastela bays in Croatia and Durres and Vlora Bay in Albania) showed slightly increasing trends. By contrast, Naples, Genoa and Bizerta Lagoon (Tunisia) showed decreasing trends. Additionally, in several cases there was an apparent decline of outlier values, such as in locations in Italy, which may reflect a general improvement in areas with particularly high levels of metal pollution.

The exposure of marine and coastal organisms to elevated concentrations of heavy metals exacerbates the ecological stress they are regularly subjected to by natural stressors, such as temperature and salinity fluctuations. The presence of toxic substances in the marine environment, even at low levels, will give rise to biochemical reactions that may cause stress to marine organisms. Among the results of prolonged stress is the suppression of the immune system, increasing susceptibility to infection. Although new techniques measuring the total response of organisms to all possible stressors have been developed, none of them can give accurate estimates of levels of acute or sublethal toxicity of contaminants. Sensitive *in situ* bioassays are needed to measure water and sediment toxicity using indigenous organisms (UNEP/MAP/MED POL 2005).

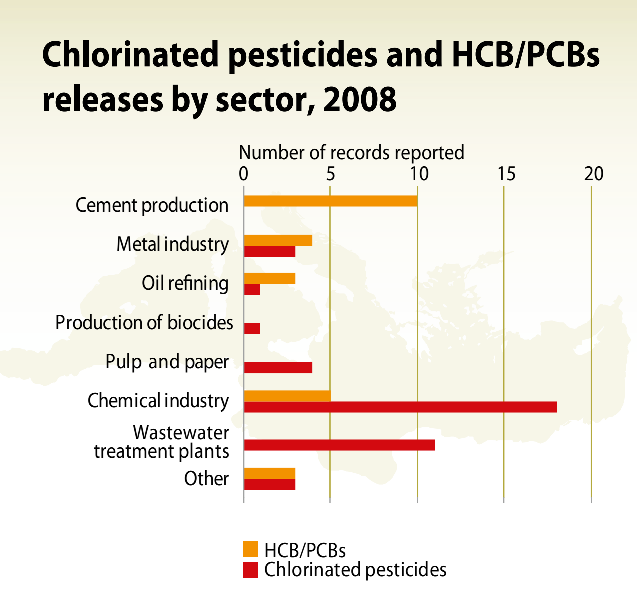
Mercury is a highly toxic element that is found in elevated concentrations in Mediterranean marine biota. Studies conducted in the 70's in pelagic fish but also recent studies revealed that Hg concentrations in Mediterranean fish are twice those found in the same species living in the Atlantic Ocean. The presence of cinnabar deposits and volcanoes in the Mediterranean, as well as the anthropogenic emissions from various land based sources, are the possible Hg sources, which are transported to the marine environment through river and point land based emissions, as well as through atmospheric precipitation (Cossa and Coquery, 2005). Risks to Mediterranean ecosystems also stem from the effects of cadmium on top predators and from lead on predators of shellfish (UNEP/MAP/MED POL 2005).

Persistent Organic Pollutants (POPs)

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. POPs persist in the environment, are capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and have potentially significant impacts on human health and the environment. POPs include certain chlorinated pesticides and industrial chemicals such as polychlorinated biphenyls (PCBs), most of which have already been prohibited in Mediterranean countries. However, POPs can also be unintentionally released, mainly as a result of combustion processes or as by-products in some industrial processes. Some examples are dioxins and furans, hexachlorobenzene (HCB), PCBs, or polycyclic aromatic hydrocarbons (PAHs).

The MED POL NBB inventory report (UNEP/MAP/MED POL 2012) states that in the Mediterranean, very high levels have been historically measured in the marine environment, especially in top predators and cetaceans. However, a general decrease of POPs concentrations has been observed over the last years, although in some cases concentrations still remain relatively elevated.

The inventory includes very few reports for the already prohibited organochlorines, which confirms that they are no longer released from industrial point sources. HCB and PCBs are mostly released as unwanted by-products in the cement and metal industry, while chlorinated pesticides are emitted by the organic chemical industry, or by wastewater treatment



Source: MEDPOL; Releases, emissions and sources of pollutants in the Mediterranean region. An assessment of 2003-2008 trends; 2012.

plants, which may collect pesticides contained in sewage and runoff waters.

Data published between 1971 and 2005 were included in a regional assessment of pollution of sediments by certain POPs, namely polychlorinated biphenyls (PCBs) and chlorinated pesticides like dichlorodiphenyltrichloroethane and its degradation products (DDTs) and hexachlorobenzene (HCB) (Gomez-Gutierrez *et al.* 2007). Despite the shortcomings in the combined datasets, the authors were able to conclude that contamination of sediments by POPs is more a local problem, mainly associated with urban/industrial and river discharges, as well as with coastal enclosures (harbours and coastal lagoons), rather than a widespread issue. They also concluded that the northern Mediterranean coast is the area of most concern for sediment pollution by POPs and that POPs have declined – with this decline being more evident for DDTs than for PCBs. This could indicate an ongoing input of PCBs, which highlights the need for improved management of the potential sources.

The recent MED POL study (UNEP/MAP/MED POL 2011) included PCBs and chlorinated pesticides (DDTs, HCB, aldrin, endrin, dieldrin and lindane). It provides an updated view of the geographical distribution and trends of POPs in biota, summarising the data mainly for blue mussels and red mullet.

PCBs were found in the vicinity of industrial and urban sites, as well as around the mouths of major rivers. Areas of concern with regard to levels of PCBs in biota include northwestern Mediterranean coastal areas, with generally high levels, especially around the cities of Barcelona, Marseille (with the highest values of up to 1.500 ng/g dry weight) and Genoa. Particularly high levels of PCBs were also found in biota from the coastal strip from Livorno to Nice and the mouths of the Rhone and Ebro rivers (indicating that rivers and wastewater discharges are major sources of PCBs). In the Adriatic Sea, PCBs were elevated in biota from the eastern bank and along the coasts of Croatia and Albania. Levels were generally lower in the Eastern Basin, but medium to high levels of PCBs were recorded in red mullets from Cyprus and Turkey and high values, also related to industrial and urban effluents, were recorded offshore from the Athens port of Piraeus.

Assessment of regional trends in PCBs is made difficult by changes in analytical and reporting methods. At coastal sites in the northwestern Mediterranean (France and Italy), where trend analysis is possible, the PCB concentrations in biota remained relatively constant or, in some cases, increased slightly. Similar trends were recorded at stations in the Eastern Mediterranean (Athens, Greece, and Izmir and Mersin, Turkey).

Despite monitoring of chlorinated pesticides by MED POL since the 1990s and the improvement of systematic monitoring during the past decade, spatial data coverage is not sufficient for drawing conclusions about the regional distribution of these compounds. Available data indicate that contaminants are not uniformly distributed throughout the Mediterranean and some hot spots have been identified for specific pesticides.

In the Western Mediterranean, areas of particular concern include estuaries (Rhone and Ebro), ports, bays and gulfs (Barcelona, Marseille-Fos, Liguria, Nador Lagoon, and the bays of Algiers, Tunis, Naples, and others). These areas have moderate levels of aldrin, HCB and DDTs. There is evidence that river inputs represent the most important source of pesticides entering the Western Mediterranean Sea.

Several stations along the Italian coast of the Adriatic Sea had moderate values of aldrin and dieldrin, while Durres and Vlora Bay (Albania) had very high levels of DDTs and lindane. Moderate concentrations of lindane and DDTs were found in the Gulf of Trieste and the Marche region (Italy), respectively. In the Eastern Mediterranean, concentrations of DDTs in biota were quite low, although moderate concentrations of DDTs were present in Izmir Bay (Turkey), at three stations south of Cyprus, as well as in Saronikos, Thermaikos and Amvrakikos Gulf (Greece) where the concentrations of aldrin and dieldrin were also very high, probably due to agricultural activities in the area.

The levels of chlorinated pesticides in mussels have declined since the 1990s, which is consistent with the banning of production and use of these compounds. The median values of pesticides in mussels from Croatia and France exhibit clear decreasing trends, as do the outlier values in the data from France. The only exception seems to be Albania (e.g., Durres and Vlora Bay), due probably to stockpiles of obsolete chlorinated pesticides. In Mersin (Turkey), chlorinated pesticides in mussels are decreasing, although occasional increases were recorded in Izmir Bay (Turkey). In general, the decrease is slower for DDT than for lindane and other chlorinated pesticides, which is consistent with the longer half-life of DDT.

The last two groups of POPs that are of concern in the Mediterranean Sea are mostly related to maritime traffic and boating. These are biocides (mainly organotin compounds such as tributyltin, known as TBT) used in antifouling paints and polycyclic aromatic hydrocarbons (PAHs) resulting from hydrocarbon oil discharges and accidental spills, among other sources. PAHs are considered along with oil pollution in the next section.

Organotins have been detected in Mediterranean waters and sediments since the late 1980s and continue to be present in substantial concentrations despite the ban on their use in 1990. TBT degradation is slow, with a half-life ranging from weeks in shelf waters to years in deep sediments (Abdulla and Linden

2008). Distribution data are poor but adequate to show that TBT has been detected in all water and sediment samples analysed in the Alboran Sea, North-western Mediterranean, the Tyrrhenian coast of Italy, the Venice lagoon, the Gulf of Saronikos (Greece), the southern coast of Turkey, the coasts of Israel and Alexandria. Surveys show an improvement following the ban on their use, especially in recreational marinas, but also show that TBT has been transported to areas far away from its sources (Abdulla and Linden 2008).

In addition to those described above (PCBs and organochlorine pesticides), industrial and domestic-use POPs, like brominated flame retardants (polybrominated diphenyl ethers, or PBDEs) have also been found in marine biota, including blue mussels.

POPs have been shown to disrupt the endocrine systems of a number of organisms and to modify the reproductive systems of Mediterranean swordfish, which may constitute a threat to the survival of the species. There is also evidence for potential trans-generational effects in small cetaceans (Abdulla and Linden 2008).

The effects of organotin biocides have been well documented in the Mediterranean. TBT is considered the most toxic substance that is intentionally introduced into marine environments. It affects non-target biota, especially in areas with high vessel density and restricted water circulation such as harbours and marinas. Marine invertebrates are very sensitive to TBT. Effects include morphological changes, growth inhibition, suppressed immunity, reduced reproductive potential and changes in population structure. Another known effect of TBT (from laboratory studies) is the development of male sexual characters in female prosobranch gastropods. This has been shown to occur at TBT concentrations well below those detected in water and sediments of the Mediterranean Sea. This development of reproductive abnormalities has been recorded in gastropods collected in areas subject to both high and low shipping activities since the early 1990s along the Catalan and Ligurian coasts, near Naples, and off the coasts of northwestern Sicily, Malta, Venice (Italy), Rovinj (Croatia) and Bizerte (Tunisia). Besides the impact on gastropods, TBT and its degradation products accumulate in tissues of marine organisms and move up the food chain. Very high concentrations have been found in top predators including the bottlenose dolphin, bluefin tuna, and blue shark collected off Italy (Abdulla and Linden 2008).

Oil pollution and polycyclic aromatic hydrocarbons

Marine transport is a main source of petroleum hydrocarbon (oil) and PAH pollution in the Mediterranean Sea. A recent IUCN report by Abdulla and Linden (2008) looked into maritime traffic effects on biodiversity in the Mediterranean Sea covering amongst others the pressure and impact of ship-borne oil discharges. Nine thousand tanker trips were recorded in 2006, carrying over 400 million tonnes of crude oil. Most trips originated or ended at port facilities in the Mediterranean. According to certain studies, approximately 0,1 % of the crude oil transported ends up deliberately dumped every year in the sea as the result of tank washing operations (Solberg & Theophilopoulos 1997; UNEP/MAP 2006). All other types of vessels are also potentially a source of discharge of oily waste. Other releases of oil from ships include amongst others loading/discharging, bunkering, dry-docking operations and discharging of bilge oil (Abdulla and Linden 2008).

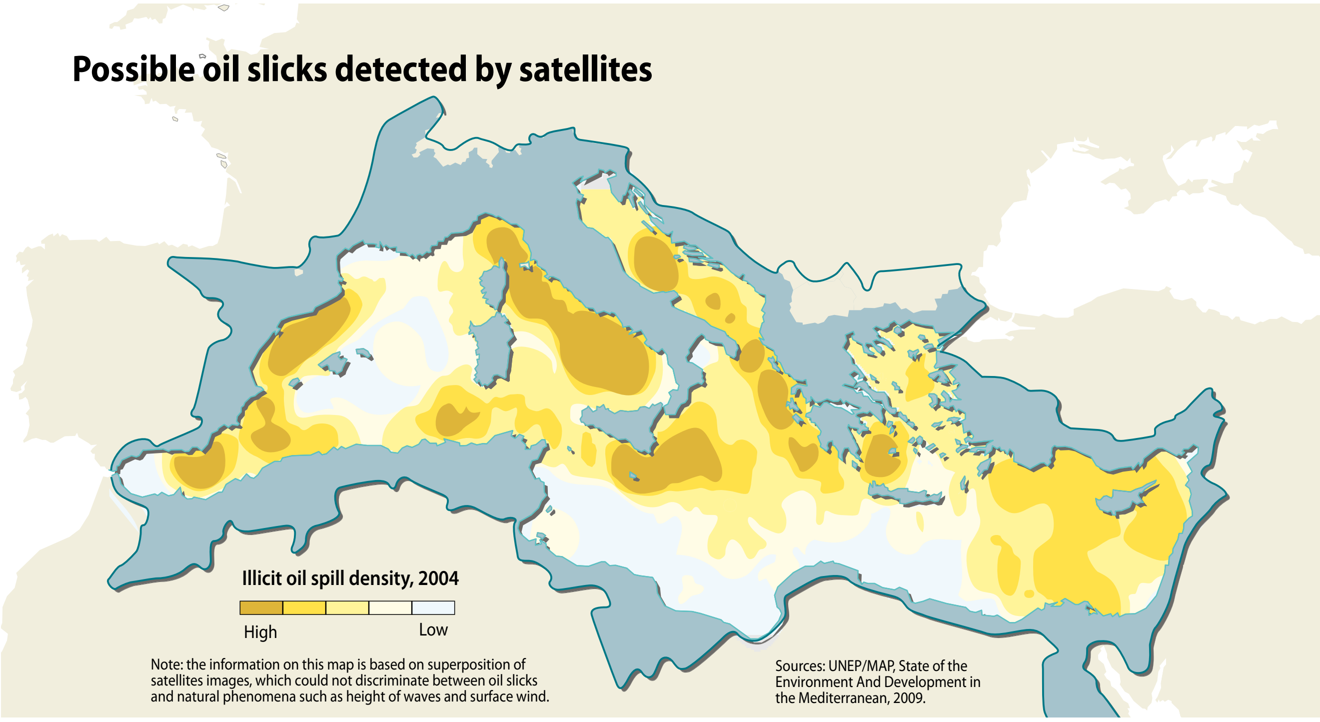
Despite the importance of the maritime sector and the potential implications of oil discharges, data on the subject are scarce. Illicit vessel discharges can be detected using satellite images, allowing the estimation of the spatial distribution of oil-spill density and the identification of hot spots (Abdulla and Linden 2008). This provides evidence that the distribution of oil spills is correlated with the major shipping routes, along the major west-east axis connecting the Straits of Gibraltar through the Sicily Channel and the Ionian Sea with the different distribution branches of the Eastern Mediterranean, and along the routes toward the major discharge ports on the northern shore of the Adriatic Sea, east of Corsica, the Ligurian Sea and the Gulf of Lion (Abdulla and Linden 2008).

Crude oil is composed of thousands of complex compounds of which PAHs are the most toxic. The amount of PAHs entering the Mediterranean Sea varies according to the types and amounts of oil discharged. Annual input is estimated at between 0,3 and 1.000 tonnes (EEA and UNEP 2006). PAHs are also introduced into the Mediterranean Sea by aquaculture activities (Tsapakis *et al.* 2010) and atmospheric particulates from the combustion of fossil fuels and incomplete combustion of biomass and solid waste (EEA and UNEP 1999).

Releases of mineral hydrocarbons and phenols are mostly (99 %) reported by the oil refining sector in a few southern countries like Egypt, Libya, Algeria or Tunisia. This sector also accounts for 66 % of volatile organic compound releases, which are also emitted by the organic chemical industry, manufacture of textiles, transport and energy production. Between 2003 and 2008, emissions of these pollutants were reduced in some countries like Algeria, Syria or Tunisia, but increased in others like Egypt or Turkey. Some countries also report data on water emissions of oils and grease. This parameter includes also non-mineral oils, and accordingly the food industry appears as the major source in Mediterranean countries, accounting for 83 % of total releases, followed by the oil refining sector (13 %) and wastewater treatment plants (3 %) (UNEP/MAP/MED POL 2012).

In some areas PAH levels are higher in offshore waters than they are nearer to land. Abdulla and Linden (2008) considered this to be due to intensive ship traffic and direct discharges from ships offshore. In nearshore waters, PAHs in sediments are generally higher near ports and industrial areas, up to 100 times higher than in the overlying water column. This is due to the adsorption of PAHs onto particles, where they become even more resistant to degradation (De Luca *et al.* 2005). Concentrations of PAHs in marine biota tend to be correlated with oil-related facilities, including refineries, terminals and ports. Most studies, however, have been carried out in the northwestern part of the Mediterranean. In addition, there is an almost total lack of information on levels in deep-sea areas. In order to be able to assess the state of contamination by petroleum hydrocarbons in the Mediterranean, more studies are needed, particularly along the southern coasts and also along major shipping routes (Abdulla and Linden 2008).

PAHs are known to affect different species at the genetic, cellular, biochemical and physiological levels. Genetic damage may result in chromosomal aberrations, impacts on embryonic stages and long-term effects such as carcinogenic and mutagenic growth in vertebrates. Some of these effects have been found as long as ten years after an oil spill incident off the coast of Liguria in Italy. Some water-soluble PAHs have been shown



to disrupt biochemical membranes, causing changes in enzymatic and receptor activities in affected organisms. Experimental studies have also shown that exposure to petroleum hydrocarbons may lead to various impacts on blood chemistry. Both laboratory and field studies have shown that petroleum hydrocarbons may result in oxidative stress. Fish exposed to petroleum hydrocarbons under chronic conditions often exhibit various types of lesions. Several field studies have shown such histopathological changes in biota from waters contaminated by oil. For example, after the Haven accident outside the port of Genoa, fish sampled in the contaminated area had lesions as long as nine years after the accident. Behavioural abnormalities resulting in lowered chances of survival in the natural environment are also observed among aquatic organisms exposed to oil spills (Abdulla and Linden 2008).

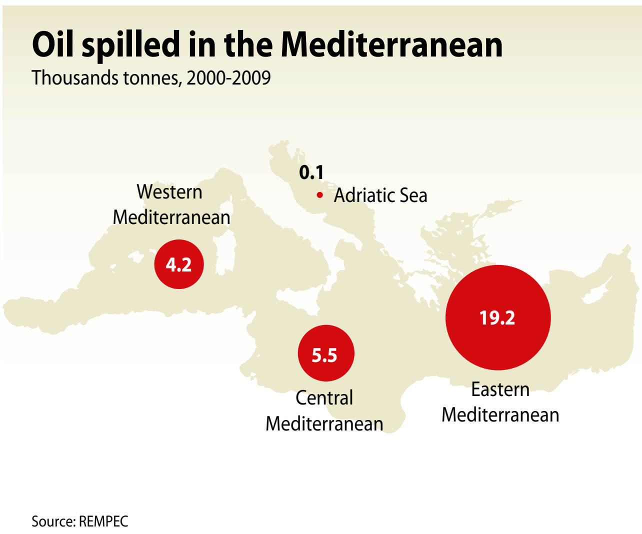
Community-level changes were detected off Livorno after the 1991 Agip Abruzzo oil spill, where several different species in the meiobenthic community reacted differently by either decreasing or increasing their population numbers. Foraminifera, turbellarians, and nematodes were particularly sensitive, while populations of copepods increased. Further research indicated an acute initial response among these organisms with rapid recovery. This indicates a high resilience to single oil spill incidents. Benthic macro-fauna may also be resilient to the effects of petroleum hydrocarbons, particularly weathered oil. Samples from the Haven oil spill showed no significant differences between tar-contaminated sites and control sites. However, other studies indicate clear impacts on the growth of shallow-water sea grass over extensive areas and for as long as eight years after a spill (Abdulla and Linden 2008).

Acute pollution events

Data used in this section are extracted from the Alerts and Accidents database maintained by REMPEC. They include incidents that have caused, or could have caused, pollution damage. The main sources of information are Lloyd's Casualty Reporting Service (LCRS) and the emergency reports sent to REMPEC by national focal points in Mediterranean countries. This database cannot be considered a comprehensive list of all the spills occurring in the Mediterranean Sea. Other incidents that are not reported in the database could also have had significant impacts on the ecosystems, such as damage to the seabed or input of organotin compounds from paints during ship groundings.

In the last decade, nearly half of the accidents leading to significant spills (of more than 100 tonnes) that were reported to REMPEC occurred in the Western Mediterranean Sea (seven accidents representing 47 % of all accidents). A third of the accidents occurred in the Eastern Mediterranean (five accidents representing 33 % of the total) and a fifth of the accidents occurred in the Central Mediterranean. No accidents were reported for the Adriatic Sea.

The cumulative amount of toxic substances spilled per year follow a different pattern. A single accident can lead to the spill of a large amount of substance, and thus the cumulative quantities are variable. The worst spill in the Mediterranean was related to



the fire and explosions on the MT Haven in 1991, sinking in the Gulf of Genoa and spilling 20 % of its 145.500 tonnes of crude oil into Italian waters. The Haven spill contaminated the Ligurian coastline as well as the coastlines of Monaco and France, as far west as Toulon.

