Mediterranean Action Plan
Barcelona Convention

UN environment
United Nations
Environment Programme

2017 Mediterranean Quality Status Report

Foreword

It has been over 40 years since the establishment of the Mediterranean Action Plan as the first UN Environment Regional Sea Programme and the adoption of the Barcelona Convention. During these four decades, monitoring and assessment of the marine and coastal environment have been central to the mandate of the MAP system, contributing to an ever deeper understanding of key thematic issues related to the Mediterranean marine and coastal environment. More than 170 MAP Technical Reports between 1986 and 2008, the Transboundary Diagnostic Analysis (TDA) of 2003 and the Initial Integrated Ecosystem Approach assessment in 2011 are just examples of the numerous products developed by the system. In the last 5 years, assessment reports include the State of the Mediterranean Marine and Coastal Environment of 2012, the Horizon 2020 joint EEA-UNEP/MAP Mediterranean report of 2014, the Marine Litter Assessment in the Mediterranean of 2015 and many other thematic assessments on climate change, biodiversity, coastal zones, and related fields.

These products have been based on available information; the challenge has always been on how to ensure comparable and quality assured data. Data on all aspects of pollution, biodiversity and coastal zone has been mostly limited to local and national assessments and often not comparable. A key milestone towards achieving an integrated monitoring programme for the Mediterranean was the adoption in 2016 of the Integrated Monitoring and Assessment Programme (IMAP), the result of work spanning over 3 years and involving scientific experts and all Mediterranean countries. IMAP is based on the ecosystem approach, its Ecological Objectives for the Mediterranean, and its indicators. IMAP is a very ambitious step now in its initial stages of implementation and requires deep commitment and complex work from the Mediterranean countries to revise their national monitoring programmes and ensure regular reporting of data to UN Environment/MAP.

In the context of implementing the Ecosystem Approach Roadmap adopted by the Contracting Parties to the Barcelona Convention in 2008, the MAP system has now delivered the first ever Quality Status Report for the Mediterranean (2017 MED QSR). This is the first assessment product based on the MAP Ecological Objectives and IMAP indicators; it builds upon existing data and is complimented with inputs from numerous diverse sources where appropriate.

The 2017 MED QSR is an important and innovative development for assessing the status of the Mediterranean ecosystem and the achievement of Good Environmental Status (GES). Despite the challenges met, given the limited availability of data and the fact that the IMAP implementation is still at an early phase, the 2017 MED QSR brings together national data and information to the regional level. It also contributes to the ongoing work at the global level, including the Regional Process on a Second World Ocean Assessment and the implementation of the 2030 Agenda for Sustainable Development, especially its ocean-related Sustainable Development Goals.

The report is available online to ensure that it can be easily accessed and read by experts, policy makers and the public. It will serve as the baseline for defining the measures for progressing towards GES in the Mediterranean and sharpening the monitoring programmes needed to feel the existing gaps.

As IMAP is implemented and a more complete data-base is established, regular thematic reports will be developed in the coming years, based more and more on quantitative rather than qualitative information. These include the 2019 State of Environment Report and the next Quality Status Report in 2023. We are confident that this progressive assessment products will provide a detailed analysis of the state of the Mediterranean marine and coastal ecosystem, and identify the key areas of national and regional action in order to achieve the Good Environmental Status of our Sea.

I am glad to introduce the delivery of the 2017 MED QSR as a very significant achievement of the MAP system, and the result of joint and integrated efforts of the Contracting Parties, Partners, and the Secretariat with the MAP Components.

Gaetano Leone
Coordinator
UN Environment/MAP-Barcelona Convention Secretariat

1. Introduction

Over 40 years ago, the **Mediterranean Action Plan (MAP)** was established as a framework of cooperation in addressing common challenges of marine environmental degradation, and in 1976 the Barcelona Convention was adopted by the Mediterranean countries. With an initial focus on pollution, which then expanded to further address biodiversity, coastal management and sustainable development, in 1995 the Convention was amended and renamed as the **Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean**. In addition to the Barcelona Convention and seven protocols addressing specific aspects of Mediterranean environmental protection and conservation, since 2008 **the Ecosystem Approach** has been the guiding principle with the ultimate objective of achieving the Good Environmental Status (GES) of the Mediterranean Sea and Coast. An Integrated Monitoring and Assessment Programme (IMAP) was adopted by the 19th Meeting of Contracting Parties (COP 19) in 2016. The 2017 Quality Status Report is the first report based on the Ecological Objectives and Common Indicators of IMAP, with a view to assess the status of the Mediterranean in achieving GES.

1.1. UN Environment/MAP and the Barcelona Convention: Vision, Goals, and Ecological Objectives

With its three dimensions (*Institutional*: Contracting Parties, UN Environment/MAP Secretariat composed of the UN Environment Coordinating Unit and seven components, and Mediterranean Commission on Sustainable Development as advisory body; *Regulatory*: seven Protocols and an extensive body of strategies, action plans and decisions; and *Implementation-related*: partnerships, programmes, projects and activities for the delivery of the mandate), the MAP system has a unique and prominent role in the Mediterranean region for the protection of the marine environment and its coastal region as a contribution to sustainable development.

The MAP was the first UNEP initiative to be developed under the Regional Seas Programme. MAP's initial objectives were to assist the Mediterranean Governments to assess and control pollution, as well as to formulate their national marine environmental policies. The Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention) and two Protocols addressing the prevention of pollution by dumping from ships and aircraft and cooperation in combating pollution in cases of emergency were also approved in 1975. In 1995, in the aftermath of the Rio Summit, the Contracting Parties decided to revise the MAP and the Convention. 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 adopted in 1995 with the following objectives:

- to ensure the sustainable management of natural marine and land resources and to integrate the environment in social and economic development, and land-use policies;
- to protect the marine environment and coastal zones, through prevention of pollution, and by reduction and as far as possible, elimination of pollutant inputs whether chronic or accidental;
- to protect nature, and protect and enhance sites and landscapes of ecological or cultural value;
- to strengthen solidarity amongst Mediterranean coastal states, in managing their common heritage and resources for the benefit of the present and future generations; and
- to contribute to the improvement of the quality of life.

In 1995, the Contracting Parties adopted substantial amendments to the Barcelona Convention of 1976 and renamed it as Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, which entered into force in 2004. The amended Convention embodies international partnership to protect the sea, its coasts, and the uses and livelihoods that it supports. It provides a critical framework for setting environmental standards and targets agreed by all the Contracting Parties, as well as for sharing important information for management.

Seven Protocols, addressing specific aspects of Mediterranean environmental conservation, and a number of regional plans complete the MAP legal framework:

1. The Protocol for the Prevention of Pollution in the Mediterranean Sea by Dumping from Ships and Aircraft (Dumping Protocol)
2. The Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (Prevention and Emergency Protocol)
3. The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (LBS Protocol), including Regional plans under Article 15 of LBS Protocol
4. The Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BD Protocol)
5. The Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Hazardous Wastes Protocol)
6. The 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)
7. The Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol).

In addition, a number of key strategies have been developed and adopted:

- Mediterranean Strategy for Sustainable Development (MSSD)
- Strategic Action Programme to address pollution from land-based activities (SAP-MED)
  and Action plans on pollution reduction deriving from specific provisions of the LBS Protocol
- Strategic Action Plan for the conservation of marine and coastal biodiversity in the Mediterranean (SAP-BIO) and Action plans on species deriving from specific provisions of the SPA-BD Protocol
- Regional Action Plan on Sustainable Consumption and Production in the Mediterranean
- Regional Strategy for Prevention of and Response to Marine Pollution from Ships (2016-2021)
- Ballast Water Management Strategy.

Finally, given the increasing impact of climate change on the marine and coastal environment of the Mediterranean, the Regional Climate Change Adaptation Framework for the Mediterranean Marine and Coastal Areas was adopted in 2016.

In 2008, the Contracting Parties committed to apply the Ecosystem Approach with its vision for *“A healthy Mediterranean with marine and coastal ecosystems that are productive and* *biologically diverse for the benefit of present and future generations".* The following three strategic goals were identified for marine and coastal areas, on the basis of the relevant priority field of action of the MSSD and the experience gained by other international and regional bodies:

a) To protect, allow recovery and, where practicable, restore the structure and function of marine and coastal ecosystems thus also protecting biodiversity, in order to achieve and maintain good ecological status and allow for their sustainable use.
b) To reduce pollution in the marine and coastal environment so as to minimize impacts on and risks to human and/or ecosystem health and/or uses of the sea and the coasts.
c) To prevent, reduce and manage the vulnerability of the sea and the coasts to risks induced by human activities and natural events;

In 2012, the Contracting Parties adopted 11 Mediterranean Ecological Objectives (EO) to achieve GES, as presented in table 1 below. Supported by thematic Correspondence Groups on Monitoring (CORMON) on pollution and marine litter, biodiversity and fisheries, and coast and hydrography, and based on the above-mentioned 11 Ecological Objectives, common indicators, Good Environmental Status definition and targets were developed and adopted by the Contracting Parties to the Barcelona Convention in in 2012 and 2013.

1.2. Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast

The Ecosystem Approach in the Mediterranean is being implemented in accordance with a seven-step roadmap. It is now fully integrated into the MAP and Barcelona Convention framework and is in line with the EU Marine Strategic Framework Directive and the decisions of the Convention on Biological Diversity (CBD) regarding the ecosystem approach and the Aichi targets.

Monitoring and assessment of the sea and coast, based on scientific knowledge, are the indispensable basis for the management of human activities, in view of promoting the sustainable use of the seas and coasts and conserving marine ecosystems and their sustainable development. The 19th Meeting of Contracting Parties in 2016 agreed on the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) in its Decision IG. 22/7 which lays down the principles for an integrated monitoring, which will, for the first time, monitor biodiversity and non-indigenous species, pollution and marine litter, coast and hydrography in an integrated manner. The IMAP implementation is in line with article 12 of the Barcelona Convention and several monitoring related provisions under different protocols with the main objective to assess GES. Its backbone are the 27 common indicators as presented in decision IG 22/7: Integrated Monitoring and Assessment Programme (see Table 1).

Table 1. List of IMAP Ecological Objectives (EOs) and Indicators

Ecological Objective	IMAP Indicators
EO 1 Biodiversity	
Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and	Common Indicator 1: Habitat distributional range (EO1) to also consider habitat extent as a relevant attribute
	Common Indicator 2: Condition of the habitat's typical species and communities (EO1)

abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	Common Indicator 3: Species distributional range (EO1 related to marine mammals, seabirds, marine reptiles)
	Common Indicator 4: Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles)
	Common indicator 5: Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, marine reptiles)
EO 2 Non-indigenous species	
Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem	Common Indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)
EO 3 Harvest of commercially exploited fish and shellfish	
Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock	Common Indicator 7: Spawning stock Biomass (EO3);
	Common Indicator 8: Total landings (EO3);
	Common Indicator 9: Fishing Mortality (EO3);
	Common Indicator 10: Fishing effort (EO3);
	Common Indicator 11: Catch per unit of effort (CPUE) or Landing per unit of effort (LPUE) as a proxy (EO3)
	Common Indicator 12: Bycatch of vulnerable and non-target species (EO1 and EO3)
EO 4 Marine food webs	
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	*To be further developed*
EO 5 Eutrophication	
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.	Common Indicator 13: Concentration of key nutrients in water column (EO5);
	Common Indicator 14: Chlorophyll-a concentration in water column (EO5)
EO 6 Sea-floor integrity	
Sea-floor integrity is maintained, especially in priority benthic habitats	*To be further developed*
EO7 Hydrography	

Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	Common Indicator 15: Location and extent of the habitats impacted directly by hydrographic alterations (EO7) to also feed the assessment of EO1 on habitat extent
EO 8 Coastal ecosystems and landscapes	
The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved	Common Indicator 16: Length of coastline subject to physical disturbance due to the influence of man-made structures (EO8);
	Candidate Indicator 25: Land use change (EO8)
EO 9 Pollution	
Contaminants cause no significant impact on coastal and marine ecosystems and human health	Common Indicator 17: Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)
	Common Indicator 18: Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)
	Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution (EO9);
	Common Indicator 20: Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9);
	Common Indicator 21: Percentage of intestinal enterococci concentration measurements within established standards (EO9)
EO 10 Marine litter	
Marine and coastal litter do not adversely affect coastal and marine environment	Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines (EO10);
	Common Indicator 23: Trends in the amount of litter in the water column including microplastics and on the seafloor (EO10);
	Candidate Indicator 24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles (EO10)
EO 11 Energy including underwater noise	
Noise from human activities cause no significant impact on marine and coastal ecosystems	Candidate Indicator 26: 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 animal
	Candidate Indicator 27: Levels of continuous low frequency sounds with the use of models as appropriate

The implementation of IMAP requires standard guidelines and approaches in monitoring the common indicators and the revision of national monitoring programmes of the Contracting

Parties to be aligned with the IMAP indicators. Regular national data reporting will contribute to thematic and overall regional assessments. The first integrated assessment based on IMAP is the 2017 Quality Status Report. It builds upon an initial Integrated Ecosystem Assessment developed in 2011, the 2012 Mediterranean State of Environment Report, as well as several thematic assessments undertaken in recent years.

1.3. Other key global and regional assessment processes

The 2030 Agenda for Sustainable Development and Sustainable Development Goals

The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) were adopted by world leaders in September 2015 at an historic UN Summit. Over the next fifteen years, with these new Goals that universally apply to all, countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. While the SDGs are not legally binding, governments are expected to take ownership and establish national frameworks for the achievement of the 17 Goals. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, which will require quality, accessible and timely data collection. Regional follow-up and review will be based on national-level analyses and contribute to follow-up and review at the global level. In recognition of the growing importance of the role of oceans in sustainable development, Goal 14 is to Conserve and sustainably use the oceans, seas and marine resources, and UN Environment will play a key role in contributing to the implementation of those environment-related indicators in coordination with other actors. As the importance of the regional dimension is increasingly recognized for the implementation of global agendas, the Regional Sea Programmes are considered to be the units of marine ecosystems that can functionally provide services to human beings surrounding these seas. Therefore, there will be close coordination between Mediterranean countries and MAP in support of the implementation and monitoring of relevant SDGs.

UN Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects (Regular Process)

At the World Summit on Sustainable Development, held in Johannesburg, South Africa, from 26 August to 4 September 2002, States agreed, to “establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment, including socio-economic aspects, both current and foreseeable, building on existing regional assessments” (the “Regular Process”). The first global integrated marine assessment was completed in 2015, with close synergies to the core areas of work of MAP. The second cycle will cover a five-year period, from 2016 to 2020, and the Regionals Seas (including MAP) are part of the working group to ensure that QSR and other assessments will be integrated into the report.

Global Environment Outlook (GEO)

The GEO global assessments provide an integrated analysis (e.g. social, economic, environmental) of major trends that have shaped the environment. These reports provide world leaders with policy options to take immediate action to address environmental issues by turning environmental discussions into practice. Using the integrated environmental assessment methodology, UN Environment has produced five GEO reports (as well as of regional GEOs) and GEO 6 is under finalization for 2017, with MAP as part of the review process. The categories of the GEO report are in line with the IMAP Ecological Objectives and it is expected that the QSR and future assessments will feed into GEO reports.

Mediterranean Strategy for Sustainable Development (MSSD)

The Mediterranean Strategy for Sustainable Development (MSSD) 2016-2025 was adopted by the Barcelona Convention contracting parties in 2016. It provides an integrative policy framework and a strategic guiding document for all stakeholders and partners to translate the 2030 Agenda for Sustainable Development at the regional, sub regional and national levels. The Strategy is built around the following vision: ***A prosperous and peaceful Mediterranean region in which people enjoy a high quality of life and where sustainable development takes place within the carrying capacity of healthy ecosystems.*** This is achieved through common objectives, strong involvement of all stakeholders, cooperation, solidarity, equity and participatory governance. 34 indicators have been agreed in relation to the following 6 objectives:

1. Ensuring sustainable development in marine and coastal areas
2. Promoting resource management, food production and food security through sustainable forms of rural development
3. Planning and managing sustainable Mediterranean cities
4. Addressing climate change as a priority issue for the Mediterranean
5. Transition towards a green and blue economy
6. Improving governance in support of sustainable Development

Whereas the IMAP indicators assess the state of the Mediterranean, the MSSD assesses the pressures and drivers. There are strong linkages between these which will be integrated in the Mediterranean State of Environment Report to be developed in 2018-2019.

EU Marine Strategic Directive (MSFD)

The development of the 2017 MED QSR compliments a number of regional and global assessments that are recent and ongoing. The EU Marine Strategic Directive (MSFD) aims to achieve Good Environmental Status of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. In order to achieve its goal, the Directive establishes European marine regions and sub-regions on the basis of geographical and environmental criteria. The Directive lists four European marine regions – the Baltic Sea, the North-east Atlantic Ocean, the Mediterranean Sea and the Black Sea – located within the geographical boundaries of the existing Regional Sea Conventions. Cooperation between the Member States of one marine region and with neighbouring countries which share the same marine waters, is already taking place through these Regional Sea Conventions. In order to achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (or Marine Strategy). In addition, because the Directive follows an adaptive management approach, the Marine Strategies must be kept up-to-date and reviewed every 6 years. The descriptors and the timeline of implementation of the MSFD are in line with the Ecological Objectives of IMAP, with the exception of the Ecological Objective EO 8 Coastal ecosystems and landscapes, therefore EU members of the Mediterranean will have the same reporting for both processes. The next MSFD Article 12 Technical Assessment for the Mediterranean will be published in 2018, and will utilize as appropriate the QSR 2017 findings. The Joint Research Centre (JRC), the European Commission's science and knowledge service also has published thematic reports in relation to the 11 descriptors of the MSFD.

Other European-wide assessments are undertaken by the European Environment Agency (EEA), including the Second regional indicator-based H2020 assessment (EEA-UNEP/MAP) in 2019 and the State of the Seas report for 2020.

1.4. Approach and Methodology for the preparation of the Mediterranean 2017 QSR

The 2017 MED QSR follows a model that has been defined in cooperation with the Contracting Parties, based on the structure of the UN Environment/MAP Mid-Term Strategy 2016-2021 and IMAP, through the Ecosystem Approach Correspondence Groups on Monitoring and the Ecosystem Approach Coordination Group. It has also considered the approach taken by other Regional Sea Programmes (i.e. OSPAR), and the work implemented at global level, such as the Regional Process on a Second World Ocean Assessment and the process on implementing the 2030 Agenda for Sustainable Development, especially its oceans related Sustainable Development Goals.

Given the limited availability of data and the fact that the IMAP implementation is still at an early phase as a number of countries are in the process of revising their national monitoring programmes to align them with IMAP, the approach for the preparation of the 2017 MED QSR reflects the time limitations and data gaps of the IMAP Common Indicators. The approach followed was to use all available data for the IMAP Common Indicators, such as the MEDPOL Monitoring Programme data, and to complement and address data gaps with inputs from numerous diverse sources where appropriate. Candidate indicators have not been assessed as they require further testing. Each Indicator assessment provides all the sources of information used, assessments, reports, publications and information provided from the Contracting Parties and other partners. This includes information related to national reports on the implementation of the Barcelona Convention and its Protocols, implementation of the National Action Plans (NAPs), Coastal Area Management Programmes (CAMPs), as well as the results of regionally and nationally driven implementation of relevant policies, programmes and projects.

As a result, the 2017 MED QSR, through systematic compilation of the Assessment Factsheets for all IMAP Common Indicators, presents the findings on the status of implementation of the appropriate assessment methods, identifies the status of information availability that are necessary for evaluation of the IMAP Common Indicators, provides details on the status of marine and coastal ecosystems and where possible, identifies the trends that are expressed through qualitative and quantitative assessment, including the graphics and animations as appropriate. It also determines the knowledge gaps and defines key directions to overcome them with the aim to enable successful implementation of the initial phase of IMAP (2016-2019). For each cluster, it provides the case studies that have been submitted by Contracting Parties and Partners.

The QSR Assessment for all IMAP Common Indicators was presented and reviewed by the relevant meetings of the Ecosystem Approach Correspondence Groups (on biodiversity, pollution, marine litter and coast and hydrography), the Ecosystem Approach Coordination Group and the meetings of the respective MAP Components Focal Points (MED POL, SPA/RAC, REMPEC, PAP/RAC), and were revised accordingly.

The delivery of this report is a unique MAP achievement based on joint and integrated efforts of the Contracting Parties, Secretariat, MAP Components and Partners.

Table of contents

Pages

1) Quality Status Report (Pollution and Litter)

Ecological Objective 5 (EO5): Eutrophication

EO5: Common Indicator 13. Key nutrients concentration in water column

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Albania, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Montenegro, Morocco, Slovenia, Spain, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO5. 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
IMAP Common Indicator	CI13. Key nutrients concentration in water column (EO5**)**
Indicator Assessment Factsheet Code	EO5CI13

RATIONALE/METHODS

Background

Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation (IMAP, 2017). Seawaters depending on nutrient loading and phytoplankton growth are classified according to their level of eutrophication. Low nutrient/ phytoplankton levels characterize oligotrophic areas, water enriched in nutrients is characterized as mesotrophic, whereas water rich in nutrients and algal biomass is characterized as eutrophic. The Mediterranean is one of the most oligotrophic seas in the world and most of its biological productivity takes place in the euphotic zone (UNEP, 1989, UNEP/MAP, 2012). The development of nutrient/phytoplankton concentration scales has been a difficult task for marine scientists because of the seasonal fluctuations of nutrient and phytoplankton concentrations, phytoplankton patchiness and small-scale eutrophication phenomena. Although long-term scientific research (UNEP/FAO/WHO1996; Krom *et al.*, 2010) has shown that the main body of the Mediterranean Sea is in good condition, there are coastal areas, especially in enclosed gulfs near big cities in estuarine areas and near ports, where marine eutrophication is a serious threat. In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally-binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive (WFD) and the European Marine Strategy Framework (MSFD) are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of Good Environmental Status (GES) for IMAP Common Indicator 13 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

In the Mediterranean area eutrophication is caused by both regional sources such as urban effluents, industrial discharges, and aquaculture activities as well as transboundary components such as agricultural runoffs, riverine outflows, and airborne nutrient deposition. The variables related to eutrophication are influenced by water circulation, but it is only recently that the general circulation pattern has been connected to regional sources of pollution including eutrophication (UNEP/MAP, 2003).

The highly populated coastal zone in the Mediterranean and the riverine input from a draining area of $1.5\ 10^6\ km^2$ (Ludwig *et al.*, 2009) induce eutrophic trends in coastal areas. The offshore waters of the Mediterranean have been characterized as extremely oligotrophic with a clear gradient toward east (Turley, 1999). The gradient is illustrated on figure 1 from data collected during the Meteor M84/3 cruise (Tanhua *et al.* 2013).

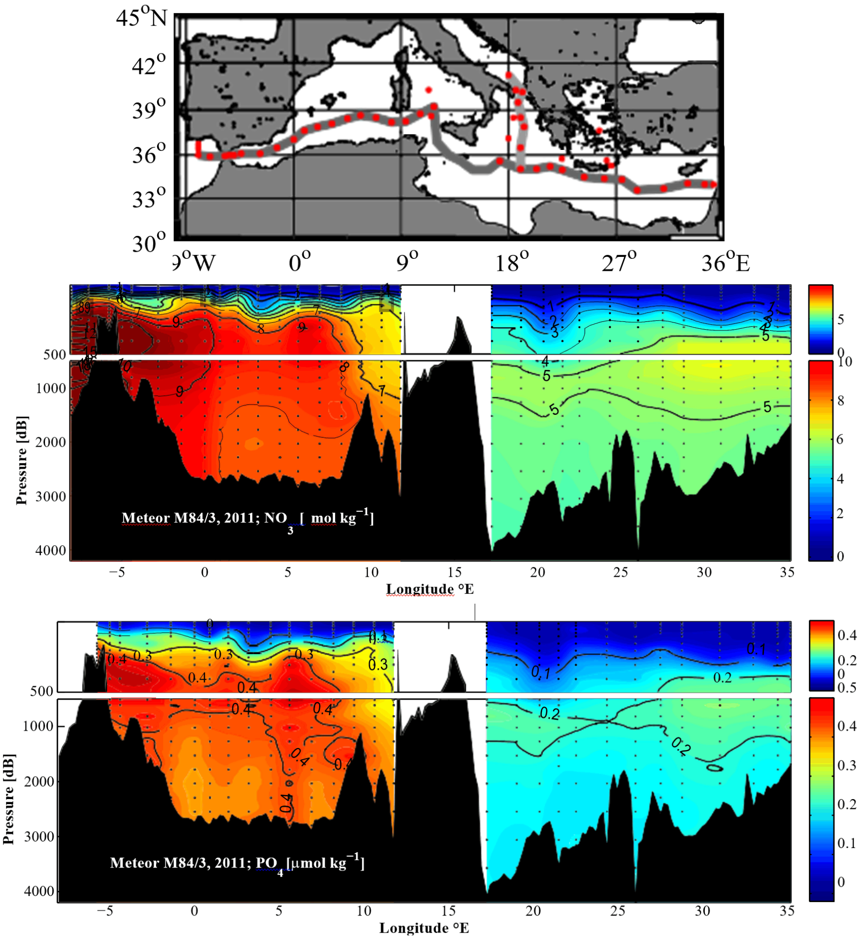

Figure 1. Distribution of nitrate (NO_3) and phosphate (PO_4) concentrations along a profile from off the coast of Lebanon to the Strait of Gibraltar during spring 2011. Data were collected during the Meteor 84/3 cruise. Reproduced from: Tanhua *et al.*, 2013.

Assessment methods

At the moment only some of the Mediterranean countries have developed a boundary approach for the assessment of eutrophication and no general assessment criteria have been agreed for the Mediterranean area for the key nutrient concentrations in the water column. This assessment effort was based only on the presentation of the geographical variability of some key nutrients (DIN – dissolved inorganic nitrogen and TP- total phosphorous; μmol L^{-1}).

For the presentation of the data Box and Whiskerplots are used. Information contained in the plot are Hspreads (interquartile range - the absolute value of the difference between the values of the two hinges) and fences that define outside and far outside values:
Lower inner fence = lower hinge - (1.5 • (Hspread))
Upper inner fence = upper hinge + (1.5 • (Hspread))
Lower outer fence = lower hinge - (3 • (Hspread))
Upper outer fence = upper hinge + (3 • (Hspread))

The whiskers show the range of observed values that fall within the inner fences. Because the whiskers do not necessarily extend all the way to the inner fences, values between the inner and outer fences are plotted with asterisks. Values beyond the outer fences are plotted with empty circles.

UNEP/MAP's Pollution Programme (MEDPOL) has a monitoring programme since 1999, based on the contribution of data from Mediterranean countries, including nutrients.

In this assessment, aware that for most of the northern Mediterranean countries data are available also in other databases (such as EEA, EIONET, EMODnet), only datasets obtained from the MED POL Database for nutrients were used. Data availability by country were as follows:
Albania (2005-2006), Bosnia and Herzegovina (2006-2008) Croatia (2009, 2011-2014), Cyprus (1999-2015), Egypt (2009, 2010), France (2009, 2010), Greece (2004-2006), Israel (2001-2012), Montenegro (2008-2012, 2014-2015), Morocco (2006,2007), Slovenia (1999-2013, 2015), Tunisia (2002-2013), Turkey (2005-2009, 2011, 2013)

RESULTS

Results and Status, including trends

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area of 1.5 million km^2 (Ludwig *et al.* 2009) that induce eutrophic trends in coastal areas. The blue offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards (Turley 1999). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Figure 1). It is observed that the Eastern Mediterranean Sea (EMS) is still the most oligotrophic area of the whole Mediterranean basin. This is due to the low nutrient content of EMS; the maximum concentrations recorded for nitrate were about 6 μmol L^{-1}, for phosphate 0.25 μmol L^{-1}, and for silicate 10–12 μmol L^{-1}, with the nitrate to phosphate ratio (N/P) >20 and in deep waters about 28:1, the EMS has been characterized as the largest phosphorus-limited body of water in the global ocean.

The coastal area of the southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are becoming limited because of the Aswan Dam and increasing trends in anthropogenic water use in the lower Nile. Eutrophic conditions in the area are mainly induced by the sewage effluents of Cairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends. This can be explained by the river inputs from northern Greece and the water inflow from the nutrient rich Black Sea.

The nutrient regime and primary productivity in the Western Mediterranean Sea (WMS) are relatively higher compared to the EMS. There is limited nutrient supply through the Strait of Gibraltar due to different nutrient concentrations between the Atlantic and Mediterranean waters. The surface water entering from the Atlantic carries nutrients directly available for photosynthesis (EEA 1999) but at low concentrations. The phosphorus (phosphate) concentrations in the inflowing waters ranges from 0.05 to 0.20 μmol L^{-1}, the nitrogen (nitrate) concentrations being about 1–4 μmol L^{-1}, and the silicon (silicate) concentration is about 1.2 μmol L^{-1} (Coste *et al.* 1988). The nutrients of the surface layer are reduced as they propagate eastwards due to mixing with poor basin water and nutrient use by phytoplankton. However, the primary productivity of the main WMS, away from the coastal areas and influenced by rivers and urban agglomerations, is still higher than the primary productivity in the EMS.

The main coastal areas in the Mediterranean which are historically known to be influenced by natural and anthropogenic inputs of nutrients are the Gulf of Lions, the Gulf of Gabès, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine). A recent work on nutrient and phytoplankton distribution along a large-scale longitudinal east–west transect (3 188 km) of the Mediterranean Sea extended over nine stations was published by Ignatiades *et al.* (2009). The results confirmed the oligotrophic character of the area and the nutrient and chlorophyll gradient characterized by decreasing concentrations from Gibraltar to the sea of Levantine. Phosphate maxima ranged from 0.05 to 0.26 μmol L^{-1}, nitrate from 4.04 to 1.87 μmol L^{-1}, chlorophyll *a* (chl*a*) from 0.96 to 0.39 μg L^{-1}.

The results of assessment and status of the key nutrients concentration in the water column are presented on Figs 3-5 showing a rather limited figure of the Mediterranean region. The main reason is the data availability and quality. On the Figure 2 are clearly visible that for the great part of the region data are missing. The implementation of water type criteria for the purpose of IMAP are also limited. Even a rather weak criteria (10 samples in 10 years in surface layer - <= 10 m) were adopted the data availability for assessment were low.

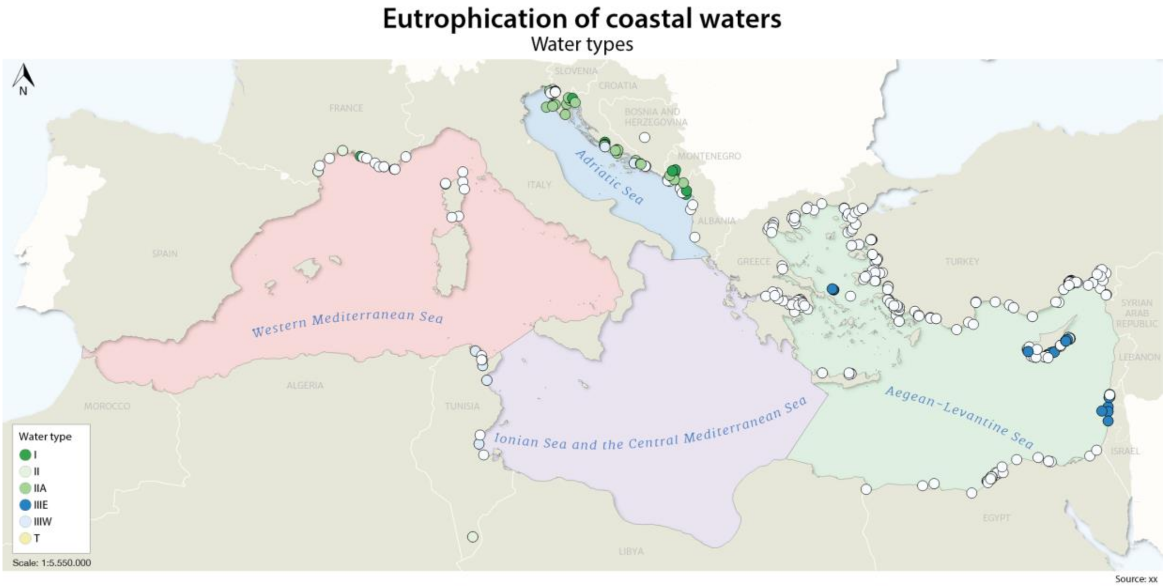

Figure 2. Stations in the Mediterranean region for which nutrient concentrations were sampled. Also are shown the water types (applicable for phytoplankton; IMAP, 2017) were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

Figure 2 presents the stations in the Mediterranean region for which nutrient concentrations were sampled used for the assessment. On Figures 3-5 data for the Adriatic and Aegean-Levantine sub regions for dissolved inorganic nitrogen (DIN) and total phosphorus (TP) were presented. DIN and TP concentration show a characteristic variability for both coastal sea (Adriatic and Aegean-Levantine Sea) indicating that no hotspot is present for DIN and TP.