The Eastern Mediterranean accounts for two-thirds of the total quantity spilled in the last decade. If the Lebanese spill of 2006 is taken out of the calculations, the Western Mediterranean, Central Mediterranean, and Eastern Mediterranean spilled roughly the same quantities (between 4.000 and 6.000 tonnes), while less than 100 tonnes was spilled in the Adriatic, according to the information made available to REMPEC.

The most common type of accident leading to a spill is a failure during cargo operations, and in most cases these incidents lead to small spills. Other types of accidents, in order of frequency, are: collisions/contacts, groundings, sinkings, and, finally, fires/explosions. In addition, a wide range of infrequent accident types are reported, including pipeline leaks.

Eutrophication

Human sources of nutrients

Nutrients in seawater present a paradox. Nutrients are, of course, essential for life. In the oligotrophic environment of the Mediterranean, the ecosystems with the most nutrients are generally the most productive and diverse. At the same time, many Mediterranean nearshore areas are threatened by nutrient over-enrichment due to coastal and watershed development. Municipal sewage is the big offender, followed by fertiliser run-off from agricultural areas, lawns and golf courses. The problem is particularly acute in shallow sub-basins with limited flushing, common features in parts of the Adriatic and along the Mediterranean's southern shore.

Many developed coastal areas suffer particularly from increased influx of dissolved nitrogen and phosphorus. Sources include untreated human sewage, animal waste, transportation, fertilisers and industrial discharges. The largest emitters of nitrogen are urban wastewater treatment (45 %), livestock farming (24 %) and the organic chemical industry (2 %). Ammonia emissions from animal manure used as fertiliser also contribute nitrogen. The main sources of phosphorus are fertiliser manufacturing (40 %), livestock farming (39 %) and urban wastewater treatment (13 %) (UNEP/MAP/MED POL 2012). Although the overall inputs of nitrogen (about 1,5–4,5 million tonnes per year) and phosphorus (about 0,1–0,4 million tonnes per year) are low compared to some other seas (e.g., Black Sea), these nutrients are problematic in coastal areas (UNEP/MAP/MED POL 2005). According to National Baseline Budget 2008 data, total nitrogen is mostly emitted by wastewater treatment plants, animal farms, the organic chemical industry in the northern Mediterranean countries and the tanning sector in the southern and eastern shores. The fertiliser industry is the main source of total phosphorus, especially in those producer countries like Tunisia, Algeria, Lebanon or Greece. Aquaculture is also reported as an important source of nutrients and suspended solids. Although total discharges are not comparable to other sectors, they can lead to localised impacts in the marine environment. Spain, Greece, Turkey, Italy and Croatia are the countries with the largest marine aquaculture development (UNEP/MAP/MED POL 2012).

Eutrophication and the human impact

In natural aquatic ecosystems, high concentrations of nutrients can result in rapid growth of phytoplankton, a process called eutrophication (UNEP/MAP 2009). Algal blooms are a common natural phenomenon associated with eutrophication. In addition, there is a shift in phytoplankton species composition, with large species favoured over smaller ones. Long-living and slow-growing plants cannot compete with fast-growing algal species. Since the larger plants provide cover and food for fish and substrate for invertebrate organisms, biodiversity suffers. Although eutrophication is a natural aging process of a water body, added nutrients from human activity can greatly speed up the process with resulting negative impacts on the ecosystem.

Agriculture is the largest non-point source of pollutants in the Mediterranean (UNEP/MAP 2011). Agriculture-related nutrients enter the sea through groundwater, lakes, wetlands, and rivers. Nitrogen consumption per surface unit of arable land is highest in countries of the northern watershed, with the exception of Bosnia-Herzegovina and Albania. In contrast, point-source release is highest on the eastern coast of the Adriatic. Other point sources of nitrogen are concentrated in the Ebro watershed, the eastern coast of the Levantine Basin and the western coast of Tunisia.

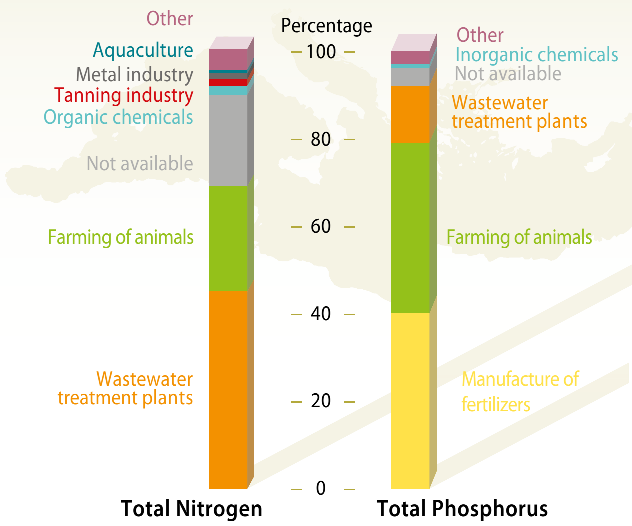
Direct effects of nutrient over-enrichment

The most eutrophic areas of the Mediterranean are linked to the mixing of nutrients from deeper waters through intense mesoscale circulation (Alboran Sea), local tidal mixing (Gulf of Gabes), or the input and alongshore redistribution of nutrients from large rivers. In addition, high chlorophyll and productivity levels have been found near large urban areas.

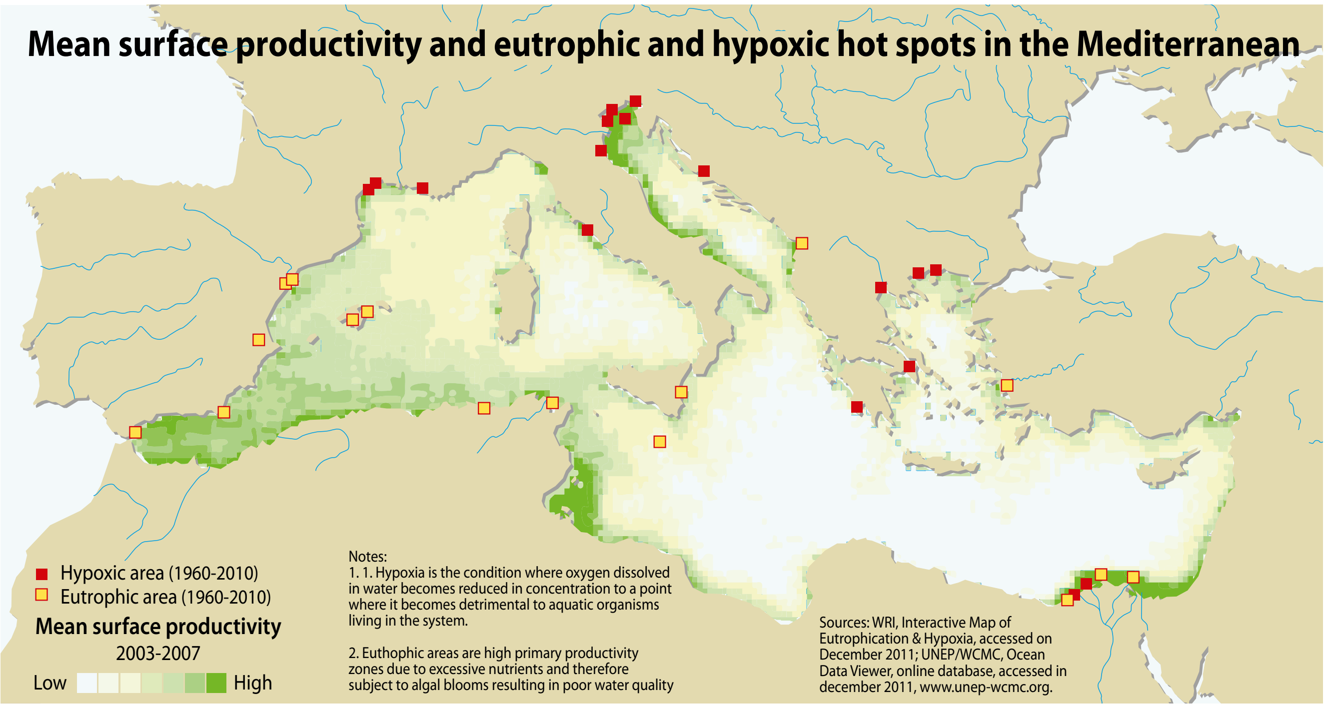
The Mediterranean phytoplankton community is not well described, but it is believed to be changing, along with the rest of the sea's ecosystem. Changes in nutrient concentrations and ratios suggest a shift in the distribution of nutrients and, therefore, of phytoplankton species (UNEP/MAP 2009). Macrophytes such as *Cystoseira* spp., *Dictyota* spp. and *Halymenia* spp. are in decline and are being replaced by short-lived algal species (UNEP/MAP/MED POL 2005).

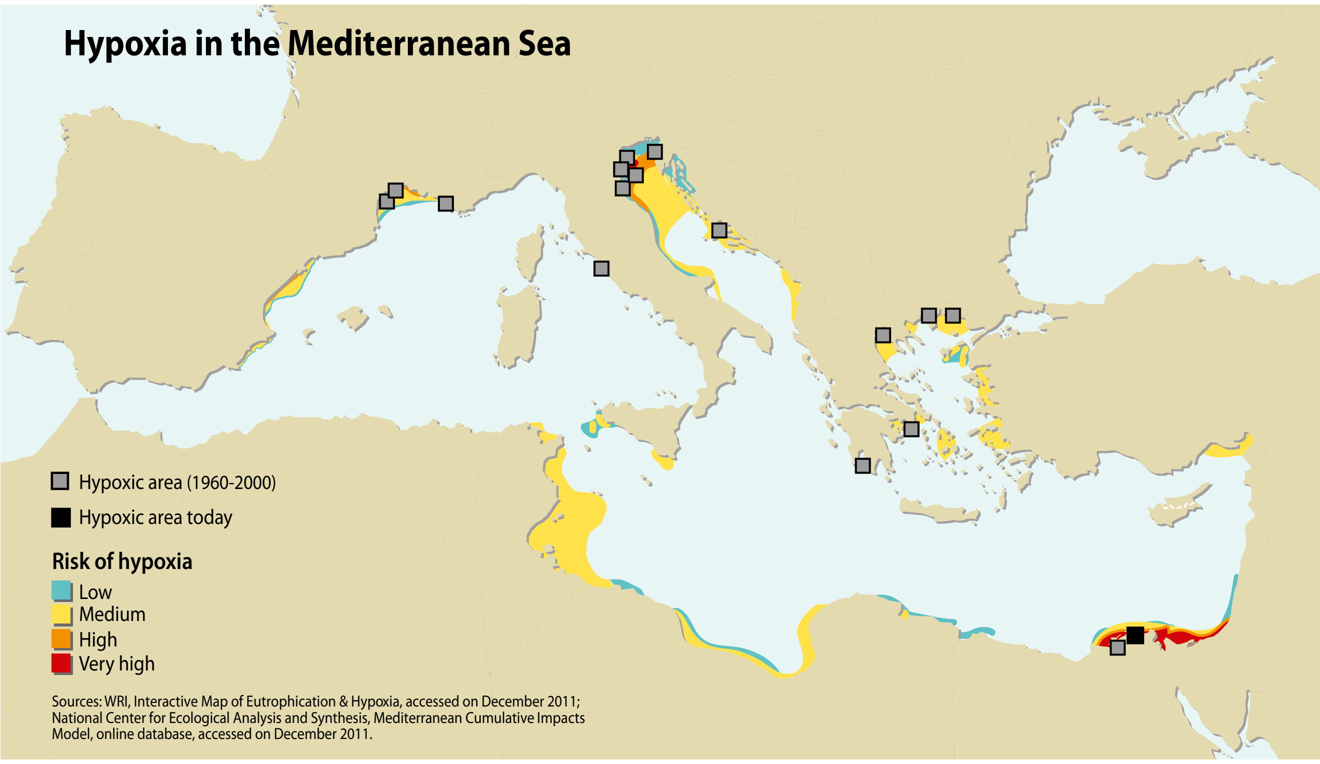
One of the most serious effects of eutrophication comes from algal blooms or red tides. At least 57 species of algae are reported to cause algal blooms in the Mediterranean (UNEP/MAP/MED POL 2005). During blooms, algae accumulate quickly, causing a discoloration of the water column. When marine algae occur in significant numbers and produce biotoxins, the result is harmful

Sources of emissions of nutrients in the Mediterranean region, 2008



Source: MEDPOL; Releases, emissions and sources of pollutants in the Mediterranean region. An assessment of 2003-2008 trends; 2012.

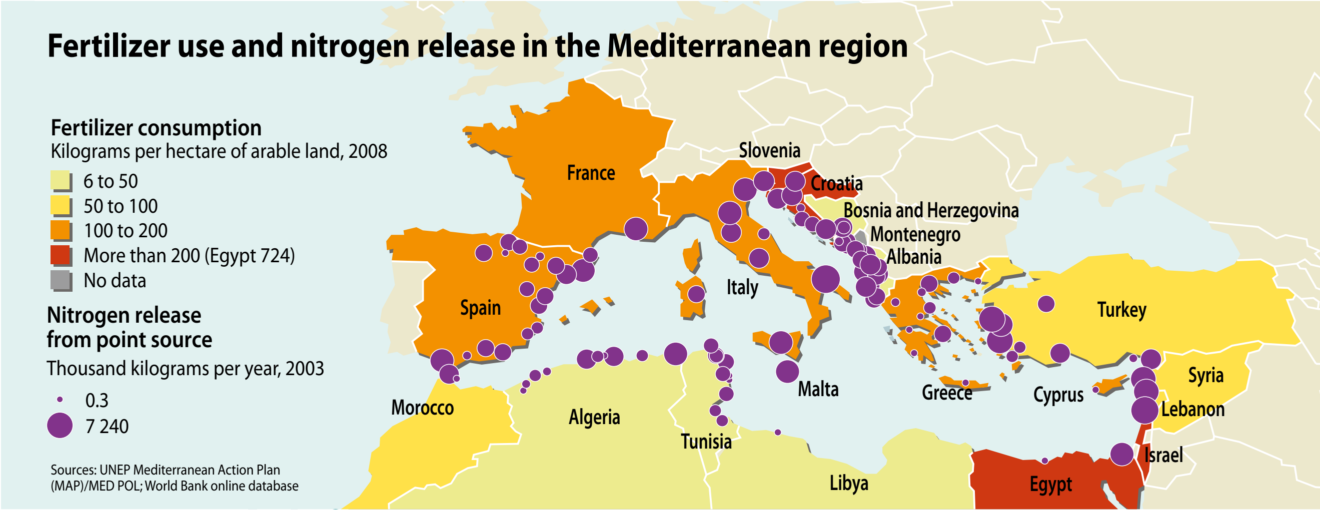




algal blooms (HABs). The impacts of HABs include human illness and mortality (from either consumption of or indirect exposure to toxins), economic losses to coastal communities and commercial fisheries, and mortality of fish, birds and mammals (UNEP/MAP 2011). The bioaccumulation of toxins in fish may also be responsible for high mortality rates in dolphins (UNEP/MAP/MED POL 2005). Although coastal pollution is not the primary cause of algal blooms, there is a direct relation between it and their frequency (UNEP/MAP/MED POL and WHO 2008).

Eutrophication can also lead to hypoxic (low oxygen) and anoxic (total oxygen depletion) conditions. The decrease in oxygen is due both to algae reducing dissolved oxygen through respiration and the decomposition of dead algae. In extreme cases, oxygen depletion can result in the death of marine organisms. Both fish and shellfish kills have been recorded in the Mediterranean (UNEP/MAP/MED POL 2005).

Numerous Mediterranean species have been lost locally as a result of eutrophication. Echinoderms (e.g., starfish, sea urchins), crustaceans and other taxa tend to disappear from heavily disturbed or polluted areas, to be replaced by a smaller number of *Polychaeta* (marine worm) species (UNEP/MAP/MED POL 2005). There have been major reductions of benthic organisms in the North Adriatic Sea, for example, as a result of recurrent anoxia in the bottom waters (UNEP/MAP/MED POL 2005). It is thought that some fifteen species of molluscs and three species of crustaceans have been lost because of these conditions. The creation of bacterial mats in anoxic zones can have long-lasting negative impacts on critical sea grass meadows (UNEP/MAP/MED POL 2005).



Impacts of nutrient over-enrichment

There are numerous socio-economic impacts associated with eutrophication including:

- toxicity or mortality in commercial fish and shellfish species leading to reduced catches;
- loss of employment and income in fisheries related to reduced resource base;
- loss of aesthetic value resulting from algal blooms;
- loss of tourism related to deteriorating water quality;
- loss of employment and income related to tourism, especially sport fishing; and
- loss of cultural heritage (UNEP/MAP/MED POL 2005).

Most susceptible to the negative impacts of eutrophication are semi-enclosed basins, estuaries and lagoons, where excess nutrients are not easily dispersed (UNEP/MAP/MED POL 2005).

Red tides are a problem for some Mediterranean fisheries. Fishing and mollusc farming in the northwestern Adriatic have been damaged by blooms of the dinoflagellate, *Dinophysis* spp., which causes Diarrhoetic Shellfish Poisoning (DSP). The occurrence of this organism has been responsible for temporary and prolonged bans on the harvesting and sale of mussels in the coastal and lagoon areas of Emilia-Romagna (UNEP/MAP/MED POL 2005). *Alexandrium tamarensis*, a dinoflagellate that produces Paralytic Shellfish Poisoning (PSP) toxins has been observed in the northern Adriatic (UNEP/MAP/MED POL 2005).

The Initial Integrated Assessment data suggest that eutrophication is still a localised phenomenon in the Mediterranean Basin. Better monitoring regimes and analysis of resulting data to determine trends will, in the future, allow robust statements of the effect of eutrophication on the ecology, as well as on fisheries and other valuable ecosystem services (UNEP/MAP 2012).

Marine Litter

Marine litter in coastlines, water column and seafloor

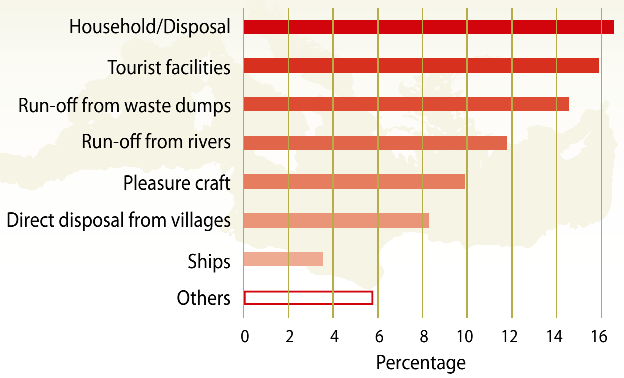
The main source of marine litter in the Mediterranean is households. Other major sources are tourist facilities, municipal dumps, ships and pleasure boats.

Most studies of marine litter in the Mediterranean have focused on beaches, floating debris and the seabed (UNEP/MAP 2012). They show that there is more marine litter in bays than in open areas (Galgani *et al.* 2010), and it is concentrated in shallow coastal areas rather than deeper waters (Koutsodendris *et al.* 2008).

A large proportion of marine litter is plastics (UNEP 2009). The impact of large plastic material on the environment has been widely studied. Effects include entanglement of marine animals in plastic and ingestion of plastic by marine organisms (EEA and UNEP 2006). More attention is now being given to the impact of microplastics from such primary sources as feedstock in the plastics industry and from the breakdown of larger plastic items (GESAMP 2010). While evidence is growing that microplastics can also have negative effects on marine organisms, little scientific investigation has gone into the problem in the Mediterranean or elsewhere (GESAMP 2010). The additional challenge of microplastics is their small size, which makes them difficult to remove from the marine environment.

Marine litter is "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment." It reaches the marine environment through deliberate disposal or unintentional discharge, either at sea or from land by way of rivers, drainage systems and wind.
Source: Galgani et al. 2010

Sources of marine litter

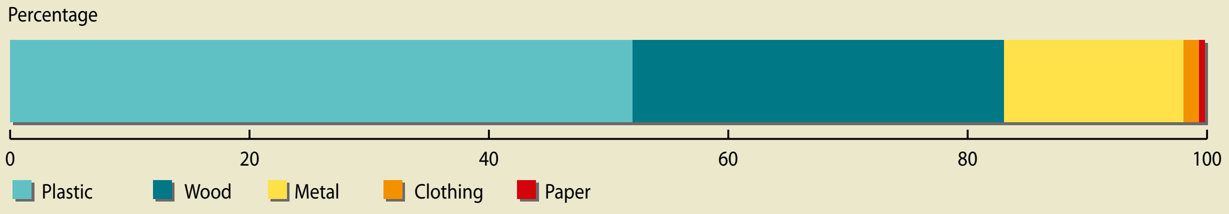


Source: UNEP/MAP - BP/RAC, 2009.

Impacts of marine litter on marine life

Around the world, marine litter kills more than a million seabirds and 100.000 marine mammals and turtles every year (UNEP/MAP 2012). Little information is currently available about the impact of marine litter on Mediterranean wildlife. The most significant effects come from entanglement in or ingestion of marine litter, especially plastics. Sea turtles in the Mediterranean, already seriously endangered through habitat loss and by catch, are further threatened by plastic marine litter, which they mistake for their main prey, jellyfish, and swallow (Galgani *et al.* 2010). The plastic can become lodged in the turtles' gastrointestinal tracts, resulting in injury or death.

Major types of marine litter in the Mediterranean



Source:UNEP/MAP, MEDPOL, *Assessment of the Status of Marine Litterin the Mediterranean*, 2011.

Marine Noise

Underwater noise is a growing concern in the Mediterranean due to increasing maritime activity, particularly in the Western Mediterranean. Underwater noise affects the communication and behaviour of marine mammals and certain fishes (UNEP/MAP 2012; Notarbartolo di Sciara and Birkun 2010). Noise from human activities can drown out the sounds that the animals rely on for communication and orientation, sometimes with serious effects, even death.

The responses of cetaceans to human-created noise fall into three categories:

- Behavioural: changes in surfacing, diving, and heading patterns; abandonment of habitat.
- Acoustic: changes in type or timing of vocalisations; masking acoustic signal over large areas.
- Physiological: temporary and permanent hearing loss; mortality (Notarbartolo di Sciara and Birkun 2010; Abdulla and Linden 2008).

Beaked whales appear to be particularly vulnerable to noise (Notarbartolo di Sciara and Birkun 2010). Incidences of mass stranding and mortality of Cuvier's beaked whales have been reported in relation to the use of military sonar in the Mediterranean (Nortarbartolo di Sciara and Birkun 2010). Seismic sonar (used in the oil and gas industry), the second major source of potential noise impacts on Mediterranean marine mammals, has received less attention. There is growing evidence that fish may also be negatively affected by noise. Possible impacts include impaired communication, stress, habitat abandonment, hearing loss, and damage to eggs (Abdulla and Linden 2008).

Marine noise is human-generated sound from such activities as high-intensity sonar and seismic surveys and from the background sounds of commercial shipping and wind farms.

The impact of military sonar on marine mammals has influenced regional marine policy in the Mediterranean in recent years, but this has not yet been translated into mitigation at a broader scale (Dolman *et al.* 2011). In 2007, the Contracting Parties to the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) adopted *Guidelines to address the impact of anthropogenic noise on marine mammals in the ACCOBAMS area*. A recent ACCOBAMS status report, however, found that no significant progress has been made to address the problem of marine noise, nor have there been any systematic attempts to coordinate industrial activities with marine mammal conservation initiatives (Notarbartolo di Sciara and Birkun 2010).

Non-indigenous Species

Distribution and trends in abundance of non-indigenous species in the Mediterranean

Both the number and rate of non-indigenous introductions to the Mediterranean have been increasing in recent years (UNEP/MAP 2009). Currently, about a thousand non-indigenous aquatic species have been identified in the Mediterranean Sea, with a new species being introduced roughly every ten days. About 500 of these species are well-established; many others are one-off observations (UNEP/MAP 2012). In addition, there are also terrestrial non-indigenous species that have been introduced into the coastal zone of the Mediterranean but these species have so far not been systematically monitored.

Benthic, or seabed-living, animals are the most plentiful non-indigenous species in the Mediterranean. Most are molluscs, crustaceans, or sea worms (UNEP/MAP 2009). More non-indigenous species are found in the Eastern Mediterranean than in the Western Mediterranean.

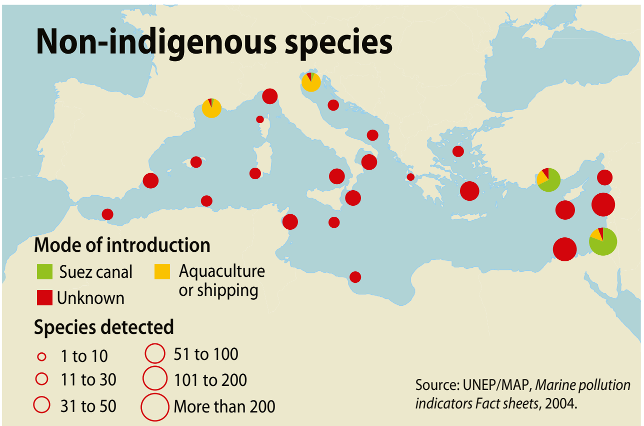
Major vectors of introduction

Non-indigenous species enter the Mediterranean through three broad avenues:

- Natural invasion through waterways such as the Suez Canal or Straits of Gibraltar;
- Transportation by ships through clinging or fouling on ship hulls, ballast water; and,
- Intentional and unintentional introduction by aquaculture activities, including commercial species, bait, and species for the aquarium trade (EEA and UNEP 1999).

Maritime transportation and aquaculture are the main ways non-indigenous species enter the Western Basin of the Mediterranean. Migration through the Suez Canal is responsible for most non-indigenous species in the Eastern Basin.

An estimated 47 % of non-indigenous species now in the Mediterranean entered through the Suez Canal, with 28 % transported by vessels and 10 % introduced through aquaculture (UNEP/MAP 2009). Species introductions from marine transport have increased because of the growth in shipping oil from the Middle East and consumer goods from Southeast Asia (UNEP/MAP 2009). The waters around Israel and Turkey have the highest number of non-indigenous species, mainly because of their proximity to the Suez Canal (UNEP/MAP 2009).



Non-indigenous species, also known as alien species, are organisms that have entered ecosystems outside of their previously known ranges and that may survive and subsequently reproduce. They can be classified as unestablished, established, invasive (rapidly increasing numbers and range), or noxious (posing a risk).
Source: Occhipinti-Ambrogi and Galil 2004

Impact of non-indigenous particularly invasive species

The vulnerability of an ecosystem to non-indigenous species depends upon the health of that system (UNEP/MAP 2012). A polluted environment, for example, is more vulnerable than a pristine one. Physical damage from dredging, bottom trawling and other forms of habitat destruction also make an environment more vulnerable to the pressures brought by non-indigenous species (UNEP/MAP 2009).

Ecological impact

The effect non-indigenous species have on native biodiversity is poorly understood in most cases (UNEP/MAP 2012). Although no recorded extinctions of native Mediterranean species have been

Some documented ecological impacts of invasive non-indigenous species:

- Predation on native species affecting marine food chains
  - Invasive non-indigenous species of fish – parrotfish (*Thalassoma pavo*), yellowmouth barracuda (*Sphyraena viridensis*), and bluefish (*Pomatomus saltator*), for example – prey on commercial fish species.
- Competition with native species
  - Invasive non-indigenous algae of the genus *Caulerpa* displaced native sea grass (*Posidonia* spp.) meadows.
  - In Israel three native species – a starfish (*Asterina gibbosa*), a prawn (*Melicertus kerathurus*), and a jellyfish (*Rhizostoma pulmo*) – decreased in abundance at the same time as three non-indigenous species – also a starfish (*A. Burtoni*), a prawn (*Maruspenaues japonicas*), and a jellyfish (*Rhopilema pulma*) – increased in abundance.
- Changes to native communities
  - One invasive non-indigenous seaweed (*Caulerpa taxifolia*) can create dense mats that affect benthic communities and reduce spawning and feeding grounds for fish.
  - Another, related non-indigenous species (*C. racemosa*) can grow over other species of seaweed and has been linked to a decrease in sponges.

Sources: UNEP/MAP 2012; EEA and UNEP 2006 directly attributed to invasive non-indigenous species, sudden changes in abundance of native species, as well as some local extirpations associated with non-indigenous species, have been reported (UNEP/MAP/BP/RAC 2009).

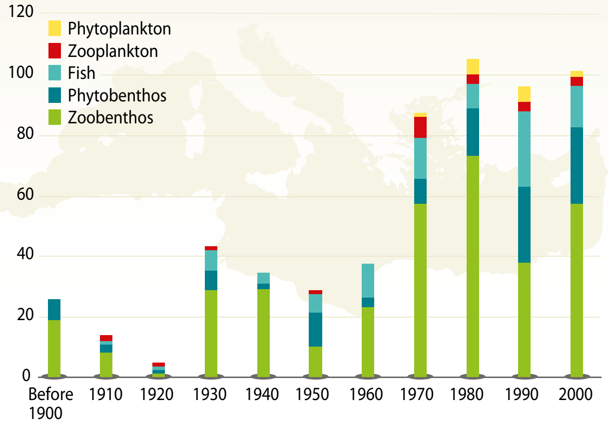
Socio-economic impact

The economic impact of non-indigenous species touches a variety of sectors, including fishing (fouled nets), aquaculture (reduced light), shipping (clogged propellers, impaired navigation), public health (toxic algae), and tourism (nuisance) (EEA and UNEP 1999). Economic losses have been documented in France and Italy as a result of fishing nets being clogged by non-indigenous macroalgae (*Womersleyella setacea* and *Acrothamnion preissii*) (UNEP/MAP 2012). The jellyfish *Rhopilema nomadica* has a negative impact on tourism, fisheries, and coastal installations in the eastern Mediterranean. The tiny, single-cell dinoflagellate *Gambierdiscus*, found in waters off the west coast of Crete, causes ciguatera, a food-borne illness that results from eating certain species of reef fish (SOE 2009).

On the other hand, some non-indigenous species are or have the potential to be important fishery resources. Examples in the Mediterranean include conch (*Strombus persicus*), prawn (*Marsupenaeus japonicus*, *Metapenaeus monocerus*, and *Metapenaeus stebbingi*), crab (*Portunus pelagicus*), and fish such as mullids (*Upenaeus moluccensis* and *U. pori*), lizard fish (*Saurida undosquamis*), Red Sea obtuse barracuda (*Sphyraena chrysotaenia*), clupeid (*Dussummieria acuta*, *Herklotsichthy punctatus*), bluefish (*Pomatomus saltator*), and rabbitfish (*Siganus rivulatus*) (EEA and UNEP 2006). A non-indigenous species of prawn (*Metapenaeus monoceros*) has partially replaced the native prawn *Penaeus kerathurus* in Tunisia with no effect on the overall catch of prawns (UNEP/MAP 2012).

Non-indigenous species over the 20th Century

Number of new species detected per decade



Source: UNEP/MAP, *Marine pollution indicators Fact sheets*, 2004.

Commercially Exploited Fish and Shellfish

Exploitation of fish and shellfish

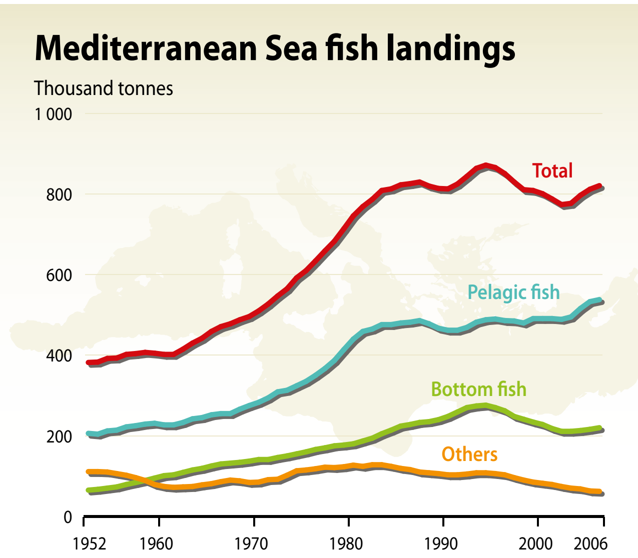
Fisheries are the greatest users of marine resources in the Mediterranean. Commercial fishing tends to be concentrated in inshore areas, although there are fisheries for pink shrimp (*Penaeus duorarum*), deepwater rose shrimp (*Parapenaeus longirostris*), and hake (*Merluccius merluccius*) on the continental slope (UNEP/MAP 2009). Total fish landings increased exponentially from 1950 to 1980, with current production fluctuating around 800.000 tonnes annually (Garcia 2011) during the last three decades. Of that total, 85 % comes from six countries: Italy, Turkey, Greece, Spain, Tunisia and Algeria (UNEP/MAP 2012).

Mediterranean fisheries are primarily coastal. The abundance and distribution of exploited species in coastal waters vary according to depth, with the continental shelf being the most productive area. The shelf extends from the coast to a depth of approximately 250 m. Fisheries in this region are highly diversified, although non-industrial fishing from small boats – less than 15 m long – dominates (UNEP/MAP 2009). The entire Mediterranean fishing fleet was estimated at 85.000 boats in 2008 but the real number is likely much higher (Sacchi 2011).

Reproductive capacity of stocks

Many fish species in the Mediterranean are over-exploited as a result of growing pressure from both commercial and recreational fisheries (UNEP/MAP 2012). In the Mediterranean overall bottom-feeding stocks are dominated by juveniles, which could indicate high fishing pressure (EEA and UNEP 2006). The overfishing of juveniles can lead to changes in population structure, which ultimately affects the sustainability and recovery of stocks (UNEP/MAP 2012). Some species also have life cycles that make them more vulnerable to over-exploitation, such as slow growth rates and older age of maturity.

Fisheries tend to target larger, more valuable species higher in the food web. As the numbers of higher predators decrease due to over-exploitation, species further down the food web start to dominate the catch. This is known as "fishing down the food web". This process appears to have been taking place in the Mediterranean at least since the mid-20th century (Pauly *et al.* 1998).



The main species of fish exploited in the coastal areas are sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicholus*) among the small pelagics, and hake (*Merluccius merluccius*), mullet (*Mullus* spp.), whiting (*Micromesistius poutasou*), angler fishes (*Lophius* spp.), sea bream (*Pagellus* spp.), octopus (*Octopus* spp.), squid (*Loligo* spp.), and red shrimp (*Aristeus antennatus*) among the demersals, and big pelagics like bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*). Landings of these species represent 70–80 % of the total fish landings in the Mediterranean. Invertebrates are also exploited, including red coral (*Corallium rubrum*), many sponge species (*Spongia* spp., *Hypospongia* spp.), and natural beds of bivalves (*Lithophaga lithophaga*, *Acanthocardia* spp., *Callista chione*, etc.) (UNEP/MAP 2012).

Key issues in Mediterranean fisheries

Over-exploitation

Over-exploitation of fish stocks is reported across the Mediterranean. More than 65 % of commercial stocks are fished beyond sustainable limits (UNEP/MAP 2012; Abdul Malak *et al.* 2011). Although commercial fisheries have the greatest impact, recreational fishing also places pressure on stocks. Some species, such as Atlantic bluefin tuna (*Thunnus thynnus*) and dusky grouper (*Epinephelus marginatus*), have been fished to such an extent that they are both listed as Endangered on the IUCN's Red List (Abdul Malak *et al.* 2011). Both croaker (*Sciaena umbra*) and shi drum (*Umbrina cirrosa*) have been listed as Vulnerable, while European plaice (*Pleuronectes platessa*), Baltic flounder (*Platichthys flesus*), European seabass (*Dicentrarchus labrax*), white grouper (*Epinephelus aeneus*), swordfish (*Xiphias gladius*), Atlantic chub mackerel (*Scomber colias*), and turbot (*Psetta maxima*) are listed as Near Threatened (Abdul Malak *et al.* 2011). Of the 86 shark, ray, and chimaera species in the Mediterranean, fifteen are Critically Endangered, nine are Endangered, and eight are Vulnerable (Abdul Malak *et al.* 2011). Another ten species are listed as Near Threatened (Abdul Malak *et al.* 2011). Recovery of many stocks has been hindered by factors other than fishing, such as pollution and increasing water temperature.

By catch

By catch – the accidental capture of non-target species in fisheries – is a serious issue in many parts of the Mediterranean. Species not eaten by humans are discarded overboard. Globally, one-quarter to one-fifth of all fish caught is thrown overboard (CMS [no date]). While some of the discards may be eaten by opportunistic ocean feeders, most are wasted (UNEP/MAP 2012). Longlines and driftnets result in significant by catch of sea turtles, marine mammals (especially whales and dolphins), seabirds, and sharks (Abdul Malak *et al.* 2011).

Direct and indirect impacts from fishing gear

Increasingly efficient fishing methods have a significant effect on many species. Changes include vessel engine power, size of gear and vessel characteristics, advances in navigation and fish-locating devices, and the development of fixed-gear fisheries that target the breeding class of several long-lived species in areas not effectively trawled in the past. All of these changes contribute to the decline of fish stocks (UNEP/MAP 2012 and UNEP/MAP/MED POL 2005). In addition, as fleets are modernised for longer voyages and navigation through rough seas, increased pressures can be expected on species in the open ocean and in deep waters (UNEP/MAP 2012).

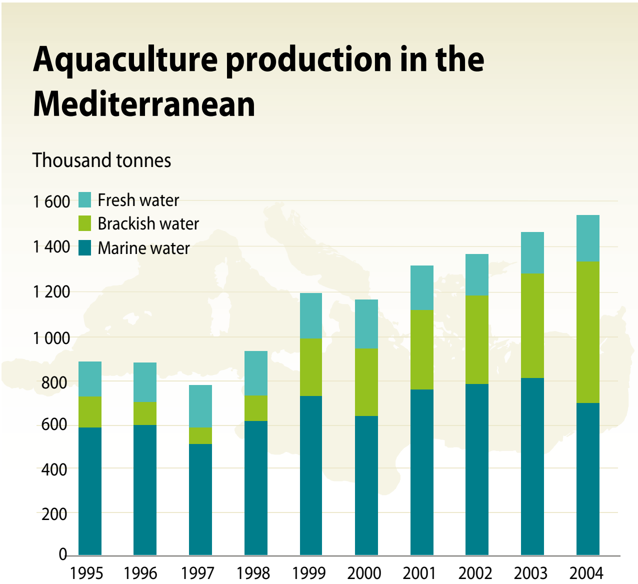
The selection of gear type affects both species and habitats. Non-selective fishing gear, such as "tonailles" – nets used for tuna – longlines, driftnets, fine-mesh nets and trawling, are the most harmful (UNEP/MAP 2012). Although driftnets have been banned in the Mediterranean, they are still in use (UNEP/MAP 2012). Ghost fishing – when lost or abandoned fishing gear continues to catch fish and other animals – is also a problem, most commonly with passive gear (e.g., longlines, gill nets, traps). The lost gear is a threat to marine species and a danger to passing boats if it becomes entangled in their propellers or in their own fishing gear.

Trawling is particularly destructive to benthic communities. It severely alters deepwater coral ecosystems and sea grass meadows and their associated fauna, reducing both the number of species and available habitat (UNEP/MAP 2012; Abdul Malak *et al.* 2011). Seamounts are particularly sensitive to fishing impacts due to their isolation and limited geographic distribution (UNEP/MAP 2012). Regulations limit the use of towed gear at depths greater than 50 m or at distances greater than 3 miles from the coast if the depth is less than 50 m. Despite the regulations, however, illegal trawl fisheries are still widespread (UNEP/MAP/MED POL 2005).

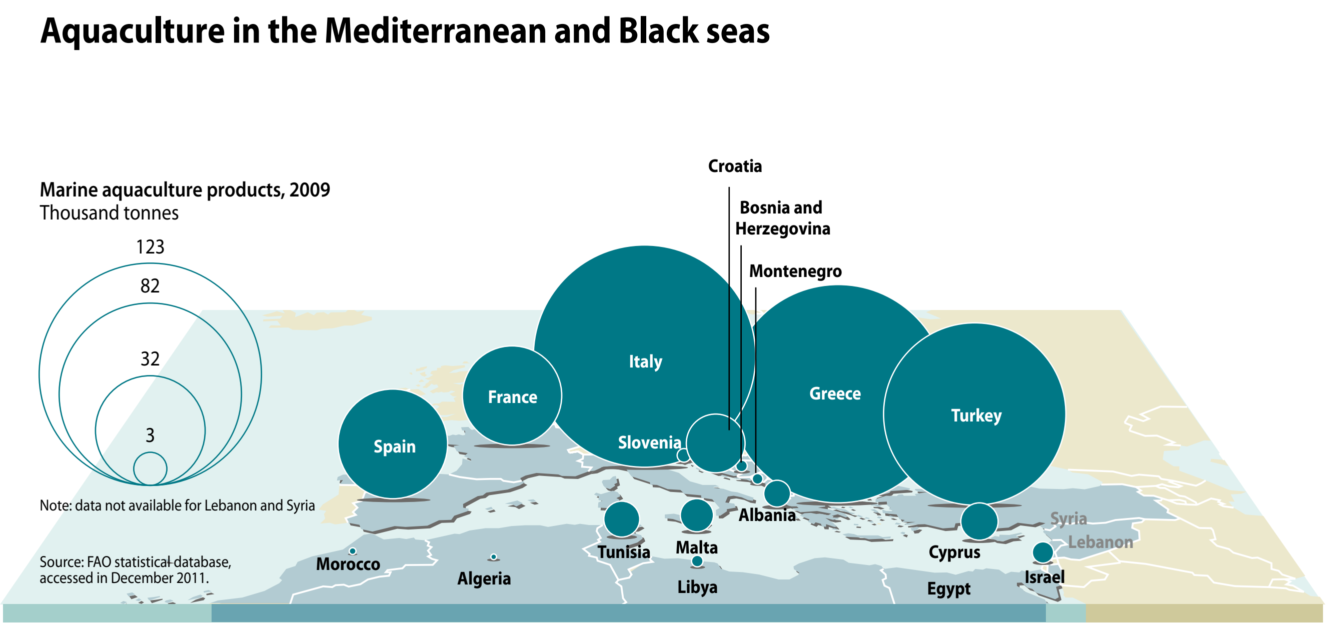
Using dynamite and poison to fish is illegal, but it is still practised in some regions (UNEP/MAP 2012). These non-selective techniques kill many non-target species and have significant negative impacts on entire ecosystems (UNEP/MAP 2012).

Artisanal fisheries, aquaculture and mariculture

The Food and Agriculture Organization defines artisanal fisheries as "traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export" (FAO/FD 2010). Ar-



Source: UNEP/MAP, State of the Environment and Development in the Mediterranean, 2009.