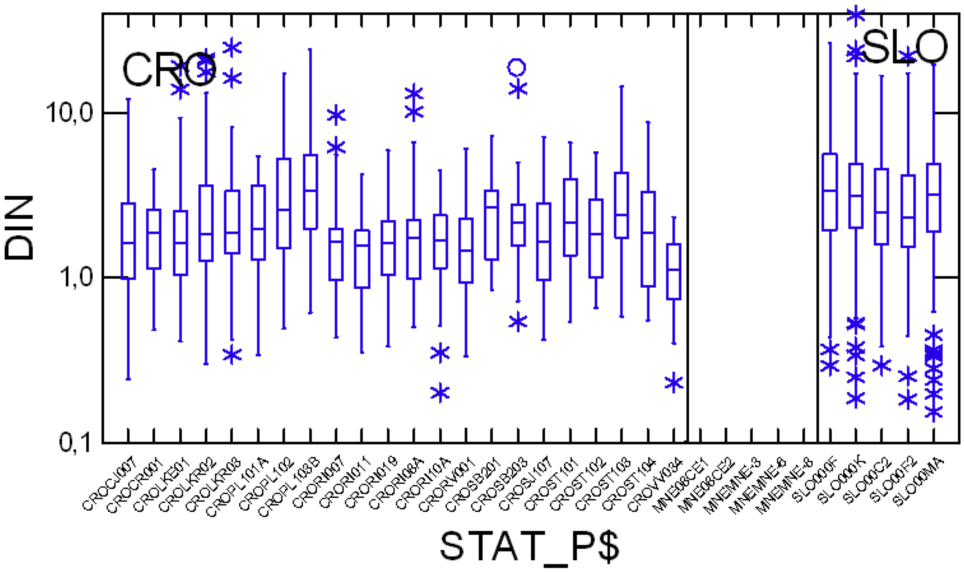

Figure 3. Box and whisker plot for dissolved inorganic nitrogen (DIN) concentration (μmol L^{-1}) in the Adriatic Sea sub region (water type IIA) for Croatia (CRO) and Slovenia (SLO)

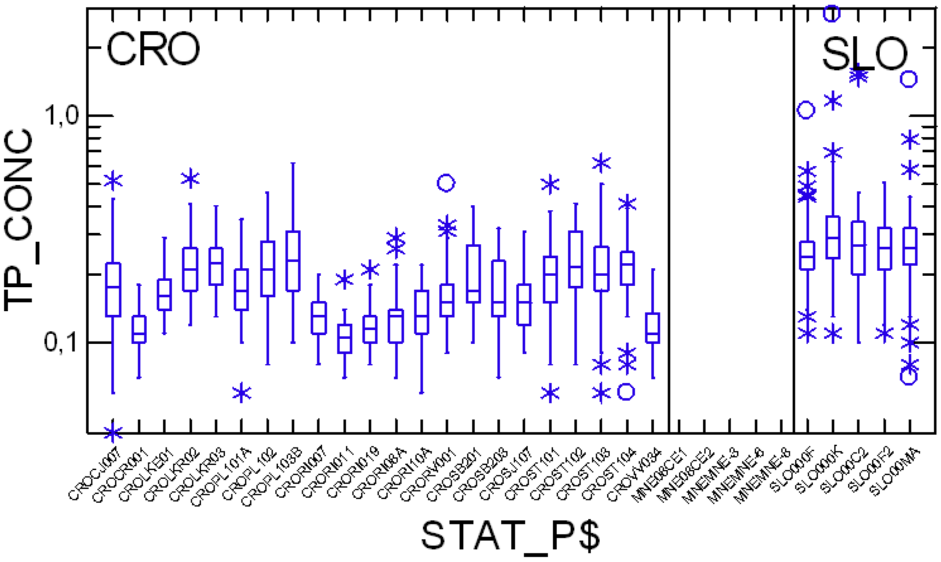

Figure 4. Box and whisker plot for Total Phosphorous (TP) concentration (μmol L^{-1}) in the Adriatic Sea sub region (water type IIA) for Croatia (CRO) and Slovenia (SLO)

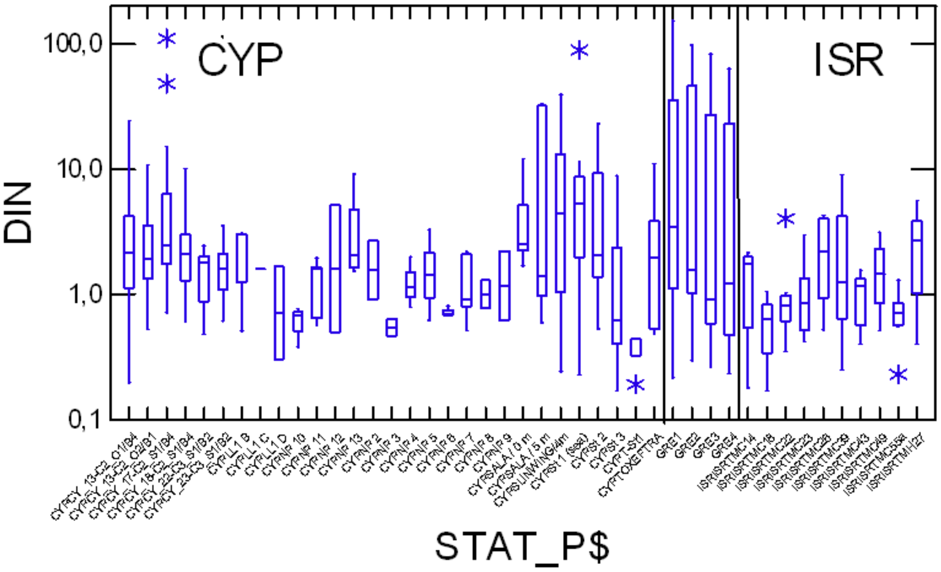

Figure 5. Box and whisker plot for dissolved inorganic nitrogen (DIN) concentration (μmol L^{-1}) in in the Aegean-Levantine Sea subregion (water type IIIE) for Cyprus (CYP) and Israel (ISR).

The available data shows that in areas where assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result also confirms the validity of this indicator in assessing eutrophication.

CONCLUSIONS

The available data show that in areas were assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result also confirm the validity of this indicator as support in assessing eutrophication. Coastal Water type assessment criteria for reference condition and boundaries for key nutrients in the water column have to be built and harmonised through the Mediterranean region, which will greatly help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling for the future implementation of IMAP.

Whilst data was available through the MEDPOL database, and substantial data is also available through EEA, EMODnet-Chemistry (http://www.emodnet-chemistry.eu/) and other sources, priority should be given to ensure Mediterranean countries regularly report quality assured data nutrient data to UNEP/MAP in line with IMAP, and ensure common reporting. Potential integration of data-sets in the future could be considered with EMODnet-Chemistry.

Key messages

- The available data show that assessment is possible. Key nutrient concentrations are within characteristic ranges for coastal areas and in line with the main processes undergoing in concerned interested area.
- Criteria for reference condition and boundaries for key nutrients in the water column have to be built and harmonised through the Mediterranean region.

Knowledge gaps

- At the eutrophication hot spots in the Mediterranean Sea a comprehensive key nutrient concentrations in the water column trend analysis would be beneficial. Significant trends need to be detected from long time series that are able to capture nutrient concentrations changes in coastal waters as the analysis of short time series can erroneously lead to interpret some spatial patterns produced by random processes nutrients concentration trends. For that reason, data availability should be improved. A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute.
- Criteria for reference condition and thresholds/boundary values for key nutrients in the water column have to be built and harmonised through the Mediterranean region. Data availability have to be improved. A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute.

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Ecological Objective 5 (EO5): Eutrophication

EO5: Common Indicator 14. Chlorophyll-a concentration in water column

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Albania, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Montenegro, Morocco, Slovenia, Spain, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO5. 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
IMAP Common Indicator	CI14. Chlorophyll-a concentration in water column (EO5)
Indicator Assessment Factsheet Code	EO5CI14

RATIONALE/METHODS

Background

Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation (IMAP, 2017). Seawaters depending on nutrient loading and phytoplankton growth are classified according to their level of eutrophication. Low nutrient/ phytoplankton levels characterize oligotrophic areas, water enriched in nutrients is characterized as mesotrophic, whereas water rich in nutrients and algal biomass is characterized as eutrophic. The Mediterranean is one of the most oligotrophic seas in the world and most of its biological productivity takes place in the euphotic zone (UNEP, 1989, UNEP/MAP, 2012). The development of nutrient/phytoplankton concentration scales has been a difficult task for marine scientists because of the seasonal fluctuations of nutrient and phytoplankton concentrations, phytoplankton patchiness and small-scale eutrophication phenomena. Although long-term scientific research (UNEP/FAO/WHO1996; Krom *et al.*, 2010) has shown that the main body of the Mediterranean Sea is in good condition, there are coastal areas, especially in enclosed gulfs near big cities in estuarine areas and near ports, where marine eutrophication is a serious threat.

In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive (WFD) and the European Marine Strategy Framework (MSFD) are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 14 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

In the Mediterranean area, eutrophication is caused by both regional sources such as urban effluents, industrial discharges, and aquaculture activities as well as transboundary components such as agricultural runoffs, riverine outflows, and airborne nutrient deposition. The variables related to eutrophication are influenced by water circulation and to regional sources of pollution including eutrophication (UNEP, 2003).

The highly populated coastal zone in the Mediterranean and the riverine input from a draining area of $1.5\ 10^6\ km^2$ (Ludwig *et al.*, 2009) induce eutrophic trends in coastal areas. The offshore waters of the Mediterranean have been characterized as extremely oligotrophic with a clear gradient toward east (Turley, 1999). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Figure 1).

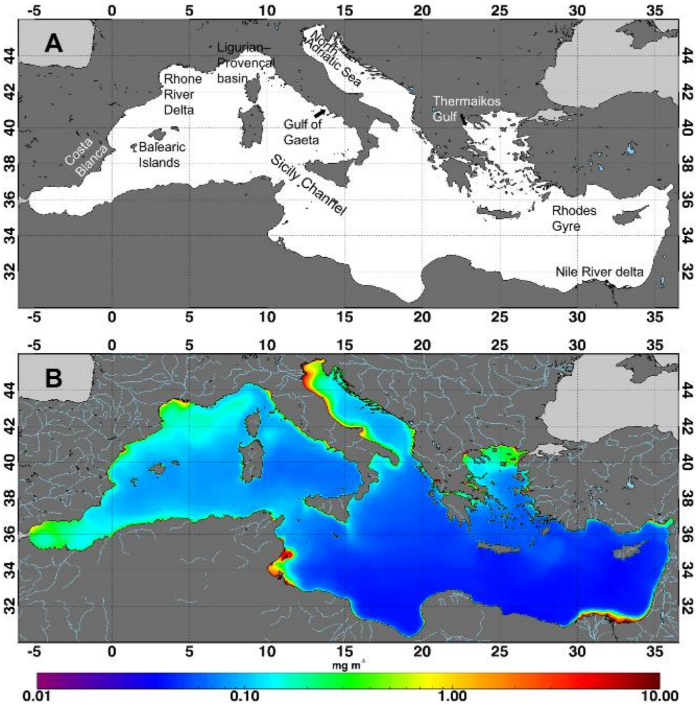

Figure 1. The Mediterranean basin and its chlorophyll *a* concentration pattern. (A) Geographic regions (B) chlorophyll a concentration ($\mu g\ L^{-1}$) climatology over the Mediterranean Sea relative to 1998–2009 time period. From: Colella *et al.*, 2016.

The assessment of eutrophication is a complex matter, since, in the case of coastal environments, "abundance and composition of phytoplankton are characterized by a high degree of space-time variability: the complexity of these areas, due mainly to the high variability of environmental factors and to the responses of the communities, make it difficult to define a regular annual cycle of phytoplankton" (Pugnetti *et al*., 2007. In Italian). This statement clearly indicates that in the field of eutrophication the statistical requirement is essential for an acceptable assessment strategy. The applied WFD requirements in regards of Coastal Water types reference conditions and boundaries in the Mediterranean were developed as a good compromise towards this challenge.

Assessment methods

UNEP/MAP's Pollution Programme (MEDPOL) has a monitoring programme since 1999, based on the contribution of data from Mediterranean countries, including chlorophyll-a. MEDPOL monitoring data was used for this assessment, noting that there are several gaps in the database where there has been inconsistent data reporting from each country over the years.

Coastal Water types reference conditions and boundaries for chlorophyll-a in the Mediterranean were agreed and adopted in the IMAP decision of 2016. (UNEP/MAP, 2016). These criteria were applied for the first time applied on the data available for the Mediterranean through the MED POL Database.

For eutrophication, it is accepted that surface density is adopted as a proxy indicator for static stability of a coastal marine system. More information on typology criteria and setting is presented in document UNEP(DEPI)/MED WG 417/Inf.15:

Type I	coastal sites highly influenced by freshwater inputs,
Type IIA	coastal sites moderately influenced not directly affected by freshwater inputs (Continent influence),
Type IIIW	continental coast, coastal sites not influenced/affected by freshwater inputs (western Basin),
Type IIIE	not influenced by freshwater input (Eastern Basin),
Type Island	coast (western Basin).

Coastal water type III was split in two different sub basins, the western and the Eastern Mediterranean s, according to the different trophic conditions and is well documented in literature. It is recommended to define the major coastal water types in the Mediterranean for eutrophication assessment (applicable for phytoplankton only; Table 1).

Table 1. Major coastal water types in the Mediterranean

	Type I	Type IIA, IIA Adriatic	Type IIIW	Type IIIE	Type Island-W
σ_t (density)	<25	25<d<27	>27	>27	All range
salinity	<34.5	34.5<S<37.5	>37.5	>37.5	All range

With the view to assess eutrophication, it is recommended to rely on the classification scheme on Chlorophyll *a* concentration (μg L^{-1}) in coastal waters as a parameter easily applicable by all Mediterranean countries based on the indicative thresholds and reference values presented in Table 2.

Table 2. Coastal Water types reference conditions and boundaries in the Mediterranean

Coastal Water Typology	Reference conditions of Chl*a* (μg L^{-1})		Boundaries of Chl*a* (μg L^{-1}) for G/M status	
	G_mean	90%	G_mean	90% percentile
Type I	1,4	3,33* - 3,93**	6,3	10* - 17,7**

Type II-FR-SP		1,9		3,58	
Type II-A Adriatic	0,33	0,8	1,5	4,0	*
Type II-B Tyrrhenian	0,32	0,77	1,2	2,9	
Type III-W Adriatic			0,64	1,7	
Type III-W Tyrrhenian			0,48	1,17	
Type III-W FR-SP		0,9		1,80	
Type III-E		0,1		0,4	
Type Island-w		0,6		1,2 – 1,22	

applicable to Gulf of Lion

** applicable to Adriatic

For the presentation of the data Box and Whisker plots are used. Information contained in the plot are Hspreads (interquartile range - the absolute value of the difference between the values of the two hinges) and fences that define outside and far outside values:

Lower inner fence = lower hinge - (1.5 • (Hspread))
Upper inner fence = upper hinge + (1.5 • (Hspread))
Lower outer fence = lower hinge - (3 • (Hspread))
Upper outer fence = upper hinge + (3 • (Hspread))

The whiskers show the range of observed values that fall within the inner fences. As the whiskers do not necessarily extend all the way to the inner fences, values between the inner and outer fences are plotted with asterisks. Values beyond the outer fences are plotted with empty circles.

In this assessment, aware that for most of the northern Mediterranean countries data are available also in other databases (i.e. EEA, EIONET, EMODnet), only datasets obtained from the MED POL Database for chlorophyll *a* were used. Data availability by country were as follows: Albania (2005-2006), Bosnia and Herzegovina (2006-2008), Croatia (2009, 2011-2014), Cyprus (1999-2015), Egypt (2009, 2010), France (2009-2010, 2011, 2012), Greece (2004-2006), Israel (2001-2012), Montenegro (2008-2012, 2014-2015), Morocco (2006, 2007), Slovenia (1999-2013, 2015-2016), Tunisia (2002-2013), Turkey (2005-2009, 2011, 2013).

RESULTS

Results and Status, including trends

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area of 1.5 million km^2 (Ludwig *et al.* 2009) that induce eutrophic trends in coastal areas. The blue offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards (Turley 1999). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Figure 1). This is due to the low nutrient content of EMS; the maximum concentrations recorded for nitrate were about 6 μmol L^{-1}, for phosphate 0.25 μmol L^{-1}, and for silicate 10–12 μmol L^{-1}, with the nitrate to phosphate ratio (N/P) >20 and in deep waters about 28:1, the EMS has been characterized as the largest phosphorus-limited body of water in the global ocean.

The coastal area of the southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are becoming limited because of the Aswan Dam and increasing trends in anthropogenic water use in the lower Nile. Eutrophic conditions in the area are mainly induced by the sewage effluents of Cairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends [1]. This can be explained by the river inputs from northern Greece and the water inflow from the nutrient rich Black Sea (Karydis and Kitsiou, 2012).

The nutrient regime and primary productivity in the Western Mediterranean Sea (WMS) are relatively higher compared to the EMS. There is limited nutrient supply through the Strait of Gibraltar due to different nutrient concentrations between the Atlantic and Mediterranean waters. The surface water entering from the Atlantic carry nutrients directly available for photosynthesis (EEA 1999) but at low concentrations. The phosphorus (phosphate) concentrations in the inflowing waters ranges from 0.05 to 0.20 μmol L^{-1}, the nitrogen (nitrate) concentrations being about 1–4 μmol L^{-1}, and the silicon (silicate) concentration is about 1.2 μmol L^{-1} (Coste *et al.* 1988). The nutrients of the surface layer are reduced as they propagate eastwards due to mixing with poor basin water and nutrient use by phytoplankton. However, the primary productivity of the main WMS, away from the coastal areas and influenced by rivers and urban agglomerations, is still higher than the primary productivity in the EMS.

The main coastal areas in the Mediterranean which are historically known to be influenced by natural and anthropogenic inputs of nutrients are the Gulf of Lions, the Gulf of Gabès, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine). A recent work on nutrient and phytoplankton distribution along a large-scale longitudinal east–west transect (3 188 km) of the Mediterranean Sea extended over nine stations was published by Ignatiades et al. (2009). The results confirmed the oligotrophic character of the area and the nutrient and chlorophyll gradient characterized by decreasing concentrations from Gibraltar to the sea of Levantine. Phosphate maxima ranged from 0.05 to 0.26 μmol L^{-1}, nitrate from 1.87 to 4.04 μmol L^{-1}, chlorophyll *a* (chl*a*) from 0.39 to 0.96 μg L^{-1}.

The results of assessment and status of chlorophyll *a* concentration in the water column are presented on Figs 2-7 showing a rather limited figure of the Mediterranean region. The main reason is the data availability and quality. In Figure 2 it is clearly visible that for the great part of the region data are missing. The implementation of water type criteria for the purpose of IMAP are also limited. Even a rather weak criteria (10 samples in 10 years in surface layer - <= 10 m) were adopted the data availability for assessment were low.

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[1] Eutrophic trends are related to the changes of impact of nutrients (pressures). They can be upward or downward. Consult Colella te al., 2016 for details of Mediterranean trend from satellite.

Figure 2. Stations in the Mediterranean region for which eutrophication parameter were sampled. Also are shown the water types (applicable for phytoplankton; IMAP. 2017) were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

On Figs 3-7 assessment data for all four sub-regions applying the Coastal Water types reference conditions and boundaries in the Mediterranean (applicable for phytoplankton; IMAP. 2017) are presented. For the Western Mediterranean Sea sub-region (Figure 3) only a limited set of data for France (from 2009 and 2012) were assessed indicating that none of the stations in the Golf of Lyon were in moderate state.

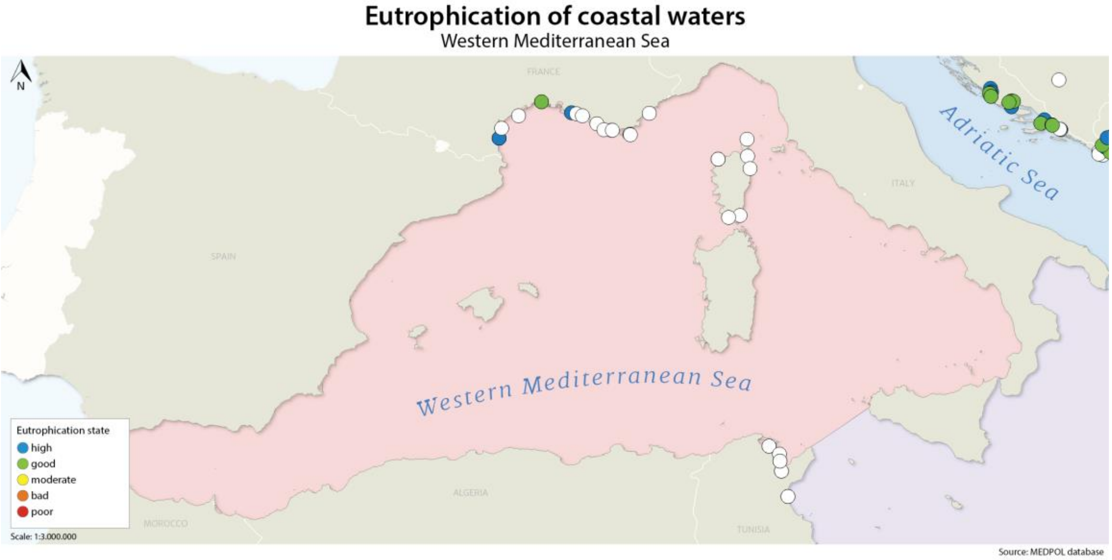

Figure 3. Stations in the Western Mediterranean Sea sub-region for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

In the Adriatic Sea sub-region (Figs 4-5) only the eastern part was assessed (Slovenia, Croatia and Montenegro). The applied criteria show that all the stations in the assessed area in good status in relation to the criteria. The Box and Whisker plot (Figure 5) shows even more details. Such a graphical representation is very useful for a geographical assessment and represent a good potential for the time series analysis.


Eutrophication of coastal waters
Adriatic Sea

Source: MEDPOL database

Figure 4. Stations in the Adriatic Sea sub-region for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

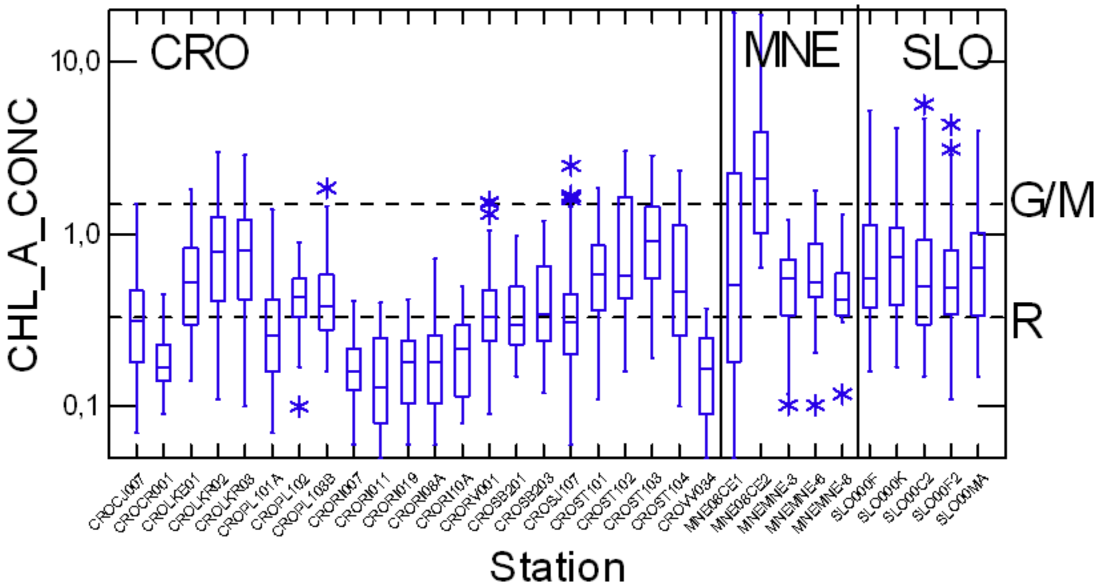

Figure 5. Box and whisker plot for chlorophyll *a* concentration in the Adriatic Sea sub-region (water type IIA) for which coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for Croatia (CRO), Montenegro (MNE) and Slovenia (SLO).

For the Ionian Sea and the Central Mediterranean Sea sub-region (the assessment was not performed as insufficient data were available.

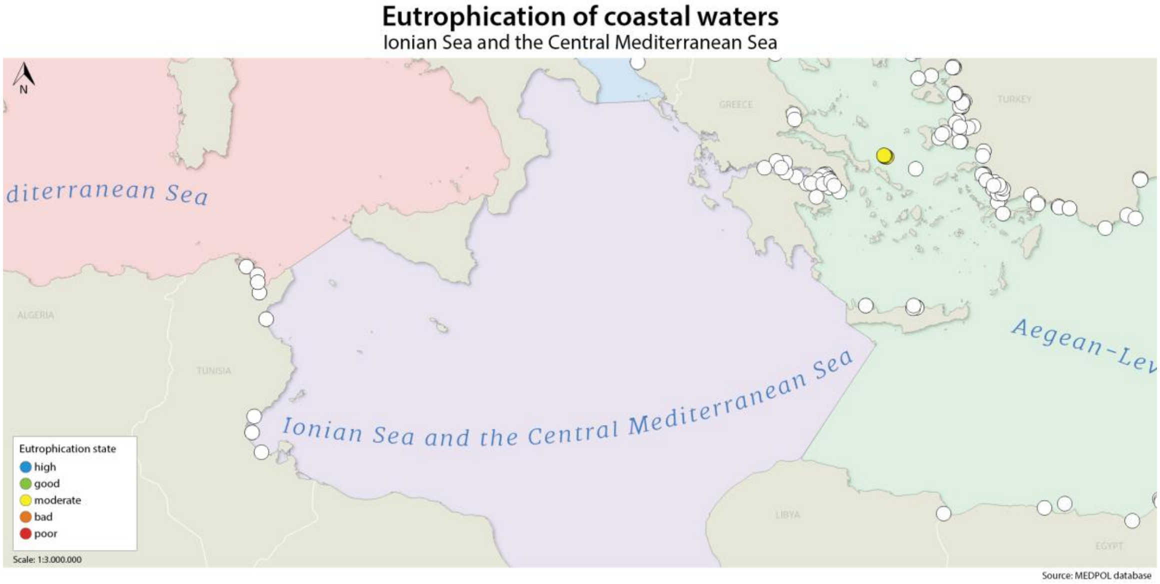

Figure 6. Stations in the Ionian Sea and the Central Mediterranean Sea subregion for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

In the Aegean-Levantine Sea subregion (Figs 7-8) the assessed country were Cyprus and Israel, and partially data for Turkey (Mersin area) were also used. The applied criteria (Water type IIIE) showed that practically all the stations in the Cyprus area are at list in good status. The Box and Whisker plot (Fig. 8) shows even more details. The data for Israel and Mersin area (Turkey) indicate that the areas were in moderate state. Probably the criteria for Water type IIIE in this area are too rigorous because it is close to the coast and ports.

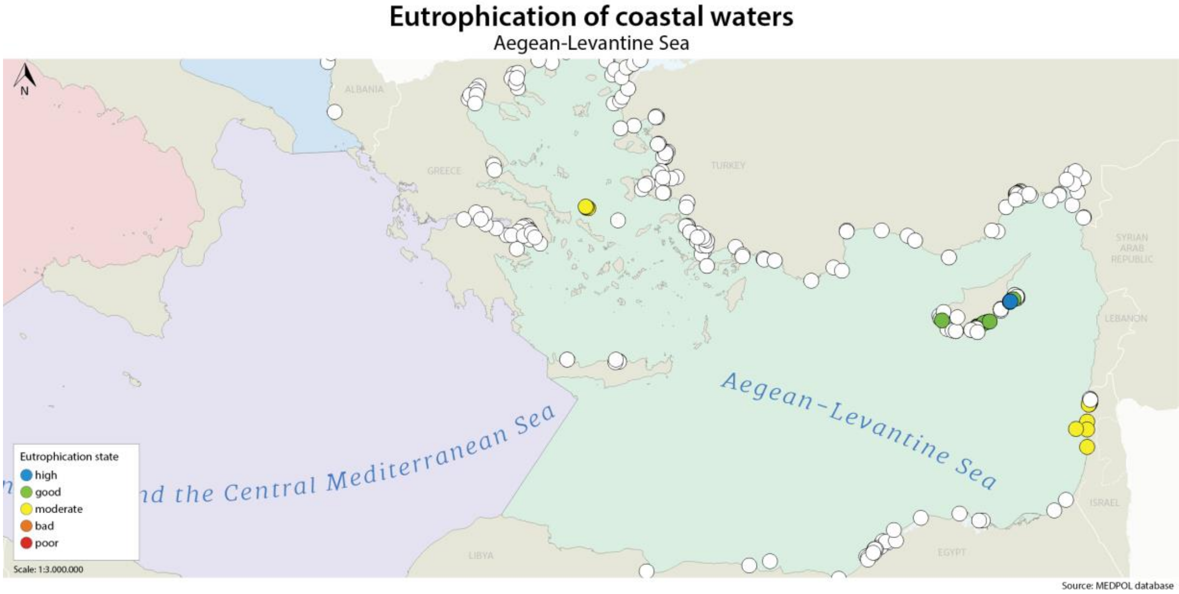

Figure 7. Stations in the Aegean-Levantine Sea sub-region for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were

minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

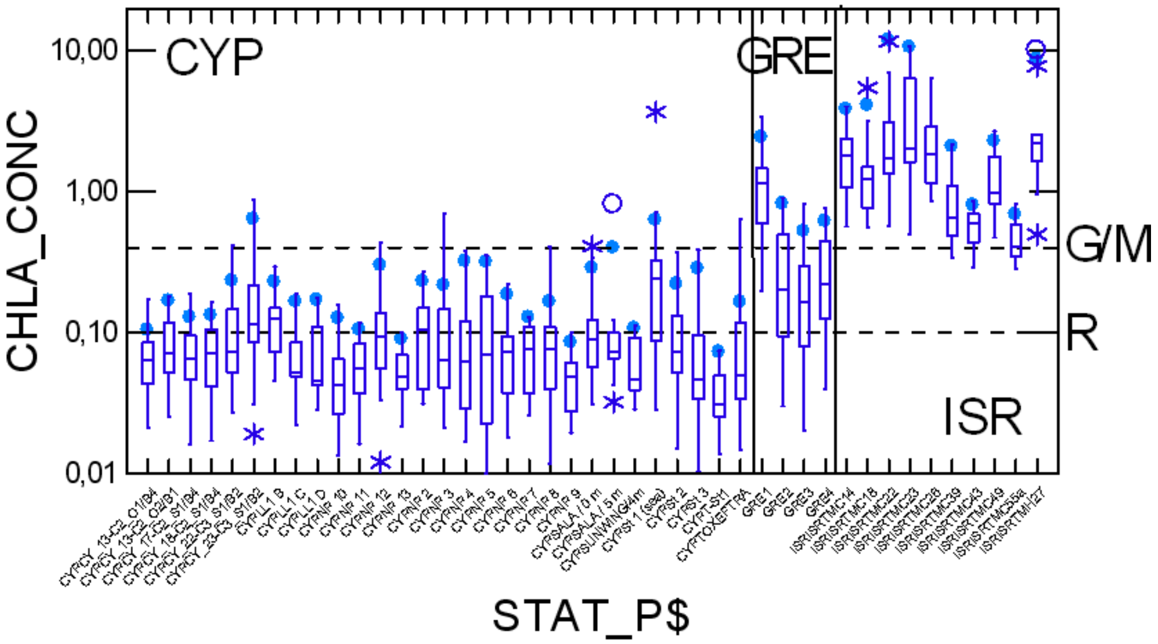

Figure 8. Box and whisker plot for chlorophyll *a* concentration in the Aegean-Levantine Sea sub-region (water type IIIE) for which coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017). The blue dots represent the 90-percentile value for Cyprus (CYP), Greece (GRE) and Israel (ISR)

At the eutrophication hot spots in the Mediterranean Sea a comprehensive chlorophyll *a* trend analysis would be beneficial. Significant chlorophyll *a* trends need to be detected from long time series that are able to capture biomass changes in coastal waters as the analysis of short time series can erroneously lead to interpret some spatial patterns produced by random processes as chlorophyll *a* concentration trends.

Satellite synoptic measurements for the estimation of chlorophyll *a* concentration trends have the potential to detect anomalous, local biogeochemical processes and to assess the different applications of environmental regulations. Recent use of this data (Colella *et al.*, 2016) allowed for a consistent monitoring of biogeochemical issues in the Mediterranean basin. At large scale, positive trends off the South-East Spanish coast, in the Ligurian–Provençal basin, and in the Rhodes Gyre region, while an intense negative trend in the North Adriatic Sea, off the Rhone River mouth, and in the Thermaikos Gulf (Aegean Sea) were detected.

This potential to assess eutrophication problems is welcome, however, the satellite framework might need of larger, multi-sensor datasets and it surely requires to be combined with the analysis of in situ supplementary, biogeochemical data.

CONCLUSIONS

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area. Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards. The Eastern Mediterranean Sea (EMS) is still the most oligotrophic area of the whole Mediterranean basin, and the largest phosphorus-limited body of water in the global ocean.

The coastal area of the southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are getting limited because of the Aswan Dam and increasing trends in anthropogenic water use in the lower Nile. Eutrophic conditions in the area are mainly induced by the sewage effluents of Cairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends explained by the river inputs from northern Greece and the water inflow from the nutrient rich Black Sea.

The nutrient regime and primary productivity in the Western Mediterranean Sea (WMS) are relatively higher compared to the EMS. However, the primary productivity of the main WMS, away from the coastal areas and influenced by rivers and urban agglomerations, is still higher than the primary productivity in the EMS.

The main coastal areas in the Mediterranean which are historically known to be influenced by natural and/or anthropogenic inputs of nutrients are the Alboran Sea, the Gulf of Lions, the Gulf of Gabès, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine).

The available data show that in areas were assessment is possible the IMAP assessment criteria for eutrophication based on CI14 (Chlorophyll *a* concentration in the water column) are applicable and confirm the main status of eutrophication in the coastal area. In term of GES achievement in these areas (Eastern Adriatic and Cyprus) it is maintained.

Coastal Water type reference condition and boundaries for CI14 (Chlorophyll *a* concentration in the water column) have to be harmonised through the south Mediterranean region which has not yet participated in the assessment effort. The assessment can also help to identify areas were the criteria have to be improved. Of great help will be the implementation of a sampling strategy with simplified approach in monitoring design and data handling.

Satellite synoptic measurements for the estimation of chlorophyll *a* concentration trends have the potential to detect anomalous, local biogeochemical processes and to assess the different applications of environmental regulations.

Key messages

- Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards.
- The main coastal areas in the Mediterranean which are historically known to be influenced by natural and/or anthropogenic inputs of nutrients are the Alboran Sea, the Gulf of Lions, the Gulf of Gabès, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine).
- The available data show that in areas were assessment is possible the IMAP assessment criteria for eutrophication based on CI14 (Chlorophyll *a* concentration in the water column) are applicable and confirm the main status of eutrophication in the coastal area.

Knowledge gaps

- There are no main gaps identified in the Mediterranean Sea concerning the assessment of the Common Indicator 14.
- However, significant chlorophyll *a* trends need to be detected from long time series that are able to capture biomass changes in coastal waters, and for that purpose data availability have to be improved.
- A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute. Satellite synoptic measurements for the estimation of chlorophyll *a* concentration trends have the potential to detect anomalous, local biogeochemical processes and to assess the different applications of environmental regulations.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Malta, Montenegro, Morocco, Slovenia, Spain, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI17. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)
Indicator Assessment Factsheet Code	EO9CI17

RATIONALE/METHODS

Background (short)

The status and impact of the chemical contamination in the marine environment is the result of the human activities (drivers and pressures) that take place all around the coastal and marine areas of the Mediterranean Sea and cause imbalance to ecosystems from their natural steady-state conditions. The sources of contaminants can be of natural origin (e.g. heavy metals) or synthetic man-made chemicals (e.g. pesticides). Primarily, harmful contaminants enter the marine ecosystem through different routes, such as atmospheric deposition or inputs from land-based (and sea-based) sources. For example, in the Mediterranean coasts, from small recreational marinas up to major commercial ports, which number thousands, have created a number of different pressures in terms of chemical pollution. At present, there are still old threats and new pressures, although the trends and levels of the so-called legacy pollutants (e.g. heavy metals, persistent organic pollutants and pesticides), have decreased significantly in the most impacted areas in the Mediterranean Sea after the implementation of environmental measures (e.g. leaded-fuels ban, mercury regulations, anti-fouling paints ban), as observed in the Western Mediterranean Sea (UNEP/MAP/MEDPOL, 2011a). The major MED POL contaminant group (i.e. heavy metals), were considered for this assessment, as there is a significant number of quality assured datasets available from Mediterranean countries. On the other hand, despite the implementation of the MED POL monitoring for chlorinated compounds during almost two decades, the availability of new data with sufficient spatial geographical coverage and quality assured impedes to further assess their occurrence in the Mediterranean Sea region, beyond known sources and hotspots in coastal areas. On the other hand, most of the recent datasets show non-detectable levels, mainly in biota matrices, which is in accordance with the earlier decreasing levels and trends observed in previous MAP reports (UNEP/MAP/MED POL 2011a, 2011b, 2012). However, there are still point and diffuse pollution sources releasing both priority and emerging chemical contaminants (e.g. pharmaceuticals, personal care products, flame retardants) in the Mediterranean Sea. The land-based sources (LBS) of contaminants impacting the coastal environment enter both via treated (or non-treated) wastewater discharges and represent a major input, whilst in terms of diffuse pollution sources, land based run-off and atmospheric deposition (wet/dry deposition and diffusive transport) are the two major contributors to the coastal areas. The sea-based sources themselves are also accounted (i.e. direct inputs from maritime and industrial activities, such as shipping, fishing, oil refining oil and gas exploration and exploitation) which could be permanent chronic sources of pollution in the marine environment, including the potential for acute pollution events.