Source: FAO statistical database, accessed in December 2011.

tisanal fisheries continue to have a presence in the Mediterranean, although their socio-economic significance varies between countries and communities. In some regions, they represent an important source of income and food security.

Artisanal fisheries are believed to have a smaller impact on biodiversity than does industrial fishing because they tend to use lower-impact gear. Because of the wide variety of gear types and target species, however, it is difficult to determine the ecosystem effects of artisanal fisheries (UNEP/MAP 2012). At the same time, artisanal fisheries themselves can be negatively impacted by other stressors, such as pollution and the loss of important habitat.

Aquaculture is the fastest growing food sector in the world, with about one-third of global fish consumption coming from farmed fish. Although the Mediterranean region has a long history of fish farming, aquaculture and particularly mariculture have undergone a dramatic expansion since the 1990s. Decreasing wild fish stocks, combined with increasing consumer demand for fish, have spurred the growth of the industry. Of particular importance to Mediterranean aquaculture are gilthead sea bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), mussels (*Mytilus galloprovincialis*) and flat oysters (*Crassostrea gigas*). More than half of aquaculture production in the Mediterranean comes from western European countries (58 %), but Greece is a global leader in the production of gilthead sea bream (UNEP/MAP 2012).

To meet the demand for fisheries products, aquaculture in the Mediterranean has expanded from land-based and inshore operations to offshore cage farming (mariculture) (CIESM 2007). For some species, such as sea bass and sea bream, a majority of farms limit their land-based activities to hatcheries, with most of the growth taking place in sea cages.

While aquaculture offers considerable economic benefits, it can also have an impact on local biodiversity. Particular effects include: organic pollution and eutrophication from waste products and uneaten feed (in some cases leading to local hypoxia and anoxia); degradation of benthic habitats under cages, including valuable sea grass meadows; release of antibiotics and biocides; spread of benthic pathogens; and introduction of non-indigenous species (UNEP/MAP 2009 and CIESM 2007).

Grow-out facilities for tuna warrant special attention for their impact on bluefin tuna and other species. In these operations, schools of tuna are live-trapped by purse seine nets and then fattened in cages until they reach marketable size. In 2004, almost 225.000 tonnes of tuna were raised by this method in the Mediterranean (UNEP/MAP 2009). Since many of the catches are undeclared, there are no accurate figures for the size of the catch. It is estimated that in 2005, 44.000 tonnes were caught, a figure which is 37 % over the legal quota and 77 % above the quota recommended by experts (UNEP/MAP 2009). This practice increases pressures on both wild tuna populations and fish that are caught to feed the penned tuna (e.g., anchovies, mackerel, sardines). It is estimated that it takes 25 kg of fish to produce 1 kg of tuna (UNEP/MAP 2009). There are also ramifications for human populations dependent upon these food fish, most notably in West Africa.

Sea-floor Integrity

Distribution of physical damage on the sea floor

Fishing is one of the major contributors to habitat damage in the Mediterranean Sea. Most of this damage comes from trawling operations. Since fishing is most intense in the Western Mediterranean, it is not surprising that impacts on marine habitats are particularly severe there (UNEP/MAP 2012). Benthic, or sea-bottom, habitats and the communities associated with them are especially vulnerable.

In sea-bottom habitats of the open seas, deep-water coral ecosystems, the feather star (*Leptometra phalangium*), the sea pen (*Funiculina quadrangularis*), and bamboo coral (*Isidella elongata*) beds are considered most vulnerable to impacts from fishing (UNEP/MAP 2012). The location and extent of these habitats, however, are not well known. Even less is known about vulnerable deep-sea fauna that inhabit abyssal plains throughout the Mediterranean.

Impact of disturbance in key benthic habitats

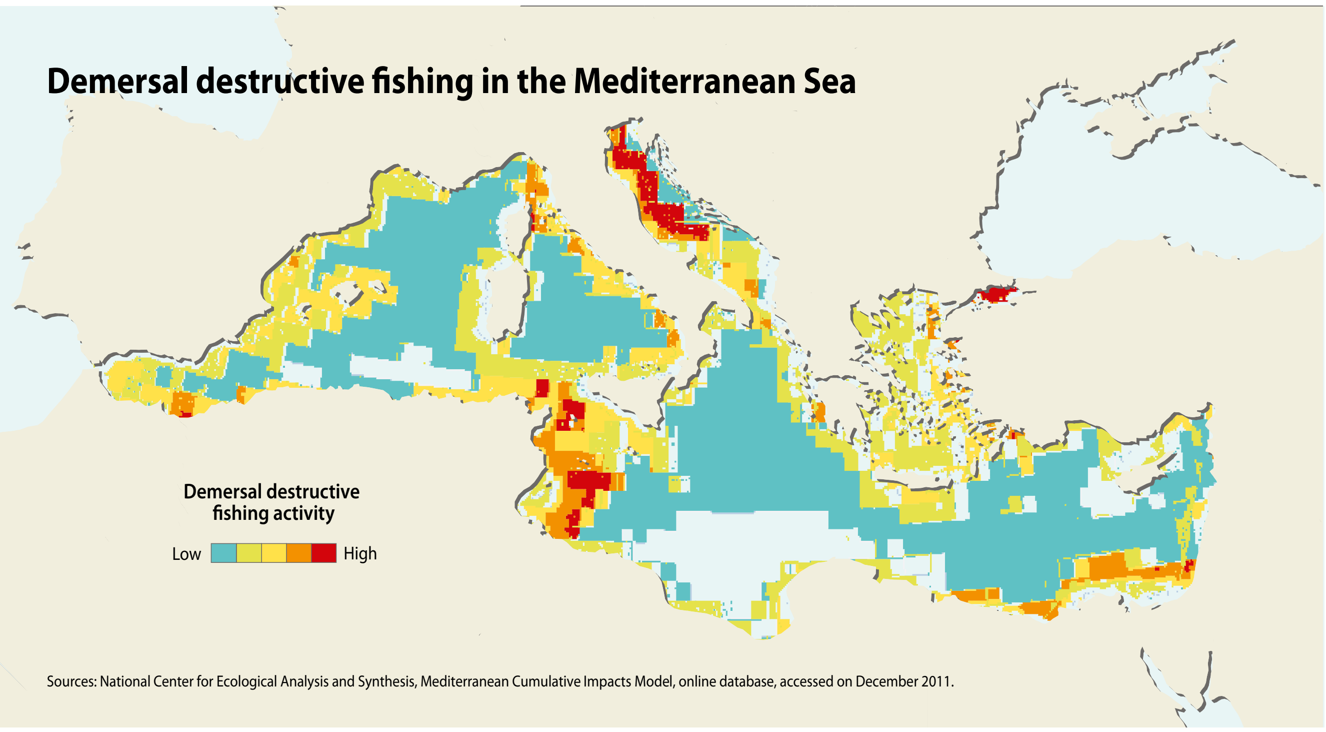
Physical damage to the sea floor can result from a number of human activities, including offshore construction, dredging, and fisheries. The impacts of offshore construction in the Mediterranean, generally drilling rigs, wind farms, and other energy facilities, have not been systematically evaluated (UNEP/MAP 2012). The construction and operation of these installations could have direct and indirect impacts on the benthic community and ecology. The behaviour and ecology of pelagic organisms could also be affected (for example, through avoiding areas with these installations) (UNEP/MAP 2012).

Trawlers, dredges, and other kinds of bottom gear used in fishing can damage the seafloor in a variety of ways. These include:

- Re-suspension, or stirring up of sediment, which impacts aquatic plants, bottom-dwelling animals and bottom-feeding fish, as well as stirring up contaminants;
- Removal of large benthic species, such as bivalves and crustaceans, some of which are important to the movement and mixing of marine sediments; and,
- Changes in the structure of benthic communities.

The physical disturbance caused by trawls can have long-lasting effects on fragile marine ecosystems. Corals and sponge communities are particularly sensitive to disturbance. Deep-water coral ecosystems, found across the western Mediterranean, have been severely impacted by trawling (UNEP/MAP 2012). Trawling is responsible for the loss of coralline red algae communities across large areas of the Mediterranean (IAR 2011). Cold-water coral reefs can be destroyed by a single trawl (Gianni 2004 in EEA 2006).

Sea grass meadows provide important spawning and nursery areas for many fish species. Sea grass meadows, however, are declining, partly as a result of trawling and partly due to the mooring of boats (UNEP/MAP/MED POL 2005). Sea grass beds that are fished regularly show lower density and biomass (UNEP/MAP/MED POL 2005).



Sources: National Center for Ecological Analysis and Synthesis, Mediterranean Cumulative Impacts Model, online database, accessed on December 2011.

Hydrographic Conditions

Human-induced alterations to the dynamics of water flows can have a profound effect on the ecology of the sea and on the delivery of ecosystem services. Although some aspects of hydrographic conditions have been well-studied in some parts of the Mediterranean, the impacts of human activities on the hydrography of the region as a whole have not been systematically assessed.

Semi-enclosed seas like the Mediterranean can become highly degraded from changes to their hydrology. Curtailing freshwater inflows to semi-enclosed seas robs them of recharging waters and nutrients. If the land around the sea is used heavily for agriculture and industry, the water reaching the basin is often of poor quality due to land-based sources of pollution (GESAMP 2001). This kind of degradation is evident in the Mediterranean Basin, especially in areas with major river drainages (Cognetti *et al.* 2000). Intensive agriculture on the limited coastal plains has come at the expense of coastal wetlands (EEA 2000), and the rate of coastal erosion is increasing due to unregulated sand mining, sprawling tourism infrastructure, urbanisation, and river damming.

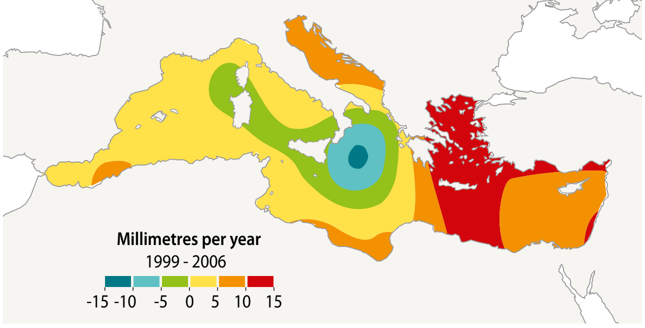
The Mediterranean's typical pattern of dry periods and flash floods affects salinity at the local scale. Salinity patterns, along with temperature, influence the direction and strength of currents, which in turn affect the ecological processes that maintain these ecosystems. Local changes to salinity, triggered by a variety of causes, are a growing phenomenon in some arid portions of the Mediterranean Basin.

Sediment delivery to the coast is a key process in the maintenance of shorelines. Damming and other freshwater diversion reduce sediment delivery and can lead to coastal erosion. Sediment delivery is directly affected by changes to water flows in river basins, but sediment fate is also influenced by nearshore conditions. For example, the construction of seawalls, groynes, or placement of offshore construction can influence whether sediment that is deposited in coastal areas and on the shoreline actually stays there.

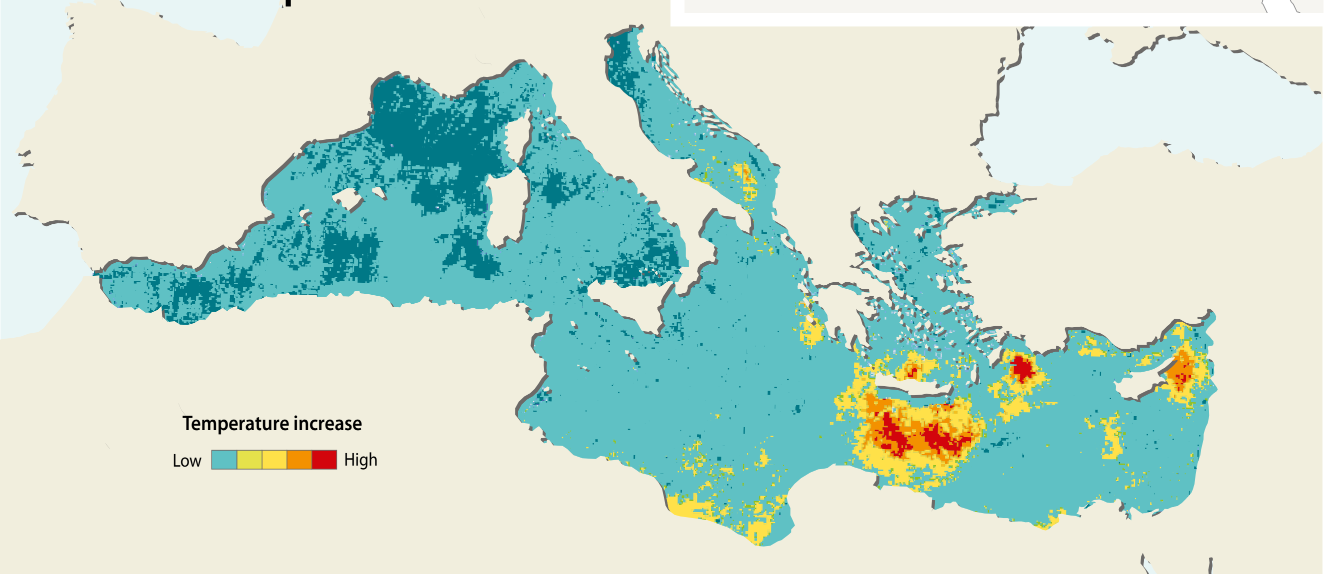
The ratio of sediment yield to annual runoff for the small mountainous rivers of the Mediterranean region is higher than the global average, yet this situation may be changing with land uses. Of the 20 Mediterranean rivers for which long-term discharge rates are known, only two (Segura and Rhone rivers) show an increase in discharge, while fourteen show a decrease of 30 % or more (Milliman and Farnsworth 2011). The result is a deepening of river channels, eroding shorelines, and eroding deltas (as in the case of the Nile, Ebro and Rhone rivers).

Climate change accelerates the rates of hydrologically-influenced degradation and can compound its impacts. According to CIESM, Western Mediterranean waters are experiencing a substantial warming trend (+0,2°C in last ten years), which could have a drastic impact on species adapted to more uniform temperatures, especially deeper water organisms accustomed to a near-constant temperature of 13°C. Sea level is rising significantly in the Eastern Mediterranean, with an average 12 cm rise registered on the Levantine coast since 1992. However, causes are not yet known, and a cause-effect relationship with climate change has not yet been established. Climate change is also expected to bring changes in both precipitation patterns and frequency of catastrophic storm events. These changes, in turn, affect coastal and offshore circulation, with effects on fisheries, biodiversity, shoreline stabilisation, sediment delivery to estuaries, land accretion, and other aspects of the ecosystem.

Sea level variations in the Mediterranean



Sea surface temperature increase



Sources: adapted from a map by National Center for Ecological Analysis and Synthesis, Mediterranean Cumulative Impacts Model, online database, accessed in December 2011.

Marine Food Webs

Ecosystem dynamics across trophic levels

Most susceptible to the negative impacts of eutrophication are semi-enclosed basins, estuaries, and lagoons, where excess nutrients are not easily dispersed (UNEP/MAP/MED POL 2005).

Red tides are a problem for some Mediterranean fisheries. Fishing and mollusc farming in the northwestern Adriatic have been damaged by blooms of the dinoflagellate, *Dinophysis* spp., which causes Diarrhoetic Shellfish Poisoning (DSP). The occurrence of this organism has been responsible for temporary and prolonged bans on the harvesting and sale of mussels in the coastal and lagoon areas of Emilia-Romagna (UNEP/MAP/MED POL 2005). *Alexandrium tamarensis*, a dinoflagellate that produces Paralytic Shellfish Poisoning (PSP) toxins has been observed in the northern Adriatic (UNEP/MAP/MED POL 2005).

The initial Integrated Assessment data suggest that eutrophication is still a localised phenomenon in the Mediterranean Basin. Better monitoring regimes and analysis of resulting data to determine trends will, in the future, allow robust statements of the effect of eutrophication on the ecology, as well as on fisheries and other valuable ecosystem services.

Proportion and abundance at different trophic levels

Overfishing is changing the distribution and abundance of a number of species in the Mediterranean. There is evidence that demersal, or bottom-dwelling stocks are becoming dominated by juveniles. Among the species affected are red mullet (*Mullus barbatus*), striped red mullet (*Mullus surmuletus*), four-spotted megrim (*Lepidorhombus boscii*) and spotted flounder (*Citharus linguatula*) (EEA and UNEP 2006).

Overfishing in the Mediterranean has also caused a collapse in red coral beds (*Corallium rubrum*), date shell (*Lithophaga lithophaga*), some sponges, such as *Hypospongia communis* and some *Spongia* species and some *Decapoda* crustaceans, such as the European lobster (*Homarus gammarus*) and the European spiny lobster (*Palinurus elephas*) (UNEP/MAP 2012). Numerous fish stocks are overexploited and experiencing declines. They include the European eel (*Anguilla anguilla*), dusky grouper (*Epinephelus marginatus*), and brown meager (*Sciaena umbra*) (UNEP/MAP 2012). Hake (*Merluccius merluccius*), mullet (*Mullus barbatus*), deep sea pink shrimp (*Parapenaeus longirostris*), sole (*Solea solea*), sardine (*Sardina pilchardus*), and anchovy (*Engraulis encrasicolus*) are also overfished in various parts of the Mediterranean (UNEP/MAP 2012).

There is a particular concern with respect to the overfishing of many big pelagic species, including the Mediterranean bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), albacore (*Thunnus alalunga*), and pelagic sharks, such as the blue shark (*Prionace glauca*) (UNEP/MAP 2012). Sharks are under particular pressure in the Mediterranean. A 2008 study of 20 shark species using records dating back to the early 19th and mid 20th century found sufficient data for only five species, and these five had all declined by more than 96 % (Ferretti *et al.* 2008). The decrease of top-level predators in the Mediterranean Sea is already altering marine food webs in many parts of the sea (Sala 2004).

Biodiversity

Species biodiversity

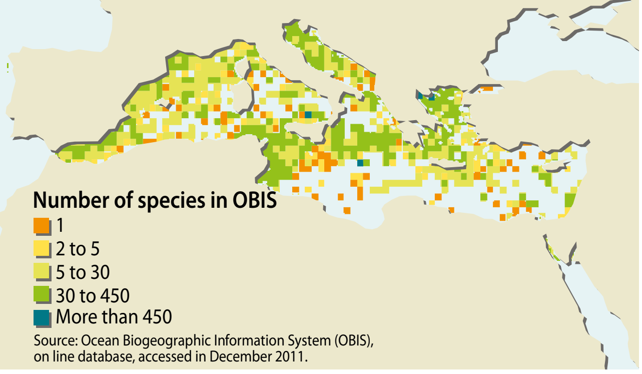
Mediterranean coastal and marine biodiversity is high by all measures. The basin supports some of the richest fauna and flora in the world and the habitat-level diversity is extraordinary. It is recognised as one the world's 25 top biodiversity hotspots, defined as areas with rich biodiversity, a large number of endemic species – species unique to the region – and critical levels of habitat loss (Meyers *et al.* 2000). There are an estimated 10.000–12.000 marine species in the Mediterranean, comprising approximately 8.500 macroscopic fauna, over 1.300 plant species, and 2.500 species from other taxonomic groups (UNEP/MAP 2012). This represents 4–18 % of the world's known marine species, depending on the taxonomic group (from 4,1 % of the bony fishes to 18,4 % of the marine mammals), in an area covering less than 1 % of the world's oceans and less than 0,3 % of its volume (UNEP/MAP 2012 and Bianchi and Morri 2000).

The level of endemism in the Mediterranean is high compared with other seas and oceans, including the Atlantic Ocean with 50 to 77 % of Mediterranean marine species being Atlantic species (found also in the Atlantic Ocean); 3 to 10 % being pan-tropical species from the world's warm seas; 5 % being Lessepsian species – species that have entered the Mediterranean from the Red Sea – while the remaining 20–30 % are endemic species: that is, species native only to the Mediterranean Sea (UNEP/MAP 2012).

The percentage of endemism is very high for sessile or sedentary groups, including ascidians (50,4 %), sponges (42,4 %), hydroids (27,1 %), and echinoderms (24,3 %). Endemism is also considerable for the other groups, such as decapod crustaceans (13,2 %) and fish (10,9 %).

Species diversity in the Mediterranean Basin tends to increase from east to west with 43 % of known species occurring in the Eastern Mediterranean, 49 % in the Adriatic, and 87 % in the Western Mediterranean (UNEP/MAP 2012). The Western Mediterranean also has more endemic species than other regions of the sea. In addition, its proximity to the Atlantic Ocean and its seasonal frontal and upwelling systems provide nutrients. The Western Basin also supports the greatest diversity of marine mammal, sea turtle and seabird life of the Mediterranean (UNEP/MAP 2012). The southeast corner of the Mediterranean, the Levant Basin, is the most biologically impoverished area. While there is an ecological basis for lower diversity in the Eastern Mediterranean, this area has also not been as well studied as other parts of the sea (UNEP/MAP 2012).

Biodiversity in the Mediterranean



Source: Ocean Biogeographic Information System (OBIS), on line database, accessed in December 2011.