Good Environmental Status (GES) for Common Indicator 17 (CI 17) can be accomplished when levels of pollution would be below a determined threshold (e.g. Environmental Assessment Criteria (EACs); ERLs). To this regard, the threshold concentrations for specific harmful chemicals should be maintained below levels were chronic effects are not expected and without deterioration trends, as well as the reduction of contaminant emissions form land-based sources should be achieved (UNEP/MAP, 2013, 2015).

Figure1: Muddy sediment sample taken with a large grab sampler. The top 1 cm layer is collected for chemical pollution analyses. The oxic and anoxic layers can be clearly observed,

Background (extended)

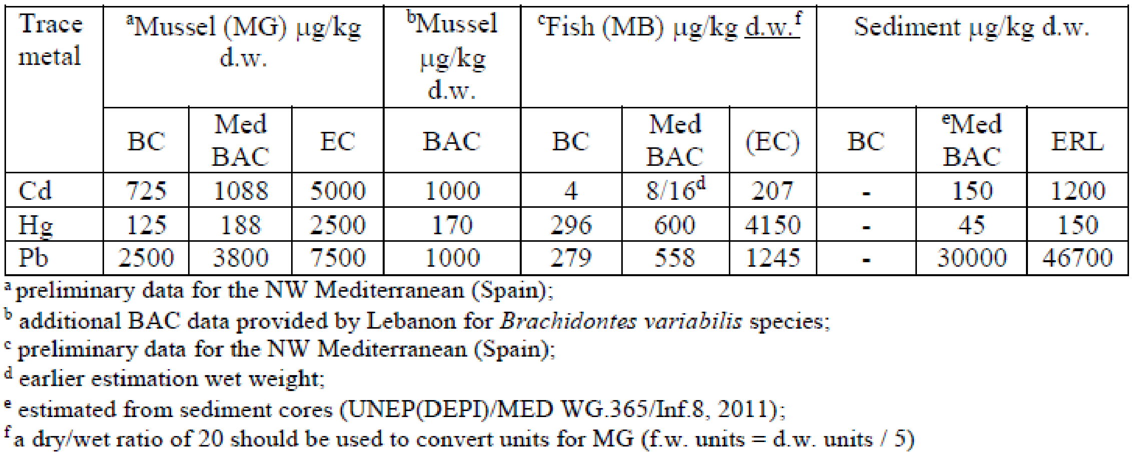
In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally-binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. The MAP/MED POL (Programme for the Assessment and Control of Marine Pollution) was implemented and the coastal long-term monitoring networks developed from 1999. Its NBB/PRTR component (National Baseline Budget/Pollutant Release and Transfer Register) allows the Contracting Parties of the

Barcelona Convention to submit the data related to national loads of pollutants discharged directly or indirectly into the Mediterranean Sea for whom it is worth marine monitoring. Since 2000, other international and national policies, such as the European Water Framework Directive (WFD) and the European Marine Strategy Framework Directive (MSFD) are developing strategies in the Mediterranean Sea which aims to its environmental protection at sub-regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 17 are based upon data for a relatively small number of chemicals, reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

Assessment methods

The method for the assessment has been undertaken by evaluating the latest and available MED POL datasets of levels of chemical contaminants against set environmental criteria (for different matrices) at a regional scale. Heavy metals (Cadmium, Mercury and Lead), petroleum hydrocarbons and persistent organic pollutants (POPs) -from the national coastal monitoring networks reported to the MEDPOL Database- were initially evaluated. However, petroleum hydrocarbons and POPs show a data scarcity, a lack of regional coverage and mostly non-detected concentrations, and therefore, this assessment focus on heavy metals (Hg, Pb and Cd) at a regional scale. Three different matrices have been considered, bivalves, fish and sediments, and their contaminant levels compared against background thresholds (BACs), (UNEP/MAP, 2016). It should be pointed out, that accurate environmental assessment criteria (EACs) defining acceptable or non-acceptable environmental chemical status in the Mediterranean Sea from an environmental perspective have not been determined yet. However, for indicative purposes an effort is made to assess GES relying on thresholds, adopted by the COP19 in February 2016 for the Mediterranean Sea (UNEP/MAP, 2016), that are based on European policy for biota (EC/EU 1881/2006 and 629/2008 Directives for maximum levels for certain contaminants in foodstuffs) and US ERL values (US Effects Range Low sediment toxicological criteria) for sediments (Table 1), although the former might not be environmentally accurate. Despite this limiting fact, this follows the approach taken by other Regional Seas (i.e. OSPAR).

Table1: IMAP Assessment Criteria for Heavy Metals and other existing assessment criteria



Trace metal	[a]Mussel (MG) µg/kg d.w.			[b]Mussel µg/kg d.w.	[c]Fish (MB) µg/kg d.w.[f]			Sediment µg/kg d.w.		
	BC	Med BAC	EC	BAC	BC	Med BAC	(EC)	BC	[e]Med BAC	ERL
Cd	725	1088	5000	1000	4	8/16[d]	207	-	150	1200
Hg	125	188	2500	170	296	600	4150	-	45	150
Pb	2500	3800	7500	1000	279	558	1245	-	30000	46700

[a] preliminary data for the NW Mediterranean (Spain);

[b] additional BAC data provided by Lebanon for *Brachidontes variabilis* species;

[c] preliminary data for the NW Mediterranean (Spain);

[d] earlier estimation wet weight;

[e] estimated from sediment cores (UNEP(DEPI)/MED WG.365/Inf.8, 2011);

[f] a dry/wet ratio of 20 should be used to convert units for MG (f.w. units = d.w. units / 5)

The species of bivalves (*Mytilus galloprovincialis, MG; Ruditapes decussates, RD; Mactracorralina, MC and Donaxtrunculus, DT)*) and fish (*Mullus barbatus MB)* were evaluated, as well as levels reported in coastal sediment samples. The methodology is based on the calculation of the percentages of stations (units) with levels below or above the BACs and above ECs and ERLs, and plotted spatially (see GIS maps under "Results"). At present, the later criteria, ECs or ERLs, determine the chemical status of the Mediterranean environment.

In brief, the latest relevant year (or years) of previously non-evaluated MED POL datasets allowing a maximum spatial coverage were selected for each country and matrix in order to construct a regional state assessment integrated over time which reflects the temporal availability of the Contracting Parties datasets. The biota datasets from countries reporting consecutive years were examined to evaluate their consistence (i.e. coordinates, values, methods, DLs) before the selection of the latest dataset for evaluation. Alternatively, the sediment datasets from Mediterranean Contracting Parties were mixed to provide a greater spatial coverage when locations changed for submitted years (ca. sediments). The datasets were also averaged when reported yearly replicate samples for the same station.

The biota metrics employed for the assessment was µg/kg dry weight (ppb) for bivalve samples (whole soft tissue) and µg/kg fresh weight (ppb) for fish (fillet tissue), for whom the methodologies and data format is harmonized through the MED POL countries. For sediments (in µg/kg dry weight), the data by stations was averaged (or by area when close stations were reported), in line with the regional scale of the assessment and the volume of data available. The levels of contaminants in sediment samples includes different fractions as available in the MED POL Database submitted by CPs and these were combined spatially for the evaluation (ranging from >60µm up to the whole sample analysis).

The datasets used from the MED POL Database for each country and matrix was as follows:

- Bivalves: Croatia (2009, 2011-2014), Egypt (2009-10), France (2012), Israel (2012-13, including 2011 for Pb), Italy (2009), Montenegro (2009-2011), Morocco (2015), Slovenia (2015), Spain (2011), Tunisia (2010-13), Turkey (2009, 2011)
- Fish: Cyprus (2014-2015), Greece (2005), Israel (2013), Spain (2006-08), Turkey (2013)
- Sediments: Croatia (2011, 2013), Egypt (2006, 2009, 2010), France (2009-2011), Greece (2005), Israel (2013), Italy (2009), Montenegro (2010-2011), Morocco (2015), Spain (2007-08, 2011), Tunisia (2012, 2013), Turkey (2013).

The quality of the major MED POL contaminant groups' datasets were considered, in particular, for heavy metals where a major number of quality assured datasets were available. In the course of preparing the current assessment, several countries provided new additional data that will be used to perform future assessments (e.g. Tunisia, Turkey, Israel, Montenegro and Slovenia). Malta provided relevantinformation on the chemical status of coastal Maltese marine waters, but due to different formats the available seawater data could not be merged with the current MED POL datasets.

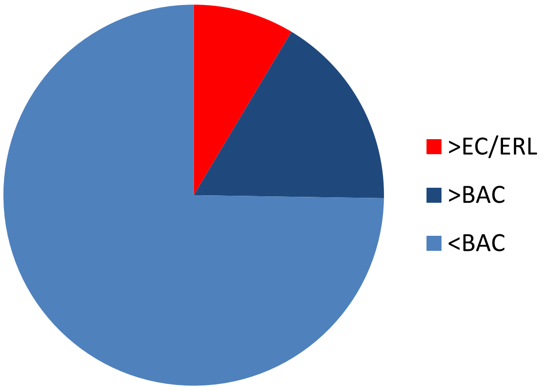


Figure 2. Graph showing the percentage of stations with contaminant concentrations below and above Background Assessment Criteria (BACs), and above ECs or ERLs for biota and sediment, respectively, see text).

RESULTS

Results and Status, including trends (brief)

The latest available datasets of contaminants reported to the MED POL Database continues to indicate lower levels of legacy pollutants and contaminants in the Mediterranean Sea biota (mainly bivalves), despite known hotspots, similarly to the previous assessment reports (UNEP/MAP, 2009; UNEP/MAP/MED POL, 2011a; UNEP/MAP, 2012a, 2012b) and temporal trends reports (UNEP/MAP/MED POL, 2011b, 2016b), whilst chemicals show their accumulation and persistence in the coastal sediments. The monitored chemical contaminants in different matrices, namely bivalves (e.g. mussels, clams), fish and sediments and their assessment against Background Assessment Criteria (BACs) and ECs and ERLs, for biota and sediment, also point to this conclusion. In general terms, for biota (bivalves and fish), the percentage of stations with acceptable environmental conditions, that is below the EC threshold criteria, range from 92% to 100% for Cd, Pb and HgT. Solely some stations assessed for Pb in mussels shows levels above Pb EC for a 8% of the stations at a regional scale. Therefore, all the MED POL assessed stations for biota show acceptable marine environmental conditions except 8% of them for Pb according these criteria. On the contrary, the calculated percentages of the monitored levels in the coastal sediments above the assessment criteria (ca. >ERLs), that is non-acceptable environmental conditions, are a 4%, 53% and 15% for Cd, HgT and Pb respectively. Mercury with a 53% of the monitored stations above the ERL in the coastal Mediterranean Sea sediments reflects the need of revised sub-regional assessment criteria, thus a mixture of natural and anthropogenic known sources might influence the assessment, especially in the Adriatic Sea, the Aegean Sea and Levantine Seas. To this regard, a revision of the current assessment criteria is under consideration (UNEP/MAP/MED POL, 2016a) which should further refine these findings in future assessments.

Figures 3 to 11 show the spatial results of the assessment performed at regional scale for the whole Mediterranean basin. The matrices evaluated were coastal populations of marine bivalves (such as *Mytilus galloprovincialis*), fish (such as *Mullus barbatus*) and sediments. Based on the EAC values recommended for indicative purposes (such as medical purpose) by COP 19 Decision IG. 22/7, overall, both the calculations and spatial plots assessments reflect some non-acceptable environmental conditions, particularly, for Pb in mussels in some locations and both Pb and HgT (53% of the stations >ERL criteria) in coastal sediments, although some are known Mediterranean Sea hotspots and natural input areas. To guarantee the control and achievement of targets (for example, to maintain current acceptable conditions for Cd and HgT in biota), avoiding future deteriorations of the environmental conditions of the coastal marine environment, there is a need for continuous monitoring and assessment.

Based on the EAC values recommended for indicative purposes by COP 19 Decision IG. 22/7, overall, both the calculations and spatial plots assessments reflect some non-acceptable environmental conditions, particularly, for Pb in mussels in some locations and both Pb and HgT (53% of the stations >ERL criteria) in coastal sediments, although some are known Mediterranean Sea hotspots and natural input areas. To guarantee the control and achievement of targets (for example, to maintain current acceptable conditions for Cd and HgT in biota), avoiding future deteriorations of the environmental conditions of the coastal marine environment, there is a need for continuous monitoring and assessment.

Results and Status, including trends (extended)

Cadmium, mercury and lead in Mediterranean bivalves.

The Figures 3 to 5 shows the distribution of the assessment performed for heavy metals in the Mediterranean Sea in bivalves. The stations are located mostly in the Western Mediterranean Sea and the Adriatic Sea sub-regions.

The assessment primarily shows that Cd and HgT levels are not above the assessment criteria, as described above, thus indicating acceptable environmental conditions using this currently accepted criteria (the ECs, the EU maximum levels permitted in foodstuffs, including marine bivalves for human consumption), although these criteria might be too elevated from an environmental protection perspective. Nevertheless, the situation in terms of heavy metal pollution is an improvement of the early reported scenario (UNEP/MAP/MEDPOL 2011a).It seems that 100% of stations are below ECs criteria, the 81% and 72% of the monitored data for Cd and HgT in bivalves, respectively, are also below the Background Assessment Criteria (BACs) which further indicates natural background levels for these heavy metals. In the same way, the Pb assessment shows the environmental status situation in the Mediterranean basin, despite major mining and industrial activities with levels above the set ECs in the coasts of Spain, Italy and Croatia still known hotspots. In detail, a 92% of the stations are below the PbEC criteria (82% below BAC and 10% above BAC), whilst a 8% above the EC indicates that the environmental situation should improve in these areas. It should be mentioned that a single set of assessment criteria has been used for the four bivalve species monitored in the Mediterranean coasts, as a first approximation, taking into account the similar sizes of the mollusks and the results reported so far (UNEP/MAP/MED POL, 2016a).

Cadmium, mercury and lead in Mediterranean fish.

The new assessment for the pilot projects implemented by some Contracting Parties with regard the monitoring of levels of contaminants in fish shows an acceptable environmental situation (Figures 6 to 8). The assessment of the heavy metals indicates an acceptable environmental status with very few stations above the BACs and none above the ECs. Particularly, the 91%, 83% and 94% of the evaluated stations in both the Western and Eastern geographical areas shows values below the BACs for Cd, HgT and Pb indicating naturally occurring levels in fish.

Cadmium, mercury and lead in Mediterranean coastal sediments.

The Figures 9 to 11 show the assessment for coastal sediments against BACs and ERLs for the latest information available in the Mediterranean Sea. The concentrations of heavy metals in the coastal sediments shows a different picture with respect the environmental information for biota, in particular for HgT and Pb. The number of samples over the ERLs values are higher in this matrix, which responds to the known environmental processes for chemical contaminants in the marine environment were the final compartment is known to be the coastal sediments. Cd shows only 6% and 49% of the evaluated stations above the ERL and BAC, respectively, therefore a 94% of sediment stations with acceptable environmental levels of cadmium below the Cd ERL. However, few of these 6% of stations are known to be impacted by anthropogenic sources, whilst others respond to different natural input processes, such as the input of Cd from the Atlantic waters through the Gibraltar Strait, which can be observed close to this area in Figure 5.

Contrarily, HgT concentrations in the coastal sediments reflect a situation far from a good environmental status (GES), according to the current regional assessment criteria, particularly in the NW Mediterranean, the Adriatic Sea, the Aegean Sea and the Levantine Sea basins. All the data assessed in the different sub-regions shows a 53% of the stations above the ERL. Thus, a 30% above the BAC and 17% below BAC in the coastal sediment sums a limited 47% of the monitored stations with acceptable environmental conditions. The main sources of this mercury in the marine environment are due to the industrial exploitation of mines of the Hg-rich natural land resources in these areas. It should be pointed out that the reference values agreed are based on information from core sediments collected in the Mediterranean Sea and the revision of these values has been proposed (UNEP/MAP MED POL, 2016a) to include sub-regional criteria to balance the potential geological background differences through the Mediterranean basins in future assessments. On the contrary, for Pb, a, different geographical composition between the Western and Eastern Mediterranean coastal sediments might overestimate the acceptable environmental conditions for the latter, if a single set of regional assessment criteria is used (UNEP/MAP/MED POL, 2016a). For Pb, a 15% of the stations are above the ERL, thus a 85% of stations with acceptable environmental conditions, with only a 11% above the BAC. As mentioned above, however, none of the stations evaluated in the Eastern Mediterranean coasts show values above the ERL, and for the Levantine Sea none of the stations show even values above the BAC criteria; therefore, reflecting that different assessment criteria for Pb at sub-regional scales in the Mediterranean Sea should be considered, thus some known hotspots for Pb inputs are known in some Eastern Mediterranean Sea locations. As for the case of HgT, the PbBAC and ERL assessment criteria, for sediments at a sub-regional scales are under proposal to refine the future assessments (UNEP/MAP MED POL, 2016a).

Persistent Organic Pollutants (POPs) and Non-halogenated compounds.

Persistent organic pollutants (POPs) include certain legacy chlorinated pesticides and industrial chemicals, such as the so called polychlorinated biphenyls (PCBs), most of which have already been prohibited at global scale under the Stockholm Convention. These chemical substances are resistant to environmental degradation processes, and therefore persistent and prone to long-range transport. In the marine environment, the bioaccumulation and biomagnification in organisms have been largely investigated, as well as their implications for human health. The scarcity of recent POPs quality assured datasets in the

MED POL Database and the fact that most of these show non-detectable levels, mainly in biota matrices, is in accordance with the earlier lowering levels and trends observed in previous reports (UNEP/MAP/MED POL 2011a, 2011b, 2012) and no further updates could be performed at present.

Similarly, the historical levels of petroleum hydrocarbons from a number of urban, industrial and sea activities in the marine environment have been reduced, probably the most significant example is the reduction of the spilled oil in the Mediterranean Sea (i.e. acute pollution) compared to previous decades. However, continuous chronic oil petroleum pollution continues associated to main harbors, sea-based sources and atmospheric inputs. Oil is composed of thousands of compounds and includes the group of the Polycyclic Aromatic Hydrocarbons (PAHs) which some of them are the current targeted compounds. Further, it is interesting to point out the overlooked importance of inputs from particular marine operations, such as the oil exploitation, due to the introduction of PAHs in the marine environment but also of other chemicals (e.g. phenols) along with the produced-water from these installations.

Emerging chemical compounds.

The occurrence of emerging compounds in the Mediterranean Sea has gained relevance over the last decade both in the northern and southern coasts. Different groups of chemicals, such as environmental phenols, pharmaceutical compounds, personal care products, polycyclic fragrances and many others are currently under investigation. Particularly, it is worth to mention as well, the recent focus on the occurrence of marine litter from nano to macro sizes in the marine ecosystems, a new major treat for the Mediterranean Sea.

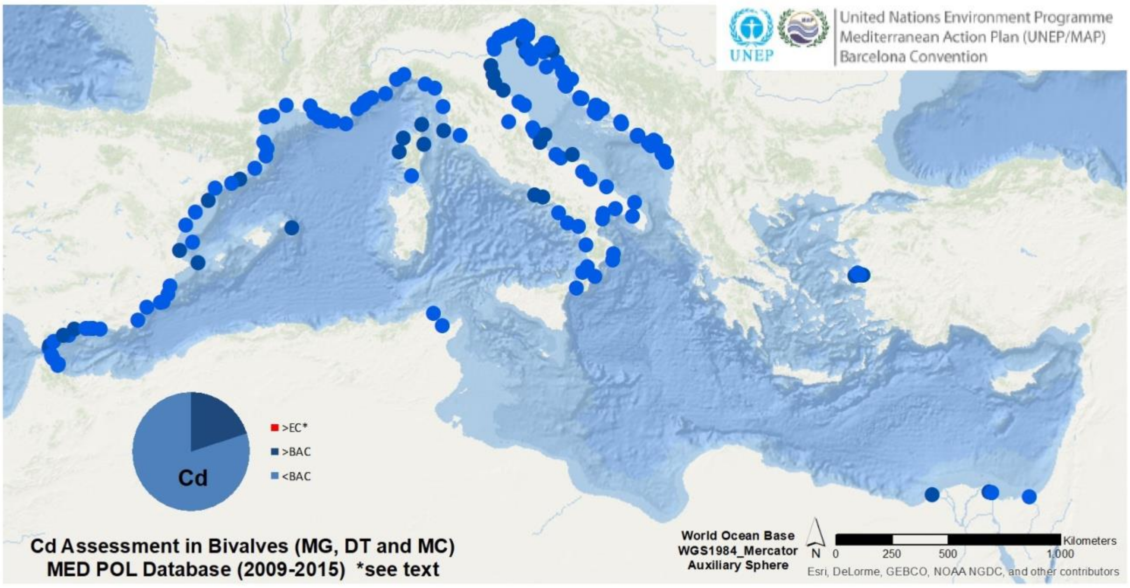


Figure 3. Regional Cadmium levels assessment against ECcriteria in bivalve sp. (*Mytilusgalloprovincialis, Ruditapesdecussates,Donaxtrunculus and Mactracorralina*) for the Mediterranean Sea

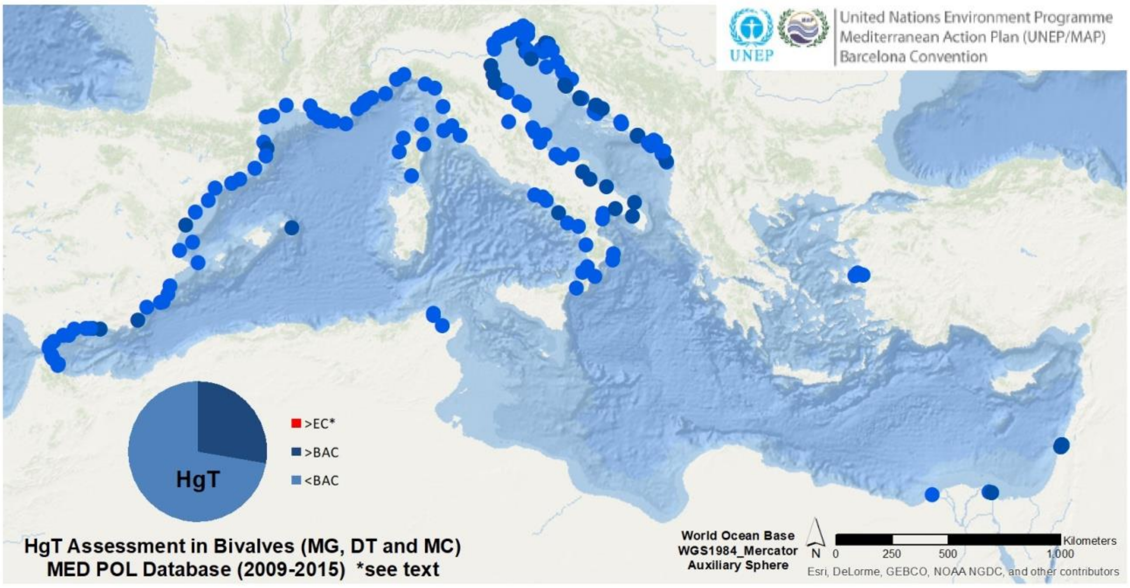


Figure 4. Regional Mercury levels assessment against EC criteria in bivalve sp. (*Mytilusgalloprovincialis, Ruditapes decussates, Donaxtrunculus and Mactracorralina*) for the Mediterranean Sea

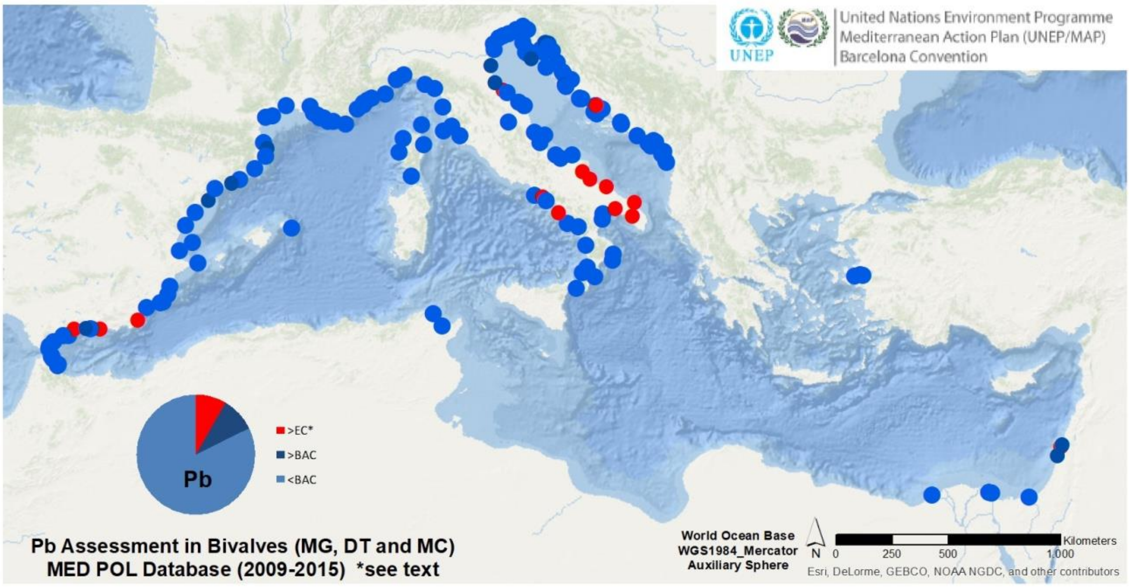


Figure 5. Regional Lead levels assessment against EC criteria in bivalve sp. (*Mytilusgalloprovincialis, Ruditapesdecussates,Donaxtrunculus and Mactracorralina*) for the Mediterranean Sea

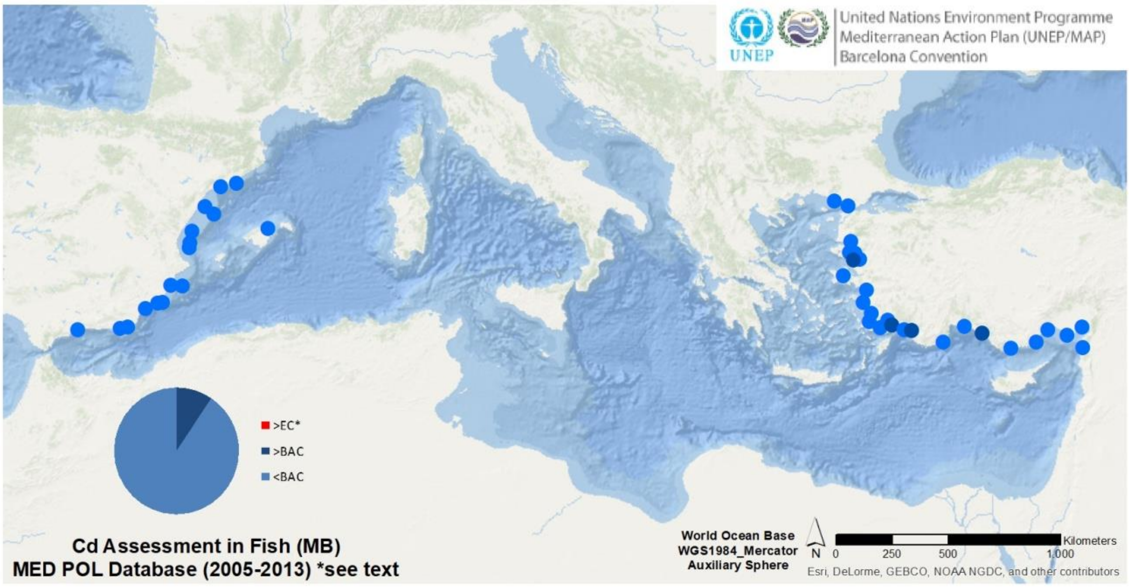


Figure 6. Regional Cadmium levels assessment against EC criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea

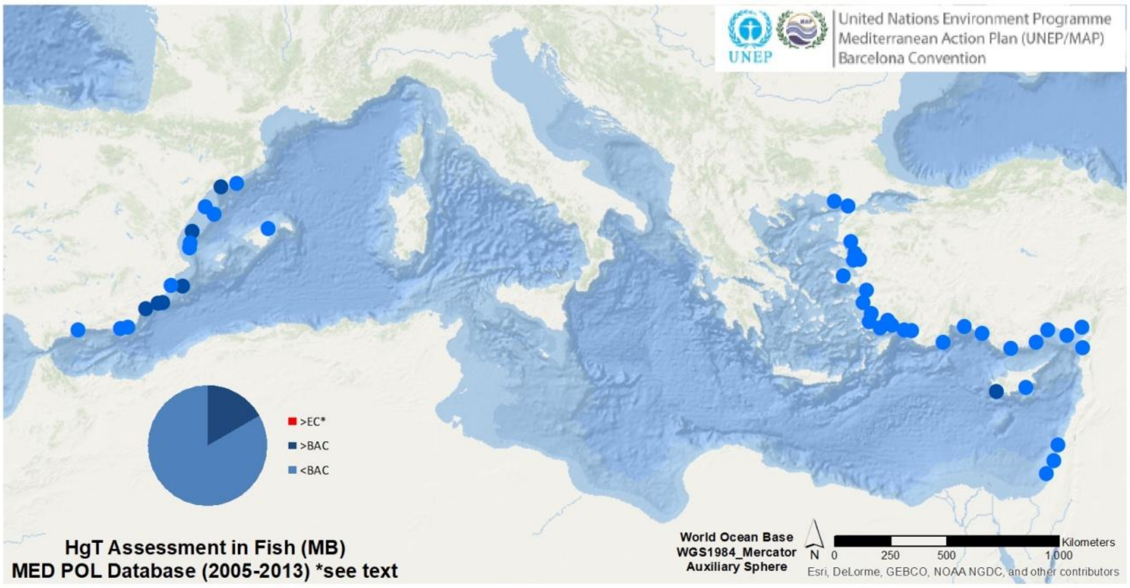


Figure 7. Regional Mercury levels assessment against EC criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea

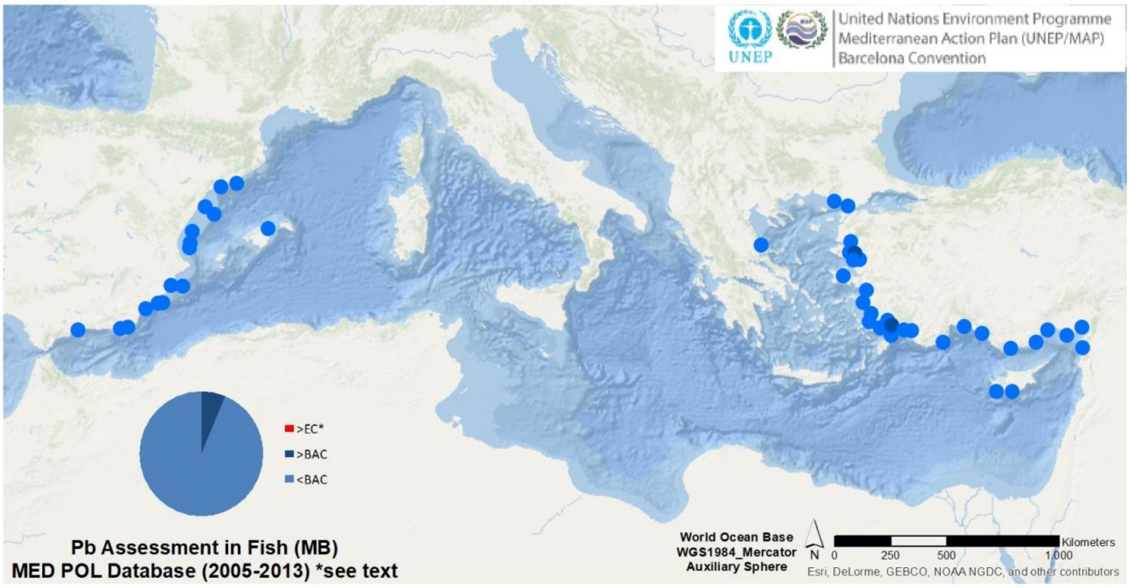


Figure 8. Regional Lead levels assessment against EC criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea

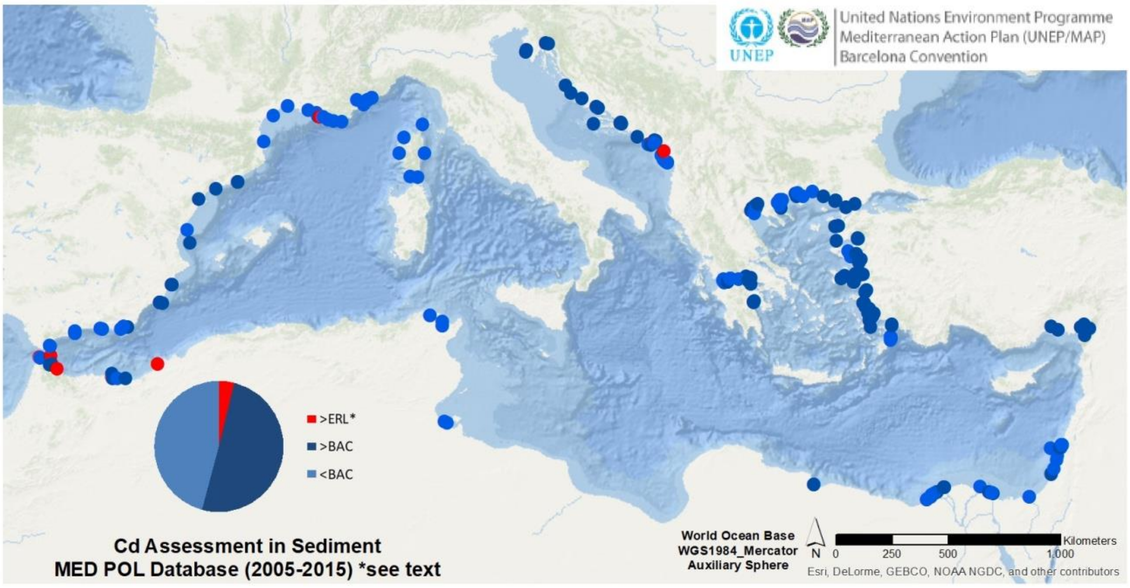


Figure 9. Regional Cadmium levels assessment against ERL criteria in sediment for the Mediterranean Sea

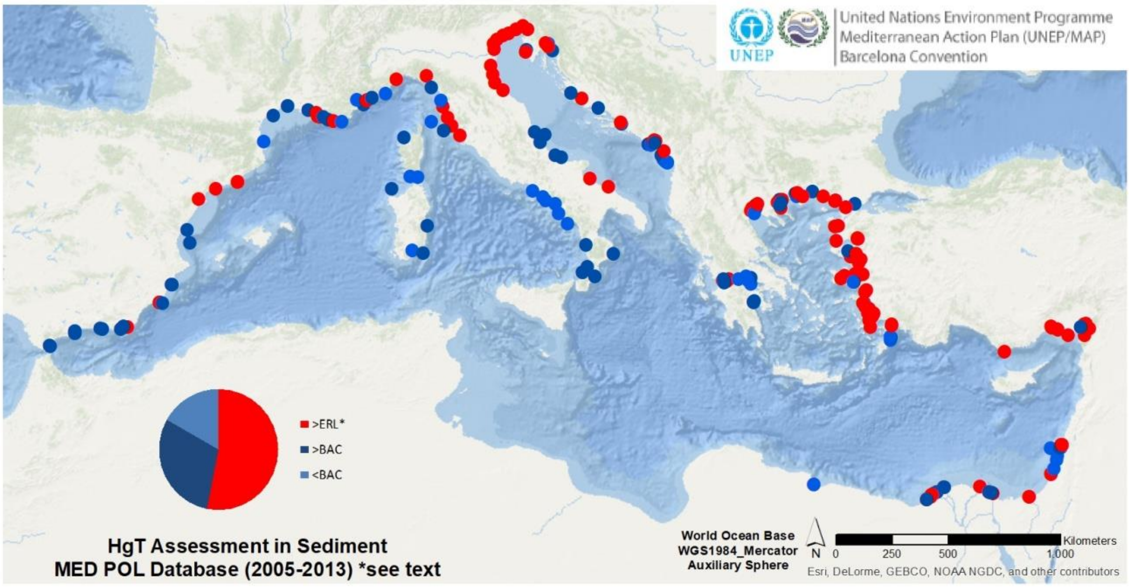


Figure 10. Regional Mercury levels assessment against ERL criteria in sediment for the Mediterranean Sea

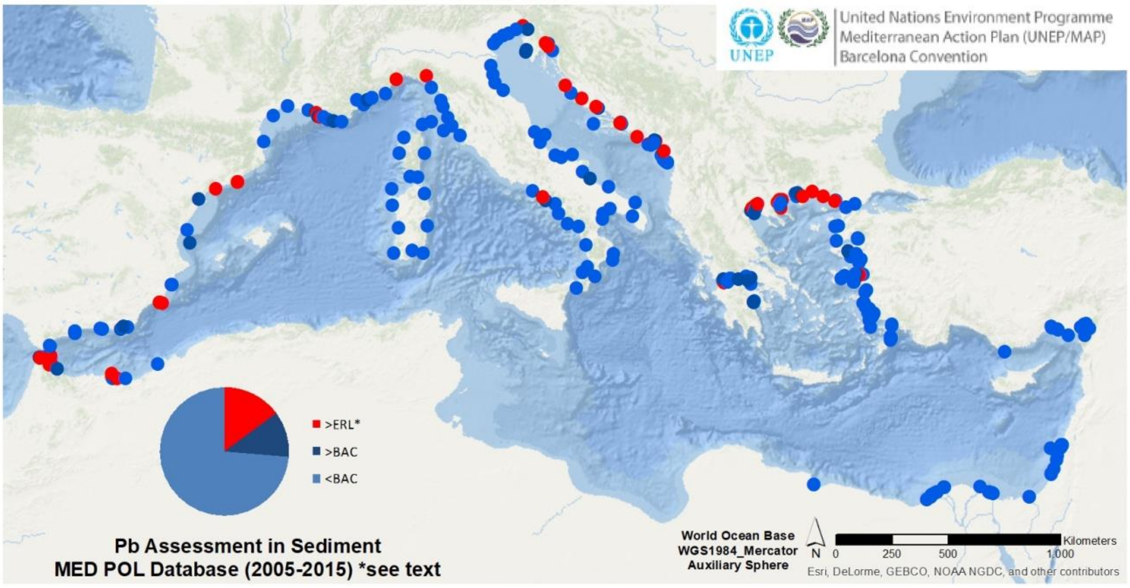


Figure 11. Regional Lead levels assessment against ERL criteria in sediment for the Mediterranean Sea

CONCLUSIONS

Conclusions (brief)

A main conclusion of this first pollution assessment against assessment criteria performed for heavy metals in the Mediterranean Sea show that environmental conditions differ largely between biota and coastal sediments. This current situation, in terms of environmental protection from chemical pollution and GES achievement, may indicate that the LBS inputs in the coastal surface waters (and/or atmospheric inputs) from both urban or industrial activities exhibit a high proportion of values in biota around natural background levels and under the EC criteria. On the contrary, historical heavy metal pollution impacted, clearly, the coastal sediments close to known historical hotspots (both industrial and natural geological point sources) in the Mediterranean Sea.

Conclusions (extended)

In terms of GES (Good Environmental Status) assessment, the biota (mussel and fish) show a situation where the acceptable conditions exist for coastal surface marine waters with levels below the assessment criteria (i.e. ECs), except for Pb in some mussel monitoring areas. These areas correspond to known coastal sites (hotspots) were measures and actions should be further considered to improve the marine environmental quality. The sediment evaluation in terms of GES show an impacted situation for the coastal benthic ecosystem, especially for HgT, which should be further investigated and assessed against assessment criteria. Therefore, these assessments should consider sub-regional differences in the Mediterranean Sea basins, in terms of natural sources and geological backgrounds. Development of the assessment criteria for sub-regional assessments should be ensured and these initial results should be taken with caution. To this regard, there is a need to consider the relationships between different policy standards and assessment metrics (i.e. WFD, MSFD, etc.) as well.

Key messages

- Levels of heavy metals in coastal water show a roughly acceptable environmental status assessed from bivalves and fish against BACs and ECs criteria.
- For Pb a 10% of the stations show levels above the set EC threshold for mussel samples.
- Heavy metal concerns are found in the coastal sediment compartment for Pb and HgT indicating an impact of these chemicals.
- For HgT, a 53% of the sediment stations assessed are above the ERL, set as regional assessment criteria for acceptable environmental conditions for the Mediterranean basin, although sub-regional differences have to be taken into account.
- Measures and actions should focus on known hotspots associated to urban and industrial areas along the coasts of the Mediterranean Sea, as well as to include sea-based sources, as these are also important inputs. Riverine inputs and coastal diffuse run-off play also an important role.
- Background and Environmental Assessment Criteria (BACs and EACs) should be continuously improved to take in consideration sub-regional specificities in the Mediterranean basins for heavy metals and trace elements.

Knowledge gaps

- The improvements in the limited spatial coverage, temporal consistency and quality assurance for monitoring activities hinder to some extent the regional and sub-regional assessments, as previously observed (UNEP/MAP/MED POL, 2011a and 2011b). The availability of sufficient synchronized datasets for a state assessment should be improved. To this regard, the evaluation performed have further shown the necessity to explore the new criteria at sub-regional scale for the determination of background concentrations of those chemicals occurring naturally, such a Pb in sediments. However, there are important gaps in the selection and measure of emerging contaminants, an issue that may be addressed by monitoring programmes. There is also a need to know the level of contaminants in deep-sea environments, and the dynamic of inputs, streams and distribution of contaminants, to be able to link sources, input entrances and environmental status. Two recent reports (UNEP/MAP MED POL, 2016a and 2016b) have reviewed and proposed updated background assessment criteria (BACs) for the Mediterranean Sea. These reports were built in line with the 2011 reports (UNEP/MAP MED POL, 2011a and 2011b).

- The current spatial assessment covered different periods according the most recent data available, despite the number of datasets did not increased significantly the potential for the evaluation of temporal trends. At present, the major studies are performed in coastal populations of marine bivalves (such as *Mytilus galloprovincialis*), fish (such as *Mullus barbatus*) and sediments. Bioaccumulation on large predator fish stocks may represent a concern that still needs to be properly addressed by ad hoc monitoring activities. Sediment sieving and normalization factors also require proper standardization to improve the comparability of monitoring data in sediments.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI18. Level of pollution effects of key contaminants where a cause and effect relationship has been established
Indicator Assessment Factsheet Code	EO9CI18

RATIONALE/METHODS

Background (short)

In most Mediterranean countries, the coastal monitoring of a range of chemicals and biological effects parameters in different marine ecosystem compartments and organisms are undertaken in response to the UNEP/MAP Barcelona Convention (1975) and its Land-Based Sources (LBS) Protocol. A considerable amount of founding actions from the past decades are available through the pollution monitoring and assessment component of the UNEP/MAP MED POL Programme, including monitoring pilot programmes to monitor ecotoxicological effects of contaminants (UNEP/MAP MED POL, 1997a, 1997b; UNEP/RAMOGE, 1999). When exposed to chemical substances some harmful effects can be observed at different levels in marine organisms. These effects depending on the level of exposure could be classified in lethal, sub-lethal and chronic. These impair the normal development and life cycle of the marine organisms. The environmental assessments have been used for the identification and confirmation of significant occurrence, distributions, levels, trends of contaminants and their effects; as well as, for the continuous development of monitoring strategies. With respect to the Ecosystem Approach Process and the Integrated Monitoring and Assessment Programme (IMAP) and related Assessment Criteria their implementation will continue under the benefits gained from this past knowledge and the policy framework built in the Mediterranean Sea (UNEP/MAP, 2016; UNEP/MAP MED POL, 2016).

Good Environmental Status (GES) for Common Indicator 18 can be accomplished (UNEP/MAP, 2013) when the contaminant effects (ca. biomarkers) are below the proposed assessment criteria (see Table 1).

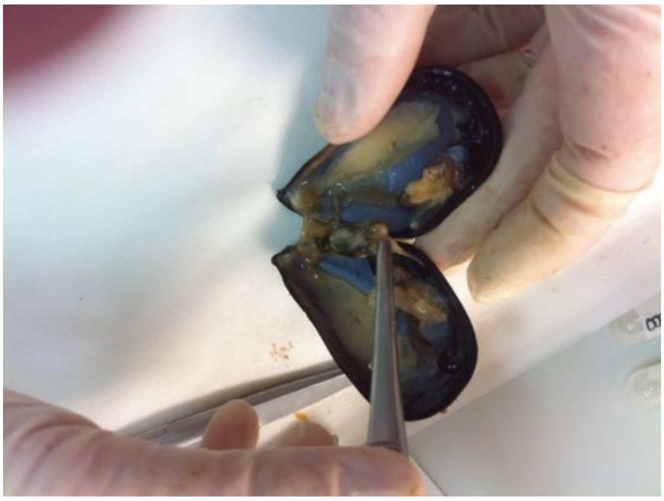


Figure 1: Preparation of a fresh mussel for both chemical and biological effects analysis by dissection of different organs.

Figure 2: Smaller mollusk bivalves (*Ruditapes decussates/Venerupisdecussata*) sampled in the network monitoring in Tunisia in the framework of the MED POL Porgramme.

Background (extended)

The marine organisms are exposed to the chemical substances released in the marine environment which cause harmful effects at subcellular and cellular organization levels of an individual, and therefore, have the potential to correlate with the disfunctioning of the populations and the ecosystem as a whole. Several pilot monitoring programmes were initiated developed by Contracting Parties (Croatia, France, Greece, Italy and Spain) with the objective to implement a biological effects monitoring onto the national networks of sampling stations for chemical monitoring in the Mediterranean Sea under the MED POL

Programme (UNEP, 1997a). The use of a number of biomarkers, bioassays and associated biological parameters in an integrated manner altogether with information on environmental chemicals should provide clearer information of the pollution effects in the marine environment. Therefore, through monitoring the biological effects we could elucidate the potential of chemical pollution damage in the marine ecosystems. A number of toxicological analysis have found consensus and have been recommended by a number of Contracting Parties, namely, Lysosomal Membrane Stability (LMS) as a method for general physiological status screening, Acetylcholinesterase (AChE) assay as a method for assessing neurotoxic effects in aquatic organisms and Micronucleus assay (MN) as a tool for assessing cytogenetic/DNA damage in marine organisms (UNEP/RAMOGE, 1999).

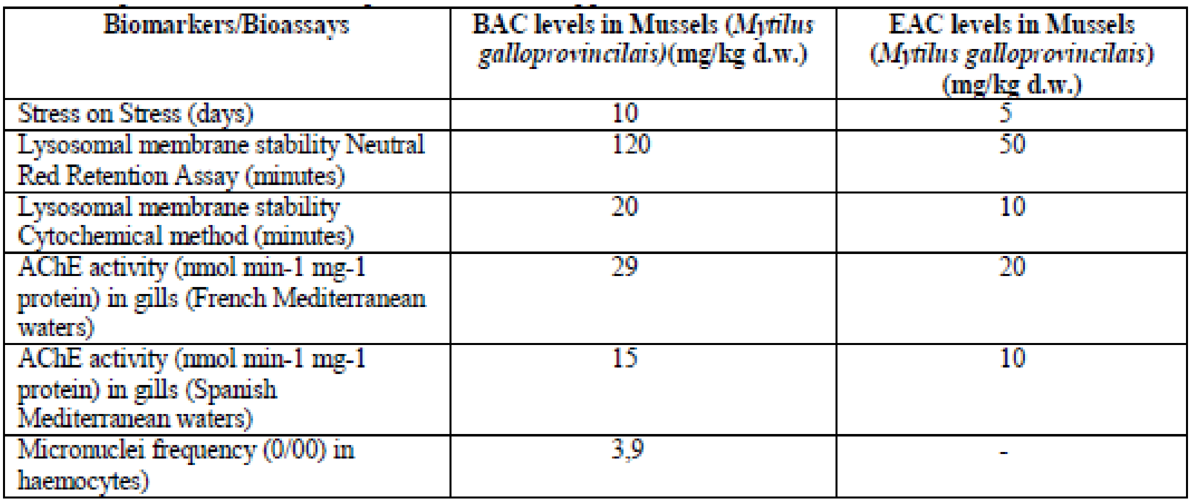
Additionally, the survival on air (or Stress on Stress, SoS), was also incorporated as a general method to determine the physiological condition in bivalves (e.g. mussels). In the latest decade, scientific research has been intensified towards alternative biological effect-based tools for integrated pollution monitoring, thus the integrative assessment revealed a more complex panorama when real samples are exposed to lowered (environmental) concentrations (i.e. sublethal to chronic effects). A number of confounding factors (e.g. nutritive status, temperature, etc.) might be hindering the cost-effectiveness and reliable use of these methods to determine the contaminant biological effects at physiological, cellular and sub-cellular levels (González-Fernández et al., 2015a and 2015b, ICES, 2012). As a consequence, most of these methods (ca. biomarkers), based on the premise of the cause-effect relationship to chemical exposure, are envisaged to found applications, for example, to monitor highly contaminated areas (hotpot stations), to assess dredging materials and to evaluate local damage after acute pollution events rather than for long-term environmental monitoring (surveillance monitoring). Ongoing research (i.e. biomarkers, bioassays) and future research trends, such as ‘omics’ developments, will further shape the selection of these evaluation tools for CI18 as recently reviewed by the European Union (EU, 2014).

Assessment methods

The present assessment has been mainly constructed based on the current status of bibliographic studies and scientific documents published in the Mediterranean Sea area, as the biological effects datasets through the MED POL Database are not yet fully available at a regional scale. The full assessment of the Common Indicator 18 will be based on the integrated evaluation of the biomarkers selected for their monitoring in the Mediterranean Sea, namely, Acetylcholinesterase activity (AChE), Lysosomal membrane stability (LMS) and Micronuclei frequencies (MN) on first instance. Further, the enzyme 7-ethoxy-resorufin-O-deethylase (EROD) and Metallothionenin (MT) has been also indicated for fish and mussel samples, respectively. For the former parameters, the environmental criteria have been developed in terms of Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) (see Table 1) and revised (UNEP/MAP/MED POL, 2016). The assessment criteria were adopted by the COP19 in February 2016 for the Mediterranean Sea (UNEP/MAP, 2016) and new assessment criteria has been proposed based on Mediterranean reference stations datasets (UNEP/MAP/MED POL, 2016). The initial revised criteria using reference stations to determine the background levels with datasets from the MED POL monitoring networks for this Common Indicator 18 are presented in the results section.

Complementary biomarkers, bioassays and histology techniques and other methods are also recommended to be carried out on a country basis (such as, comet assay, hepatic pathologies assessment, etc.) to contribute to the assessment of the CI18.The assessment of biomarker responses against Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) will allow to establish if the responses measured belong to the levels that are not causing deleterious biological effects (<BACs), levels where deleterious biological effects are possible (>BACs) or levels where deleterious biological effects are likely to occur (>EACs) in the long-term (UNEP/MAP MED POL, 2016; UNEP/MAP, 2016).

Table 1: Environmental Assessment Criteria for Biological Effects assessments under IMAP (UNEP/MAP, 2016).



Biomarkers/Bioassays	BAC levels in Mussels (*Mytilus galloprovincilais*)(mg/kg d.w.)	EAC levels in Mussels (*Mytilus galloprovincilais*) (mg/kg d.w.)
Stress on Stress (days)	10	5
Lysosomal membrane stability Neutral Red Retention Assay (minutes)	120	50
Lysosomal membrane stability Cytochemical method (minutes)	20	10
AChE activity (nmol min-1 mg-1 protein) in gills (French Mediterranean waters)	29	20
AChE activity (nmol min-1 mg-1 protein) in gills (Spanish Mediterranean waters)	15	10
Micronuclei frequency (0/00) in haemocytes)	3,9	-

RESULTS

Results and Status, including trends (brief)

In the Mediterranean Sea, a number of different studies focusing in different marine species and organizational levels are being undertaken which should provide the basis for integrated assessments in marine pollution. However, a clear correlation related to sub lethal and chronic exposures of environmental trace concentrations of contaminants is difficult to achieve.

The biological effects have recently been extended to studies in mussels exposed to outfall effluents and complex mixtures of pollutants by using a battery of biomarkers (de los Ríos et al., 2012), pelagic fish (Fossi et al., 2002; Tomasello et al., 2012) and combining wild and caged mussels (Marigómez et al., 2013), as well as in acute pollution accidental episodes such as oil spills (Marigómez et al., 2013b, Capó et al., 2015).

In the Eastern Mediterranean, the LMS (by neutral red retention method, NRR) and the AChE levels have been evaluated in mussels *Mytillus galloprovincialis* collected from Thermaikos and Strymonikos Gulfs in northern Greece (Dailanis et al., 2003) and more recently including a number of marine species from the Eastern Mediterranean and the Black Sea (Tsangaris et al., 2016).

In the Adriatic Sea, the use of biomarkers has found applications in the monitoring of the anthropogenic impact due to the exploitation of gas fields (Gomiero et al. 2015), as well as studies of the genetic stability caused by pollution have been investigated by Croatian laboratories (Stambuk et al. 2013).

In the southern Mediterranean Sea, trials have been undertaken on the integrated use of biomarkers, and the development of biomarker indexes to study the spatial and temporal variations in locations with different levels of pollution, such as Algeria (Benali, et al., 2015) and the Lagoon of Bizerte in Tunisia (Ben Ameur et al., 2015; Louiz et al., 2016).

In the northwest Mediterranean, investigations of benthic fish associated to the continental platform, (*Soleasolea* and *Mullus barbatus)* have been investigated for hepatic and branchial biomarkers, as well as studies using a battery of biomarker responses for biological effects to elucidate the sentinel species in pollution monitoring (Siscar, et al., 2015, Martinez-Gómez et al., 2012) have been performed. In the coastal environment, the rivers flowing into the Mediterranean such as Llobregatriver (Spain), have also been used as locations to investigate the biological effects in invertebrate communities (Prat, et al., 2013; de Castro-Català, 2015).

Recently, within new methodological trends, such as metabolomic responses and differences in metabolite profiles, were observed in clams (*Ruditapesdecussatus*) between control and polluted sites in the Mar Menor Lagoon in the Western Mediterranean (Campillo, et al. 2015). These biological effects based tools have been also tested for the direct effects of pharmaceuticals in laboratory experiments in the Mediterranean Sea (Mezzelani, et al., 2016). These biological effects tools have also been used in high value commercial species, such as tuna (*Thunnusthynnus*) in Mediterranean Sea (Maisano et al. 2016).

Results and Status, including trends (extended)

The Figures 3to 5shows the biomarkers evaluation results for the MED POL reference stations datasets extracted from the proposed revision document (UNEP/MAP/MED POL, 2016) in the Mediterranean Sea to show the differences at sub-regional levels and to compare to the current IMAP assessment criteria.

In detail, it should be noticed in Figure 3, that the LMS-NRR results (median value) for the reference stations in the Mediterranean Sea are below the standard acceptable values (both <BACs and <EACs) set by OSPAR (ICES, 2012) to assess healthy biota specimens for this biomarker. Therefore, these discrepancies being datasets for reference stations might reflect the influence of confounding factors in the environment in relation to general stress biomarker responses (e.g. nutritive status, hypoxia, spawning state, temperature, etc.), and therefore, hindering the correlation with the exposure to hazardous chemical substances, as discussed recently in the literature (Minguez et al. 2012; Cuevas et al., 2015; González-Fernández et al., 2015a, 2015b). In any case, the development of Med BCs and Med BACs in Mediterranean mussels with the number of datasets provided is not conclusive within the MEDPOL biological effects monitoring component. In Figure 4, the Adriatic Sea sub-region show an AChE inhibition half way to unacceptable levels of biological effects (i.e. between <BAC and >EAC) for reference stations, which should be further investigated, and contrasts with the median level determined in the WMS sub-region, thus being both reference areas from Croatia and Spain, respectively. Figure 5, shows that the sub-regions medians for reference stations are safely below the calculated Med BAC for micronuclei frequencies , despite high uncertainty (above the calculated Med BAC) in Middle Adriatic Sea. Further information and details can be found in UNEP/MAP/MED POL (2016) report.

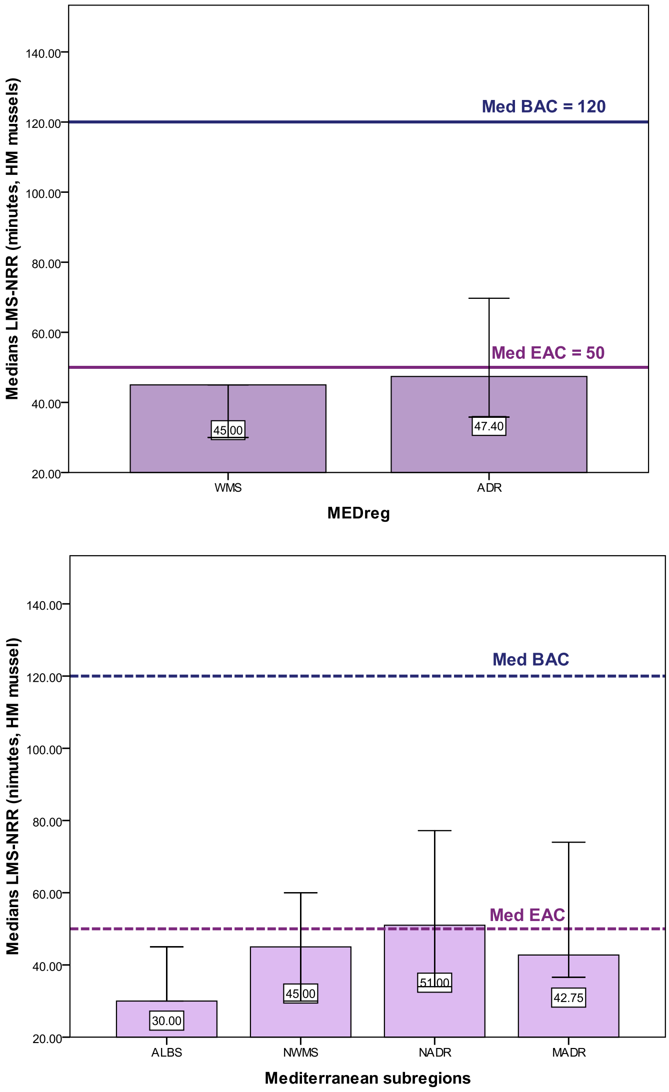


Figure 3. LMS-NRR (Neutral red retention) medians (BCs) in mussel by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.

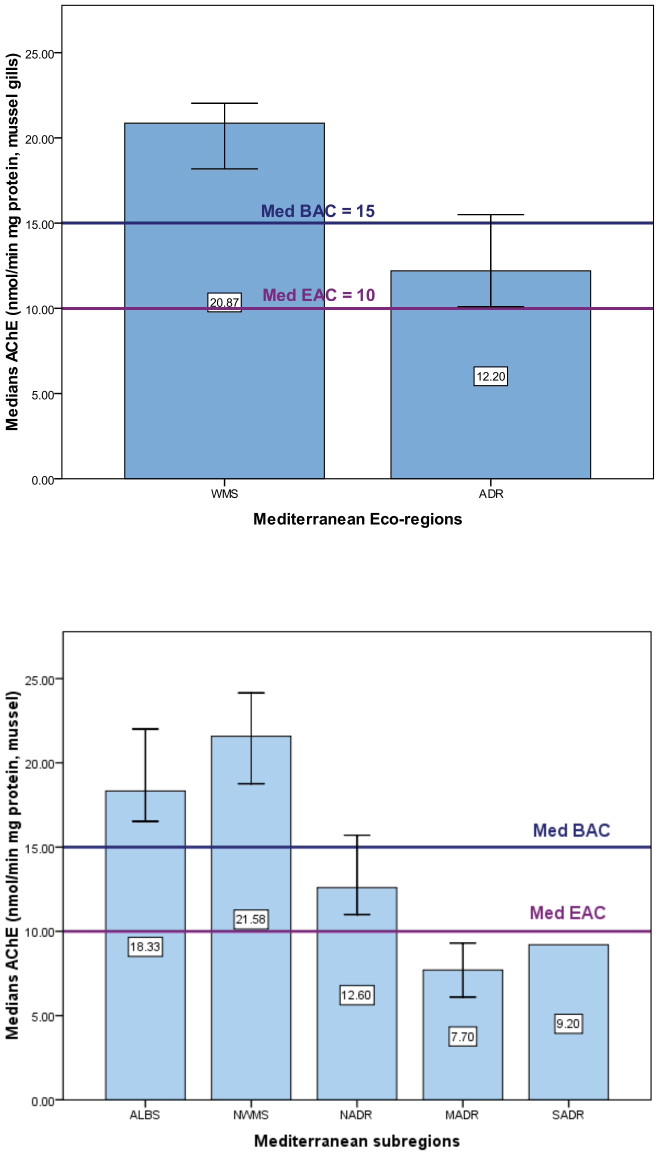


Figure 4. Metallothioneins medians (BCs) in mussel digestive gland by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.

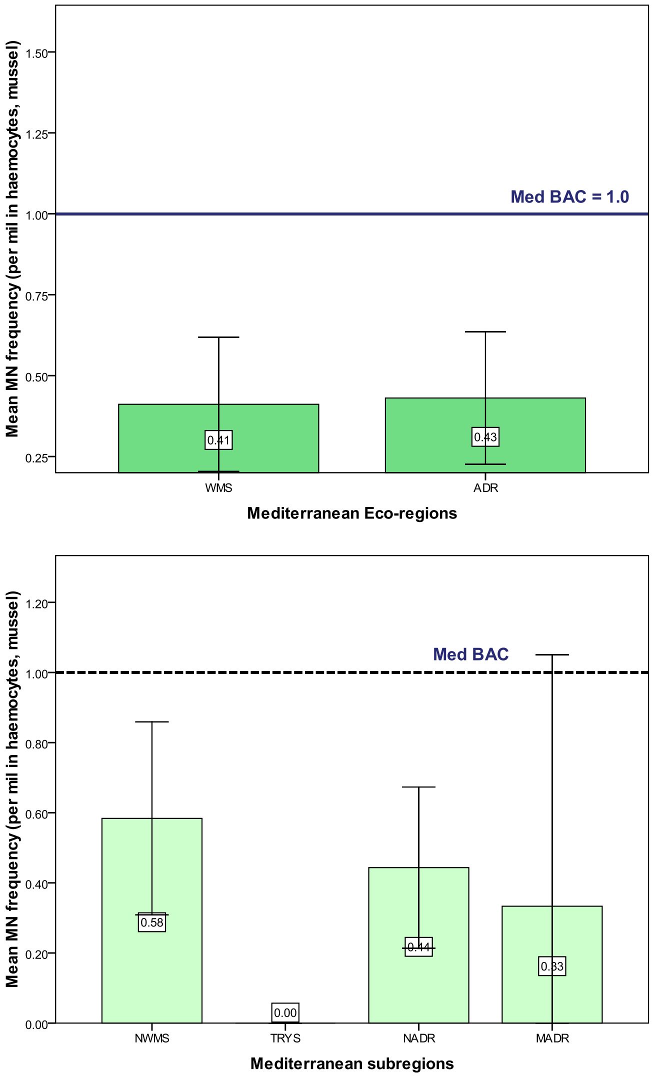


Figure 5. Micronuclei frequency medians (BCs) in mussel by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.

CONCLUSIONS

Conclusions (brief)

The ongoing research developments and controversy with regard biological effects and toxicological methods (*ca*. confounding factors) is one of the main reasons for the slow implementation of these techniques in marine pollution monitoring programs in the Mediterranean Sea, although as mentioned, some are proposed within the framework of the MED POL Programme. At present, in many Mediterranean countries, different research programmes and projects leaded by universities, research centers and government agencies are undergoing and will be the providers of the future quality assured and reliable measurements, as well as new tools, to guarantee the correct implementation of a biological effects programme to assess the Common Indicator 18 in the Mediterranean Sea. Both biological effects parameters and contaminants concentration measurements need to take into consideration these biological factors, as they affect directly the responses and bioaccumulation of marine organisms, respectively. It is recommended to make the assessments in the same period each time, selecting the period of more physiologic stability of the species.

Conclusions (extended)

Assessing biological effects in a similar manner to contaminant concentrations, the ICES/OSPAR has proposed three categories (two threshold criteria), and it has been the framework to evaluate the Mediterranean Sea MED POL datasets. Assessing biomarker responses against BACs and EACs allows establishing if the responses measured are at levels that are not causing deleterious biological effects, at levels where deleterious biological effects are possible or at levels where deleterious biological effects are likely to occur in the long-term. In the case of biomarkers of exposure, only BAC can be estimated, whereas for biomarkers of effects both BAC and EAC can be established. However, unlike contaminant concentrations in environmental matrices, biological responses cannot be assessed against guideline values without consideration of factors such as species, gender, maturation status, season and temperature.

It is important to point out that a few BACs for biomarkers of exposure and effects (Stress on Stress, Acetylcholinesterase activity-AChE and Miclonuclei Frequency) have been determined for the Mediterranean Sea (mussel) and proposed to the Contracting Parties for use on indicative purpose in pilots. However, the biological responses cannot be assessed against guideline values without strong consideration of confounding factors. To this regard, ensuring systematic and accurate long-term monitoring of the bioaccumulation of chemical contaminants in biota has been addressed for many decades now. The monitoring strategy minimizes the environmental variability (e.g. sampling month (pre-spawning), pooling of samples, calculation of condition factors, etc.). For biological effects, however, these confounding factors are difficult to control in the field, as well as the combination of them, which affect the organisms' responses and their uncertainty in relation to the cause-effect pollution relationship, an issue which still need to be addressed.

Key messages

- Biological effects monitoring tools still in a research phase for biomarker techniques (i.e. method uncertainty assessments and confounding factors evaluations) which limits the implementation of these tools in the long-term marine monitoring networks.
- Lysosomal Membrane Stability (LMS) as a method for general status screening, Acetylcholinesterase (AChE) assay as a method for assessing neurotoxic effects and Micronucleus assay (MN) as a tool for assessing cytogenetic/DNA damage in marine organisms have been selected as primary biomarkers.

Knowledge gaps

- Important development areas in the Mediterranean Sea over the next few years should include: confirmation of the added value of these batteries of biomarkers in long-term marine monitoring as 'early warning' systems; test of new research-proved tools such as 'omics', analytical quality harmonization, development of suites of assessment criteria for the integrated chemical and biological assessment methods, and review of the scope of the biological effects monitoring programmes.
- Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs of CI18 within the IMAP implementation and GES assessments.

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Ecological Objective 9 (EO9): Pollution

EO9: Common Indicator 19. Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution

GENERAL

Reporter:	REMPEC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional surveys, research and publications
Mid-Term Strategy (MTS) Core Theme	Land and Sea Based Pollution
Ecological Objective	Ecological Objective 9 (EO9) – Pollution: Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution (EO9)
Indicator Assessment Factsheet Code	EO9CI19

RATIONALE/METHODS

Background (short)

Increasing shipping and maritime activities are important drivers for anthropogenic pressure on the marine environment in the Mediterranean Sea. Pressure from maritime transport includes potential chemical pollution from oil and Hazardous and Noxious Substances (HNS), dumping of garbage at sea, release of sewage, biofouling and non-indigenous species introduction. As documented in a great number of scientific researches, chemical pollution by oil and other harmful substances has impacts on water, seabed, fauna and flora. The level of risk of an accident occurring in the Mediterranean Sea is driven by two factors: traffic density as well as routes for oil and chemical tankers. In addition, illicit discharges of oil from ships remain a concern.

Mediterranean coastal States recognised the need to give special protection to the Mediterranean against pollution due to the operation of ships when the Mediterranean Action Plan (MAP) was adopted on 4 February 1975. The 1967 Torrey Canyon oil spill accident, which resulted in massive oil pollution, raised the public awareness on pollution from shipping activities. Concern was expressed regarding possible oil and other harmful substances that may be released in the Mediterranean Sea, a semi-closed marine area. This led to the establishment of the MAP first Regional Activity Centre (ROCC – Regional Oil Combating Centre, now REMPEC – Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea) and to the adoption of the Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency ("the 1976 Emergency Protocol") to the Convention for the Protection of the Mediterranean Sea Against Pollution ("the Barcelona Convention"). This Protocol was revised in 2002 to include prevention of pollution from ships to emergency situations and is today referred to as the Protocol concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea ("the 2002 Prevention and Emergency Protocol"). The Protocol addresses pollution incidents, which includes both accidental pollution and illicit discharges. Pollution from oil and other hazardous substances were also addressed internationally in a number of conventions adopted under the aegis of the International Maritime Organization (IMO), some of which provides for stricter regime in the Mediterranean Sea. Although action at regional and international level has resulted in a significant decrease of massive oil pollutions from ships, incidents and illegal discharges are still responsible for the release of oil, oily mixtures and other HNS at sea. It is on these grounds that the Contracting Parties to the Barcelona Convention included a Common Indicator (CI 19) on "*occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution*" under Ecological Objective 9.