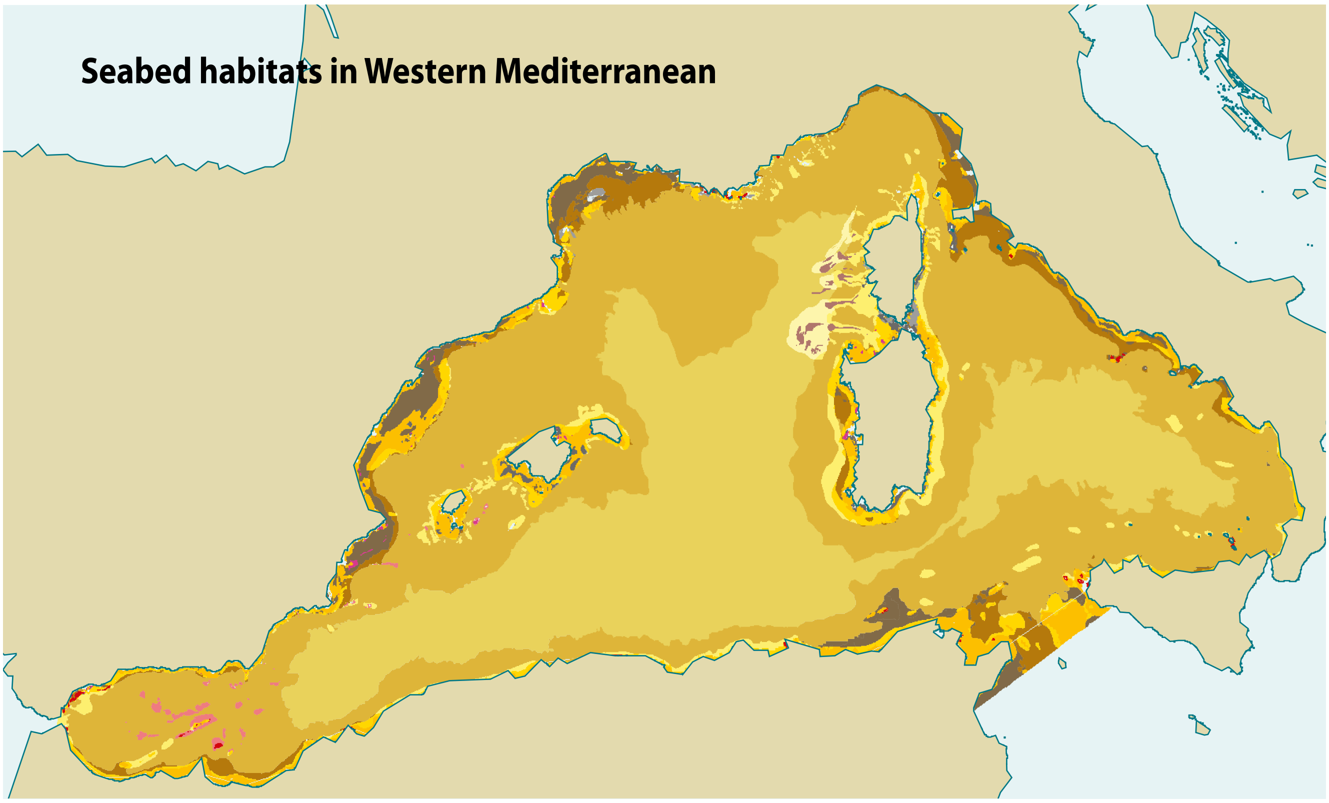
Species distribution also varies according to depth, with most flora and fauna being concentrated in shallow waters up to 50 m in depth. Although this zone accounts for only 5 % of Mediterranean waters, 90 % of the known benthic plant species are found here, as are some 75 % of the fish species (UNEP/MAP/RAC/SPA 2010). The high seas of the Mediterranean also support a great variety of marine life in areas of high productivity (gyres, upwellings and fronts) (UNEP/MAP/RAC/SPA 2010). Very little is known about the deep-sea areas of the Mediterranean.

Although the Mediterranean Basin is high in biodiversity, many of its species are threatened by a range of human activities. The loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and green (*Chelonia mydas*) marine turtles are all found in the region. While the loggerhead remains relatively abundant, it seems to have almost deserted the Western Basin. The other two species are becoming increasingly rare. Nesting sites for the herbivorous and migratory green turtle are in Cyprus, Turkey, Syria, Egypt, Lebanon and Israel. There is a total of only 2.000 nesting females at these sites, and this number is declining. Important nesting sites for the loggerhead turtle are on the coasts of Greece and Turkey, on a number of Mediterranean islands, and in Tunisia, Libya and Egypt along the North African coast. The leatherback turtle is more rare in the Mediterranean and has no permanent nesting sites, although there are some breeding records for Israel and Sicily.

Populations of the Audouin's gull (*Larus audouinii*) have reached dangerously low levels, in part because the species depends on rocky islands and archipelagos as breeding sites free from disturbance and competition with opportunistic yellow-legged gulls. Several species of birds typical of the Mediterranean climatological region are threatened in their European and, possibly, in the whole of their Mediterranean range because of the loss of suitable disturbance-free habitat. Of particular note are the endangered white pelican (*Pelecanus onocrotalus*), Dalmatian pelican (*Pelecanus crispus*), great white heron (*Egretta alba*), and slender-billed gull (*Larus genei*).

The Mediterranean is very important for migratory birds. Twice a year, some 150 migratory species cross the narrow natural passages in the regions of the Straits of Gibraltar (between Spain and Morocco), Sicily Strait (between Tunisia and Italy), Messina (Italy), Belen Pass (Turkey), the Lebanese coast, and the Suez Isthmus (Egypt), taking advantage of the wetlands occurring on their way.

Several species of marine mammals have reached dangerously low population levels. Their survival has become questionable unless immediate measures are taken for their conservation. The species for which this is most evident is the Mediterranean monk seal (*Monachus monachus*) which breeds on rocky islands and archipelagos free from human disturbance. The population of these seals in the Mediterranean is probably fewer than 300



Shallow
- Photic rock or biogenic reef
- Aphotic rock or biogenic reef
- Sands
- Muds
- Coarse or mixed sediments

Abyssal
- Sands
- Muds

Shelf
- Rock or biogenic reef
- Sands
- Muds
- Coarse or mixed sediments

Bathyal
- Sands
- Muds
- Coarse or mixed sediments

Source: adapted from the European Marine Observation and Data Network, EUSeaMap web-GIS, accessed on December 2011.

individuals. Their greatest concentration occurs along the Turkish and Greek coasts. Very small populations remain in Cyprus, Croatia and maybe Libya, with vagrants occurring in Syria, Algeria and Tunisia.

About twenty cetacean species have been reported in the Mediterranean Sea, about half of which come from Atlantic populations entering the sea only sporadically. Only nine small cetacean species and three large whale species are sighted frequently in the Mediterranean Sea. They are the minke whale (*Balaenoptera acutorostrata*), fin whale (*Balaenoptera physalus*), short-beaked common dolphin (*Delphinus delphis*), long-finned pilot whale (*Globicephala melas*), Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), sperm whale (*Physeter macrocephalus*), false killer whale (*Pseudorca crassidens*), striped dolphin (*Stenella coeruleoalba*), rough-toothed dolphin (*Steno bredanensis*), bottlenose dolphin (*Tursiops truncatus*) and Cuvier's beaked whale (*Ziphius cavirostris*). The Aegean Sea is of particular importance to the harbour porpoise (*Phocoena phocoena*), a rare species not found elsewhere in the Mediterranean region except in the Black Sea (UNEP/MAP 2012).

The Mediterranean fish fauna is diverse, but fisheries are generally declining. Of the 900 or so known fish species, approximately 100 are commercially exploited. Unsustainable catch rates of rays (including the disappearance of certain taxa from commercial catches) and other demersal species are of special concern (Tudela 2004). Fisheries impacts extend beyond elasmobranchs, finfish, or other target species. Longline fishing is a main cause of seabird mortality in the Mediterranean, while longline and other fisheries kill sea turtles incidentally (Tudela 2004). Longline fleets are a particular threat to the loggerhead turtle population, as are trawlers and small-scale gears in some areas, such as in the Gulf of Gabès. Driftnet fisheries and, to a much lesser extent, small-scale fisheries using fixed nets and purse seines, appear to account for the highest impact on the region's cetaceans. They are also responsible for the highest rates of direct human-induced mortality. The population of monk seals in the Mediterranean continues to be at risk from direct mortality by artisanal fishing crews and, to a lesser extent, by their gear.

Habitat biodiversity

The Mediterranean Basin has a wide array of habitats that include sea grass beds, intact rocky shorelines, persistent frontal systems, estuaries, underwater canyons, deepwater coral assemblages and sea mounts (UNEP/MAP 2012).

Sea grass meadows are among the most important and productive habitats in the Mediterranean, providing spawning and nursery grounds for many commercial species. Five species of sea grasses are found in the Mediterranean: *Cymodocea nodosa*, *Halophila stipulacea*, *Posidonia oceanica*, *Zostera marina* and *Zostera noltii*. The endemic *Posidonia oceanica* meadows are considered to be the most important of the sea grass ecosystems, supporting 25 % of the fish species in the Mediterranean (UNEP/MAP/RAC/SPA 2010 and UNEP/MAP 2009). *Posidonia oceanica* meadows play a central role in stabilising the seashore and in maintaining water quality, particularly through oxygen production. The stability of the seashore is maintained by these meadows. In a number of places, the disappearance of sandy beaches has followed the disappearance of sea grass meadows (Batisse and de Grissac 1995). *Posidonia oceanica* meadows are among the most important fish nursery areas in the Mediterranean. Two sea grass species (*Posidonia oceanica* and *Zostera marina*) are among species considered Endangered (see List of Endangered or Threatened Species in Annex).

The total economic value of sea grasses is estimated at over 15.000 Euros per hectare (UNEP/MAP 2009). Despite their ecological and economic value, sea grass meadows are likely declining in areal extent. This is at least in part due to trawling activities (UNEP/MAP/MED POL 2005). Endemic sea grasses in the northwest Mediterranean are also threatened by the invasion of an exotic tropical species of sea grass, *Caulerpa taxifolia*, that was accidentally released in 1984 and has now spread.

Coralligenous communities, formed by the accumulation of calcareous algae – of the order Corallinales – are the next most important biodiversity hotspot in the Mediterranean after *Posidonia* meadows (UNEP/MAP/RAC/SPA 2010). These concretions are common throughout most of the Mediterranean and are found at 40–120 m in depth (UNEP/MAP 2009). They support over 17.000 species, including many species of commercial interest. Many small sharks also inhabit these reefs. Reef communities are particularly threatened by the use of bottom gear in fisheries.

Wetlands and lagoons are also highly productive, supporting both marine and coastal (terrestrial and freshwater) organisms. They perform numerous other functions related to flood control, recreation, tourism, fisheries, and agriculture, as well as chemical and physical reduction of pollution. Wetlands and lagoons provide breeding and wintering areas for a great variety of birds and are essential stopover points on the migratory routes of numerous bird species. Nonetheless, a significant number of Mediterranean wetlands have been "reclaimed" over history. Important lagoon systems remain in Spain (Valencia), France (Languedoc and Giens), Italy (Sardinia, Tuscany, Apulia, and Venice), Central Greece, Cyprus, Morocco (Nador), Algeria, in many places in Tunisia and across the entire Nile delta in Egypt. Estuaries constitute another important and widespread habitat, as there are some 70 sizeable rivers and streams flowing into the Mediterranean. Finally, the region's rocky shores have characteristic biogenic constructions, including platforms with *Lithophyllum lichenoides* (a calcareous alga) on steep coasts and vermetid platforms (with built-up deposits of shells of the gastropod *Dendropoma*) on calcareous coasts (Batisse and de Grissac 1995).

These and other coastal ecosystems are also important for endangered species. The Mediterranean monk seal uses caves as terrestrial habitat. Endangered marine turtles use sandy beaches for nesting, sea grass meadows for feeding and sea grass meadows or muddy bottoms for wintering. Marine birds use wetlands, rocky shores or islands for nesting and resting.

High seas, areas lying outside of the territorial waters of the Mediterranean countries, comprise a large part of the Mediterranean (2,5 million km^2) (UNEP/MAP 2012). This habitat type supports a great variety of marine species. Upwellings, gyres, and fronts (areas where water masses of different temperatures meet) are distinctive features of the high seas (UNEP/MAP/RAC/SPA 2010). Upwellings, in particular, are among the most productive marine ecosystems. The high seas are especially important to marine turtles, whales, and top predators such as sharks, dolphins, and seabirds.

Particularly vulnerable species and habitats

Mediterranean species and habitats face a number of pressures from human activities, including over-exploitation; degradation of critical habitats; invasive alien species; pollution, including excess nutrients, toxic pollutants, and litter; and the use of non-selective fishery gear (e.g., drift nets and purse seine nets) (UNEP/MAP/MED POL 2005).

While there is no evidence of species loss in the Mediterranean, the status of a number of species is of concern. As of 2012, over 120 marine and freshwater species have been identified under the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Sea (see Annex). There is insufficient information to determine whether there has been a loss of genetic biodiversity.

Among the most endangered marine vertebrate species are: the Mediterranean monk seal; common bottlenose dolphin, short-beaked common dolphin, and striped dolphin; sperm whale; green turtle, leatherback turtle and loggerhead turtle; and cartilaginous fishes (sharks, rays, and chimaeras) (UNEP/MAP/MED POL 2005).

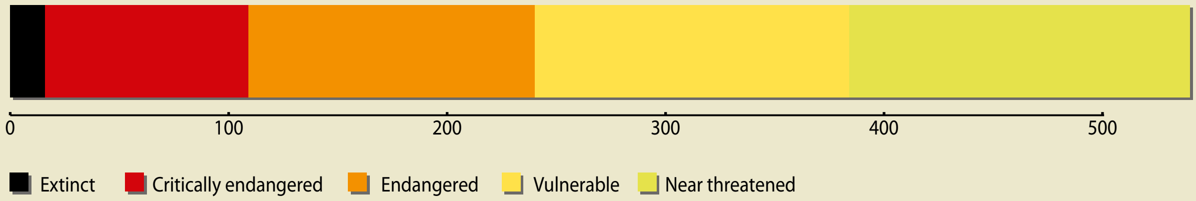
Monk seals were once present throughout the Mediterranean but are now limited mainly to the Aegean coast (UNEP/MAP 2012). Their numbers have been greatly reduced by poaching, by catch, habitat destruction, and population fragmentation (UNEP/MAP 2012). The Mediterranean monk seal is now listed as Critically Endangered on the IUCN's Red List (UNEP/MAP 2009).

Dolphins are vulnerable to reduced prey availability as a result of overfishing, habitat degradation, by catch and pollution. It has been proposed that the common bottlenose dolphin and striped dolphin be listed as Vulnerable, while the short-beaked common dolphin has been assessed as Endangered (Notabartolo di Sciara and Birkun 2010).

Sea turtles are vulnerable to human activities throughout their life cycle. Contributing to their decline in the Mediterranean are past exploitation; entanglement in fishing gear; loss of sea grass meadows which serve as feeding grounds for adult turtles; degradation of beach nesting habitat due to sand extraction, tourism, light pollution, etc.; pollution and plastic waste; and increased ship traffic. Approximately 2.500 sea turtles are caught annually as by catch by Eastern Adriatic trawl fisheries and over 4.000 are caught by Italian fisheries (UNEP/MAP 2012). Loggerhead and green turtles have been listed as Endangered by the IUCN while the leatherback turtle is listed as Critically Endangered (UNEP/MAP 2012 and Seminoff 2004).

Chondrichthyans (cartilaginous fishes) of the Mediterranean are in a particularly dire situation. Nearly 7 % of the world's sharks, rays, and chimaeras live in the Mediterranean Sea.

Number of species in IUCN Red List categories from Mediterranean countries



Source: IUCN, *The Mediterranean: a Biodiversity Hotspot Under Threat*, 2008.

Note: this includes Amphibians, Birds, Cartilaginous fishes, Crabs and Crayfish, Endemic freshwater fishes, Mammals, Dragonflies and Reptiles

Thirty-six (42 %) of the 86 species that live and breed in the Mediterranean are threatened. Of these, fourteen species are Critically Endangered, nine are Endangered, and eight are Vulnerable (Abdul Malak *et al.* 2011). This compares with approximately 20 % of cartilaginous fishes being threatened at a global level (Abdul Malak *et al.* 2011). Ten Mediterranean species are Near Threatened, while only ten are classified as of Least Concern. A further 25 species are considered Data Deficient – not enough information exists to assess their condition. Twenty-four species are protected by the Barcelona Convention through listing in Annex II of the SPA/BD Protocol (see List of Endangered or Threatened Species in Annex of this report). The greatest threat to these cartilaginous fishes is from fisheries by catch, followed by pollution, habitat loss and degradation, and human disturbance. Their vulnerability is increased by their life history characteristics. They are slow growing, late to mature, and have low fecundity and productivity and long gestation periods.

Seabirds of conservation concern nest in the Western Mediterranean. The Spanish Mediterranean, in particular, has one of the most diverse communities of breeding and migratory seabirds in Europe, including all three endemic seabird species (Yelkouan shearwater, *Puffinus yelkouan*; Balearic shearwater, *Puffinus mauretanicus*; and Audouin's gull, *Larus audouinii*) (UNEP/MAP 2012). In the Eastern Mediterranean, seabirds are threatened by habitat loss due to drainage, water diversion, changes in annual water regime, eutrophication, reed cutting, and landfills, chemical pollution, and hunting (UNEP/MAP 2012).

Benthic communities including seamount communities, volcanic vent communities, bryozoans, corals, hydroids and sponges are vulnerable to human disturbance. The mechanical disturbance of marine habitats that occurs with some activities such as trawling, dredging, dumping, and oil, gas, and mineral exploration and extraction can substantially change the structure and composition of benthic communities (Froude 1998).

As in other heavily fished areas of the world, these benthic impacts are apparent in the Mediterranean (Dayton *et al.* 1995; Thrush *et al.* 1998). Fishing practices that have deleterious effects on the seabed involve the use of bottom trawling gears, namely otter trawls, beam trawls, and dredges. Some aggressive fishing practices that affect rocky bottoms are dynamite fishing and fishing for coral and date mussels (Tudela 2004). GFCM recommendation 2005/1 on bottom trawling in the Mediterranean leaving off-limits depths greater than 1.000 m may provide significant protection for benthic marine biodiversity if it is efficiently enforced. However, trawling also affects shallow-water sea grass beds, both by stirring up sediments and by directly damaging the mass of vegetation. These fisheries are a major threat to *Posidonia* beds.

Overall, there are still considerable gaps in the knowledge of marine species and habitats in the Mediterranean, and the knowledge that does exist is patchy in distribution (UNEP/MAP 2012). The SPA & Biodiversity Protocol identifies over 100 species that are of special conservation interest in the Mediterranean. Even the information on these species and their habitats, however, is sometimes limited (UNEP/MAP 2012).

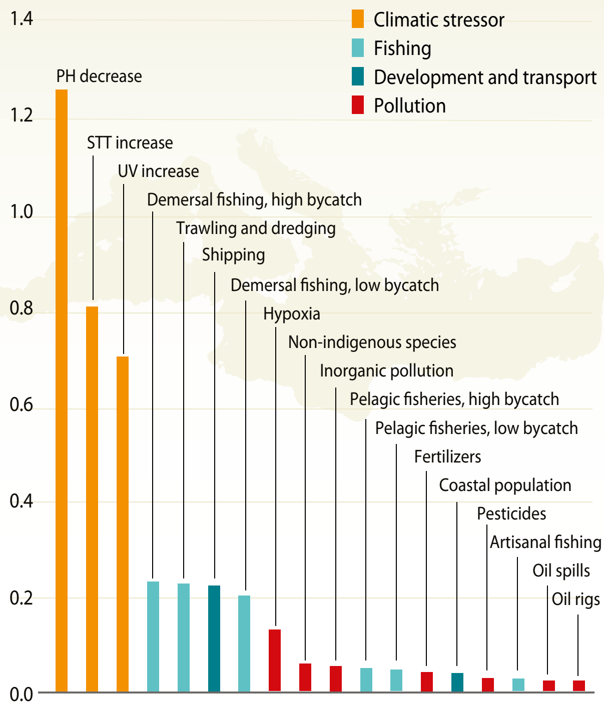
Cumulative and Concurrent Impacts

None of the factors affecting the Mediterranean Sea and its coasts, along with its inhabitants, exist in isolation. Different pressures act over time and in unison to affect the resilience of ecosystems and their ability to deliver ecosystem services. Increasing and multiple uses of ocean space increase the chances that certain threats will cause more impact when occurring simultaneously than the additive effect of individual pressures. Thus, nutrient over-enrichment can cause eutrophication more quickly when occurring in waters warmed by climate change, for example; introduced species can become more quickly invasive in ecosystems where food webs have been altered by fishing. The combined effect of nutrient over-enrichment, over-fishing of certain functional groups like grazing fishes, and climate change can act together to cause imbalances in nearshore ecosystems and loss of ecosystem services. Threats that work synergistically to cause even greater impact than individual threats acting alone should thus be monitored.

Nonetheless, understanding cumulative impacts – multiple impacts occurring through time – is notoriously difficult, especially in the absence of a monitoring regime that efficiently tracks pressures and their impacts. In the absence of such research regimes, as is the case in the Mediterranean, modelling helps us understand the impacts of multiple threats acting simultaneously.