Background (extended)

Risk of accidents. The Mediterranean is a major shipping lane. It is estimated that around 80% of global trade by volume and over 70% of global trade by value are carried by sea (UNCTAD, 2015), with approximately 15% of global shipping activity by number of calls and 10% by vessel deadweight tons (dwt) (REMPEC, 2008) taking place in the Mediterranean. The area is an important transit route for shipping, with two of the narrowest and busiest straits in the world: the Strait of Gibraltar and the Bosphorus Strait. The Mediterranean is a major transit route. In 2006, around 10,000, mainly large, vessels transited the area en-route between non-Mediterranean ports. In addition to hosting an important transit lane for international shipping, the Mediterranean Sea is also a busy traffic area due to Mediterranean Sea born traffic (movement between a Mediterranean port and a port outside the Mediterranean), and short sea shipping activities. It is estimated that around 18% of the shipping traffic in the Mediterranean Sea takes place between two Mediterranean ports (REMPEC, 2008). Figure 1 is a representation of the maritime traffic in the Mediterranean Sea.

Although several factors contribute to maritime casualties, the correlation between traffic density and accidents causing a pollution is confirmed by the fact that "collisions allisions" represent the first cause of accidents (26%) resulting in an oil spill as recorded by The International Tanker Owners Pollution Federation Limited (ITOPF) between 1970 and 2016. In the Mediterranean, the "collision/contact" category accounts for 17% of accidents reported to REMPEC, after "grounding" (21%). The contribution of other accident types are as follows: "fire/explosion": 14%, "cargo transfer failure": 11%, "sinking": 9%, and "other accidents": 28%. Several studies, based on the daily traffic crossing the Istanbul Strait and the Bosphorus, identified the east Mediterranean / Black Sea area as one of the top areas presenting the greatest probability of a shipping accident occurring.

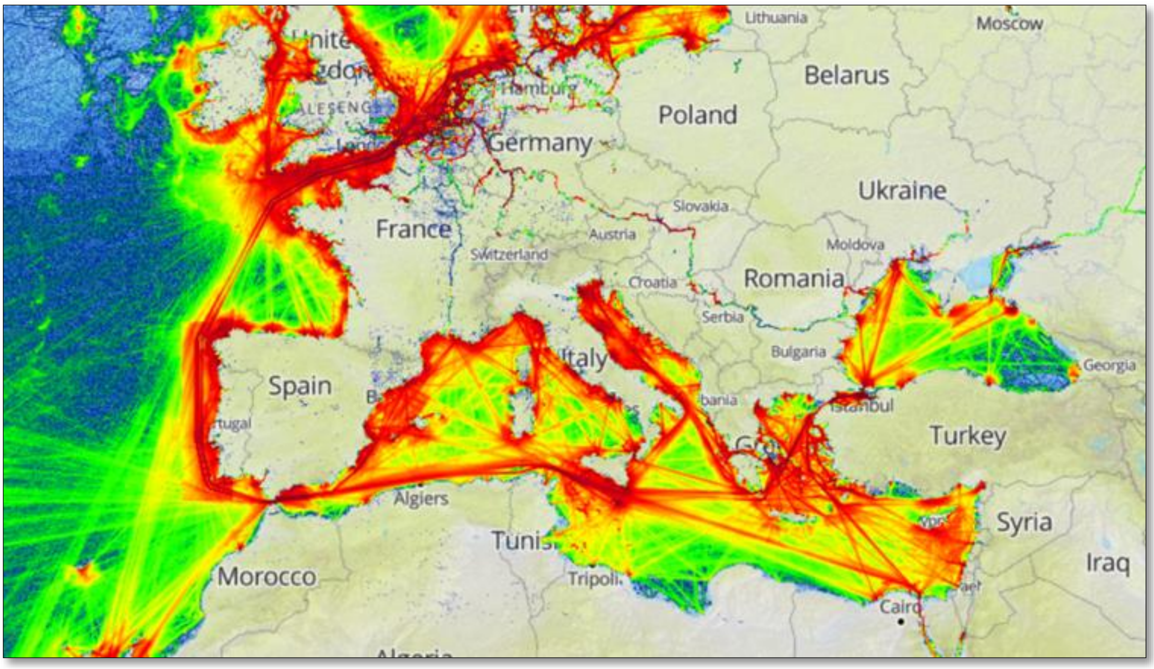

Figure 1: Density of maritime traffic in the Mediterranean Sea (Source: MarineTraffic, 2017).

The Mediterranean is an important route for oil tankers' shipments. The Mediterranean Sea is also a major route for tankers. The REMPEC study mentioned above shows that the Mediterranean is both a major load and discharge centre for crude oil. Approximately 18%, or 421 million tonnes, of global seaborne crude oil shipments which in 2006 amounted to approximately 2.3 billion tonnes, take place within or through the Mediterranean. The following figures (Figure 2, Figure 3 and Figure 4) present the oil export areas and overseas destinations through the Mediterranean Sea.

Figure 2: Oil export source and destinations (North Africa) (Source: Tankers International Ltd., 2006).

Figure 3: Oil export source and destinations (Middle East) (Source: Tankers International Ltd., 2006).

Figure 4: Oil export source and destinations (Black Sea) (Source: Tankers International Ltd., 2006).

Figures 3 and 4 above emphasis that the East Mediterranean area is at risk: in addition to being an area where traffic is dense, it is also a hot spot because of tanker routes from the Black Sea and the Middle East.

Deliberate discharges at sea. It was demonstrated, with the use of satellite imagery and other observation tools that deliberate oil pollution occurrences are high along busy traffic lanes. In the Mediterranean, there is evidence that the distribution of oil spills is correlated with the major shipping routes, along the major west-east axis connecting the Strait of Gibraltar through the Sicily Channel and the Ionian Sea with the different distribution branches of the Eastern Mediterranean, and along the routes towards the major discharge ports on the northern shore of the Adriatic Sea, east of Corsica, the Ligurian Sea and the Gulf of Lion (UNEP/MAP, 2012).

Assessment methods

Assessment of accidents. In the Mediterranean region, under the 2002 Prevention and Emergency Protocol, the assessment of occurrences, origins and extents of oil and HNS pollution from ships is carried out on the basis of pollution reports (POLREP) sent by the Contracting Parties to the Barcelona Convention to REMPEC and other affected States to notify a pollution or an event that could result in a pollution. These reports provide details on the incidents, including the position, extent, characteristics, sources and cause, trajectory of pollution, the forecast and likely impacts, as well as sea state and meteorological information.

The reports sent to REMPEC are also used to feed the database on alerts and accidents in Mediterranean Sea (the Mediterranean Alerts and Accidents Database) maintained by the Centre. Records of oil spills and accidents likely to cause spillages of oil in the Mediterranean started in 1977, while accidents involving other HNS are reported since 1988. Another main source of information used to populate the Mediterranean Alerts and Accidents Database is the Lloyd’s List Intelligence Casualty Reporting Services (LCRS).

Accidents recorded in this database are accidents that caused or were likely to cause pollution by oil or other HNS in the Mediterranean Sea area. Accidents included are:

- Accidents occurring in the Mediterranean Sea as defined in the Barcelona Convention;
- Accidents involving any type of ship, which resulted in an oil spill, a spill or release of a HNS, or in a loss or damage to a container containing HNS;
- Accidents on land (terminals, storage tanks, pipelines, industries, power plants, etc.) that resulted in entry into the sea of oil or HNS;
- Accidents involving one or more oil tankers or chemical tankers (either laden or not);
- Collisions, groundings or other accidents causing serious damage to the ships involved, in particular if these carried or could carry significant quantities of fuel oil as bunkers;
- Accidents involving sinking of vessels that had on board any quantity of oil as bunkers; and
- Accidents involving sinking of vessels that carried HNS as cargo (either in bulk or in packaged form).

Assessment of illicit discharges. Monitoring of illicit discharges is conducted to detect violations of requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) and collect evidence for prosecuting ships offenders. The POLREP can also be used by a Contracting Party to the Barcelona Convention to report a deliberate discharge to REMPEC.

Methods: The following methods are used to detect pollution and assess its origin and extent:

Oil:

- Expert human eye observation;
- Aerial observation (human eye observation and/or remote sensing equipment);
- Satellite imagery analysis to assess the extent and fate of an oil slick; and
- Sampling and analysis to determine the nature of the substance at sea, on shore and on board vessels. The Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983 (“the Bonn Agreement”) developed an internationally recognised procedure for sampling at sea, analysis and interpretation of results.

The following can be identified:

- Volume of oil: internationally recognised guidance is used based on oil type and appearance to assess thickness (mm) and volume of oil (m^3/km^2) at sea (Bonn Agreement Oil Appearance Code – BAOAC);
- Location and coverage of slick at sea (latitude and longitude – GPS);
- Characteristics of oil (persistent vs. non persistent / viscosity); and
- Origin of slick (if visible ship name and IMO number, offshore installations identification number). Backtracking oil using trajectory modelling methods help to identify ship source.

On-shore monitoring will be used to assess the extent of impacted shorelines, type and degree of contamination as well as impact on habitats and wildlife casualties.

Hazardous and Noxious Substances (HNS):
Detection of HNS pollution events and assessment of impacts are primarily achieved on site by expert human eye observation, complemented with real time monitoring, sampling and analysis, as well as the use of modelling tools. Conclusions of any risk assessment for HNS will be based on a number of information including identification of incident circumstances and location, identification of the involved chemical, its properties / toxicity, and its form (packaged / bulk) as well as identification of sensitive neighbouring areas and environment conditions.

RESULTS

Results and Status, including trends (brief)

On the one hand, statistical data analyses indicate a significant downward trend in accidental pollution from ships, for both oil and HNS. This decrease can also be seen both in the number of accidents causing these pollutions and in the volumes of pollutants discharged at sea. On the other hand, the same observation cannot be made with regard to illicit discharges from ships. There is no sufficient data to identify an upward or downward trend, but based on 2016 data provided by the European Maritime Safety Agency (EMSA), it can be argued that a significant number of illegal releases are still occurring.

Results and Status, including trends (extended)

Key findings for accidents. There is a decrease in the number of major oil spills worldwide. Maritime casualties involving oil have decreased substantially over the years, despite a growth in the volume of oil moved by ships. Today, according to ITOPF statistics, 99.99% of crude oil transported by sea arrives safely at its destination. As shown in Figure 5, the average number of large oil spills from tankers, i.e. greater than 700 tonnes, has progressively diminished over the years, to an average of 1.7 spills per year between 2010 and 2016. Correspondingly there is a decrease in the frequency of accidents causing pollution in the Mediterranean.

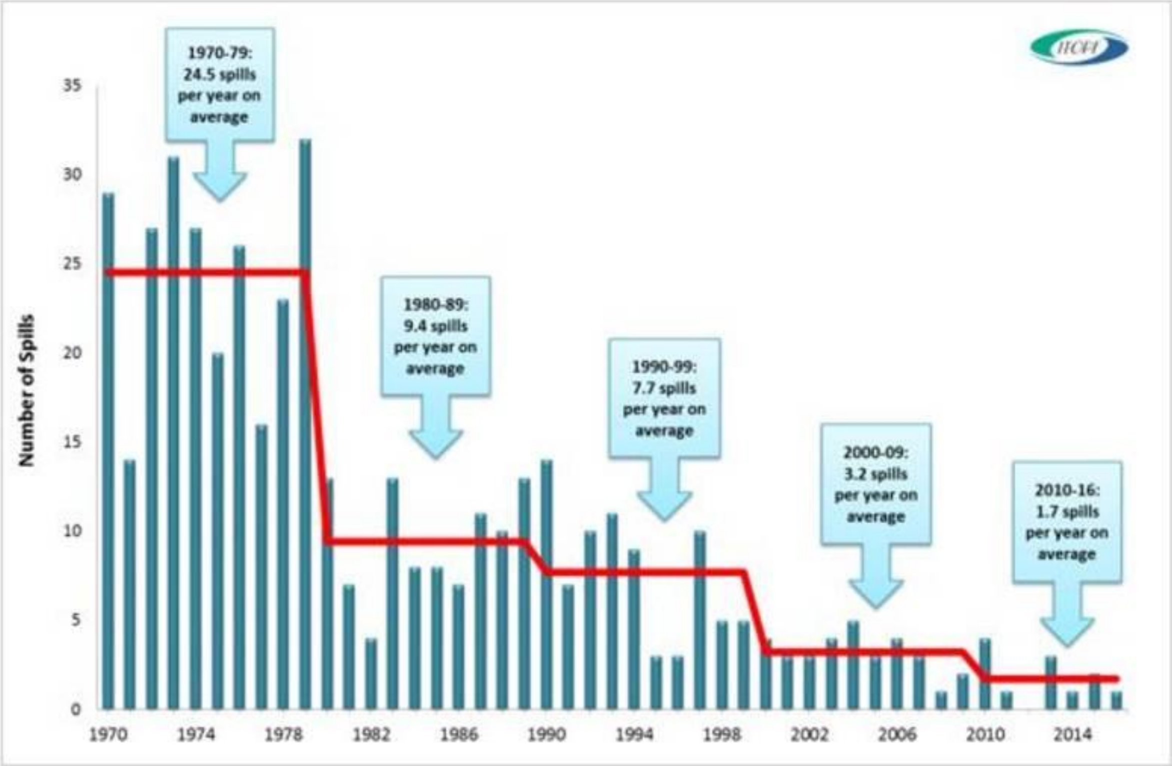

Figure 5: Number of large oil spills (>700 tonnes) from 1970 to 2016 (Source: ITOPF, 2016).

Oil: Major oil spills occurred frequently between 1977 and 1981 but have become rare events since then, with the last major accident being the MT “HAVEN” accident off Genoa in April 1991, with 144,000 tonnes of crude oil spilled (REMPEC, 2011). In terms of volume of oil released at sea, the data available in the Mediterranean Alerts and Accidents Database indicates that, between 1 January 1994 and 31 December 2013, approximately 32,000 tonnes of oil entered into the Mediterranean Sea as a result of accidents. This includes approximately 15,000 tonnes originating from the 2006 Eastern Mediterranean incident which occurred in the power plant of Jieh, Lebanon, between the 13th and 15th of July 2006. The fuel which did not burn was released in the marine environment. The exact quantity of the burnt fuel remains unknown but, according to the estimate communicated by the Lebanese authorities, between 13,000 and 15,000 tonnes were released as a consequence of the spill. The Lebanese spill is the fifth biggest spill reported since 1977 in the Mediterranean Sea, the largest spill being the spill related to the explosion of the MT HAVEN in 1991, which sunk with its cargo of 144,000 tonnes of crude oil in the Italian waters. In terms of accidents causing pollution, the number of accidents resulting in an oil spill dropped from 56% of the total number of accidents for the period 1977 – 1993, to 40% for the period 1994 – 2013. 61% of the incidents resulted in a spillage inferior to 1 tonne.

HNS: In the Mediterranean, the quantities of HNS accidentally spilled considerably decreased during the period 1994 – 2013. Since 2003, the release of HNS has become insignificant compared to the period 1994 – 2002. The last two major accidents occurred in 1996 namely:

- the sinking of Kaptan Manolis I in Tunisia, with 5,000 tonnes of phosphates on board; and
- the sinking of Kira off Greece, releasing 7,600 tonnes of phosphoric acid.

The worst HNS spill in the Mediterranean was the sinking of the Continental Lotus in 1991 in the Eastern Mediterranean, with 51,600 tonnes of iron on board. On the basis of the data available in the Mediterranean Alerts and Accidents Database, the geographical distribution of accidents indicates that the majority of accidents occur in the Eastern Mediterranean area (Cyprus, Egypt, Israel, Lebanon, Syrian Arab Republic, Turkey) if Greece, which is treated separately in Figure 6 below, is included.

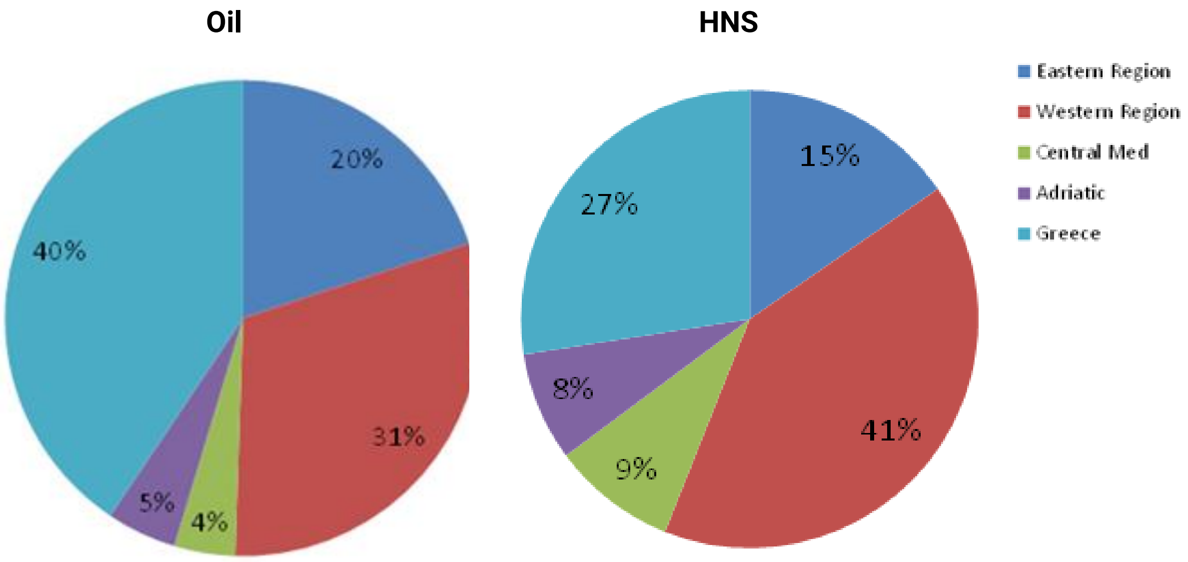

Figure 6: Geographical distribution of accidents from 1994 to 2013 (Source: REMPEC).

Key Findings for Illicit Discharges. The Mediterranean Alerts and Accidents Database contains a category for “Illicit Discharges”. Only 5 cases were reported (1 in 2012, 1 in 2013 and 3 in 2015). By nature, as they are illegal, illicit discharges of oil are not voluntarily reported by the ship source. The use of satellite imagery can be a useful tool to provide a better picture of the number of oil spills from ships, however, unless evidence is provided that a detected illicit discharge originates from a specific ship, no definite conclusion can be made as to whether or not the spill is caused by any ship, and therefore it is difficult to precisely assess the number of illicit discharges actually happening.

Trends: oil pollution occurrences still an issue in the Mediterranean.
In 2016, the CleanSeaNet platform of EMSA recorded a total of 1,073 detections of probable pollution occurrences, and a total of 1,060 detections of possible pollution occurrences in the area covering the Mediterranean Sea and the Atlantic Ocean coasts of Morocco, Portugal, Spain and France (Figure 7). Although there is no judicial evidence that all occurrences characterised as oil spills are actually discharges from ships, the map provides a clear indication that oil pollution incidents from ships is still of concern.

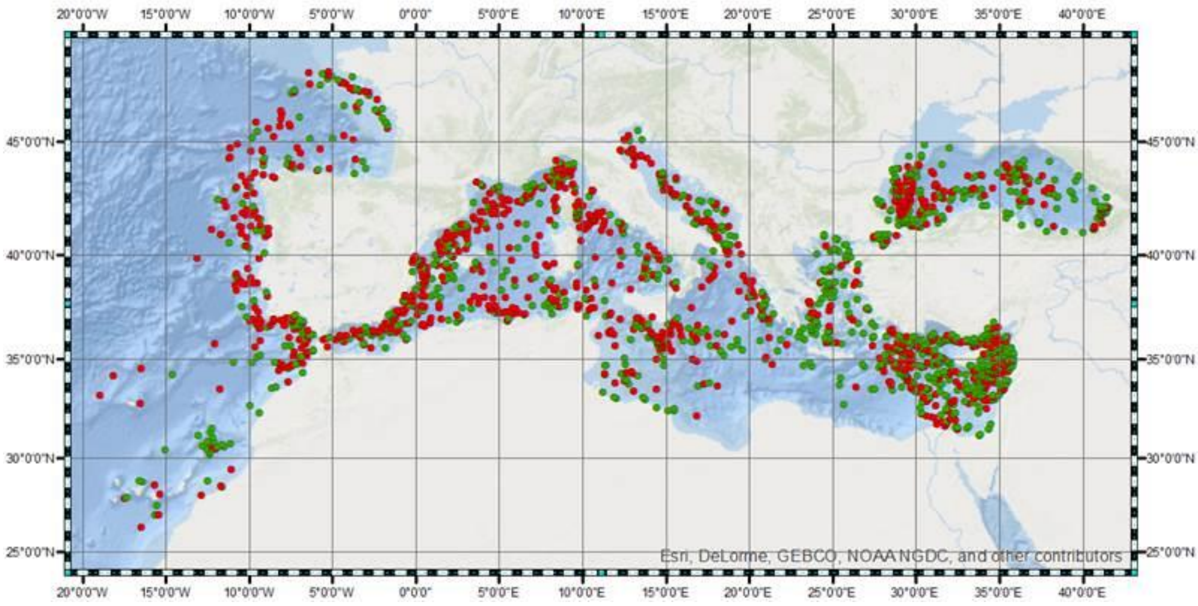

Figure 7: Number of spills detected in 2016 by satellite imagery (Source: CleanSeaNet, EMSA, 2016). Class A (red dots on the map): the detected spill is most probably oil (mineral or vegetable/fish oil) or a chemical product. Class B (green dots on the map): the detected spill is possibly oil (mineral/vegetable/fish oil) or a chemical product.

CONCLUSIONS

Conclusions (brief)

The rates of accidents have gone down globally and regionally despite the increase in shipping transportation and it can be concluded that the impact of the international regulatory framework adopted through the IMO as well as technical cooperation activities undertaken at regional level is very positive, especially as far as prevention of accidental pollution is concerned. However, risks associated with the transport by ships of oil and HNS with possible harmful consequences on biota and ecosystems cannot be completely eliminated, especially in vulnerable areas such as the Mediterranean Sea. In addition, efforts have to be made to strengthen monitoring and reporting of illicit discharges from ships.

Conclusions (extended)

Decrease of pollution occurrences globally.

Accidents rates have gone down globally and regionally despite the increase in shipping transportation. Accidental pollution from both oil and HNS has decreased which can be related to the adoption and implementation of environmental maritime conventions addressing oil and HNS pollution prevention, preparedness and response. Indeed, statistical analysis indicates that there is a correlation between the period where the IMO regulatory framework was put in place (in the 70') and the years when this downward trend started to happen (in the 80'). It can therefore be concluded that the impact of the international regulatory framework adopted through the IMO as well as technical cooperation activities undertaken at regional level is very positive, especially as far as prevention of accidental pollution is concerned. However, the issue of illicit discharges from ships remains of concern, especially in semi-enclosed areas where the ability of the marine environment to regenerate is less likely to happen.

Oil pollution long-term effects.

It is also important to keep in mind that recovery of habitats following an oil spill can take place from between a few seasonal cycles (plankton) to several years (within one to three years for sand beaches and exposed rocky shores; between 1 and 5 years for sheltered rocky shores; between 3 and 5 years for saltmarshes; and up to 10 years or greater for mangrove).

According to ITOPF, while considerable debate exists over the definition of recovery and the point at which an ecosystem can be said to have recovered, there is broad acceptance that natural variability in ecosystems makes a return to the exact pre-spill conditions unlikely. Most definitions of recovery instead focus on the re-establishment of a community of fora and fauna that is characteristic of the habitat and functions normally in terms of biodiversity and productivity.

Therefore, despite the progress achieved in mitigating oil spill incidents from ships, it is clear that continuous monitoring of illicit discharges occurrences as well as cumulative effects and impacts, and continuous monitoring of accidental post-spill consequences on biota and ecosystems are needed.

Key messages

- Chronic sources (illicit discharges) of pollution into the marine environment from ships are the principal target for pollution reduction, as the trends for acute pollution (accidents) are controlled and decreasing.

Knowledge gaps

- The information collected via pollution reports is related to specific pollution events and not always useful or compatible with the information needed to assess the status of the marine environment.
- Maintaining the Mediterranean Alerts and Accidents Database is a prerequisite and the condition for being able to measure Common Indicator CI19.
- There is no obligation for countries to carry out environmental surveys of sea and shorelines affected by a spill. Systematic environmental shorelines assessment post spill is today recognised as a “must do” practice and can provide information on biota on a case by case basis.
- Very little data is available regarding illegal discharges from ships.
- Environmental monitoring and reporting: the focus of IMO conventions and guidelines relating to prevention of marine pollution is on ships’ compliance monitoring rather than on monitoring or measuring the state of the marine and coastal environment. The same can be noted with respect to reporting obligations. Reporting is required in the case of an accident causing pollution or in case of an illegal pollution is discovered (operational discharges). This perspective is reflected in the 2002 Prevention and Emergency Protocol. Therefore, the information collected is related to specific pollution events and not always useful or compatible with the information needed to assess the status of the marine environment.
- Accidents monitoring and reporting: there is an increase in the number of accidents reported to REMPEC, which is most likely due to a better compliance by the

Contracting Parties to the Barcelona Convention to report casualties, as required by Article 9 of the 2002 Prevention and Emergency Protocol. It is of utmost importance that the Contracting Parties to the Barcelona Convention continue to report on accidents as accurately as possible, as it is paramount that REMPEC continues to maintain the Mediterranean Alerts and Accidents Database to keep track of pollution events. This is a prerequisite and the condition for being able to measure Common Indicator CI19.

- Impact on biota affected by pollution: for the reason explained above, there is little information on the impact of pollution events caused by shipping on biota. Ship generated pollution impact is usually considered from a response perspective (protection of sensitive areas and facilities). There is no obligation for countries to carry out environmental surveys of sea and shorelines affected by a spill. However, systematic environmental shorelines assessment post spill is today recognised as a "must do" practice in terms of assessing the level of cleanliness of the affected area, as well as from a remediation perspective.
- Illicit discharges from ships: There is very little data is available regarding discharges from ships. As these are illegal operations by nature (when not within the limits set by MARPOL), it is extremely difficult to get information on occurrences and extent of spills. Marine surveillance requires aerial means and equipment (planes, airborne radars and sampling sets) or special technology such as the use of satellite images. There is no regionally centralised system for surveying the Mediterranean waters as defined in the Barcelona Convention. The CleanSeaNet platform, the European satellite-based oil spill monitoring and vessel detection service, is a good resource, but only available in principle to countries that are Members States of the European Union.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood
Indicator Assessment Factsheet Code	EO9CI20

RATIONALE/METHODS

Background (short)

The human exposure to chemical contaminants through commercial fish and shellfish species (ca. fisheries and aquaculture, respectively) is one the main concerns with regard the occurrence of pollutants in the marine environment. Wild and farmed marine species are exposed to environmental chemical contaminants through different mechanisms and pathways according their tropic level, which include from filter feeding to predatory species (bivalves, crustaceans, fish, etc.). The understanding of the health risks to humans (maximum levels, intake, toxic equivalent factors, etc.), through the consumption of potentially contaminated seafood is a challenge and a priority policy issue for governments, as well as a major societal concern.

GES for Common Indicator 20 can be achieved when the concentrations of contaminants in seafood are within regulatory limits set by legislation for human consumption.

Figure1: Major seafood species commercialized in the Mediterranean Sea in a fish market in Athens, Greece, CommonseafoodMediterranean_CGuitart.jpg

Background (extended)

There exist both bioaccumulation and biomagnification processes of the harmful chemicals released in the marine environment. Common examples are the well-known bioaccumulation processes of heavy metals and organic compounds in commercial bivalve species (such as *Mytillus galloprovincialis* in the Mediterranean Sea) or alkyl mercury compounds in fish (e.g. methylmercury in tuna fish), however, many of the current emerging chemicals have also been detected in commercial fisheries. There are different initiatives and regulations at national and international level, which have established public health recommendations and maximum regulatory levels for some contaminants (mainly, for legacy pollutants) in numerous marine commercial target species. The methylmercury potential poisoning continues as a global priority policy issue. In 2013 the Global Legally Binding Treaty (the Minamata Convention on Mercury) was relaunched by UNEP (UNEP, 2002). Further, the USFDA (US Food and Drugs Administration), the EFSA (European Food Safety Authority) and FAO/WHO (Food and Agriculture Organization and World Health Organisation) (FAO/WHO, 2011), are also leading national and international authorities with regard seafood safety and regulatory levels to assess this Common Indicator 20. In relation to this, as mentioned, the European Council (EC) has introduced maximum levels for chemical contaminants, and subsequent amendments, including recently PCDDs, PCDFs and dioxin-like-PCBs in fishery products (Official Journal of the European Union, 2006 and 2011) which could serve as a preliminary target levels in the Mediterranean Sea.

Assessment methods

The present assessment has been undertaken based on bibliographic studies and scientific documents in the Mediterranean Sea thus there are not yet representative MED POL datasets available for this Common Indicator 20. More, the assessment of the CI 20 will be based, tentatively, on the statistics about the number of detected contaminants and their deviations from legal permissions in commercial fish species set by national, European and international regulations within national jurisdictional areas. These areas will need to be further defined from a spatial scale perspective (i.e. limited by national jurisdiction boundaries, GFCM-FAO subdivisions, etc.) within IMAP. The levels set by the European Regulations (Official Journal of the European Union, 2006 and 2011, see Table 1) and other international standards (such as WHO) can be of initial application to harmonize and compare future available datasets in the Mediterranean Sea. However, at present, the majority of the available datasets are hold in databases from surveys by national food laboratories, as well as regulatory and inspection bodies. Therefore, the frequencies in the number and excess of the occurrence on a temporal basis would define the GES achievement with regard to this common indicator (UNEP/MAP, 2013).

Table 1. Summary of current regulatory levels set by the European Union (extracted from Maggi et al., 2014; PLOS ONE Journal).

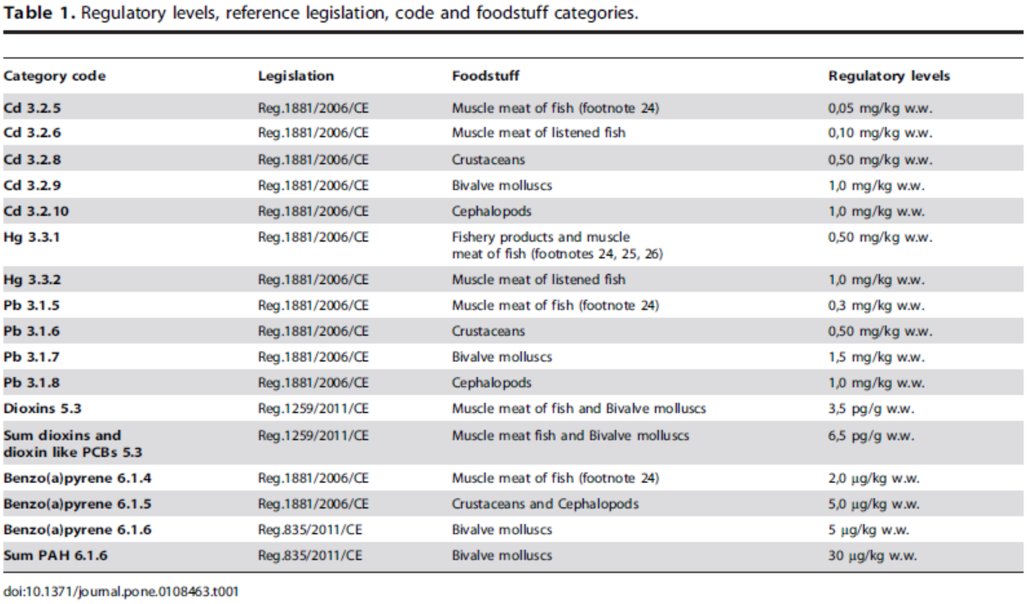

Table 1. Regulatory levels, reference legislation, code and foodstuff categories.

Category code	Legislation	Foodstuff	Regulatory levels
Cd 3.2.5	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	0,05 mg/kg w.w.
Cd 3.2.6	Reg.1881/2006/CE	Muscle meat of listened fish	0,10 mg/kg w.w.
Cd 3.2.8	Reg.1881/2006/CE	Crustaceans	0,50 mg/kg w.w.
Cd 3.2.9	Reg.1881/2006/CE	Bivalve molluscs	1,0 mg/kg w.w.
Cd 3.2.10	Reg.1881/2006/CE	Cephalopods	1,0 mg/kg w.w.
Hg 3.3.1	Reg.1881/2006/CE	Fishery products and muscle meat of fish (footnotes 24, 25, 26)	0,50 mg/kg w.w.
Hg 3.3.2	Reg.1881/2006/CE	Muscle meat of listened fish	1,0 mg/kg w.w.
Pb 3.1.5	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	0,3 mg/kg w.w.
Pb 3.1.6	Reg.1881/2006/CE	Crustaceans	0,50 mg/kg w.w.
Pb 3.1.7	Reg.1881/2006/CE	Bivalve molluscs	1,5 mg/kg w.w.
Pb 3.1.8	Reg.1881/2006/CE	Cephalopods	1,0 mg/kg w.w.
Dioxins 5.3	Reg.1259/2011/CE	Muscle meat of fish and Bivalve molluscs	3,5 pg/g w.w.
Sum dioxins and dioxin like PCBs 5.3	Reg.1259/2011/CE	Muscle meat fish and Bivalve molluscs	6,5 pg/g w.w.
Benzo(a)pyrene 6.1.4	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	2,0 µg/kg w.w.
Benzo(a)pyrene 6.1.5	Reg.1881/2006/CE	Crustaceans and Cephalopods	5,0 µg/kg w.w.
Benzo(a)pyrene 6.1.6	Reg.835/2011/CE	Bivalve molluscs	5 µg/kg w.w.
Sum PAH 6.1.6	Reg.835/2011/CE	Bivalve molluscs	30 µg/kg w.w.

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RESULTS

Results and Status, including trends (brief)

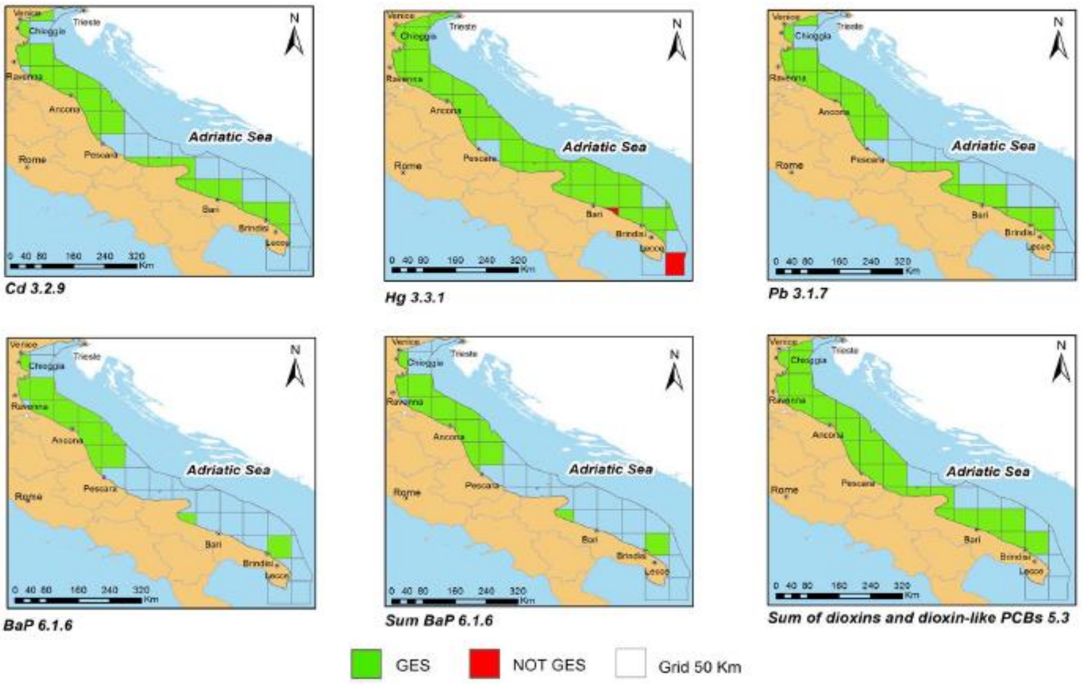
With regard the content of chemical contaminants fish and shellfish, different research studies have been recently conducted in the Mediterranean Sea taking into account a number of legacy and emerging chemicals. At present, scattered datasets all along the Mediterranean sub-basins mostly from research studies are available with few assessments recently undertaken under European marine policy (e.g. the Descriptor 9 under EU Marine Strategy Framework Directive) by European Contracting Parties of the Barcelona Convention. Overall, no major significant concerns or extreme high levels were observed and no confirmation based on temporal trends have been performed yet. Future harmonization and data sharing will improve the assessment in the Mediterranean Sea at a regional scale for this CI 20.

Results and Status, including trends (extended)

In the Eastern Mediterranean, selected heavy and essential metals (Cd, Pb, Cu and Zn) have been determined in some different brands and types of fishery products in Turkey (Çelik and Oehlen, 2007; Mol, S., 2011). Dioxins, dioxin-like and non dioxin-like PCBs have been also determined in Greek farmed fish (Costopoulou et al., 2016) and the levels found were well below the limits set by EU Legislation. In the Ionian Sea, the levels of a large set of toxic metals (As, Cd, Cr, Pb, Mn, Ni, V and Zn) were assessed in fish and shellfish from the Gulf of

Catania (Copat et al., 2013, 2014), and did not exceed the limits set by the EU legislation. However, a more recent study in the same area found levels exceeding the legal limits for some species, such as gastropods and fish (Giandomenico et al., 2016). The concentrations and congener specific profiles of legacy and emerging compounds, such as PCBs, PCDDs and PCDFs have been determined in various edible fish from the Adriatic Sea. The results obtained shown that levels were under the recommendations of the EU legislation (Storelli et al., 2011). Similarly, PCBs and PCDD/F concentrations and congener specific profiles were also determined in seafood (e.g. fish and cephalopods) in supermarkets in Southern Italy (Barone et al., 2014). Further, in terms of shellfish contamination levels transferred to seafood consumers, cultured and harvested bivalves have been recently evaluated in the Adriatic Sea (Croatia), and shown no risk (Milun, V., 2016). With regard an assessment performed under the context of the EU Marine Strategy Framework Directive (MSFD), Italy developed a full methodology and assessed the Descriptor 9 for heavy metals and PAH , which is equivalent to the EO9 Common Indicator 20 (Figure 2 and 3). Nevertheless, the datasets for synthetic compounds and their spatial coverage were somehow limited (Maggi, et al., 2014). Fish, molluscs, and crustaceans of commercial size of 69 different species were sampled and analyzed for total mercury (HgT), and were evaluated for their compliance with the EU Maximum Residue Limits (MRLs, Table 1) (Bambrilla, et al., 2013). Further, Naccari et al (2015), reported the residual levels of Pb, Cd and Hg in different species, caught from FAO zones around Italy; particularly, small pelagic, benthic and demersal fishes. Whilst in all samples was observed the absence of Pb, small concentrations of Cd and higher Hg levels were found, as well as differences between the two subdivisions. Only Cd concentrations exceeded the EU regulatory limits in different fish species, despite a large number of uncontaminated samples, 67%, 84% and 62% for Cd in mackerel, mullet and seabream, respectively.

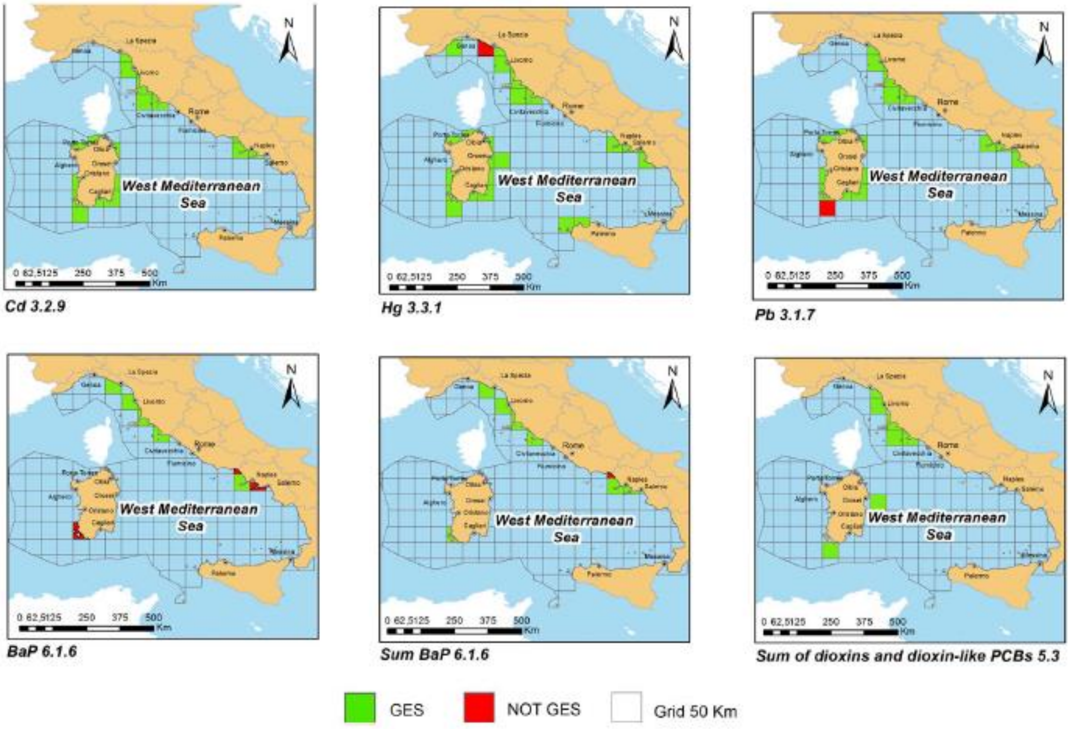
In the NW Mediterranean, mercury contamination was studied in deep-sea organisms to understand the transfer, fate and human implications of contaminated commercial species (Koenig et al., 2013). France, as a part of a specific monitoring programme, determined, heavy metals in gastropods, echinoderms and tunicates, which are also consumed locally in the Mediterranean Sea (Noël, L. et al., 2011). In the southern Mediterranean countries, Morocco has investigated the exposure of the coastal population to mercury via seafood consumption (Elhsmri, H., 2007). From a human health perspective, beyond environmental levels and compliance regulatory limits, some studies have been investigated both for legacy and emerging chemical of concern to assess the intake of seafood products to end-consumers. To this regard, it is worth to mention the study of the intake of arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs), polybrominated diphenylethers (PBDEs), polychlorinated diphenylethers (PCDEs), hexachlorobenzene and polycyclic aromatic hydrocarbons (PAHs) through fish and seafood consumption by children of Spain (Martí-Cid et al., 2007). Similarly, the estimated dietary intake of dioxins and dioxin-like PCBs in food marketed were also studied for seafood consumers in Spain (Marin, et al., 2011).



Cd 3.2.9 Hg 3.3.1 Pb 3.1.7

BaP 6.1.6 Sum BaP 6.1.6 Sum of dioxins and dioxin-like PCBs 5.3

Figure 2: Results on Metals, PAH and Dioxins/Dioxin-like PCBs in Adriatic Sea Sub-region (AS), (Maggi, C., Lomiri, S., et al., 2014).



Cd 3.2.9 Hg 3.3.1 Pb 3.1.7

BaP 6.1.6 Sum BaP 6.1.6 Sum of dioxins and dioxin-like PCBs 5.3

Figure 3: Results on Metals, PAH and Dioxins/Dioxin-like PCBs in Western Mediterranean (WMS), (Maggi, C., Lomiri, S., et al., 2014).

CONCLUSIONS

Conclusions (brief)

At present, few research studies and EU policy driven reports (ca. MSFD) in some Mediterranean countries have investigated the occurrence of contaminants in seafood from an environmental perspective (ca. Ecosystem Approach), which are exceeding the maximum regulatory levels established within regulatory standards. Overall, from available studies, no major significant concerns or extreme high levels were observed within these recent research studies by different authors and no confirmation based on temporal trends have been performed yet.

Conclusions (extended)

For future assessments within this indicator, the GFCM-FAO defined areas in the Mediterranean Sea (Area 37 and their subdivisions), could be selected and assessed under different national strategies, although harmonized at a regional scale, to evaluate contaminants in commercial species to assess CI20 under IMAP. A recent study with tuna (*Thunnus thynnus*) in Mediterranean FAO areas, shown that residues of PCBs and PBDEs are present. The study concludes that the Mediterranean area show the highest levels for these chemical compounds (Figure 4) compared to other evaluations in FAO areas worldwide (Chiesa et al., 2016).

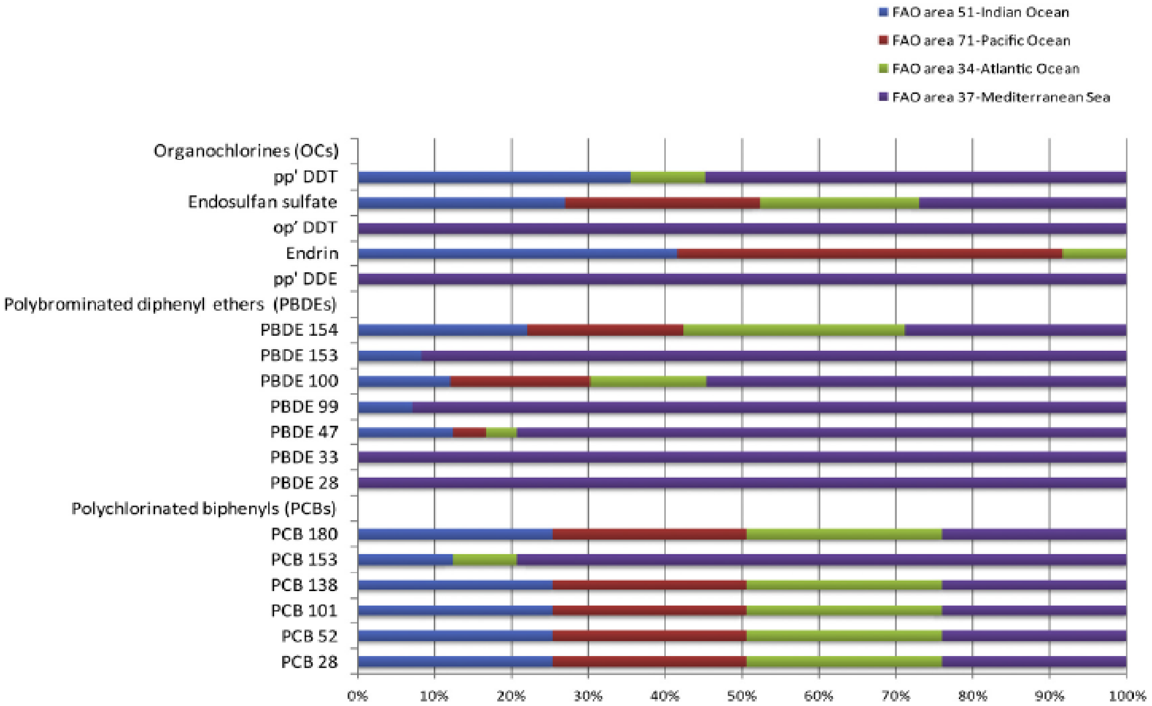


Figure 4: Comparison of POPs levels in different FAO areas worldwide (source: Chiesa et al., 2016)

Key messages

- Regular datasets are unavailable to perform an assessment of the Common Indicator 20.
- Chemical contaminants occurrence in fish and shellfish and the possible intake scenarios for population have been studied in different locations, including some of the FAO delimited zones in the Mediterranean Sea for a number of legacy and emerging contaminants within research studies.
- Pelagic, demersal and benthic species have been targeted and investigated to assess GES in terms of potential seafood contamination and to reflect the health condition of the marine ecosystem

Knowledge gaps

- The regular information required to assess this indicator is clearly lacking on a regional scale (ca. comparable and quality assured data), and at sub regional scale to some extent to be able to perform a complete assessment.
- Monitoring protocols, risk-based approaches, analytical testing and assessment methodologies would need to be further developed focusing on the harmonization between Contracting Parties.
- The liaison with national food safety authorities, research organisations and/or environmental agencies will be required.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI21. Percentage of intestinal enterococci concentration measurements within established standards
Indicator Assessment Factsheet Code	EO9CI21

RATIONALE/METHODS

Background (short)

The Mediterranean Sea continues to attract every year an ever-increasing number of international and local tourists that among their activities use the sea for recreational purposes. Back in 2005, the number of sewage treatment plants was doubled with respect the precedent decade and the water quality with regard to fecal pollution clearly improved (UNEP/MAP MED POL, 2010). The establishment of sewage treatment plants and the construction of submarine outfall structures have decreased the potential for episodes of microbiological pollution; despite few major coastal hotpots still exist. A revision of the Mediterranean guidelines for bathing water quality was formulated in 2007 based on the WHO Guidelines for Safe Recreational Water Environments (WHO, 2003) and on the EC Directive for Bathing Waters (Directive 2006/7/ EU). Later on, a revised UNEP/MAP proposal was made in an effort to provide updated criteria and standards that could be used in the Mediterranean countries, as well as to harmonize their legislation in order to provide homogenous information and data (UNEP/MAP, 2012a). High levels of enterococci bacteria in recreational marine waters (coasts, beaches, tourism spots, etc) are known to be indicative of human pathogens due to non-treated discharges into the marine environment and cause human infections (Kay et al., 2004; Mansilha et al, 2009). Therefore, these new standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol should be further used to define GES in bathing and recreational waters.

GES for Common Indicator 21 will be accomplished when concentrations of intestinal enterococci would be within the established standards (UNEP/MAP, 2013).

Figure 1: A high bathing water quality in Mediterranean beaches is a key element within safe recreational activities in the coastal environment

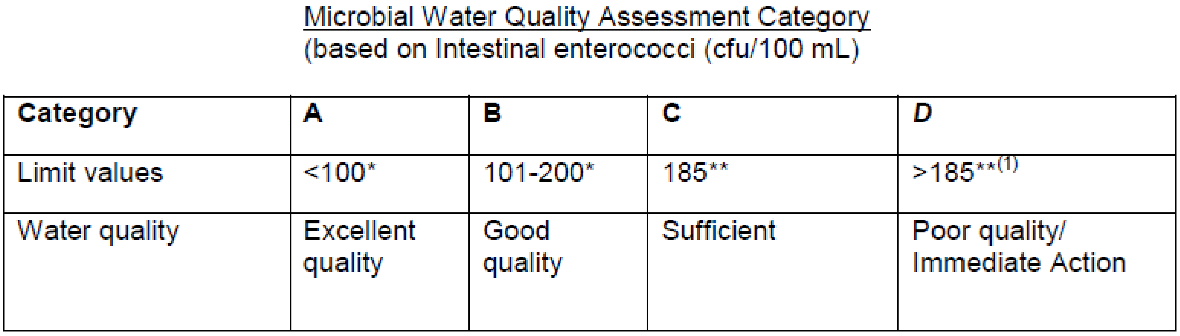
Background (extended)

High levels of enterococci bacteria in recreational marine waters (coasts, beaches, tourism spots, etc.) are known to be indicative of human pathogens due to non-treated discharges into the marine environment and cause human infections (Kay et al., 2004; Mansilha et al, 2009). Therefore, these standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol should be further used to define GES in bathing and recreational waters. Currently, is the only faecal indicator bacteria recommended by the US Environmental Protection Agency (EPA) for brackish and marine waters. The simplicity of the analytical methods for their measurements has favoured the use of enterococci species as a surrogate of polluted recreational waters. The World Health Organization has been concerned with health aspects of the management of water resources for many years and published various documents concerning the safety of environmental waters and its importance for health, including marine waters. A revision of the Mediterranean guidelines (UNEP/MAP, 2012) for bathing water quality were formulated in 2007 based on the WHO Guidelines for Safe Recreational Water Environments (WHO, 2003) and on the EC Directive for Bathing Waters (Directive 2006/7/ EU).

Assessment methods

The present assessment has been undertaken based on reference documents, as no sufficient updated datasets at regional scale are available. The future assessments of Common Indicator 21will be based on the statistics from datasets submitted by local national authorities or/and the corresponding agencies. Standards of application within IMAP Common Indicator 21 compliance by Mediterranean countries will be the proposed criteria adopted by decision IG.20/9, which includes the intestinal enterococci sample criteria (see table below):

Table 1: Microbiological Water Quality Criteria for intestinal enterococci sp., Source: Decision IG. 20/9, UNEP/MAP, 2012.



Microbial Water Quality Assessment Category
(based on Intestinal enterococci (cfu/100 mL)

Category	**A**	**B**	**C**	***D***
Limit values	<100*	101-200*	185**	>185**(1)
Water quality	Excellent quality	Good quality	Sufficient	Poor quality/ Immediate Action

RESULTS

Results and Status, including trends (brief)

As mentioned, the datasets for the most Eastern and Southern Mediterranean countries are not updated recently, and therefore, the full assessment at regional scale for Common Indicator 21 is not possible. An assessment report from the European Environment Agency (EEA) Report on Bathing Water Quality (from 2015) merged with MED POL data for Tunisia (from 2014) shows about a 90% or higher of the sites monitored during the bathing season for some Contracting Parties of the Barcelona Convention classified as good or excellent. Exceptions are Albania and Tunisia were around a 40% and 10%, respectively, show a poor sanitary condition of the bathing and recreational waters. The temporal trends were calculated by the EEA (EEA, 2015) and exhibit an steady-state and conservative trend for almost all the countries with respect the number of acceptable sites were bathing water quality is controlled.

Results and Status, including trends (extended)

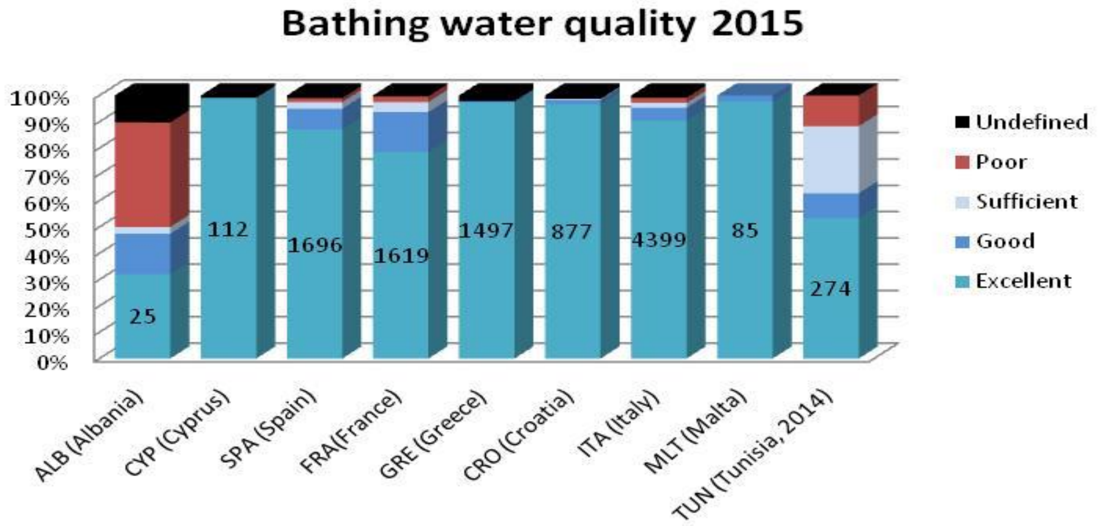


Figure 2: Percentages of the bathing water quality assessment with respect Common Indicator 21 in 2015 for some Contracting Parties of the Barcelona Convention. Please, note France and Spain data includes also the Atlantic coastal sites, in any case, with almost a 100% of sites with good and excellent quality. (Source: EEA, 2015 and MED POL Database for Tunisia).

CONCLUSIONS

Conclusions (brief)

The implementation of measures (e.g. sewage treatment plants) to reduce, among others, the faecal pollution in coastal waters, has been a story-of-success in the Mediterranean Sea through the UN Mediterranean Action Plan. The generalization of the domestic waters depuration in a number of countries the latest decade has demonstrated the benefits of implementing the LBS protocol and environmental measures to reduce pollution, despite some few improvements still need to be taken.

Conclusions (extended)

In the Mediterranean region over the latest decades there has been an amelioration of the wastewater treatment which prevents inputs of contaminants in coastal areas, including microbial pollution.

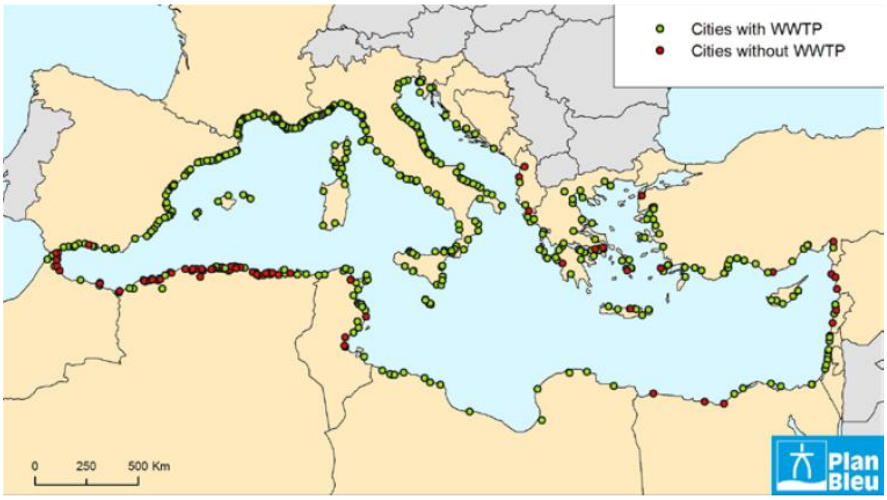


Figure 3: Waste water treatment in the Mediterranean coasts back in 2010 to prevent microbiological pollution of bathing waters (Source: EEA, 2014, based on MAP Technical Report Series No 157, 2004; UNEP/MAP, 2011 and UNEP(DEPI)/MED WG.357/Inf.7).

Key messages

- An increasing trend in measurements is needed to be able to test that levels of intestinal enterococci comply with established standards for GES achievement under Common Indicator 21.

Knowledge gaps

- The lack of recent datasets on microbiological pollution in the Mediterranean Sea submitted to the MAP Secretariat is the main current gap and concern, and therefore, to be able to monitor the future progresses under the Common Indicator 21.

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Ecological Objective 10 (EO10): Marine Litter

EO10: Common Indicator 22. Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source)

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional and national surveys, research and publications and as appropriate data from national monitoring programmes of the Contracting Parties.
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment.
IMAP Common Indicator	Common Indicator 22 (CI22): Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source).
Indicator Assessment Factsheet Code	EO10CI22

RATIONALE/METHODS

Background (short)

Much of what we know on the presence of marine litter (abundance, distribution, origin) in the marine and coastal environment comes from information collected on marine litter stranded on beaches (Ryan et al., 2009). Beach marine litter has drawn a lot of attention and numerous surveys and corresponding campaigns have been organized. However, a comparison among all these different studies is made difficult as the majority of these studies use different sampling protocols, techniques and methods. As in all marine compartments, plastics are predominant among the collected marine litter items found stranded on beaches. Several NGOs have been very active in tackling the problem, increasing the environmental awareness of the citizens, along with engaging them in marine litter related surveys, events and actions. Most of the available information on beach marine litter for the Mediterranean Sea comes from standing-stock surveys.

Monitoring of marine litter found stranded along the coastline of the Mediterranean still remains a priority. Special attention should be drawn upon the quantification and characterization of litter pollution found on beaches along with providing comparable datasets to support national and regional assessment of beach marine litter (JRC, 2013). This is also the key to introduce and implement effective policy and management measures. An in depth and comprehensive understanding of the level of threat posed by marine litter to biota and ecosystems at regional should be based upon reliable, quality assured, homogenized and comparable datasets and all efforts should target towards that direction.

Background (extended)

Even the most remote parts of the Mediterranean are affected by marine litter. The findings of the “Assessment of the status of marine litter in the Mediterranean” (2009) undertaken by UN Environment/Mediterranean Action Plan(MAP) MED POL in collaboration with the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), the Hellenic Marine Environment Protection Association (HELMEPA), and Clean up Greece Environmental Organization, illustrate that although useful data on types and quantity of marine litter exists in the region, it is inconsistent and geographically restricted mainly to parts of the North Mediterranean.

The economic values from coastal recreation are considerable (Ghermandi and Nunes, 2013). Clean seas and beaches are key to attract local and international tourism and are an integral part of the UN Environment/MAP Integrated Monitoring Assessment Programme of the Mediterranean Sea and Coast and related Assessment Criteria (IMAP) and the European Marine Strategy Framework Directive (MSFD), in which marine litter is one of the key indicators to assess Good Environmental Status (GES) and the effectiveness of policy measures (Brouwer et al., 2017; Galgani et al., 2013). Beach marine litter have been argued to pose a significant cost on society, in particular in the way they affect coastal tourism and recreation (UNEP, 2009).

The issue of marine litter and related information on the quantities and types in the Mediterranean is rather complex; as most Contracting Parties have not yet put in place their official monitoring programmes and thus do not submit related data on marine litter. In these cases, the situation can only be addressed principally by scientific institutions and sub-regional and local authorities in most countries, and by competent NGOs. Collection of information is a task that requires considerable human resources directly and indirectly related to the subject along with a sophisticated central coordination mechanism. Existing NGO initiatives in the region are often a relatively systematic and reliable source for quantities and types of litter . NGO efforts are the most significant in terms of surveying and cleaning beaches and the sea and for providing information on the volume and types of marine litter existing in the Mediterranean. However, the role of the Contracting Parties is very important and all national monitoring programmes, when in place, should take into consideration a harmonized approach/methodology to be applied at regional level.

Furthermore, initiatives of varying importance are being implemented by NGOs, local authorities and other partners at the national and local level in almost all Mediterranean countries. Thousands of volunteers have gathered with the purpose not only to clean the coasts, rivers and lakes in their local communities but also to raise awareness amongst students, citizens, and various stakeholders about the serious implications of marine litter, as well as to inspire people to make a difference and improve their daily environmental conduct.

Strandline, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on the temporal and spatial distribution of marine litter. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. Stranding fluxes are therefore difficult to assess, and a decrease in marine litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of the marine litter found on beaches and very high densities have been found in some areas.

One of the major problems for beach marine litter is due to the different data cards, standards, and measures (i.e. classification, measurement by weight or number etc.), used in each initiative, while certain crucial information is completely lacking (i.e. length of coast cleaned, type of coast, proximity of coast to sources of litter, etc.) (UNEP/MAP, 2015).

Important policy achievements have been expanded at the regional level in the Mediterranean. The UN Environment/Mediterranean Action Plan(MAP) has adopted the Strategic Framework for Marine Litter Management in 2012 (Decision IG.20/10 - 17th Meeting of the Contracting Parties of the Barcelona Convention). Following, the Regional Plan on Marine Litter Management in the Mediterranean in the Framework of Article 15 of the Land Based Sources Protocol was adopted in 2013 (Decision IG.21/7 – 18th Meeting of the Contracting Parties of the Barcelona Convention), together with a decision (IG.22/10) in 2016 to support the implementation of the Marine Litter Regional Plan including Fishing-for-Litter Guidelines, an Assessment Report, Baselines Values, and Reduction Targets (19th Meeting of the Contracting Parties of the Barcelona Convention). In addition, the Integrated Monitoring and Assessment Programme of the Mediterranean Sea Coast and Related Assessment Criteria adopted in 2016 (Decision IG.22/7 – 19th Meeting of the Contracting Parties of the Barcelona Convention) two common and one candidate indicators on marine litter, along with an Integrated Monitoring and Assessment Guidance document (UNEP(DEPI)/MED IG.22/Inf7 - 19th Meeting of the Contracting Parties of the Barcelona Convention).

Assessment methods

The current assessment has been based on recent key assessments, reports and publications by UN Environment/MAP, and other projects and initiatives. The UN Environment/MAP 2015 Marine Litter Assessment in the Mediterranean report has been used as the main source for this indicator assessment factsheet.

Strandline surveys, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on temporal and spatial distribution. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. It should be noted that small fragments measuring less than 2.5 cm, also referred to as meso-litter (versus macro-litter), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of marine litter found on beaches and very high densities have been found in some areas.

More sophisticated strategies for monitoring beach marine litter can be also applied including the following aspects: selection of survey sites (100m stretch) and number of sites, frequency and timing of surveys, documentation and characterization of sites, selection of sampling unit and units for quantifying marine litter, collection and identification of marine litter items (survey forms, master list of items), size limit and classes of items, and removal and disposal of litter.

The recruitment and training of the corresponding staff and groups of volunteers is a requirement for any long-term marine litter assessment (UNEP, 2009). Staff and volunteers should have a very good level of understanding on the context and purpose of the marine litter assessment programme. Quality assurance and quality control of the collected data should be also ensured, mainly addressed through a consistent way of collecting and characterizing data at regional level.

RESULTS

Results and Status, including trends (brief)

It is currently difficult to assess the impact of marine litter on beaches due to the limited spatial availability of data and information in the Mediterranean (with most data found on northern shores), and also because of lack incomparability between data due to the differing methodologies used. Mediterranean NGOs have significantly contributed in providing data and information on the temporal and spatial distribution of marine litter found stranded on beaches through beach clean-up campaigns and dedicated monitoring surveys but many of these are still not comparable to give a complete picture at regional level. Also, little is known on the accumulation and loading rates and correspondingly stranding fluxes and rates are difficult to assess.

Information is available on the main types of beach marine litter comprising of plastic, glass, paper, metal, polystyrene, cloth, rubber, fishing-related items, munitions, wood, smoking-related items, sanitary waste, and other un-identified items (Table 1). According to the 2016 International Coastal Cleanup (ICC) report, the top items for the Mediterranean Sea are: cigarette butts, plastic beverage bottles, food wrappers, plastic bottle caps, straws/stirrers, other plastic bags, glass beverage bottles, plastic grocery bags, metal bottle caps, and plastic lids. Plastics are the predominant type of marine litter found on beaches accounting for over 80% of the recorded marine litter (UNEP/MAP, 2015). Within these marine litter types, specific items are found more frequently i.e. cigarette butts, food wrappers, plastic bottles, caps, straws and stirrers, grocery plastic bags, glass bottles, other plastic bags and cans. Most of the recorded marine litter items are derived from land-based sources (including poor waste management practices, recreational and tourism activities).

Table 1: Composition/ sources of marine litter in the Mediterranean

Source (Literature)	**Items/Consistency (beaches; top five)**	**Type of material**	**Sources**
IPA Adriatic DeFishGear (2016)	Items (top 5): -Plastic pieces 2.5 cm >< 50 cm : 19.89% -Polystyrene pieces 2.5 cm >< 50 cm: 11.93% -Cotton bud sticks: 9.17% -Plastic caps/lids from drinks: 6.67% -Cigarette butts and filters: 6.60%	Plastics: 91%	Recreational & tourism: 40% Households(combined) : 40% Coastal tourism: 32,3% Toilet/sanitary: 26,2% Household: 11,2% Waste collection: 6% Recreational: 5,6%
Marine Litter Watch (MLW) / European Environment Agency (EEA)	- Other types: 32% - Cigarette butts: 18% - Plastic pieces 2.5><50 cm: 11% - Shopping bags (incl. pieces): 7% - Cotton butt sticks: 6% - Plastic caps/lids drinks: 6% - Polystyrene pieces 2.5><50 cm: 6% - Glass/ceramic fragments <2.5 cm: 4% - String and cord (less than 1cm): 4% - Crisps packet/sweets wrappers: 3% Drink bottles <=0.5lt: 3%	Plastics: 64% Glass: 4%	
Öko-Institut (2012; figures mainly from UNEP, 2009)	-Cigarette butts: 29,1% - Caps/lids: 6,7% - Beverage cans: 6,3% - Beverage bottles (glass): 5,5% - Cigarette lighters: 5,2%	Beaches: 37-80% plastics Floating: 60-83% plastics Sea-floor: 36-90% plastics	Recreational/shoreline activities: >50%, Increase in tourism season
Ocean Conservancy/ ICC 2002-2006			Beach litter: recreational activities: 52% Smoking-related activities: 40% waterways activities: 5%
JRC IES (2011)		Beach:83% plastics/polystyrene	

Shoreline activities (including poor waste management practices, tourism and recreation), along with sea/waterway activities, smoking-related activities, dumping and improper disposal of medical/personal hygiene items are among the main beach marine litter sources

(Table 1). Tourism has a significant share in the generation of beach marine litter. During the summer period population is almost doubled in the coastal areas of the Mediterranean Sea, with a corresponding increase in waste generation, reaching up to 75% of the annual waste production for some areas. Similarly, marine litter concentration has also been found to double during summer. Public awareness, citizen engagement and participation are an important contribution in tackling the problem of marine litter along the shorelines of the Mediterranean Sea.

Results and Status, including trends (extended)

Strandline surveys, cleaning, and regular surveys at sea more recently being organized in many Mediterranean countries with the aim of providing information on the temporal and spatial distribution of marine litter. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. One major challenge is that small fragments measuring less than 2.5 cm, also referred to as meso-litter (versus macro litter), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of the litter found on beaches and very high densities have been found in some areas.