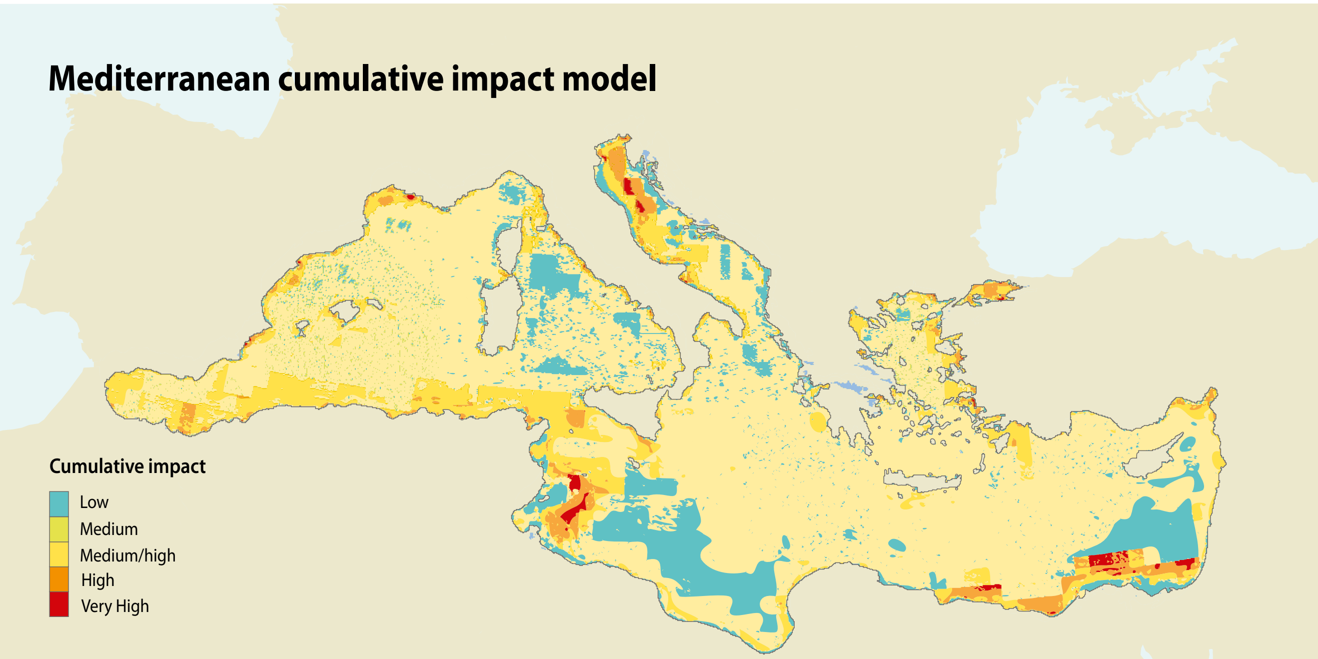
The National Center for Ecological Analysis and Synthesis (NCEAS) has undertaken modelling to perform comprehensive spatial analysis and mapping of human pressures throughout the Mediterranean Basin. This work builds on a previous global analysis of cumulative human impacts (Halpern *et al.* 2008), including additional information to better reflect the specific pressures and ecosystems of the Mediterranean Sea and coasts. A total of

Sources of environmental impact on the Mediterranean Sea



Sources: National Center for Ecological Analysis and Synthesis, Mediterranean Cumulative Impacts Model.

Mediterranean cumulative impact model



Sources: adapted from a map by National Center for Ecological Analysis and Synthesis, Mediterranean Cumulative Impacts Model, online database, accessed in December 2011.

22 spatial datasets of human activities and stressors and 19 ecosystem types were assembled and used in the analyses and maps (NCEAS 2008).

The analysis concluded that pressures that exert the greatest impacts on Mediterranean marine ecosystems are climate change, demersal fishing, ship traffic, and, in coastal areas, run-off from land and invasive non-indigenous species. The lowest estimated impacts are associated with oil spills and oil rigs, due to a combination of the limited spatial extent of these pressures and their overlap with habitats with relatively low vulnerability to these potential threats. The analysis shows distinct spatial patterns in the distribution of cumulative human impacts.

Supporting the findings of the Initial Integrated Assessment done in support to the Ecosystem Approach process, the NCEAS modelling suggests that the Adriatic and Alboran seas are the most impacted by multiple human pressures, while the Western Mediterranean and the Tunisian Plateau/Gulf of Sidra are the least. Coastal areas within the territorial waters of nations, particularly Spain, France, Italy, Tunisia and Egypt suffer the greatest cumulative impact from multiple pressures, with estimated cumulative impact scores up to ten times greater than in the high seas.

It must be noted that the modelling of cumulative impacts only suggests areas for further study. Ground-truthing is needed to see if the models accurately reflect the extent to which multiple human pressures are causing ecological impacts and potentially undermining the delivery of ecosystem services. In addition to establishing a systematic monitoring regime to derive needed information on condition and trends, future research will have to elucidate cause and effect relationships, not just correlations. The milestones recently achieved in the application of the Ecosystem Approach roadmap, namely the setting of ecological objectives and operational objectives, together with indicators, form the basis for such a rationalised approach to deriving information for all future assessments. Establishing targets, and analysing trend information to know when targets are being approached, will provide the kind of robust scientific information needed to allow management priorities to be determined and to guide effective ecosystem-based management.

PART 3

Regulatory Framework, Major Findings and Gaps and Next Steps in the Ecosystem Approach

The Mediterranean countries have for long been aware of the need to take action in order to palliate the degradation of Mediterranean marine and coastal ecosystems and have designed a multitude of sectorial or integrated policy instruments within different frameworks. In the context of the Barcelona convention, the application of the Ecosystem Approach represents a renewed emphasis on implementation and integration that will strengthen the ability to understand and address cumulative risks and effects as well as to better focus action on priority targets. Simply put, the Ecosystem Approach brings MAP's many sectorial analyses and management measures into a single integrated framework which will result in an adaptive management strategy that will be periodically monitored, evaluated and revised through six-year management cycles.

Regional and Global Governance and Regulatory Instruments

The Barcelona Convention system

The main regulatory instrument aimed at the protection of the Mediterranean marine and coastal environment is the "Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean" (Barcelona Convention) which entered into force in 2004 replacing the 1976 "Convention for the Protection of the Mediterranean Sea Against Pollution".

The Barcelona Convention's main objectives are "to prevent, abate, combat and to the fullest extent possible eliminate pollution of the Mediterranean Sea Area" and "to protect and enhance the marine environment in that Area so as to contribute towards its sustainable development." Under the Barcelona Convention, protection of the marine environment is pursued "as an integral part of the development process, meeting the needs of present and future generations in an equitable manner."

In applying the Barcelona Convention, the Contracting Parties are bound by (i) the precautionary principle, (ii) the polluter-pays principle, (iii) the commitment to undertake environmental impact assessment of activities likely to cause significant adverse impact on the marine environment, (iv) the obligation to promote cooperation amongst states in environmental impact assessment procedures related to activities with transboundary effects, and (v) the commitment to promote integrated management of the coastal zone.

Today all 21 countries surrounding the Mediterranean Sea, as well as the European Union, are Contracting Parties to the Barcelona Convention. It now has a total of seven associated Protocols:

- The Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea (Dumping Protocol, adopted 1976, in force 1978, amended 1995),
- The Protocol concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency (Emergency Protocol, adopted 1976, in force 1978), replaced by the Protocol concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (Prevention and Emergency Protocol, adopted 2002, in force 2004),
- The Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-based Sources and Activities (LBS Protocol, adopted 1980, in force 1983; amended 1996, in force 2008),
- The Protocol Concerning Mediterranean Specially Protected Areas (SPA Protocol, adopted 1982, in force 1986) replaced by The Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA & Biodiversity Protocol, adopted 1995, in force 1999),
- Protocol for the Protection of the Mediterranean Sea Against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (Offshore Protocol, adopted 1994, in force 2011),
- Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Hazardous Wastes Protocol, adopted 1996, in force 2008),
- Protocol on Integrated Coastal Zone Management (ICZM Protocol, adopted 2008, in force 2011)

Out of these seven Protocols only the 1995 amendment of the Dumping Protocol is not in force nowadays. In fact in 2011 two very important Protocols, the Offshore Protocol and the ICZM Protocol came into force. The ICZM Protocol provides for better coordination, integration and holistic management of human activities in the coastal zones where understanding and taking into account the ecosystems is essential prerequisite of sustainable development.

In order to further the progress in the implementation of the principles contained in some of the above Protocols the Barcelona Convention system has produced policy instruments such as the Strategic Action Programme to Address Pollution from Land-Based Activities (SAP/MED), the Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region (SAP/BIO), the Action Plan for the implementation of the ICZM Protocol and the Mediterranean Strategy on Sustainable Development (MSSD). The adoption of these action plans and strategies by the Contracting Parties is a clear indication of the determination of the countries to take concrete action to combat land-based pollution, contribute to maintaining and restoring marine biodiversity and promoting the sustainable development of the coastal zone.

The SAP/MED, adopted in 1997, is an action-oriented plan identifying priority target categories of substances and activities originating from land-based sources to be eliminated or controlled by the Mediterranean countries (UNEP/MAP/MED POL, 1999). The SAP/MED has associated action plans at national level. The National Action Plans (NAPs) to address land-based pollution were prepared during 2004–2005 by all Mediterranean countries through a participatory approach. They consider the environmental and socio-economic issues, policy and legislative frameworks, and the management, institutional, and technical infrastructure available in the country to formulate principles, approaches, measures, priority actions and deadlines for the implementation of SAP within the national framework. In the short-term, domestic financial resources are allocated to the actions from the annual budget; longer-term financial mechanisms are also identified, earmarked or developed, to ensure sustainability. The National Action Plans will be revised in line with the Ecosystem Approach priorities.

In addition, since 2009 and in the framework of article 15 of the LBS Protocol the Contracting Parties have also adopted six regional plans with concrete timeframes to phase out substances that are toxic, persistent and liable to accumulate. The plans are aimed to reduce BOD5 from urban waste water and the food sector; Mercury; and DDT; and to the following POP (Persistent Organic Pollutant) substances: Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Mirex, Toxaphene; Alpha hexachlorocyclohexane, Beta exachlorocyclohexane, Hexabromobiphenyl, Chlordecone and Pentachlorobenzene; Tetrabromodiphenyl ether, Pentabromodiphenyl ether, Hexabromodiphenyl ether and Heptabromodiphenyl ether; Lindane and Endosulfan; Perfluorooctane sulfonic acid, its salts and perfluorooactane sulfonyl fluoride.

The SAP/BIO adopted in 2003 establishes a measurable framework of actions for the implementation of the 1995 SPA Protocol. The SAP/BIO assesses the status of marine and coastal biodiversity, evaluates the main problems affecting biodiversity and identifies concrete remedial actions at national and regional levels (UNEP/MAP/RAC/SPA 2003). In addition, eight regional biodiversity oriented action plans have been adopted within the MAP context. Seven of these directly concern conservation for the most threatened and most emblematic species and sensitive habitats in the Mediterranean. These include the monk seal; marine turtles, especially the green turtle; cetaceans, especially the bottlenose dolphin; bird species like the Audouin's gull; cartilaginous fishes like the great white shark and the saw-shark; marine plants i.e. macrophytes and plant assemblages seen as natural monuments, like *Posidonia* barrier reefs; coralligenous and other calcareous bioconcretions, like coralline algal frameworks. The eighth, concerning introductions of species and invasive species, aims at developing coordinated measures to prevent, check and monitor the effects of such introductions. Additionally, through the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol), the Contracting Parties to the Barcelona Convention established the List of Specially Protected Areas of Mediterranean Importance (SPAMI's List) in order to promote cooperation in the management and conservation of natural areas, as well as in the protection of threatened species and their habitats. Since the 17th ordinary meeting of the Contracting Parties to the Barcelona Convention and its Protocols (2012), the SPAMI List includes 32 sites, among which one encompasses an area established also on the high sea: the Pelagos Sanctuary for marine mammals.

The Action Plan for the implementation of the ICZM Protocol, recently adopted in February 2012, relies on country-based planning and regional coordination and is aimed at supporting the implementation of the Protocol at the regional, national and local level, strengthening the capacities of the Contracting Parties to implement the Protocol and use ICZM policies, instrument, tools and processes and promote the Protocol regionally and globally. As envisaged under the ICZM Protocol, the action plan relies on the adoption of national strategies and coastal implementation plans and programmes for the implementation of the ICZM Protocol. A number of national strategies are underway or proposed and these should mutually reinforce the development of the common regional framework.

Status of ratification of Barcelona Convention and its Protocols

Convention and Protocols ratification

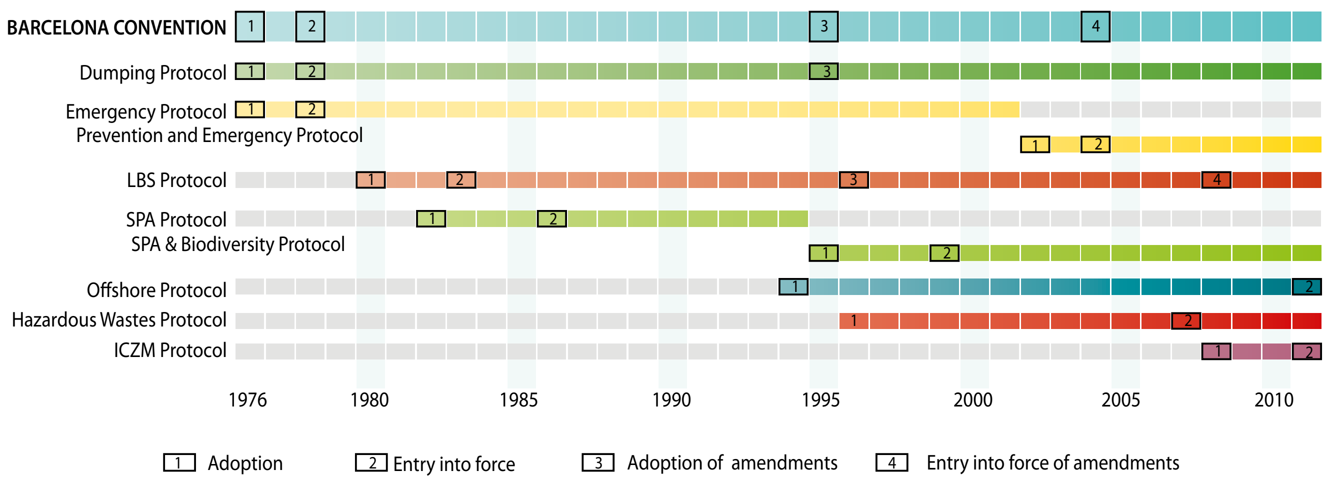
- BARCELONA CONVENTION
- Dumping Protocol
- Prevention and Emergency Protocol (former Emergency Protocol)
- LBS Protocol
- SPA & Biodiversity Protocol (former SPA Protocol)
- Offshore Protocol
- Hazardous Wastes Protocol
- ICZM Protocol

- Not ratified
- Initial protocol ratified, replacement protocol not ratified or amendments not accepted
- Initial protocol not ratified, replacement protocol ratified

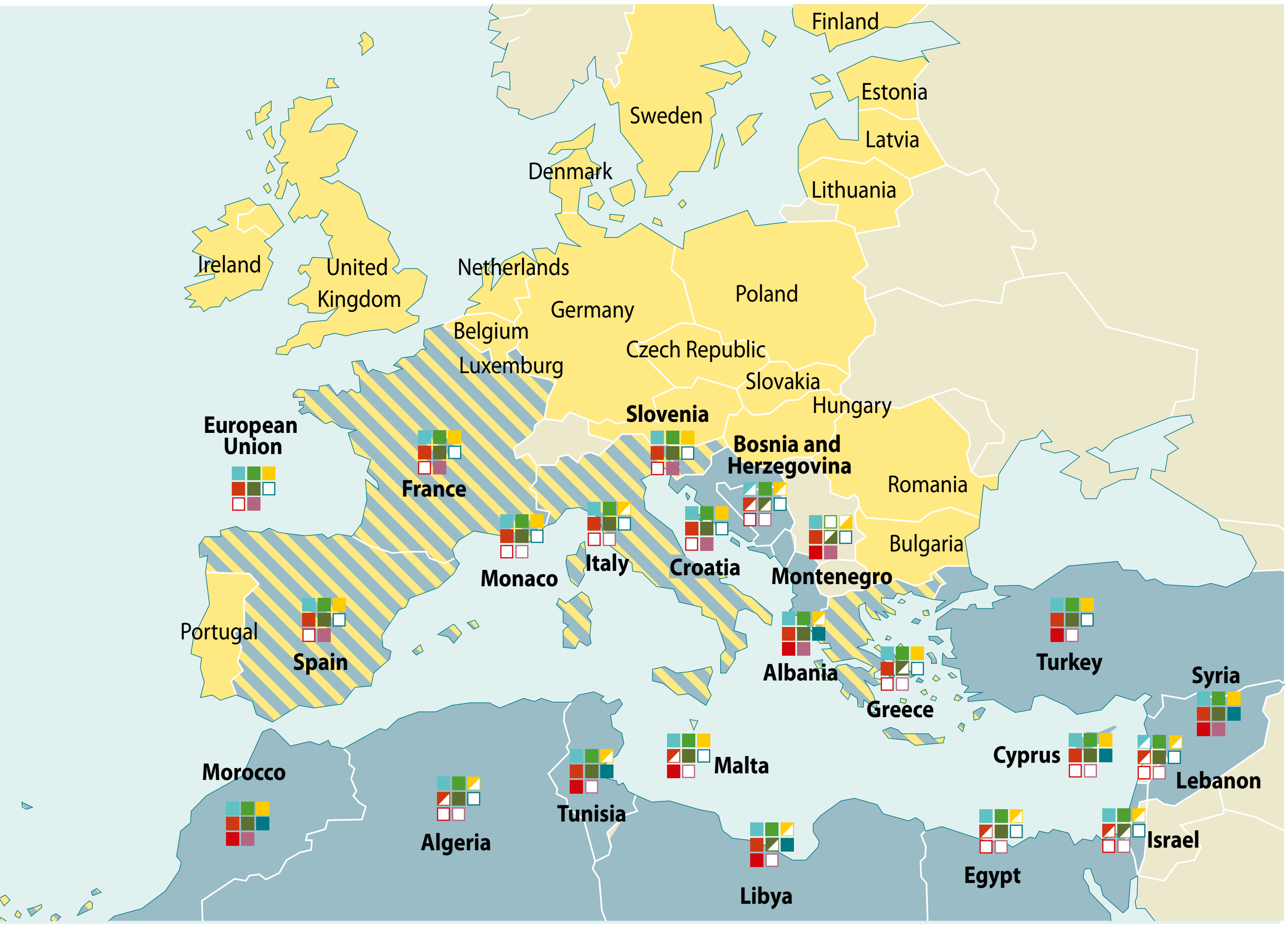
- European Union member
- Country member of the Barcelona Convention

Sources: UNEP Mediterranean Action Plan (MAP)

Timeline of Barcelona Convention and its Protocols



Source: UNEP Mediterranean Action Plan (MAP)



The Contracting Parties to the Barcelona Convention also adopted in 2005 the Mediterranean Strategy for Sustainable Development (MSSD), which results from a consultation process that mobilised most Mediterranean stakeholders including governments, the civil society through the participation of NGOs and key experts. The purposes of the Strategy are to: contribute to economic development while building on Mediterranean assets; reduce social disparities and fulfill MDGs while strengthening diversity; ensure sustainable management of natural resources and change consumption and production patterns; and improve governance at local, national and regional levels.

The MSSD is built around the following seven interdependent priority fields of action on which progress is essential for the sustainable development of the Mediterranean:

- better management of water resources and demand;
- improved rational use of energy, increased renewable energy use and mitigation of and adaptation to climate change;
- sustainable mobility through appropriate transport management;
- sustainable tourism as a leading economic sector;
- sustainable agriculture and rural development;
- sustainable urban development; and
- sustainable management of the sea, coastal areas and marine resources.

The Mediterranean Commission on Sustainable Development (MCSD) assists the Contracting Parties to convey their commitment to sustainable development and to the effective implementation, at the regional and national levels, of the decisions of the Earth Summit and the United Nations Commission for Sustainable Development. The MCSD allows synergies between the MAP system and other institutions and civil society concerning sustainable development in the region.

Two additional strategies assist the Contracting Parties in their task of implementing the Prevention and Emergency Protocol. The first one adopted in 2005, lists the priority issues to be addressed when implementing the Prevention and Emergency Protocol and include, for each of these issues, precise commitments and a timetable for the implementation of the various specific set objectives. The Regional Strategy for Prevention of and Response to Marine Pollution from Ships contains twenty-one objectives to be achieved by 2015, as well as a set of implementation goals, a timetable for its implementation, and a list of relevant international conventions and European legislation. The second one was adopted in 2012 with the objective to establish the framework for a regional harmonised approach in the Mediterranean on ships' ballast water control and management which is consistent with the requirements and standards of the2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) as outlined in its Article 13.3.