Based on the data provided by the Ocean Conservancy, processed and analyzed by HELMEPA from beach clean-ups in Mediterranean countries within the framework of the International Coastal Cleanup (ICC) campaign, the main types of litter found on Mediterranean beaches, are listed in Tables 2, 3 and 4.

Table 2: Main types of beach marine litter in the Mediterranean (ICC after UNEP, 2011)

Plastics: bags, balloons, beverage bottles, caps/lids, food wrappers/ containers, six-pack holders, straws/stirrers, sheeting/tarps, tobacco packaging and lighters
Glass: beverage bottles, light bulbs
Paper and cardboard of all types
Metals: aluminium beverage cans, pull tabs, oil drums, aerosol containers, tin cans, scrap, household appliances, car parts
Polystyrene: cups/plates/cutlery, packaging, buoys
Cloth: clothing, furniture, shoes
Rubber: gloves, boots/soles, tires
Fishing related waste: abandoned/lost fishing nets/line and other gear
Munitions: shotgun shells/wadding
Wood: construction timber, crates and pallets, furniture, fragments of all the previous
Cigarette filters and cigar tips
Sanitary or sewage related litter: condoms, diapers, syringes, tampons
Other: rope, toys, strapping bands

Table 3: Top ten items in the Mediterranean Sea (International Coastal Clean-up, ICC, 2016). Total number is the number of items collected on 94.4 km of beaches from 11 different countries (Albania, Algeria, Bosnia/Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Morocco, Slovenia, Spain, and Turkey)

	cigarette butts	plastic beverage bottles	food wrappers	plastic bottle caps	straws/ stirrers	other plastic bags	glass beverage bottles	plastic grocery bags	metal bottle caps	plastic lids
Total collected number	68561	17652	8429	16809	16061	4026	2914	3908	2918	6833
number /100m	73	19	9	18	17	4	3	4	3	7

Table 4: Top fifteen beach litter items for the Mediterranean Sea and their share and average frequency per 100m coast line, based OSPAR screening (after JRC 2016)

Description	Average # / 100m	Share
Cutlery/trays/straws (total)	131	17%
Cigarette butts	112	14%
Caps/lids (total)	110	14%
Drink bottles (total)	91	12%
Bags (e.g. shopping)	43	5%
Cotton bud sticks	37	5%
Bags	35	4%
Plastic/polystyrene pieces 2.5 cm >< 50 cm (total)	30	4%
Bottles	28	4%
Crisp/sweet packets and lolly sticks (total)	26	3%
Food incl. fast food containers	15	2%
Cigarette packets	12	2%
Cigarette lighters	11	1%
Drink cans	11	1%
Other sanitary items	9	1%
TOTAL	**701**	**89%**

By far the most predominant type of marine litter in the Mediterranean are cigarette filters (closely followed by cigar tips), which constitute a concern to the region and can be found even in the most remote coastal areas. Thus, 4822 volunteers collected 68,561 cigarette butts in 2015, which corresponds to almost 14.2 cigarette butts per volunteer, while the corresponding average in 2013 was 19.6, compared to the global average in 2006 which was only 3.66 cigarette butts per volunteer. The degradation time for each type of litter is an important factor, as some may degrade fast, in the range of months or years, indicating more concern. It is also important to note that in the ICC Campaign, the small fragments do not appear in the corresponding list of recorded beach marine litter items.

Table 5: Composition/ sources of marine litter in the Mediterranean

Source (Literature)		Items/Consistency (beaches; top five)	Type of material	Sources
IPA Adriatic DeFishGear (2016)		Items (top 5): -Plastic pieces 2.5 cm >< 50 cm : 19.89% -Polystyrene pieces 2.5 cm >< 50 cm: 11.93% -Cotton bud sticks: 9.17% -Plastic caps/lids from drinks: 6.67% -Cigarette butts and filters: 6.60%	Plastics: 91%	Recreation tourism:40 Household % Coastal tou Toilet/sani Household Waste coll Recreation
Marine Litter Watch (MLW) / European Environment Agency (EEA)	-	- Other types: 32% - Cigarette butts: 18% - Plastic pieces 2.5><50 cm: 11% - Shopping bags (incl. pieces): 7% - Cotton butt sticks: 6% - Plastic caps/lids drinks: 6% - Polystyrene pieces 2.5><50 cm: 6% - Glass/ceramic fragments <2.5 cm: 4% - String and cord (less than 1cm): 4% - Crisps packet/sweets wrappers: 3% - Drink bottles <=0.5lt: 3%	Plastics: 64% Glass: 4%	
Öko-Institut (2012; figures mainly from UNEP, 2009)		-Cigarette butts: 29,1% - Caps/lids: 6,7% - Beverage cans: 6,3% - Beverage bottles (glass): 5,5% - Cigarette lighters: 5,2%	Beaches: 37-80% plastics Floating: 60-83% plastics Sea-floor: 36-90% plastics	Recreation activities: > Increase in season
Ocean Conservancy/ ICC 2002-2006				Beach litte recreationa 52% Smoking-re 40% waterways
JRC IES (2011)			Beach:83% plastics/polystyrene	

Marine litter items cannot always be linked to a specific source as several marine litter items can be attributed to more than one source, means of release, geographic origin, pathways or transport mechanism (Veiga et al., 2016). The origin of marine litter is often categorized into land-based and sea-based sources. Similarly, riverine litter is sometimes considered to be land-based, even though littering can originate from boats and ships navigated in rivers. Possible riverine sources include the following: public littering on riverbanks or directly in the river, and waste from cities and harbours; poor waste management practices, fly tipping; improper disposal or loss of products from industrial and agricultural activities; debris from the discharge of untreated sewage, either through lack of waste - treatment facilities or from sewer overflows; and storm water discharges (González et al., 2016).

Marine litter from smoking related activities accounts for almost 40% of total marine litter in the same period, and 53.5% of the top ten items counted in 2013. Although the number of litter items from smokers dropped significantly between 2004 and 2005, since 2005 it has been on the rise again. The figure in the Mediterranean is considerably higher than the global average, and constitutes a serious problem that has to be given priority in a Regional Strategy to address the issue.

Many studies on local beach surveys and marine litter collection provide information on the link between marine litter and tourism. During the summer season, the population of seaside towns are sometimes double to those present in wintertime. In some tourist areas, more than 75% of the annual waste production is generated during the summer season. According to statistics from holiday destinations in the Mediterranean (Bibione-Italy and Kos-Greece), tourists generate an average of 10% to 15% more waste than inhabitants. In the example of Kos Island, the tourism period lasts from April till October, with 70% of the total annual waste produced during this period (UNEP 2011).

Malta, where over 20% of the Global Net Production is generated from tourism, realized an increase of packaging (37% of Municipal Solid Waste (MSW)) in 2004 and introduced "bring-in sites" with 400 stations installed by 2006 (State of the Environment Report Malta 2005, in UNEP 2011). Unfortunately, no new data regarding the results of the introduction are yet available, and the latest report from 2005 still indicates an increasing waste production per capita with tourism. Since then, a resource management approach for the period 2014-2020 has been put in place. The Waste Management Plan for the Maltese islands (WMP: Section 2.1 – Municipal Solid Waste) provides an insight on the amount of MSW generated during 2004-2011 together with the amounts of MSW that have been recovered and recycled. Additionally, the WMP states that in 2010 municipal waste generated per capita was reduced to 595.5 kg, which corresponds to 50.8 kg less municipal waste per capita than in 2009. The total amount of generated MSW also includes those generated by tourists. However, the per capita figure quoted for 2010 does not include the annual number of tourists visiting Malta.

Research funded by the Balearic Government in 2005 (Martinez-Ribes *et al.*, 2007) focused on the origin and abundance of beach litter in the Balearic Islands, including Mallorca, Menorca, and Ibiza, which are all main tourist destinations. This fundamental study shows similarities to other tourist areas and is therefore very helpful regarding the sources of littering, which are highly connected to tourism. Litter found in summertime is twice as much as in winter (Figure 1).

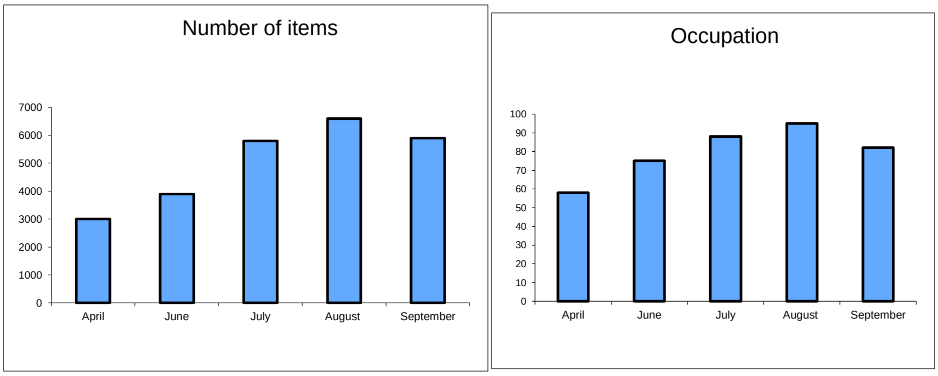

Figure 1: Monthly variation of litter items (A) and percentage of hotel occupation for the corresponding date (B) in the Balearic Islands (Source Martinez-Ribes et al., 2007)

In another example, Israel achieved good results with their pollution abatement Clean Coast Index, involving Municipalities and NGOs in beach clean-ups (Ministry of Environmental Protection, 2008). Although there is no data concerning the types and quantities of marine litter pollution in the coastal area, the published index shows a 30% reduction of littered beaches. Raising public awareness with leaflets and competitions in tourist and public areas supported the strategy, and the ongoing efforts will be continued on a yearly basis to continue tackling the marine litter problem along the shorelines of Israel. In another case, data from a monitoring experiment on a sample of 52 beaches in France (Mer-terre.org) confirmed the existence of tourism and fishing related activities as main sources of marine litter.

The IPA-Adriatic DeFishGear project provided valuable data on beach litter from its one-year long surveys carried on beaches in the seven countries of the Adriatic-Ionian macro-region, namely Albania, Bosnia and Herzegovina, Croatia, Italy, Greece, Montenegro and Slovenia. More specifically, 180 beach transects were surveyed in 31 locations, covering 32,200 m^2 and extending over 18 km of coastline. The majority of marine litter items were artificial polymer materials accounting for 91.1% of all beach litter. Shoreline sources -including poor waste management practices, tourism and recreational activities, which accounted for 33.4% of total marine litter items collected on beaches. When looking at the sea-based sources of litter (i.e. fisheries and aquaculture, shipping) these ranged from 1.54% to 14.84% among countries, with an average of 6.30% at regional level for beach litter.

Standing stock evaluations of beach marine litter reflect the long-term balance between inputs, land-based sources or stranding, and outputs from export, burial, degradation and clean-ups. Recording the rate at which litter accumulates on beaches through regular surveys is currently the most commonly-used approach for assessing long-term accumulation patterns and cycles. The majority of studies performed to date have demonstrated densities in the 1 item/m^2 range, but also show a high variability in the density of marine litter depending on the use or on the characteristics of each beach site (UNEP/MAP, 2015). Plastic accounts for a large proportion of marine litter found on beaches in many areas, although other specific types of plastic are widely-found in certain areas, according to type (Styrofoam, etc.) or use (fishing gear). For ICC 2016 (Table 6), cigarette butts, plastic bags, fishing equipment, and food and beverage packaging are the most commonly-found items, accounting for over 80% of litter stranded on beaches.

Table 6: Top ten items by country (International Coastal Clean-up, ICC 2016) expressed as number of items/100m of beach

	Number of items per 100 m									
COUNTRY	Cigarette butts	Plastic beverage bottles	Food	Plastic bottle caps	Straws, stirrers	Other plastic bags	Glass beverage bottles	Plastic grocery bags	Metal bottle caps	Plastic lids
Albania	535	39	55	26	35	27	5	25	8	1
Cyprus	30	7	8	3	4	1	1	3	2	2
Egypt	1	1	1	4		1	1	1		
France	34	3	3	2	1	3	1	4	1	1
Greece	71	16	5	15	14	2	2	4	3	10
Italy[2]							5			
Malta		2					1			
Morocco	7	13	1	23	5	7	10	5	13	3
Slovenia	63	2	5	6	2	6	0	1	1	
Spain	83	21	20	36	39	9	5	6	5	7
Turkey	613	811	14				137	12		

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[2] The participation of Italy to ICC was limited to only 16 volunteers in a very small portion of coastline, so data reported in table 6 are not representative of the Italian situation.

Data from *Clean up Greece* between 2004 and 2008 indicated however the importance of plastic and paper which are abandoned and wind born on island beaches. On isolated beaches, other visible and larger sized marine litter items (metal, rubber, glass, and textile) have increased due to illegal dumping. The abundance, nature, and possible sources of litter on 32 beaches on the Balearic Islands (Mediterranean Sea) were investigated in 2005 (Figure 2). Mean summer abundance in the Balearics reached approximately 36 items per linear meter, with a corresponding weight of 32±25 g m^{-1}, which is comparable to the results of other studies in the Mediterranean. Strong similarities between islands and a statistically significant seasonal evolution of litter composition and abundance were demonstrated. During summer (the high tourist season), litter contamination was doubled to that in the low season and showed a heterogeneous nature associated with beach use. Again, cigarette butts were the most abundant item, accounting for up to 46% of the objects observed in the high tourist season. In contrast, plastics related to personal hygiene/medical items were predominant in wintertime (67%). In both seasons, litter characteristics suggested a strong relationship with local land-based origins. While beach users were the main source of summer litter, low tourist season litter was primarily attributed to drainage and outfall systems.

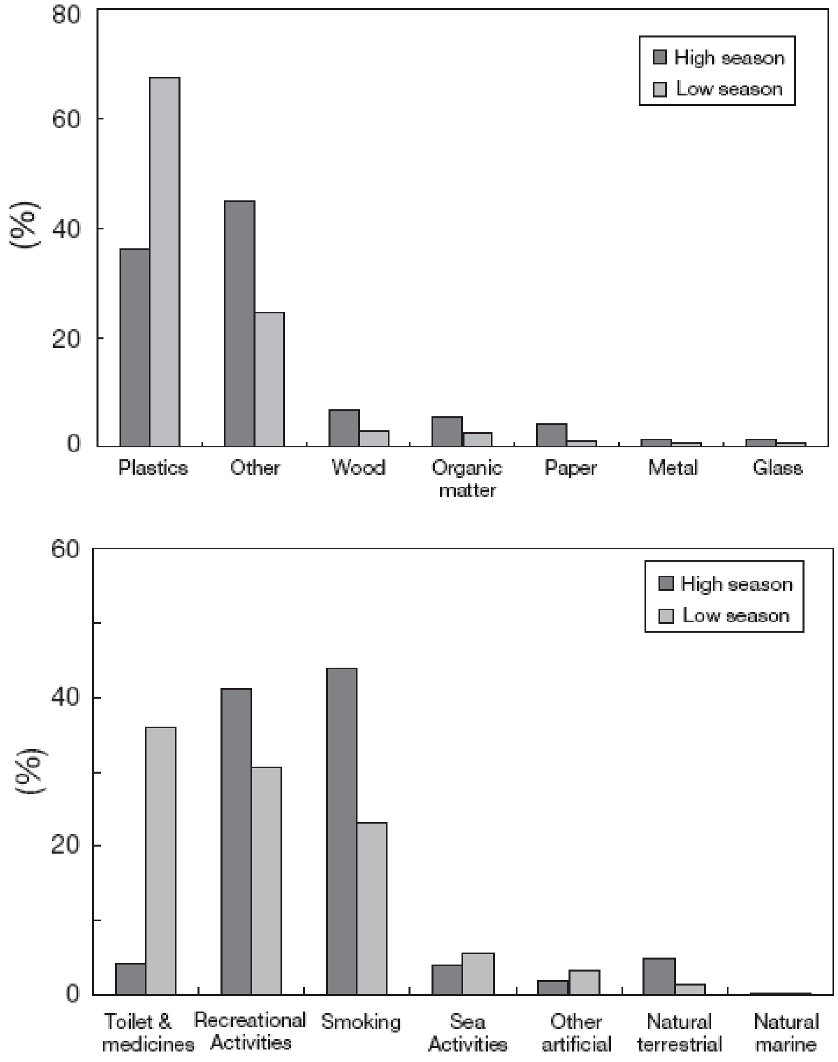

Figure 2: Litter composition (A) and estimated origin (B) of the litter collected in low and high tourist season in Balearic Islands (source Martinez-ribes et al., 2007)

CONCLUSIONS

Conclusions (brief)

Knowing the amounts of marine litter found stranded on beaches can help us assess the potential harm to the environment and would also enhance our knowledge on sources (JRC, 2013).Currently there is limited data and great spatial variability on the amounts and composition of marine litter reflecting the different characteristics along the shorelines of the Mediterranean.

Existing studies however indicate that the main types of beach litter are of land-based origin, coming from poor waste management practices, recreational and tourism activities, household items and smoking related waste (Table 4). For the time being, it is difficult to draw conclusions regarding the overall increase or decrease of marine litter in the Mediterranean (UNEP/MAP, 2015). Assessments of the composition of beach litter in different regions of the Mediterranean Sea show that synthetic polymer items (bottles, bags, caps/lids, fishing nets, and small pieces of unidentifiable plastic and polystyrene) make up the largest proportion of overall marine litter pollution.

Conclusions (extended)

The amount of marine litter originating from recreational/tourism activities greatly increases during and after the tourism season. Smoking related wastes in general also seems to be a significant problem in the Mediterranean, as several surveys suggest (UNEP 2009). According to the analysis of data collected, shoreline and recreational activities were the main source every year during the last decade, until it was surpassed by smoking-related waste (UNEP, 2011). In addition, the fishing industry is a significant source, as well as the shipping industry, especially off the African coast (UNEP, 2013).

National case studies may provide more detailed information on local constraints and effective factors related to the distribution of marine litter. National data coming from national monitoring programmes on marine litter will also improve the picture for beach marine litter. It is important to note, that volunteer groups should be informed about the necessity to submit standardized research data for statistical purposes. Clean up actions by NGOs are usually organized to raise awareness and not so much for data collection, and cleanup programmes should increase public knowledge of the scientific relevance of information and information sharing.

There are certain limitations to the results on beach marine litter in the Mediterranean. As it has been already stated for the moment the Contracting Parties are not submitting official marine litter data to the Secretariat as a result of the national monitoring programmes. The smaller sized items are not included in most of the case among the cleanup campaigns items list and thus these results are not at all representative for the presence of smaller fragments i.e. micro-litter along the beaches in the Mediterranean.

However, interesting observations have been made on the proliferation of lighter marine litter items in the Mediterranean (plastics, aluminum and smoking-related litter), as opposed to heavier items from basic use (bottles, cans, see Figure 3) or marine litter originating from dumping activities (household appliances, construction materials, tires, etc.). This could be related to the efficiency of preventive actions (easier collection, recycling, adoption and/or implementation of stricter legislation with regards to dumping activities, etc.) for larger items and the difficulty to manage inputs from sources such as the general public.

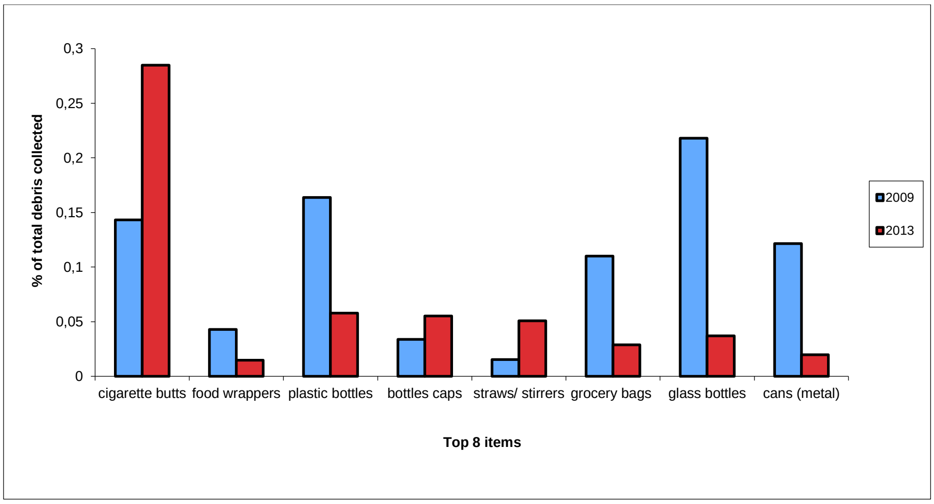

Figure 3: Changes in percentages of the top 8 items in the Mediterranean Sea between 2009 and 2013. Data from Ocean Coastal Cleanup on types of litter of 303522 items and 110698 items collected in 2009 and 2013 respectively on beaches from Greece, Turkey, Egypt and Spain (data from http://www.oceanconservancy.org/)

Environmental awareness is also observed when the general public, becomes conscious of the impact of its actions, and thus do not use beaches as disposal sites for heavy litter items as lightheartedly as they did in the past. The removal of these heavier items, combined with the persistent nature of plastics and other lighter marine litter items which can still be found in considerable numbers in the Mediterranean, has led to the changing nature of marine litter in the region.

Key messages

- Information on beach marine litter exists but the picture is still fragmented and is geographically restricted to the northern part of the Mediterranean.
- Plastics are the major components with cigarette butts, food wrappers and plastic bags being the top marine litter items.
- Land-based sources are predominant but they have to be further specified. Tourism is directly affecting marine litter generation on beaches.
- There is an urgent need to develop and implement the Integrated Monitoring and Assessment Programme for the Mediterranean Sea and Coast (IMAP) related to Common Indicator 22, and corresponding data are submitted to the Secretariat at national level.

Knowledge gaps

- Information on the distribution, quantities and identification of marine litter sources for beach marine litter needs to be further advanced. For the moment information and data are inconsistent for the Mediterranean.
- In that aspect, monitoring strategies should be encouraged at regional level based on harmonized and standardized monitoring and assessment methods.
- Mapping of the shorelines and coasts at basin scale, where marine litter accumulates, needs to be implemented.

- Accumulation and stranding fluxes needs to be evaluated coupled with information on corresponding loads and linkage with specific sources.
- Efforts should be enhanced towards engaging citizens, informing them about certain aspects and effects of marine litter found stranded on beaches, along with make responsible citizens (responsible consumption and littering behavior).
- Harmonized beach clean-up campaign at basin scale should be organized based on a science-based protocol which will enable the collection of relevant scientific information.

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Ecological Objective 10 (EO10): Marine Litter

EO10: Common Indicator 23. Trends in the amount of litter in the water column including microplastics and on the seafloor

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional and national surveys, research and publications and as appropriate data from national monitoring programmes of the Contracting Parties.
Mid-Term Strategy (MTS) Core Theme:	1-Land and Sea Based Pollution
Ecological Objective	Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment
IMAP Common Indicator	Common Indicator 23 (CI23): Trends in the amount of litter in the water column including microplastics and on the seafloor
Indicator Assessment Factsheet Code	EO10CI23

RATIONALE/METHODS

Background (short)

The marine environment is directly linked to human life. Nowadays, marine litter is found widespread in the environment, from shallow water till the deep abyssal plains, posing one of the major threats for the marine environment.

The Mediterranean Sea has been described as one of the areas most affected by marine litter in the world. Human activities generate considerable amounts of waste, and quantities are increasing, although they vary between countries. Some of the largest amounts of municipal solid waste (MSW), generated annually per person occur in the Mediterranean Sea (208 – 760 kg/year, http://atlas.d-waste.com/). Plastic, which is the main marine litter component, has now become ubiquitous and may comprise up to 90% for seafloor litter.

Surveys conducted to date in the Mediterranean Sea, show considerable spatial variability for marine litter. Accumulation rates vary widely and are influenced by many factors, such as the presence of large cities, shore use, hydrodynamics, and maritime activities. Marine litter is even more abundant in enclosed areas, which has some of the highest densities of marine litter stranded on the sea floor, sometimes reaching over 100,000 items/km^2 (Galgani et al., 2000). The estimated plastic densities of floating litter in the Mediterranean Sea seems to be of the same range as in the five sub-tropical gyres. To date, the fate of these marine litter items is still questionable and the identification of areas where litter permanently accumulate is a major challenge.

In the Gulf of Lion, plastic densities on the deep-sea floor has not changed over the years (1994 – 2009) although the abundance of marine litter in deep waters was found to increase over the years in the Central Mediterranean (Koutsodendris et al., 2008; Ioakeimidis et al., 2014).

Background extended

The global amount of marine litter entering into the oceans has been calculated at between 4.8 and 12.7 million tons, only for plastics (Jambeck et al., 2015). The deep-sea floor is probably the final global sink for this marine litter mostly comprising of plastic. The Mediterranean Sea has been described as one of the areas most affected by marine litter in the world and plastic in particular, is highly impacted by hydrodynamics, geomorphology, and human factors. The Mediterranean geomorphology is very peculiar with not extensive shelves and deep-sea environments that can be also influenced by the presence of coastal canyons. Continental shelves are proven accumulation zones, but they often gather smaller concentrations of marine litter than canyons; as litter is washed offshore by currents associated with offshore winds and river plumes.

Most marine litter is comprised of high-density materials and hence sinks. Even low-density synthetic polymers such as polyethylene and polypropylene, may sink under the weight of fouling or additives. The fouling of litter by a wide variety of bacteria, algae, animals and fine-grained accumulated sediments, increases their weight and marine litter can sink to the seafloor. In the Mediterranean, plastic which is the main marine litter component, is ubiquitous in the marine environment and may comprise up to 90% of the recorded seafloor marine litter.

Floating litter comprises the mobile fraction of marine litter in the marine environment, as it is less dense than seawater. However, the buoyancy and density of plastics may change during their stay in the sea due to weathering and biofouling (Barnes et al., 2009). Polymers comprise the majority of floating marine litter, with figures reaching up to 100%. Although synthetic polymers are resistant to biological or chemical degradation processes, they can be physically degraded into smaller fragments and hence turn into micro litter, measuring less than 5 mm.

The Mediterranean Sea is often referred to as one of the places with the highest concentrations of marine litter in the world. For floating litter, very high levels of plastic pollution are found, but densities are generally comparable to those being reported from many coastal areas worldwide (UNEP/MAP, 2015). A 30-year circulation model using various input scenarios showed the accumulation of floating litter in ocean gyres and closed seas, such as the Mediterranean Sea, made up 7-8% of the total litter expected to accumulate (Lebreton et al., 2012).

There are several studies investigating the abundance of marine litter in the Mediterranean Sea. The abundance of floating microplastic fragments was investigated in the Mediterranean Sea by Kornilios et al., 1998; Collignon et al., 2012; Fossi et al., 2012; Collignon et al., 2014; de Lucia et al., 2014; Pedrotti et al., 2014; Cozar et al., 2015; Panti et al., 2015; Fossi et al., 2016 ; Ruiz-Orejón 2016 and Suaria et al., 2016. Few studies have been also published on the abundance of floating macro and mega litter in Mediterranean waters (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015). Information also exist on the abundance of seafloor marine litter for the Mediterranean Sea (Galil et al., 1995; Galgani et al., 1996, 2000; Ioakeimidis et al., 2014; Pham et al., 2014; Ramirez-Llodra et al., 2013).

Floating litter can be transported by currents until they sink to the sea floor, are deposited on the shore, or are degraded over time. Marine litter that reaches the seafloor may have already been transported considerable distance, only sinking when weighted down by entanglement and fouling. The consequence is the accumulation of marine litter on specific seafloor locations in response to local sources and oceanographic conditions (Galgani et al., 2000; Keller et al., 2010; Watters et al., 2010; Ramirez-L lodra et al., 2013; Pham et al., 2013). Moreover, seafloor litter tends to become trapped in areas of low circulation. Once marine litter reaches the seafloor, lies on the seafloor and it may even be partly buried in areas of very high sedimentation rate (Ye and Andrady, 1991).

In terms of data availability on marine litter lying on the seafloor of the Mediterranean, there are several studies investigating the abundance of marine litter (Galil et al., 1995; Galgani et al., 1996, 2000; Ioakeimidis et al., 2014; Pham et al., 2014; Ramirez-Llodra et al., 2013, Vlachogianni et al., 2017) but the information is still fragmented and geographically restricted to the northern Mediterranean.

Marine litter and plastic in particular it was believed to last in the marine environment for decades or even hundreds of years when in surface (Gregory and Andrady, 2003), likely far longer when in deep sea (Barnes et al., 2009). However, recent studies (Ioakeimidis et al., 2016) have found that the degradation of plastics in the marine environment may occur much faster than it was expected. Surveys conducted to date show considerable spatial variability on marine litter abundance. Accumulation rates vary widely and are influenced by many factors, such as the presence of large cities, shore use, hydrodynamics, and maritime activities. They are higher in enclosed seas such as the Mediterranean basin, which has some of the highest densities of marine litter stranded on the sea floor, sometimes reaching over 100,000 items / km² (Galgani et al., 2000). Plastic densities on the deep sea floor did not change between 1994 and 2009 in the Gulf of Lion (Galgani et al., 2011). Conversely, the abundance of litter in deep waters, such as the central Mediterranean, was found to increase over the years (Koutsodendris et al., 2008; Ioakeimidis et al., 2014).

In the Mediterranean, reports from Greece (Koutsodendris et al., 2008; Ioakeimidis et al., 2014) classify land-based sources (up to 69% of litter) and vessel-based sources (up to 26%) as the two predominant litter sources. In addition, litter items have variable floatability and hence variable dispersal potential.

Important policy achievements have been expanded at the regional level in the Mediterranean. The UN Environment/Mediterranean Action Plan(MAP) has adopted the Strategic Framework for Marine Litter Management in 2012 (Decision IG.20/10 - 17th Meeting of the Contracting Parties of the Barcelona Convention). Following, the Regional Plan on Marine Litter Management in the Mediterranean in the Framework of Article 15 of the Land Based Sources Protocol was adopted in 2013 (Decision IG.21/7 – 18th Meeting of the Contracting Parties of the Barcelona Convention), together with a decision (IG.22/10) in 2016 to support the implementation of the Marine Litter Regional Plan including Fishing-for-Litter Guidelines, an Assessment Report, Baselines Values, and Reduction Targets (19th Meeting of the Contracting Parties of the Barcelona Convention). In addition, the Integrated Monitoring and Assessment Programme of the Mediterranean Sea Coast and Related Assessment Criteria adopted in 2016 (Decision IG.22/7 – 19th Meeting of the Contracting Parties of the Barcelona Convention) two common and one candidate indicators on marine litter, along with an Integrated Monitoring and Assessment Guidance document (UNEP(DEPI)/MED IG.22/Inf7 - 19th Meeting of the Contracting Parties of the Barcelona Convention).

Assessment methods

The current assessment has been based on recent key assessments, reports and publications by the UN Environment/MAP, and other projects and initiatives. The UN Environment/MAP 2015 Marine Litter Assessment in the Mediterranean report has been used as the main source for this indicator assessment factsheet. For the moment, there is no reporting toUN Environment /MAP on floating and seafloor marine litter and the assessment is based on the available data and information from reports and scientific publications. Several approaches, protocols and units (items/km, items/km^2, kg/km^2, kg/h) have been used. However, the expression of the abundance of marine litter found float at sea or lying on the seafloor in items per surface are (m^2, km^2, ha^2) coupled with information on weight seems to be the most appropriate. Nowadays the harmonization of all the sampling methodologies is among the top-priorities of the marine litter agenda.

A. Floating Marine Litter

Visual assessment of floating macro-litter particles include the use of research vessels, marine mammal surveys, commercial shipping carriers, and dedicated litter observations (UNEP/MAP, 2015). Aerial surveys have also been employed for larger items. For floating micro-litter particles, the manta-trawl net system is used for sampling the surface layers of the seas. The net it pulls is made of thin mesh (normally with mesh size of 333μm) and the whole trawl is towed behind a vessel. Then, laboratory work is required in order to analyze the collected samples.

B. Seafloor Marine Litter

Most of the data and information on seafloor marine litter come from general strategies for the investigation of seabed marine litter which are often similar to those used to assess the abundance and type of benthic species. Several approaches are applied in order to assess seafloor litter abundance and distribution: i) visual surveys with SCUBA in shallow waters; ii) opportunistic sampling using otter-trawls; and iii) observation tools (Remote Operated Vehicles - ROV etc.).

The most common approach to evaluate sea-floor litter distributions is opportunistic sampling. This type of sampling is usually coupled with regular fisheries surveys and programmes on biodiversity, since methods for determining seafloor litter distributions (e.g. trawling, diving, video) are similar to those used for benthic and biodiversity assessments. Monitoring programmes for demersal fish stocks, undertaken as part of the Mediterranean International Bottom Trawl Surveys (MEDITS), operate at large regional scale and provide data using a harmonized protocol, which may provide a consistent support for monitoring litter at Regional scale on a regular basis and within the Ecosystem Approach (EcAp) requirements.

The use of observation tools i.e. Remote Operated Vehicles (ROVs) and Submersible Vehicles is a possible approach for deep-sea environments (Galgani et al. 1996; Pham et al., 2014). These methods unfortunately require considerable financial means but are of great use for areas that cannot be accessed by other means. The use of observation tools helped scientists assess marine litter far beyond the commonly used fishing grounds (sandy bottoms) and the continental shelf, and extend the assessment of marine litter in bathyal and abyssal environments, reaching in depths up to 4km.

RESULTS

Results and Status, including trends (brief)

A. Floating Marine Litter

The abundance of floating macro and mega litter in Mediterranean waters has been reported at quantities measuring over 2 cm range from 0 to over 600 items per square kilometer (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015) (Figures 1, 2). Plastics are predominant among floating marine macro- and micro-litter items.