In order to use an integrated and holistic framework for the management of human activities in the Mediterranean the

Issues covered	Protocols under the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention)							Ecosystem Approach
	Dumping Protocol[1]	Prevention and Emergency Protocol[2]	LBS Protocol[3]	SPA & Biodiversity Protocol[4]	Offshore Protocol[5]	Hazardous Wastes Protocol[6]	ICZM Protocol[7]	
Coastal ecosystems and landscapes	▪	▪	▪	■	▪	▪	■	■
Pollution	■	■	■	■	■	■	■	■
Eutrophication	▪	▪	■	▪	▪	▪	■	■
Marine litter	■	▪	■	■	■	■	■	■
Marine noise	▪	▪	▪	▪	▪	▪	▪	■
Non-indigenous species	▪	▪	▪	■	▪	▪	▪	■
Commercially exploited fish and shellfish	▪	▪	■	■	▪	▪	▪	■
Seafloor integrity	▪	▪	▪	■	■	▪	■	■
Hydrographical conditions	▪	▪	▪	▪	▪	▪	■	■
Marine food webs	▪	▪	■	▪	▪	▪	▪	■
Biodiversity	▪	▪	■	■	▪	▪	■	■

1. Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea
2. Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea
3. Protocol on the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities
4. Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean
5. Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil
6. Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal
7. Protocol on Integrated Coastal Zone Management in the Mediterranean

Issues covered	Policy instruments related to the Barcelona Convention and its Protocols								
	SAP/MED[1]	Regional Plans on reduction or elimination of substances or their inputs[2]	Regional Strategy for Prevention of and Response to Marine Pollution from Ships	SAP/BIO[3]	Action Plans for endangered or threatened species and sensitive seascapes[4]	Action Plan for Invasive Species[5]	Mediterranean Strategy on Ships' Ballast Water Management	ICZM Action Plan[6]	MSSD[7]
Coastal ecosystems and landscapes	▪	▪	▪	■	■	▪	▪	■	■
Pollution	■	■	■	■	■	▪	▪	■	■
Eutrophication	■	■	■	▪	■	▪	▪	▪	■
Marine litter	■	▪	■	■	▪	▪	▪	▪	■
Marine noise	▪	▪	▪	■	▪	▪	▪	▪	▪
Non-indigenous species	▪	▪	■	■	■	■	■	▪	▪
Commercially exploited fish and shellfish	▪	▪	▪	■	■	▪	▪	▪	■
Seafloor integrity	▪	▪	▪	■	■	▪	▪	▪	▪
Hydrographical conditions	▪	▪	▪	▪	▪	▪	▪	■	▪
Marine food webs	▪	▪	▪	▪	■	■	▪	▪	▪
Biodiversity	▪	▪	▪	■	■	■	■	■	■

1. The MED POL Strategic Action Programme to Address Pollution from Land-Based Activities
2. See separate table: Regional Plans on reduction or elimination of substances or their inputs in the framework of the implementation of Article 15 of the LBS Protocol
3. The Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region
4. See separate table: Action Plans for the conservation and/or management of endangered or threatened species and sensitive seascapes
5. Action Plan Concerning Species Introductions and Invasive Species in the Mediterranean Sea
6. Action Plan for the implementation of the ICZM Protocol
7. The Mediterranean Strategy for Sustainable Development

Contracting Parties committed (Decision IG 17/6 of the 2008 Almeria meeting of the Contracting Parties) to the progressive application of the Ecosystem Approach. The Contracting Parties have since made substantive progress in implementing the roadmap that was also adopted as part of the same decision. As mentioned in the Preface the latest milestone achieved is the agreement of the Ecological Objectives for the Ecosystem Approach, which were adopted by the last Meeting of the Contracting Parties in February 2012, and to which Part II of this report is devoted.

Also in 2008 the Contracting Parties decided to put in place the Compliance Procedures and Mechanisms under the Barcelona Convention and its Protocols, which led to the establishment of the Compliance Committee. The procedures and mechanisms on compliance are a set of tools aimed to allow for the better implementation of the provisions of the Barcelona Convention and its Protocols. The role of the Committee is to provide advice and assistance to Contracting Parties to assist them comply with their obligations under the Barcelona Convention and its Protocols and to generally facilitate, promote, monitor and secure such compliance.

Ecological objectives, operational objectives and indicators

Agreed at the 17th COP meeting (UNEP/MAP, 2012)

Biodiversity

Ecological Objective	Operational Objectives	Indicators
Biological diversity is maintained or enhanced. The quality and occurrence of coastal[1] and marine habitats[2] and the distribution and abundance of coastal[3] and marine species[4] are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	Species distribution is maintained	Distributional range
		Area covered by the species (for sessile/benthic species)
	Population size of selected species is maintained	Population abundance
		Population density
	Population condition of selected species is maintained	Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates)
	Key coastal and marine habitats are not being lost	Potential / observed distributional range of certain coastal and marine habitats listed under SPA protocol
		Distributional pattern of certain coastal and marine habitats listed under SPA protocol
		Condition of the habitat-defining species and communities

1. By coastal it is understood both the emerged and submerged areas of the coastal zone as considered in the SPA/BD Protocol as well as in the definition of coastal zone in accordance with Article 2e and the geographical coverage of Article 3 of the ICZM Protocol
2. Regarding benthic habitats currently, sufficient information exists to make a prioritization amongst those mentioned in the UNEP/MAP - RAC/SPA list of 27 benthic habitats and the priority habitats in areas beyond national jurisdiction following CBD decisions VIII/24 and VIII/21 paragraph 1 . These could include from shallow to deep: biocoenosis of infralittoral algae (facies with vermetids or trottoir), hard beds associated with photophilic algae, meadows of the sea grass Posidonia oceanica, hard beds associated with Coralligenous biocenosis and semi dark caves, biocoenosis of shelf-edge detritic bottoms (facies with Leptometra phalangium), biocoenosis of deep-sea corals, cold seeps and biocoenosis of bathyal muds (facies with Isidella elongata). Amongst pelagic habitats upwelling areas, fronts and gyres need special attention and focus.
3. By coastal it is understood both the emerged and submerged areas of the coastal zone as considered in the SPA/BD Protocol as well as in the definition of coastal zone in accordance with Article 2e and the geographical coverage of Article 3 of the ICZM Protocol
4. On the basis of Annex II and III of the SPA and Biodiversity Protocol of the Barcelona Convention

Non-indigenous species

Ecological Objective	Operational Objectives	Indicators
Non-indigenous[1] species[2] introduced by human activities are at levels that do not adversely alter the ecosystem	Invasive non-indigenous species introductions are minimized	Spatial distribution, origin and population status (established vs. vagrant) of non-indigenous species
		Trends in the abundance of introduced species, notably in risk areas
	The impact of non-indigenous particularly invasive species on ecosystems is limited	Ecosystem impacts of particularly invasive species
		Ratio between non-indigenous invasive species and native species in some well studied taxonomic groups

1. The term non-indigenous refers to an organism that may survive and subsequently reproduce, outside of its known or consensual range. Non-indigenous may be further characterized as un-established or vagrant, established, invasive and noxious or particularly invasive. Occhipinti-Ambrogi and Galil (2004). Marine Pollution Bulletin 49 (2004) 688–694. doi:10.1016/j.marpolbul.2004.08.011
2. The list of priority (indicator) species introduced by human activities will be derived by consensus, based on information from the CIESM Atlas of Exotic Species in the Mediterranean and the DAISIE project (European Invasive Alien Species Gateway) a database tracking alien terrestrial and marine species in Europe

Harvest of commercially exploited fish and shellfish

Ecological Objective	Operational Objectives	Indicators
Populations of selected commercially exploited fish and shellfish[1] are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock	Level of exploitation by commercial fisheries is within biologically safe limits	Total catch by operational unit[2]
		Total effort by operational unit
		Catch per unit effort (CPUE) by operational unit
		Ratio between catch and biomass index (hereinafter catch/biomass ratio).
		Fishing mortality
	The reproductive capacity of stocks is maintained	Age structure determination (where feasible)
		Spawning Stock Biomass (SSB)

1. The choice of indicator species for collecting information for Ecological Objective 3 should be derived from fisheries targeting species listed in Annex III of Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (species whose exploitation is regulated) and the species in the GFCM Priority Species list (http://www.gfcm.org/gfcm/topic/166221/en). Choice of indicators should cover all trophic levels, and if possible, functional groups, using the species listed in Annex III of SPA and/or, as appropriate the stocks covered under regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy
2. Operational unit is "the group of fishing vessels which are engaged in the same type of fishing operation within the same Geographical Sub-Area, targeting the same species or group of species and belonging to the same economic segment"

Marine food webs

Ecological Objective	Operational Objectives	Indicators
Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability	Ecosystem dynamics across all trophic levels are maintained at levels capable of ensuring long-term abundance of the species and the retention of their full reproductive capacity	Production per unit biomass estimates for selected trophic groups and key species, for use in models predicting energy flows in food webs
	Normal proportion and abundances of selected species at all trophic levels of the food web are maintained	Proportion of top predators by weight in the food webs
		Trends in proportion or abundance of habitat-defining groups
		Trends in proportion or abundance of taxa with fast turnover rates

Eutrophication

Ecological Objective	Operational Objectives	Indicators
Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.	Human introduction of nutrients in the marine environment is not conducive to eutrophication	Concentration of key nutrients in the water column
		Nutrient ratios (silica, nitrogen and phosphorus), where appropriate
	Direct effects of nutrient over-enrichment are prevented	Chlorophyll-a concentration in the water column
		Water transparency where relevant
		Number and location of major events of nuisance/toxic algal blooms caused by human activities[1]
	Indirect effects of nutrient over-enrichment are prevented	Dissolved oxygen near the bottom, i.e. changes due to increased organic matter decomposition, and size of the area concerned[2]

1. The connection between eutrophication and toxic algal blooms is subject of devoted research at the moment. The connection between the two is not clearly established as not all the ecosystems react in the same way. In fact recent surveys in UK/Ireland in the framework of OSPAR have allowed concluding on the lack of relation between the them and therefore the number and location of major events of nuisance/toxic algal blooms should always be regarded cautiously as an indicator of a direct effect of nutrient over-enrichment.
2. Monitoring to be carried out where appropriate

Sea-floor integrity

Ecological Objective	Operational Objectives	Indicators
Sea-floor integrity is maintained, especially in priority benthic habitats[1]	Extent of physical alteration to the substrate is minimized	Distribution of bottom impacting activities[2]
		Area of the substrate affected by physical alteration due to the different activities[2]
	Impact of benthic disturbance in priority benthic habitats is minimized	Impact of bottom impacting activities[2] in priority benthic habitats
		Change in distribution and abundance of indicator species in priority habitats[3]

1. E.g. coastal lagoons and marshes, intertidal areas, seagrass meadows, coralligenous communities, sea mounts, submarine canyons and slopes, deep-water coral and hydrothermal vents
2. E.g bottom fishing, dredging activities ,sediment disposal, seabed mining, drilling, marine installations, dumping and anchoring, land reclamation, sand and gravel extraction
3. Indicator species to be used to assess the ecosystem effects of physical damage to the benthos could refer to disturbance-sensitive and/or disturbance-tolerant species, as appropriate to the circumstances, in line with methodologies developed to assess the magnitude and duration of ecological effects of benthic disturbance

Hydrography

Ecological Objective	Operational Objectives	Indicators
Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	Impacts to the marine and coastal ecosystem induced by climate variability and/or climate change are minimized	Large scale changes in circulation patterns, temperature, pH, and salinity distribution
		Long term changes in sea level
	Alterations due to permanent constructions on the coast and watersheds, marine installations and seafloor anchored structures are minimized	Impact on the circulation caused by the presence of structures
		Location and extent of the habitats impacted directly by the alterations and/or the circulation changes induced by them: footprints of impacting structures
		Trends in sediment delivery, especially in major deltaic systems
		Extent of area affected by coastal erosion due to sediment supply alterations
	Impacts of alterations due to changes in freshwater flow from watersheds, seawater inundation and coastal freatic intrusion, brine input from desalination plants and seawater intake and outlet are minimized	Trends in fresh water/sea water volume delivered to salt marshes, lagoons, estuaries, and deltas; desalination brines in the coastal zone
		Location and extent of the habitats impacted by changes in the circulation and the salinity induced by the alterations
		Changes in key species distribution due to the effects of seawater intake and outlet

Coastal ecosystems and landscapes

Ecological Objective	Operational Objectives	Indicators
The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved	The natural dynamic nature of coastlines is respected and coastal areas are in good condition	Areal extent of coastal erosion and coastline instability
		Changes in sediment dynamics along the coastline
		Areal extent of sandy areas subject to physical disturbance[1]
		Length of coastline subject to physical disturbance due to the influence of manmade structures
	Integrity and diversity of coastal ecosystems, landscapes and their geomorphology are preserved	Change of land-use[2]
		Change of landscape types
		Share of non-fragmented coastal habitats

1. Physical disturbance includes beach cleaning by mechanical means, sand mining, beach sand noursihment
2. Land-use classess according to the classification by Eurostat-OCDE, 1998: http://unstats.un.org/unsd/environment/q2004land.pdf

Pollution

Ecological Objective	Operational Objectives	Indicators
Contaminants cause no significant impact on coastal and marine ecosystems and human health	Concentration of priority[1] contaminants is kept within acceptable limits and does not increase	Concentration of key harmful contaminants in biota, sediment or water
	Effects of released contaminants are minimized	Level of pollution effects of key contaminants where a cause and effect relationship has been established
	Acute pollution events are prevented and their impacts are minimized	Occurrence, origin (where possible), extent of significant acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution
	Levels of known harmful contaminants in major types of seafood do not exceed established standards	Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood[2]
		Frequency that regulatory levels of contaminants are exceeded
	Water quality in bathing waters and other recreational areas does not undermine human health	Percentage of intestinal enterococci concentration measurements within established standards
		Occurrence of Harmful Algal Blooms within bathing and recreational areas

1. Priority contaminants as listed under the Barcelona Convention and LBS Protocol
2. Traceability of the origin of seafood sampled should be ensured

Marine litter

Ecological Objective	Operational Objectives	Indicators
Marine and coastal litter do not adversely affect coastal and marine environment[1]	The impacts related to properties and quantities of marine litter in the marine and coastal environment are minimized	Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source
		rends in amounts of litter in the water column, including microplastics, and on the seafloor
	Impacts of litter on marine life are controlled to the maximum extent practicable	Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles[2]

1. A policy document on marine litter strategy, taking fully into account the activities envisaged for the implementation of the EA roadmap, is being prepared by MEDPOL and will be submitted to the MAP Focal Point for approval. The approved document will be used as the basis for the formulation of an action plan for the reduction of marine litter
2. Marine mammals, marine birds and turtles included in the regional action plans of the SPA/BD Protocol

Energy including underwater noise

Ecological Objective	Operational Objectives	Indicators
Noise from human activities causes no significant impact on marine and coastal ecosystems	Energy inputs into the marine environment, especially noise from human activities is minimized	Proportion of days and geographical distribution where loud, low and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals
		Trends in continuous low frequency sounds with the use of models as appropriate

Other regional and global instruments and processes

Additional regulatory instruments, processes and commissions complementary to the Barcelona Convention system, have been put in place by international unions or bodies in order to address environmental and natural resource issues affecting the Mediterranean Sea.

Since 1949, the General Fisheries Commission of the Mediterranean (GFCM) has been promoting the development, conservation, rational management, and best utilisation of living marine resources, as well as the sustainable development of aquaculture in the Mediterranean, Black Sea, and connecting waters. Of the 21 Mediterranean coastal states, 20 are now members of the GFCM. Another international regulatory body that issues policies relevant for the Mediterranean area is the International Commission for the Conservation of Atlantic Tunas (ICCAT), which issues recommendations aiming at ensuring the maximum sustainable catch. The Secretariat of UNEP/MAP Barcelona Convention and the GFCM signed an MoU in May 2012, to further their shared goals and objectives in relation to the conservation of marine environment and ecosystems and the sustainable use of marine living and other natural resources in their fields of competence.

Several international conventions and agreements are relevant for the environment and management of the Mediterranean Sea. At the global level the most important one is the United Nations Convention of the Law of the Sea covering many aspects of the marine environment. Many other conventions are also relevant including those dealing specifically with marine pollution (i.e. MARPOL 73/78, London Convention), chemical pollution (i.e. Stockholm, Basel and Rotterdam Conventions) and biodiversity (i.e. Convention on Biological Diversity, Ballast Water Convention, Bonn and RAMSAR Conventions). At the regional level under the Bonn Convention, and developed with the cooperation of the Secretariats of the Barcelona Convention and the Bern Convention, ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area) is a cooperative tool to reduce threats to cetaceans in Mediterranean and Black Sea waters and improve the knowledge of these animals.

Further at the European level European Union Member States that are Contracting Parties to the Barcelona Convention are also bound by the different policy instruments issued by the European Commission like the Integrated Maritime Policy, the Marine Strategy Framework Directive (which also uses the Ecosystem Approach framework and stretches its application across the whole marine environment), the Common Fisheries Policy, the

	Regional Plans on reduction or elimination of substances or their inputs in the framework of the implementation of Article 15 of the LBS Protocol					
			Regional Plan on POPs[3]			
Issues covered	Regional Plan on Mercury[1]	Regional Plan on BOD_5[2]	Regional Plan on Polybrominated diphenyl ethers (PBDEs)[4]	Regional Plan on Lindane and Endosulfan[5]	Regional Plan on Perfluorooctane sulfonic acid (PFOS), its salts and Perfluorooctane sulfonyl fluoride (PFOSF)[6]	Regional Plan on Alpha-HCH, Beta-HCH, Chlordecone, Hexabromobiphenyl, Pentachlorobenzene[7]
Coastal ecosystems and landscapes	·	·	·	·	·	·
Pollution	■	■	■	■	■	■
Eutrophication	·	■	·	·	·	·
Marine litter	·	·	·	·	·	·
Marine noise	·	·	·	·	·	·
Non-indigenous species	·	·	·	·	·	·
Commercially exploited fish and shellfish	■	■	·	·	·	·
Seafloor integrity	·	·	·	·	·	·
Hydrographical conditions	·	·	·	·	·	·
Marine food webs	■	·	·	·	·	·
Biodiversity	·	·	·	·	·	·

1. Regional Plan on the reduction of inputs of Mercury in the framework of the implementation of Article 15 of the LBS Protocol
2. Regional Plan on the reduction of BOD5 in the food sector in the framework of the implementation of Article 15 of the LBS Protocol
3. Regional Plan on the elimination in the framework of the implementation of Article 15 of the LBS Protocol, 1996 of Alpha hexachlorocyclohexane; Beta hexachlorocyclohexane; Hexabromobiphenyl; Chlordecone; Pentachlorobenzene; Tetrabromodiphenyl ether and Pentabromodiphenyl ether; Hexabromodiphenyl ether and Heptabromodiphenyl ether; Lindane; Endosulfan, Perfluorooctane sulfonic acid, its salts and perfluorooactane sulfonyl fluoride
4. Regional Plan on the phasing out of Hexabromodiphenyl ether, Heptabromodiphenyl ether, Tetrabromodiphenyl ether and Pentabromodiphenil ether in the framework of the implementation of Article 15 of the LBS Protocol
5. Regional Plan on the phasing out of Lindane and Endosulfan in the framework of the implementation of Article 15 of the LBS Protocol
6. Regional Plan on the phasing out of Perfluorooctane sulfonic acid, its Salts and Perfluorooctane sulfonyl fluoride in the framework of the implementation of Article 15 of the LBS Protocol
7. Regional Plan on the elimination of Alpha hexachlorocyclohexane, Beta hexachlorocyclohexane, Chlordecone, Hexabromobiphenyl, Pentachlorobenzene in the framework of the implementation of Article 15 of the LBS Protocol

Water Directive (with implications for coastal waters and land-based pollution) and the ICZM Recommendation.

Besides the directives and recommendations issued by the European Commission the Council of Europe has also fostered the development of The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) dealing with biodiversity preservation and the European Landscape Convention which has implications for the management of the coastal zone.

	Action Plans for the conservation and/or management of endangered or threatened species[1] and sensitive seascapes						
Issues covered	Action Plan for the Monk Seal[2]	Action Plan for Marine Turtles[3]	Action Plan for Cetaceans[4]	Action Plan for Marine Vegetation[5]	Action Plan for Bird Species[6]	Action Plan for Cartilaginous Fishes[7]	Action Plan for Coralligenous and other Calcareous Bio-Concretions[8]
Coastal ecosystems and landscapes	■	■	·	■	■	·	·
Pollution	·	·	■	■	■	■	■
Eutrophication	·	·	·	·	·	·	■
Marine litter	·	·	·	·	·	·	·
Marine noise	·	·	·	·	·	·	·
Non-indigenous species	·	·	·	■	■	·	■
Commercially exploited fish and shellfish	·	·	·	·	·	■	·
Seafloor integrity	·	·	·	■	·	·	■
Hydrographical conditions	·	·	·	·	·	·	·
Marine food webs	·	·	·	·	·	■	·
Biodiversity	■	■	■	■	■	■	■

1. Including, but not limited to, the species listed as endangered or threatened in Annex II of the Protocol Concerning Specially Protected Areas (SPAs) and Biological Diversity in the Mediterranean
2. Action Plan for the Management of the Mediterranean Monk Seal (*Monachus monachus*)
3. Action Plan for the Conservation of Mediterranean Marine Turtles
4. Action Plan for the Conservation of Cetaceans in the Mediterranean Sea
5. Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea
6. Action Plan for the Conservation of Bird Species Listed in Annex II of the Protocol Concerning Specially Protected Areas (SPAs) and Biological Diversity in the Mediterranean
7. Action Plan for the Conservation of Cartilaginous Fishes (*Chondricthyans*) in the Mediterranean Sea
8. Action Plan for the Conservation of the Coralligenous and other Calcareous Bio-Concretions in the Mediterranean Sea

	Other Regional agreements		
Issues covered	ACCOBAMS[1]	Bern Convention[2]	European Landscape Convention
Coastal ecosystems and landscapes	·	·	■
Pollution	·	·	·
Eutrophication	·	·	·
Marine litter	■	·	·
Marine noise	■	·	·
Non-indigenous species	·	·	·
Commercially exploited fish and shellfish	·	·	·
Seafloor integrity	·	·	·
Hydrographical conditions	·	·	·
Marine food webs	■	·	·
Biodiversity	■	■	·

1. Special Agreement for the Conservation of Small Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic area (under the Bonn Convention)
2. The Convention on the Conservation of European Wildlife and Natural Habitats

	Regional and international regulatory bodies	
Issues covered	GFCM[1]	ICCAT[2]
Coastal ecosystems and landscapes	·	·
Pollution	·	·
Eutrophication	·	·
Marine litter	·	·
Marine noise	·	·
Non-indigenous species	·	·
Commercially exploited fish and shellfish	■	■
Seafloor integrity	■	·
Hydrographical conditions	·	·
Marine food webs	■	■
Biodiversity	■	■

1. FAO General Fisheries Commission for the Mediterranean
2. International Commission for the Conservation of Atlantic Tunas

Issues covered	International (global) conventions and agreements (MEAs)										
	UNCLOS[1]	MARPOL 73/78[2]	London Convention[3]	BWM Convention[4]	Intervention Convention[5]	OPRC Convention[6]	AFS Convention[7]	FAO Code: Pesticides[8]	Stockholm Convention[9]	Basel Convention[10]	Rotterdam Convention[11]
Coastal ecosystems and landscapes	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Pollution	■	■	■	▪	■	■	■	■	■	■	■
Eutrophication	■	■	▪	▪	▪	▪	▪	▪	▪	▪	▪
Marine litter	■	■	■	▪	▪	▪	▪	▪	▪	▪	▪
Marine noise	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Non-indigenous species	■	▪	▪	■	▪	▪	■	▪	▪	▪	▪
Commercially exploited fish and shellfish	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Seafloor integrity	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Hydrographical conditions	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Marine food webs	■	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Biodiversity	■	▪	▪	■	▪	▪	▪	▪	▪	▪	▪

1. United Nations Convention on the Law of the Sea
2. International Convention for the Prevention of Pollution from Ships
3. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
4. International Convention for the Control and Management of Ships Ballast Water & Sediments
5. International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties
6. International Convention on Oil Pollution Preparedness, Response and Co-operation
7. International Convention on the Control of Harmful Anti-fouling Systems on Ships
8. International Code of Conduct on the Distribution and Use of Pesticides (FAO)
9. Stockholm Convention on Persistent Organic Pollutants (POPs)
10. The Basel Convention on transboundary movements of hazardous wastes
11. The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

Issues covered	International (global) conventions and agreements (MEAs) (continued)				
	CBD[1]	CITES[2]	RAMSAR Convention[3]	Bonn Convention[4]	FAO Code: Fisheries[5]
Coastal ecosystems and landscapes	■	▪	■	▪	▪
Pollution	▪	▪	▪	▪	▪
Eutrophication	▪	▪	▪	▪	▪
Marine litter	▪	▪	▪	▪	▪
Marine noise	▪	▪	▪	▪	▪
Non-indigenous species	▪	▪	▪	▪	▪
Commercially exploited fish and shellfish	▪	▪	▪	▪	■
Seafloor integrity	▪	▪	▪	▪	▪
Hydrographical conditions	▪	▪	▪	▪	▪
Marine food webs	■	▪	▪	▪	■
Biodiversity	■	■	■	■	■

1. Global Convention on the Protection of Biological Diversity
2. Convention on International Trade in Endangered Species of Wild Fauna and Flora
3. RAMSAR Convention on Wetlands of International Importance
4. The Convention on the Conservation of Migratory Species of Wild Animals
5. FAO Code of Conduct for Responsible Fisheries

Major Findings on the Pressures and State of the Mediterranean Sea Environment

The analysis presented here, based mostly on the information contained in the Initial Integrated Assessment (UNEP/MAP 2012) and complemented with further up-to-date information from peer reviewed publications and reports, allows to summarise on the pressures, state and known impacts of each of the major issues identified as follows:

- Coastal development and sprawl, driven by urban and touristic development, leading to fragmentation, degradation and loss of habitats and landscapes, including the destabilisation and erosion of the shoreline. Special attention should be paid to the degradation of transitional areas, including deltas, estuaries and coastal lagoons, which serve as critical nursery areas for commercial fisheries and support unique assemblages of species but also to the broader coastal zone.

- Chemical contamination of sediments and biota caused by pollution from urbanisation, industry, anti-foulants and atmospheric transport. Although environmental conditions are improving in regard to certain pollutants in many Mediterranean areas, thanks to improved control of land based pollution releases, contamination linked to hazardous substances remains a problem in many areas.

- Eutrophication caused by human-mediated input of nutrients into marine waters is a source of concern, especially in coastal areas near large rivers and/or cities. Impacts of eutrophication include algal blooms, some of them harmful and hypoxia. The direct socioeconomic impacts are related to toxicity or mortality of harvested fish and shellfish, loss of aesthetic value of coastal ecosystems, and reduced water quality impacting tourism.

- The impact of marine litter, concentrated especially in bays and shallow areas, is increasingly regarded as a matter of concern across the Mediterranean.

- The impact of marine noise on biota, especially marine mammals and fish, requires targeted research. Intense maritime traffic, particularly in the Western Mediterranean, and intense offshore exploration and military activities in specific locations, suggest potentially serious impacts.

- Invasive non-indigenous species have increased in recent years, particularly in the easternmost reaches of the Mediterranean. Documented impacts on natural diversity include predation, alteration of the food chain, niche competition and modification of habitats, leading to a variety of impacts on fishing, aquaculture, shipping, human health and tourism.

- Over-exploitation beyond sustainable limits affects many of the commercially exploited fish stocks of the Mediterranean. The result is changes in species diversity, with some species regarded as Endangered, Vulnerable or Near-Threatened. Over-exploitation also leads to changes in community structure, the food web and, ultimately, ecological processes and the delivery of ecosystem services. Other pressures brought by the intense fishing activity in the Mediterranean include by catch, non-selective fishing methods and destructive fishing. Understanding how multiple pressures reduce sustainable limits of harvest is necessary for effective fisheries management, which is crucial in a part of the world where seafood is both culturally and economically vital. While touted as a means of reducing pressure on wild stocks, aquaculture production, which has increased noticeably since the 1990s, adds new pressures. These include organic pollution leading to eutrophication and eventual benthic anoxia, inorganic pollution through the release of antibiotics and biocides, and the introduction of non-indigenous species.

- Seafloor integrity is affected mainly by bottom fishing, but also by dredging and offshore installations. Bottom-fishing pressure is highest on the western margin of the Adriatic Sea and in the westernmost part of the Ionian Sea. Bottom fishing and dredging lead to the resuspension of sediment and organisms and to changes in the structure of benthic communities. The impact of offshore installations is not well researched.

- Changed hydrographic conditions caused by local disruption of circulation patterns by human-made structures, changes in freshwater fluxes to the sea, brine release from desalination plants, or climate change influence both nearshore and offshore areas. Changes in freshwater flows also affect sediment delivery to the coastal zone near river mouths, with impacts on coastline stability and key systems, such as dune-beach complexes.

- Marine food webs have been affected by fisheries pressures that led to the estimated reduction on average of one trophic level in the fisheries catches during the last half-century, increased jellyfish numbers and reduced abundance of large predator species.

- Finally the state of biodiversity reflects the cumulative effects of the pressures affecting the Mediterranean coastal and marine environment. Although there is still high diversity in the Mediterranean, some species of reptiles, marine mammals, birds, and fish are reaching dangerously low abundance levels. The Mediterranean also hosts a diverse array of habitats of commercial, ecological and cultural importance. Many are under a variety of pressures. Complicating the issue, many offshore areas, where upwellings develop and seamounts provide important habitat, are located beyond national jurisdiction.

Gap Analysis

Currently, there is a general lack of information about some pressures, as well as insufficient consistently collected data to establish trends. Where quantification is possible, it remains challenging to link ecological impacts to particular stressors or pressures. However, monitoring undertaken to meet the obligations of the Barcelona Convention and its Protocols has provided a starting point for developing a systematic monitoring regime that will provide the needed information in the future.

There are also critical gaps in the information available on the ecology and environmental status of offshore areas, especially areas beyond national jurisdiction (ABNJ). These areas are significant, and little or no monitoring and surveillance currently takes place there. Therefore, expanding research to include offshore pelagic environments and the deep sea is recommended. The Barcelona Convention provides a useful framework for cooperation in this regard and some work has already been undertaken as witnessed by the establishment of a SPAMI in the Areas Beyond National Jurisdiction (ABNJ), the Pelagos Sanctuary or the work carried out regarding identification of Ecologically or Biologically Significant Areas (EBSAs) in the Mediterranean, which was acknowledged at the last meeting of Contracting Parties (2012). Inclusion of offshore considerations will ensure that future management is more ecosystem-based.

Overall, the rich marine biodiversity of the Mediterranean Sea remains relatively little-known, despite increasing research efforts by the international scientific community. Knowledge of marine and coastal biodiversity is not homogeneous throughout the Mediterranean and has many gaps. Even information on the Specially Protected Areas and Biodiversity Protocol species and habitats, which are of conservation interest in the Mediterranean, is sometimes limited.

There are also gaps in understanding of the impacts of human activity on marine and coastal biodiversity. The gaps exist at several levels: scientific knowledge, availability of legal tools, enforcement of existing laws, public awareness, concrete action and operative plan implementation.

Finally, mapping available data is an important step in assessing the state of the environment. Currently, such mapping is inadequate in the Mediterranean region. A Mediterranean-wide inventory of critical habitats–sea grass beds, intact rocky shorelines, persistent frontal systems, estuaries, deepwater coral assemblages and sea mounts–could provide basic information on areas associated with high delivery of ecosystem services. Much of the information already exists or is currently being collected through national reporting or regional projects. This information should be mapped in the next phase of ECAP and added to existing map layers to support GIS analysis. Identifying areas subject to multiple threats will give Mediterranean countries a clearer picture of the overall state of the Mediterranean coastal and marine environment.

Next Steps in the Application of the Ecosystem Approach

The Ecosystem Approach process is guiding Mediterranean countries towards better assessment capability. Ecological objectives, operational objectives, and indicators, have all been identified. Once baselines have been established, mechanisms can be put into place to derive trend information. Consideration should also be given to establishing early warning systems that could alert governments and institutions when species or ecosystems approach critical thresholds, where such thresholds have been determined. A crucial next step for Contracting Parties will be discussing and adopting methodologies for determining targets, so that management can be as effective as possible.

Cause and effect must be considered in order to link particular human activities to documented environmental outcomes. For example, if chlorophyll-a production is heightened in an area, it will be important to determine if this is caused by nutrient loading from land-based sources or by changes at sea. Knowing the drivers behind impacts is essential to crafting an effective management response.

A systematic and optimised monitoring program should look at both environmental quality or ecological status and management effectiveness. In other words, information should also be collected on what sort of management exists, whether regulations are being enforced, and the level to which there is local compliance with regulations. The lack of this sort of information hinders development of effective management responses. Optimally, monitoring would provide the data needed in the future for both environmental assessment (whether ecological objectives are being met) and management effectiveness assessment (whether management objectives are being met). Thought should be given to optimising data compatibility between the environmental monitoring stream and the management evaluation stream. Both information streams should feed the Ecosystem Approach process.

Once targets for the different indicators are agreed the crafting of adequate management responses will be crucial in achieving the objectives of the Ecosystem Approach. These management measures can be addressed directly to curve the pressures brought by the different human activities or to the driver bringing the pressures to levels allowing the achievement of the objectives. Obviously the stakeholders and the society in general will play a central role in modulating these drivers. The use of the Sustainable Consumption and Production (SCP) approach could complement other management tools in order to address discharges from land-based sources and activities, extraction of non-living resources, and fisheries and mariculture. Consequently, SCP could have a relevant contribution to the achievement of the ecological objectives linked firstly to eutrophication and contaminants, and secondly to the seafloor integrity, biological diversity and marine food webs.

With the complete application of the Ecosystem Approach the management of human activities in the Mediterranean will eventually lead into measures that take into account the interconnectivity between different habitats/ecosystems (freshwater to coasts to nearshore to pelagic environments) and deal with multiple pressures producing cumulative impacts over time. Given the complexities and scales, the holistic character of the Ecosystem Approach will allow management measures to be focused on those pressures/ impacts causing the most damage to Mediterranean ecosystem functioning, and especially those about which measures can be taken (e.g. not much can be done about introduced species coming through the Suez Canal, but more could be done about maintaining the integrity of food webs to prevent introduced species from becoming invasive).

At some time in the future, if the full application of the Ecosystem Approach is achieved, sectorial management (fisheries for instance) should be influenced not only by monitoring to see if sector specific thresholds are being approached, but also by the whole integrated Ecosystem Approach framework allowing the consideration of ecosystem wide relationships and cross sectorial pressures and impacts. This should finally guide the selection of a series of sectorial management measures leading to greater benefits than those resulting from considering each sector independently.

The interconnectivity between different habitats/ecosystems, the ecosystem wide relationships and the scale of some of the major issues affecting the Mediterranean environment makes transboundary regional cooperation a must. The best hope for achieving ecosystem-based management in the Mediterranean is to have robust and systematic management within countries, but at the same time working together through the framework that the Barcelona Convention provides.

ANNEX

List of endangered or threatened species

List of endangered or threatened species

Annex II to the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean Revised at the 17th COP meeting (UNEP/MAP, 2012)

Sea grasses
Cymodocea nodosa (Ucria) Ascherson
Posidonia oceanica (Linnaeus) Delile
Zostera marina Linnaeus
Zostera noltii Hornemann

Macroalgae
Caulerpa ollivieri Dostál
Cystoseira genus (except *Cystoseira compressa*)
Fucus virsoides J. Agardh
Laminaria rodriguezii Bornet
Sargassum acinarium (Linnaeus) Setchell
Sargassum flavifolium Kützing
Sargassum hornschuchii C. Agardh
Sargassum trichocarpum J. Agardh
Gymnogongrus crenulatus (Turner) J. Agardh
Kallymenia spathulata (J. Agardh) P.G. Parkinson
Lithophyllum byssoides (Lamarck) Foslie (Synon. *Lithophyllum lichenoides*)
Ptilophora mediterranea (H. Huvé) R.E. Norris
Schimmelmannia schousboei (J. Agardh) J. Agardh
Sphaerococcus rhizophylloides J.J. Rodríguez
Tenarea tortuosa (Esper) Lemoine
Titanoderma ramosissimum (Heydrich) Bressan & Cabioch (Synon. *Goniolithon byssoides*)
Titanoderma trochanter (Bory) Benhissoune *et al.*

Sponges
Aplysina sp. plur.
Asbestopluma hypogea Vacelet & Boury-Esnault, 1995
Axinella cannabina (Esper, 1794)
Axinella polypoides Schmidt, 1862
Geodia cydonium (Jameson, 1811)
Petrobiona massiliana (Vacelet & Lévi, 1958)
Sarcotragus foetidus (Schmidt, 1862) (synon. *Ircina foetida*)
Sarcotragus pipetta (Schmidt, 1868) (synon. *Ircinia pipetta*)
Tethya sp. plur.

Jellyfish
Astroides calycularis (Pallas, 1766)
Errina aspera (Linnaeus, 1767)
Savalia savaglia Nardo, 1844 (synon.*Gerardia savaglia*)

Bryozoans
Hornera lichenoides (Linnaeus, 1758)

Molluscs
Charonia lampas (Linnaeus, 1758) (= *Ch. Rubicunda* = *Ch. Nodifera*)
Charonia tritonis variegata (Lamarck, 1816) (= *Ch. Seguenziae*)
Dendropoma petraeum (Monterosato, 1884)
Erosaria spurca (Linnaeus, 1758)
Gibbula nivosa (Adams, 1851)
Lithophaga lithophaga (Linnaeus, 1758)
Luria lurida (Linnaeus, 1758) (= *Cypraea lurida*)
Mitra zonata (Marryat, 1818)
Patella ferruginea (Gmelin, 1791)
Patella nigra (Da Costa, 1771)
Pholas dactylus (Linnaeus, 1758)
Pinna nobilis (Linnaeus, 1758)
Pinna rudis (= *P. pernula*) (Linnaeus, 1758)
Ranella olearia (Linnaeus, 1758)
Schilderia achatidea (Gray in G.B. Sowerby II, 1837)
Tonna galea (Linnaeus, 1758)
Zonaria pyrum (Gmelin, 1791)

Crustaceans
Ocypode cursor (Linnaeus, 1758)
Pachylasma giganteum (Philippi, 1836)

Echinoderms
Asterina pancerii (Gasco, 1870)
Centrostephanus longispinus (Philippi, 1845)
Ophidiaster ophidianus (Lamarck, 1816)

Fishes
Acipenser naccarii (Bonaparte, 1836)
Acipenser sturio (Linnaeus, 1758)
Aphanius fasciatus (Valenciennes, 1821)
Aphanius iberus (Valenciennes, 1846)
Carcharias taurus (Rafinesque, 1810)
Carcharodon carcharias (Linnaeus, 1758)
Cetorhinus maximus (Gunnerus, 1765)
Dipturus batis (Linnaeus, 1758)
Galeorhinus galeus (Linnaeus, 1758) (*)
Gymnura altavela (Linnaeus, 1758)
Hippocampus guttulatus (Cuvier, 1829) (synon. *Hippocampus ramulosus*)
Hippocampus hippocampus (Linnaeus, 1758)
Huso huso (Linnaeus, 1758)
Isurus oxyrinchus (Rafinesque, 1810) (*)
Lamna nasus (Bonnaterre, 1788) (*)
Lethenteron zanandreai (Vladykov, 1955)
Leucoraja circularis (Couch, 1838) (*)
Leucoraja melitensis (Clark, 1926) (*)
Mobula mobular (Bonnaterre, 1788)
Odontaspis ferox (Risso, 1810)
Oxynotus centrina (Linnaeus, 1758)
Pomatoschistus canestrini (Ninni, 1883)
Pomatoschistus tortonesei (Miller, 1969)
Pristis pectinata (Latham, 1794)
Pristis pristis (Linnaeus, 1758)
Rhinobatos cemiculus (E. Geoffroy Saint-Hilaire, 1817) (*)
Rhinobatos rhinobatos (Linnaeus, 1758) (*)
Rostroraja alba (Lacépède, 1803)
Sphyrna lewini (Griffith & Smith, 1834) (*)
Sphyrna mokarran (Rüppell, 1837) (*)
Sphyrna zygaena (Linnaeus, 1758) (*)
Squatina aculeata (Dumeril, in Cuvier, 1817)
Squatina oculata (Bonaparte, 1840)
Squatina squatina (Linnaeus, 1758)
Valencia hispanica (Valenciennes, 1846)
Valencia letourneuxi (Sauvage, 1880)

Reptiles
Caretta caretta (Linnaeus, 1758)
Chelonia mydas (Linnaeus, 1758)
Dermochelys coriacea (Vandelli, 1761)
Eretmochelys imbricata (Linnaeus, 1766)
Lepidochelys kempii (Garman, 1880)
Trionyx triunguis (Forskål, 1775)

Seabirds and Shorebirds
Calonectris diomedea (Scopoli, 1769)
Ceryle rudis (Linnaeus, 1758)
Charadrius alexandrinus (Linnaeus, 1758)
Charadrius leschenaultii columbinus (Lesson, 1826)
Falco eleonorae (Géné, 1834)
Halcyon smyrnensis (Linnaeus, 1758)
Hydrobates pelagicus (Linnaeus, 1758)

Larus armenicus (Buturlin, 1934)
Larus audouinii (Payraudeau, 1826)
Larus genei (Breme, 1839)
Larus melanocephalus (Temminck, 1820)
Numenius tenuirostris (Viellot, 1817)
Pandion haliaetus (Linnaeus, 1758)
Pelecanus crispus (Bruch, 1832)
Pelecanus onocrotalus (Linnaeus, 1758)
Phalacrocorax aristotelis (Linnaeus, 1761)
Phalacrocorax pygmeus (Pallas, 1773)
Phoenicopterus ruber (Linnaeus, 1758)
Puffinus mauretanicus (Lowe, PR, 1921)
Puffinus yelkouan (Brünnich, 1764)
Sterna albifrons (Pallas, 1764)
Sterna bengalensis (Lesson, 1831)
Sterna caspia (Pallas, 1770)
Sterna nilotica (Gmelin, JF, 1789)
Sterna sandvicensis (Latham, 1878)

Marine Mammals
Balaenoptera acutorostrata (Lacépède, 1804)
Balaenoptera borealis (Lesson, 1828)
Balaenoptera physalus (Linnaeus, 1758)
Delphinus delphis (Linnaeus, 1758)
Eubalaena glacialis (Müller, 1776)
Globicephala melas (Trail, 1809)
Grampus griseus (Cuvier G., 1812)
Kogia simus (Owen, 1866)
Megaptera novaeangliae (Borowski, 1781)
Mesoplodon densirostris (de Blainville, 1817)
Monachus monachus (Hermann, 1779)
Orcinus orca (Linnaeus, 1758)
Phocoena phocoena (Linnaeus, 1758)
Physeter macrocephalus (Linnaeus, 1758)
Pseudorca crassidens (Owen, 1846)
Stenella coeruleoalba (Meyen, 1833)
Steno bredanensis (Cuvier in Lesson, 1828)
Tursiops truncatus (Montagu, 1821)
Ziphius cavirostris (Cuvier G., 1832)

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The Mediterranean Sea is complex in its ecology and its social dimensions. Twenty-one countries border the basin of this heavily used and highly valued sea. The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) provides a critical framework for setting standards and targets acceptable to all the Contracting Parties, as well as for sharing necessary information. As Contracting Parties to the Barcelona Convention, the Mediterranean countries, together with the European Union, are determined to meet the challenges of protecting the marine and coastal environment of the Mediterranean while boosting regional and national plans to achieve sustainable development.

The main objective of the Barcelona Convention, its protocols and strategies, is to effect real changes that will improve the environment in the Mediterranean Sea area. To achieve that objective, it is essential to determine whether progress is being made and to identify where better performance is needed.