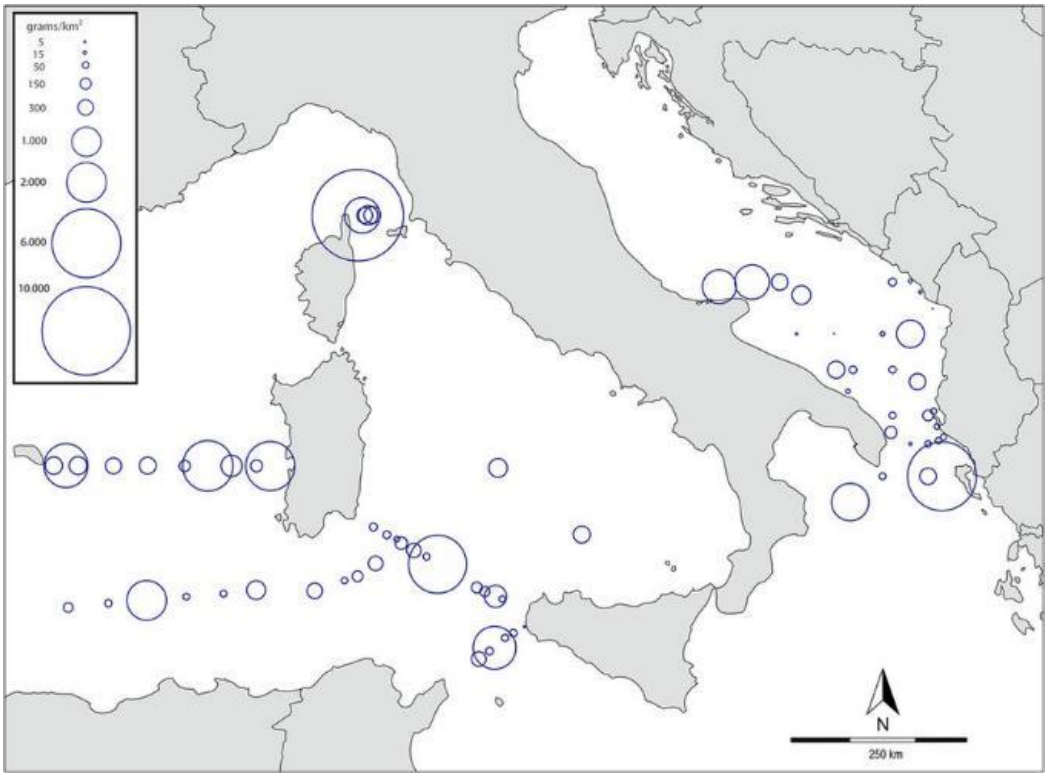

Figure 1: Map of the central-western Mediterranean Sea showing the distribution of plastic densities expressed as grams of plastic per km^2 (after Suaria et al., 2016)

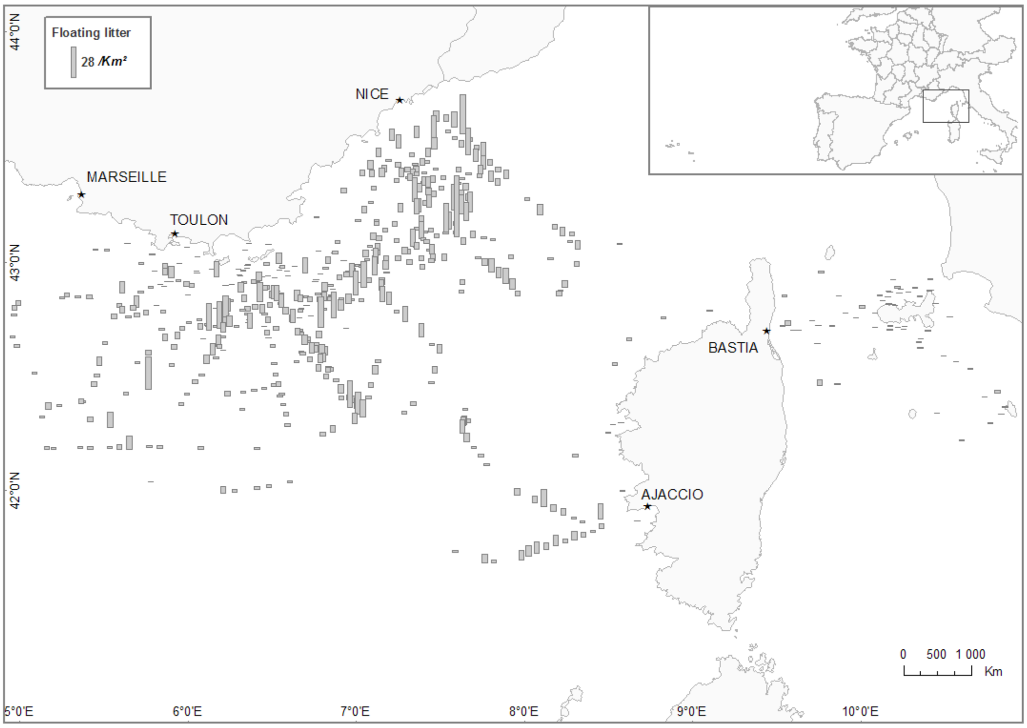

Figure 2: Distribution of floating litter in the northwestern Mediterranean Sea (2006-2008) (visual observations). IFREMER/SHOM map using data from the Ecocean/ParticipeFutur project for initial MSFD assessment (Gerigny et al., 2011)

B. Seafloor Marine Litter

The 2015 UN Environment /MAP Marine Litter Assessment report states that approximately 0.5 billion litter items are currently lying on the Mediterranean Seafloor. There is, however, a great variability in the abundance of seafloor marine litter items ranging from 0 to over 7,700 items per km² depending on the study area. Plastic is the major marine litter component, found widespread in the continental shelf of the Mediterranean, ranging up to 80% and 90% of the recorded marine litter items.

There is no clear picture as yet, on the abundance (number and mass) of marine litter lying on the Mediterranean seafloor, from the shallow water till the deep abyssal plain (Figure 3). The information is only limited and fragmented as only few studies exist regarding marine litter on the Mediterranean seafloor. In addition, the geographical distribution of marine litter items is highly impacted by hydrodynamics, geomorphology, and human factors. To date, the majority of studies are geographically restricted to the Northern part of the Mediterranean Sea. Most of the studies have been using traditional fish stock assessment methods i.e. otter trawlers, but recently new, costly and more sophisticated techniques have been also used. There still remains however very limited knowledge on the existence and importance of the corresponding accumulation areas in the Mediterranean.

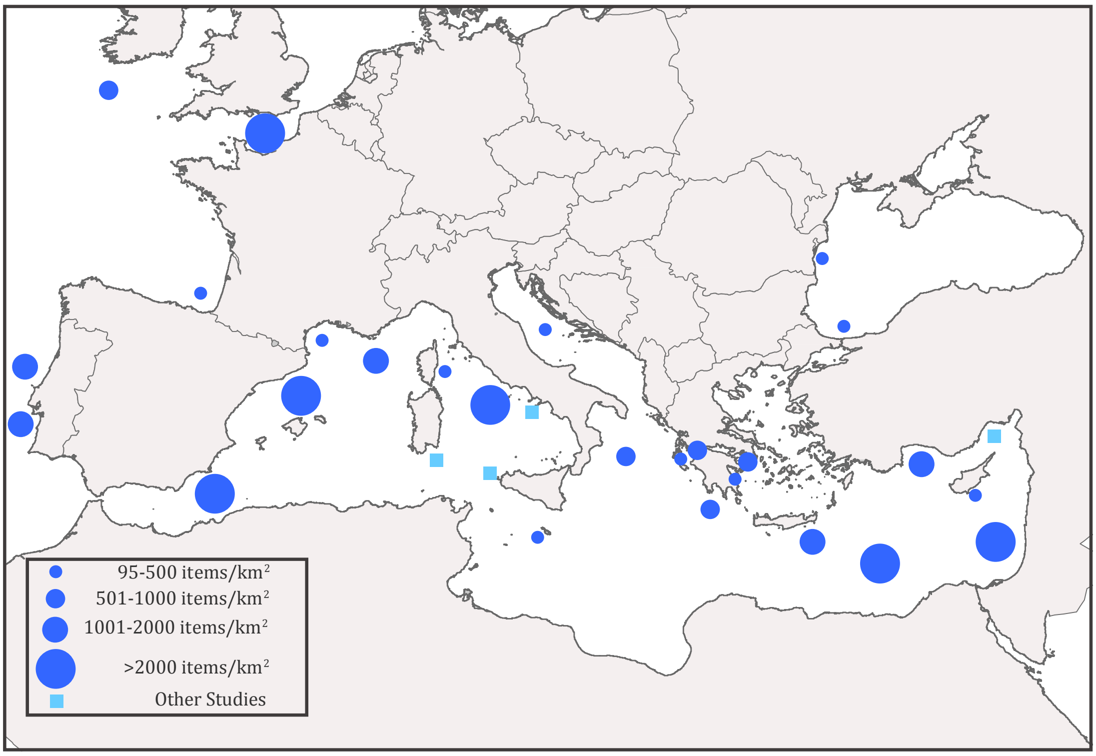

Figure 3: Seafloor marine litter distribution in the Mediterranean and other European Seas (Ioakeimdis, 2015)

Results and Status, including trends (extended)

A. Floating Marine Litter

In the Ligurian Sea, data was collected through ship-based visual observations in 1997 and 2000; 15-25 items/km^2 were found in 1997, which decreased to 1.5-3 items in 2000 (Aliani et al., 2003). In the regional assessment conducted by the IPA-Adriatic DeFishGear project (Vlachogianni et al., 2017), the average density of floating macro-litter in coastal Adriatic waters was found 332 ± 749 items/km^2 and in the Adriatic-Ionian waters 4 ± 3 items/km^2. In the Adriatic waters, the highest average abundances were recorded in the coastal waters of Hvar Aquatorium (Croatian coast) (576 ± 650 items/km^2; median 393 items/km^2), followed by the Gulf of Venice (475 ± 1203 items/km^2; median 154 items/km^2) and Cesenatico related area (324 ± 492 items/km^2; median 210 items/km^2). During the surveys carried out by observers on ferries on the same areas floating macro-litter abundances were found about two times higher in the Adriatic (5.03 ± 3.86 items/km2) when compared to the Ionian Sea (2.94 ± 2.54 items/km2). Plastic items were dominant (Coastal: 91.4%; Adriatic-Ionian: 91.6%) of total items), followed by paper (Coastal 7.5%; Adriatic-Ionian: 5.1%) and wood items (Coastal: 2.1%; Adriatic-Ionian: 1.4%). The most abundant categories were bags (Coastal: 26.5%; Adriatic-Ionian: 20.4%), plastic pieces (Coastal: 20.3%; Adriatic-Ionian: 21.5%), sheets (Coastal: 13.3%; Adriatic-Ionian: 12.5%), fish polystyrene boxes (Coastal: 11.4%; Adriatic-Ionian: 12.5%), cover/packaging (Coastal: 8.1%), other plastic items (Coastal: 6.0%; Adriatic-Ionian: 2.9%), polystyrene pieces (Coastal: 3.9%; Adriatic-Ionian: 3.6%), and bottles (Coastal: 1.3%; Adriatic-Ionian: 7.7%).

Floating litter was also quantified during marine mammal observation cruises in the northern western basin Mediterranean Sea in a 100 x 200 km offshore area between Marseille and Nice and in the Corsican channel. A maximum density of 55 items/km² was found, with a clearly discernible spatial variability relating to residual circulation and a Liguro-Provencal current vein routing litter to the West (Gerigny et al., 2011 and Figure 2).

A subsequent survey made in the Eastern Mediterranean (Topcu et al., 2010) reported densities of less than 2.5 items/ km^2. More recently, results from Suaria and Aliani (2014), dedicated to the first large-scale survey of anthropogenic litter (>2 cm) in the central and western part of the Mediterranean Sea (Figure 4). Throughout the entire study area, densities ranged from 0 to 194.6 items/km^2, with a mean abundance of 24.9 items/km^2. The highest litter densities (>52 items/km^2) were found in the Adriatic Sea and in the Algerian basin, while the lowest densities (<6.3 items/km^2) were observed in the Central Tyrrhenian and in the Sicilian Sea. All the other areas had mean densities ranging from 10.9 to 30.7 items/km^2.

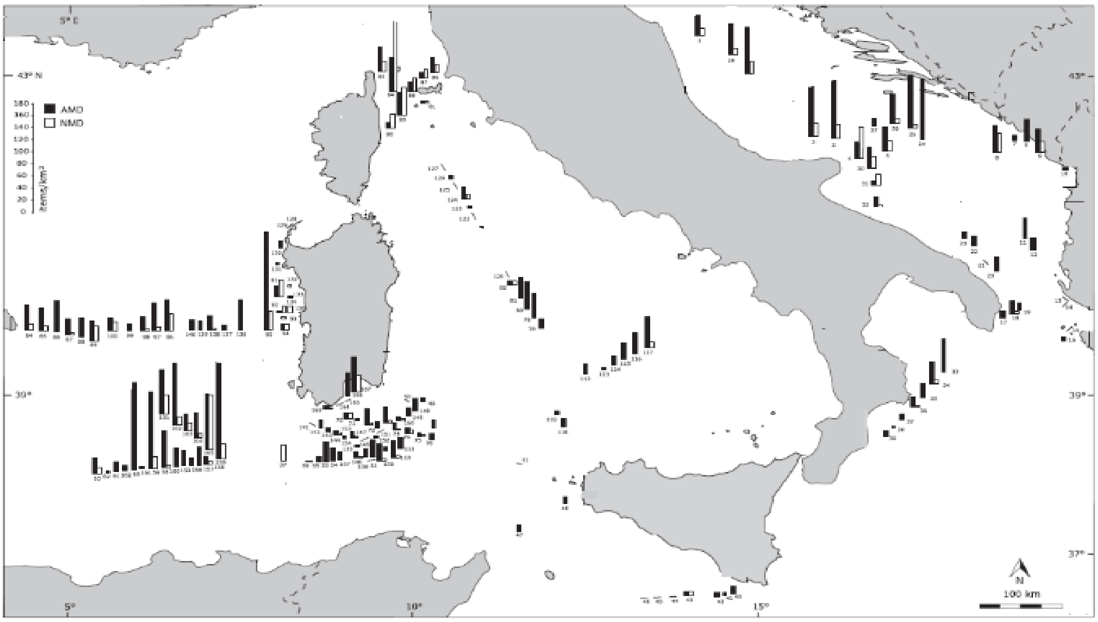

Figure 4: Anthropogenic (black bars) and Natural (white bars) Marine Litter densities (items/km2) in the Western, Adriatic and Northern Ionian basins of the Mediterranean Sea (From Suaria and Aliani, 2014)

Suaria et al. (2016) along with presenting their results (Figure 1) on the distribution of plastic densities in the central Mediterranean Sea, are also providing a detailed comparison table (Table 1) on floating microplastic concentrations based on the available studies performed in the Mediterranean Sea.

Table 1: Floating microplastic concentrations in the Mediterranean Sea

Study Area	**Year**	**Net mesh**	**Samples**	**Mean Abundance**	**Reference**
Cretan Sea	1997	500 μm	25	119 ± 250 g/km^2	Kornilios et al., 1998
NW Med.	2010	333 μm	40	0.116 items/m^2 2020 g/km^2	Collignon et al., 2012
Ligurian/ Sardinian Sea	2011	200 μm	23	0.31 ± 1.0 items/m^2	Fossi et al., 2012

Bay of Calvi (Corsica)	2011 - 2012	200 µm	38	0.062 items/m^2	Collignon et al., 2014
W. Med.	2011 - 2012	333 µm	41	0.135 items/m^2 187 g/km^2	Faure et al., 2015
W. Sardinia	2012 - 2013	500 µm	30	0.15 items/m^3	de Lucia et al., 2014
Ligurian Sea	2013	333 µm	35	0.103 items/m^2	Pedrotti et al., 2014
NW Sardinia	2012 - 2013	200 µm	27	0.17 ± 0.32 items/m^3	Panti et al, 2015
Ligurian Sea	2011 - 2013	200 µm	70	0.31 ± 1.17 items/m^3	Fossi et al., 2016
Med.	2013	200 µm	39	0.243 items/m^2 423 g/km^2	Cózar et al., 2015
Central W Med.	2011 - 2013	333 µm	71	0.147 items/m^2 579.3 g/km^2	Ruiz-Orejón et al., 2016
W Med/ Adriatic	2013	200 µm	74	0.40 ± 0.74 items/m^2 1.00 ± 1.84 items/m^3 671.91 ± 1544.16 g/km^2	Suaria et al., 2016

Data may also be obtained from NGOs, such as HELMEPA, a Greek organization of maritime stakeholders, who invited its member managing companies with ships traveling in or transiting the Mediterranean to implement a programme for the monitoring and recording of litter floating on the sea surface. During the period February – April 2008, 14 reports were received by HELMEPA member-vessels containing information on litter observations from various sea areas in the Mediterranean. In total, observations of 1,051.8 nautical miles (n.m.) of Mediterranean Sea resulted in the recording of 500.8 Kg of marine litter. The total length of observation for floating marine litter carried out by HELMEPA member vessels was 1,051.8 nautical miles (1,947 kilometers), corresponding to an observation area of around 172.8 km^2. The width of observation depended on the weather conditions, the sea state, the position of the observer, the use of binoculars, the freeboard and volume of marine litter, etc., and generally fluctuated between 22 and 150 meters. Observations were carried out mainly in the eastern Mediterranean (Aegean Sea, Libyan Sea and Eastern Mediterranean Levantine Sea), in the Alboran Sea between Spain and Morocco, and in the Adriatic Sea. The total marine litter recorded was 366 items, corresponding to a concentration of one item per 3 n.m., or 2.1 items per km^2. The concentration of marine litter ranged from 0.08 to 71 items/n.m. relatively higher concentrations of marine litter were observed along routes close to coastal areas, while there were cases in which lengthy observations (more than 120 n.m.) revealed no existence of marine litter. Plastics accounted for about 83.0% of marine litter items, while all other major categories accounted for about 17%, as the following graph shows. Based on weight extrapolations, the average quantity of marine litter was estimated to be 230.8 kg/km^2 (ranging from 0.002 to 2,627.0 kg/km^2). Relatively heavy items such as steel drums, wooden pallets, and crates observed on the sea surface were responsible for the majority of marine litter in certain routes. In terms of the length of observation, the average weight was 0.47 kg/n.m.

B. Seafloor Marine Litter

In the Mediterranean Sea, no more than 15 studies exist (Fig. 3), dedicated on the assessment and accumulation of marine litter on the seafloor by using otter-trawl, with the corresponding cod-end mess size ranging from 10 mm to 15,000 mm. So far, in the Western Mediterranean Sea, the Gulf o Lions (1993-94: 633-1935 items/km^2; 1996: 3900 items/km^2; 1996-97: 143 items/km^2), the Catalan Coast (2009: 7003±6010 items/km^2; 2007-2010: 0.02-3264.6 kg/km^2) and the Murcian Coast (4424±3743 items/km^2) have been studied (Galgani et al., 1995; Galgani et al., 1996; Galgani et al., 2000; Sanchez et al., 2013; Ramirez-Llodra et al., 2013). In the Central Mediterranean Sea, data on seafloor marine litter exist for the areas of the Eastern Ionian Sea (2300 items/km^2), Corsica (1993-94: 633-1935 items/km^2; 1998: 229 items/km^2), Adriatic Sea (1998: 378 items/km^2; 2011-2012: 47.9±23.4-170.6±35.8 kg/km^2) and the Tyrrhenian Sea (2009: 5950 items/km^2) (Galgani et al., 1995; Galgani et al., 2000; Sanchez et al., 2013; Misfud et al., 2013; Strafella et al., 2015). The Eastern Mediterranean is the less studied among the three compartments (western, central, eastern Mediterranean.). Galil et al. (1995) assessed 200-8,500 items/km^2 in several areas in the Eastern Mediterranean Sea while more targeted studies have been conducted in the Saronikos Gulf (2013-2014: 1211±594 items/km^2) Gulf of Patras (1997-98: 240 items/km^2; 2000-2003: 313 items/km^2; 2013-2014: 641±579 items/km^2), the Gulf of Echinades (1997-98: 89-240 items/km^2; 2000-2003: 313 items/km^2; 2013-2014: 416±379 items/km^2), the Gulf of Corinth and Lakonikos Gulf (165 items/km^2), the Antalya (115-2,762 items/km^2) and the Mersin (0.01-5.85 kg/h) bays (Galil et al., 1995; Stefatos et al., 1999; Koutsodendris et al., 2008; Guven et al., 2013; Eryasar et al., 2014).

Counts from 7 surveys and 295 samples in the Mediterranean Sea and Black Sea (2,500,000 km^2;worldatlas.com) indicate an average density of 179 plastic items/ km^2 for all compartments, including shelves, slopes, canyons, and deep-sea plains, in line with trawl data on 3 sites described by Pham et al., 2014. On the basis of this data, we can assume that approximately 0.5 billion litter items are currently lying on the Mediterranean Sea floor (UNEP/MAP, 2015).

In the Adriatic and Ionian Seas. within 121 transects (hauls) conducted in the framework of the IPA-Adriatic DeFishGear project, 510 ± 517 items/km^2 were recorded on an aggregated basis at regional level, with the a mean weight per haul found at 65 ± 322 kg/km^2. From the 11 locations, the highest density of litter items was found in the North Corfu area (Greece) with the average density being at 1,099 ± 589 items/km^2, followed by the South area of the Western Gulf of Venice with 1,023 ± 616 items/km^2. In terms of weight, the highest quantity of litter was found in the South area of the Gulf of Venice (average density 339 ± 910 kg/km^2) (Vlachogianni et al., 2017).

Plastics have been found widespread in the continental shelf of the Mediterranean, exceeding in some areas the 80% of the recorded marine (Table 2).

Table 2: Plastic abundance (%) lying on the seafloor of the Mediterranean Sea

Stydy Area	**Plastic (%)**	**Reference**
Gulf of Lions (France)	64-77%	Galgani et al., 1995b; Galgani et al., 2000
Catalanian Provence (Spain)	60%	Sanchez et al.
Murcian Provence (Spain)	84%	Sanchez et al.
Central Med	87%	Sanchez et al., 2013
Corsica (France)	77%	Galgani et al., 1995

Maltese islands	47%	Misfud et al., 2013;
North-Central Adriatic Sea	24-62%	Strafella et al., 2015
Eastern Mediterranean Sea (Italy, Greece, Egypt, Cyprus, Israel).	36%	Galil et al. 1995
Gulf of Patras (Greece)	81%	Stefatos et al. 1999
Echinades Gulf (Greece)	56%,	Koutsodendris et al. 2008
Gulf of Patras (Greece)	60%	Ioakeimidis et al. 2014
Echinades Gulf (Greece)	67%	Ioakeimidis et al. 2014
Antalya (Turhey)	81%	Guven et al., 2013
Mersin (Turkey)	73%	Eryasar et al., 2014
Limassol Gulf (Cyprus)	59%	Ioakeimidis et al. 2014
Saronikos Gulf (Greece)	95%	Ioakeimidis et al. 2014
Argolikos Gulf (Greece)	75%	Ioakeimidis et al., 2015

In a study on 67 sites conducted in the Adriatic Sea using commercial trawl analysis of marine litter sorted and classified in major categories confirmed that plastic is dominant in terms of concentration by weight, followed by metal (UNEP/MAP, 2015). The highest concentration of litter was found close to the coast, likely as a consequence of high coastal urbanization, river inflow, and extensive navigation. Metals and glass/ceramics reached maximum values of 21.9% and of 22.4%, respectively in a study conducted in 4 study areas in the Eastern Mediterranean (Saronikos; Patras and Echinades Gulfs; Limassol Gulf) (Ioakeimidis et al., 2014).

Moreover, marine litter from circalittoral and deeper bottoms off the Maltese islands (Central Mediterranean), collected during the 2012 MEDITS trawl surveys, were assessed with a view to identify the major marine litter items and classify them in accordance with the MSFD/TGML categories for seafloor marine litter items. Although this exercise is very preliminary and should not be interpreted as a scientific assessment of marine litter present on the seabed, the results are similar to those reported by Mifsud et al. (2013) for the 2005 sessions of MEDITS surveys. Based on the 2012 photos, which were available for 40 MEDITS stations, 290 items were recorded and the litter items constituted predominantly of plastic items (48%), followed by Glass/ceramics (26%) and metal (19%).

Very limited studies in the Mediterranean have investigated the presence of seafloor litter in shallow waters. Only one study records marine litter in Greece (Saronikos Gulf, Western Crete, South-Peloponesse, Santorini island., West Greece), in depths ranging from the shoreline (0m) till the 25m (Katsanevakis & Katsarou, 2004). In the Saronikos Gulf were recorded 31,660 items/km^2 (Plastics: 47%, Metals: 31%), Western Crete 18,944 items/km^2 (Plastics: 45%, Metals: 28%), South Peloponesse 14,025 items/km^2 (Plastics: 47%, Metals: 33%), Santorini island 9,133 items/km^2 (Plastics: 52%, Metals: 31%).

The first assessment of marine litter in the deep-sea environment of the Mediterranean Sea was conducted back in 1995 by Galgani et al. (1996) in the marine Canyon of Marseille-Nice (1623 items/km2). Nowadays, in the Mediterranean Sea such data exist only for the Western (NW Mediterranean: 1935 items/km^2; French Mediterranean: 3 items/km^2) and the Central Mediterranean Sea (Tyrrhenian Sea: 30,000-120,000 items/km^2), while no relevant data exist for the Eastern Mediterranean Sea (Galgani et al., 1996; Galgani et al., 2000; Bo et al., 2014; Fabri et al., 2014; Angiolillo et al., 2015).

The distribution and abundance of large marine litter items were investigated on the continental slope and bathyal plain of the northwestern Mediterranean Sea during annual cruises undertaken between 1994 and 2009 (Galgani et al., 2011). Different types of marine litter were enumerated, particularly plastic pieces, plastic and glass bottles, metallic objects, glass, and diverse materials including fishing gear items. The results showed considerable geographical variation, with concentrations ranging from 0 to 176 pieces of litter/ha. In most stations sampled, plastic bags accounted for a very high percentage (more than 70%) of total litter. In the Gulf of Lions, only small amounts of litter were collected on the continental shelf. Most of the litter was found in canyons descending from the continental slope and in the bathyal plain, with high amounts occurring to a depth of more than 500 m.

Information regarding the abundance of small plastic particles accumulating in the deep-sea sediments is still very limited. However, plastic particles sized in the micrometer range have been found in deep-sea sediments ranging from 1000 to 5000m depth (Van Cauwenberghe et al., 2013; Woodall et al., 2014).

CONCLUSIONS

Conclusions (brief)

Plastic is the main component of floating marine litter and also for those lying on the Mediterranean seafloor, from shallow water, the continental shelf, till the deep abyssal plains. Regarding marine litter (floating and on seafloor) that are accumulating in the Mediterranean basin, no safe conclusion can be drawn for the moment. Probably hydrodynamics and geomorphology favor the constant circulation. More consistent, interconnected and interlinked studies need to be promoted in order to have a better picture at basin scale. The comparability of the existing and future studies seem to be a key point towards an integrated assessment at basin scale. The Mediterranean Sea is heavily impacted by floating marine litter items, giving concentrations comparable to those found in the 5 sub-tropical gyres. Moreover, the seafloor seems to be the final global sink for most marine litter items with densities ranging from 0 to over 7,700 items per km^2. The deep-sea canyons are of particular concern as they may act as a conduit for the transport of marine litter into the deep sea. As in any other marine litter cases, the human activities (fishing, urban development, and tourism) are primarily responsible for the increased abundance of marine litter items in the Mediterranean Sea.

Conclusions (extended)

Marine litter and mainly plastics are present in the Mediterranean basin from the shallow water, the continental shelf, till the abyssal plains, in all different sea compartments and basins and thus, posing an important problem for the marine environment. Unfortunately, so far, we do not have a clear picture regarding the areas in the Mediterranean where the accumulation of marine litter and plastics is significant although several ongoing studies try to give a clearer picture. The Eastern Mediterranean is certainly the least studied of the three compartments (western, central, eastern).

The Mediterranean Sea is very peculiar as there are no areas where marine litter permanently accumulate. Instead, the constant circulation is favored. The picture is fragmented as only through nonrecurring studies information becomes available and this is not enough to drawn safe results or even to partially assess the situation. In addition, information on floating and seafloor marine litter is only available for the northern part of the Mediterranean Sea. The combination of the last two points makes the assessment of floating and seafloor marine litter in regional scale almost impossible.

A. Floating Marine Litter

Once floating litter has entered into the marine environment, the hydrographic characteristics of the basin may play an important role in its transport, accumulation, and distribution. Atlantic surface waters enter the Mediterranean Sea through the strait of Gibraltar and circulate anticlockwise in the whole Algero-Provencal Basin, forming the so-called Algerian Current, which flows until the Channel of Sardinia and most often leads to the generation of a series of anticyclonic eddies 50–100 km in diameter wandering in the middle basin (UNEP/MAP, 2015). Despite not being permanent, these mesoscale features could act as retention zones for floating litter and would help explain the high litter densities found in the central Algerian basin at around 80 nautical miles from the nearest shore. For the southern Adriatic Sea, it should be noticed that about one-third of the total mean annual river discharge into the whole Mediterranean basin flows into this basin, particularly from the Po River in the northern basin and the Albanian rivers (UNEP, 2012).

The highest densities found in the Adriatic Sea and along the North-western African coast are related to some of the heaviest densities in coastal population of the entire Mediterranean basin (UNEP/MAP 2015). The Adriatic Sea has more than 3.5 million people along its shores, which along with fisheries and tourism seems to be the most significant sources for floating marine litter in the region. In addition, the significant cyclonic gyres which are found in the central and southern Adriatic Sea (Suaria and Aliani, 2014), are favoring the retention of floating marine litter in the middle of the basin. This is also the Case in the Northeastern part of the Aegean Sea, where densities of floating litter are higher due to circulating waters and Black sea/Mediterranean Sea water exchanges.

Coastal population is an important aspect also for the North African countries in particular also have the highest rates of growth in coastal population densities, including touristic densities. Algeria, for instance, has a coastal population that has increased by 112% in the last 30 years, and it currently represents one of the most densely populated coastlines in the whole basin (UNEP, 2009). In addition, it should be noted that in some countries appropriate recycling facilities have not been fully implemented yet, and the cost of proper solid waste disposal is still often beyond their financial capacity (UNEP, 2009). Suaria and Aliani (2014), demonstrated that 78% of all sighted objects were of anthropogenic origin, 95.6% of which were petrochemical derivatives (i.e. plastic and Styrofoam). The authors then evaluated the number of macro-litter items currently floating on the surface of the whole Mediterranean basin to be more than 62 million.

As for anthropogenic litter accumulating in oceans gyres and convergence zones, the existence of Floating Marine Litter accumulation zones is a stimulating hypothesis, as their presence was supported recently (Mansui et al., 2015). The existence of one or more "Mediterranean Garbage Patches" should be investigated in more detail, as there are no permanent hydrodynamic structures in the Mediterranean Sea where local drivers may have a greater effect on litter distribution (CIESM, 2014).

B. Seafloor Marine Litter

The deep-sea floor is probably the final global sink for most marine litter and there are several areas in the Mediterranean for which marine litter have been recorded in densities exceeding 1000 items/km^2 (i.e. Gulf of Lions, Catalan Coast, Murcian Coast, Corsica, Saronikos Gulf, Antalya Coast). However, long-term data is scarce for the Mediterranean Sea. Density of litter collected on the sea floor between 1994 and 2014 in the Gulf of Lion

(France), does not clearly show any significant trends with regards to variations in marine litter quantities (Galgani, 2015). In another example in Greece (Gulf of Patras, Echinades Gulf) albeit the increase of marine litter abundance plastic percentage seems to remain stable over the years. In much deeper marine environments, Galgani et al. (2000) observed decreasing trends in deep sea pollution over time off the European coast, with extremely variable distribution and litter aggregation in submarine canyons.

The abundance of plastic litter is very location-dependent, with mean values ranging from 0 to over 7,700 items per km². Mediterranean sites tend to show the highest densities, due to the combination of a populated coastline, coastal shipping, limited tidal flows, and a closed basin with exchanges limited to Gibraltar. In general, bottom litter tends to become trapped in areas with low circulation, where sediments accumulate.

Only a few studies have focused on litter located at depths of over 500 m in the Mediterranean (Galil, 1995; Galgani et al., 1996, 2000, 2004; Pham et al., 2014; Ramirez-Llodra et al., 2013). Submarine canyons may act as a conduit for the transport of marine litter into the deep sea. Higher bottom densities are also found in particular areas, such as around rocks and wrecks, and in depressions and channels. In some areas, local water movements carry litter away from the coast to accumulate in high sedimentation zones. The distal deltas of rivers may also fan out into deeper waters, creating high accumulation areas.

A wide variety of human activities, such as fishing, urban development, and tourism, contribute to these patterns of seabed litter distribution. Fishing litter, including ghost nets, prevails in commercial fishing zones and can constitute a considerable share of total litter. It has been estimated that 640,000 tons of ghost nets are scattered overall in the world oceans, representing 10% of all marine litter (UNEP, 2009). More generally, accumulation trends in the deep sea are of particular concern, as plastic longevity increases in deep waters and most polymers degrade slowly in areas devoid of light and with lower oxygen content.

Key messages

- The abundance of floating litter in Mediterranean waters has been reported at quantities measuring over 2 cm range from 0 to over 600 items per square kilometer (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015).
- The 2015 UN Environment/MAP Marine Litter Assessment report states that approximately 0.5 billion litter items are currently lying on the Mediterranean Seafloor. Moreover, there is great variability in the abundance of seafloor marine litter items ranging from from 0 to over 7,700 items per km² depending on the study area.
- However, the information on floating and seafloor marine litter in the Mediterranean is fragmented and is spatially restricted mainly to its northern part. To this extent, no basin-scale conclusions can be exerted and information is only available at local level.
- There are many areas with significant marine litter densities, ranging from 0 to over 7,700 items per km² depending on the study area. Plastic is the major marine litter component, found widespread in the continental shelf of the Mediterranean, ranging up to 80% and 90% of the recorded marine litter items.

Knowledge gaps

- Research and monitoring have become critical for the Mediterranean Sea, where information is inconsistent. UN Environment/MAP-MED POL (2013), MSFD (Galgani et al., 2011), the European project STAGES (http://www.stagesproject.eu), and CIESM (2014) recently reviewed the gaps and research needs of knowledge, monitoring, and management of marine litter. This requires scientific cooperation among the parties involved prior to reduction measures due to complexity of issues.

- Accumulation rates vary widely in the Mediterranean Sea and are subject to factors such as adjacent urban activities, shore and coastal uses, winds, currents, and accumulation areas. Additional basic information is still required before an accurate global litter assessment can be provided. Moreover, the available data are geographically restricted in the northern part of the Mediterranean Sea.
- For this, more valuable and comparable data could be obtained by standardizing our approaches. In terms of distribution and quantities, identification (size, type, possible impact), evaluation of accumulation areas (closed bays, gyres, canyons, and specific deep-sea zones), and detection of litter sources (rivers, diffuse inputs), are the necessary steps that would enable the development of GIS and mapping systems to locate hotspots.
- An important aspect of litter research to be established is the evaluation of links between hydrodynamic factors. This will give a better understanding of transport dynamics and accumulation zones. Further development and improvement of modelling tools must be considered for the evaluation and identification of both the sources and fate of litter in the marine environment. Comprehensive models should define source regions of interest and accumulation zones, and backtrack simulations should be initiated at those locations where monitoring data are collected.
- For monitoring, there is often a lack of information needed to determine the optimum sampling strategy and required number of replicates in time and space. Moreover, the comparability of available data remains highly restricted, especially with respect to different size class categories, sampling procedures, and reference values.
- Data on floating and seafloor marine litter are inconsistent and geographically restricted in only few areas of the Mediterranean Sea. In addition to that, the lack on long-term assessment data makes the assessment of trends of the years extremely difficult. Sources needs also to be further specified and linked to macro- and micro-litter contribution. Moreover, monitoring and assessment of marine litter should be done in a consistent way, based on common protocols and standardized methods, leading to comparable results at basin scale. Effective management practices are also missing, requiring strong policy will and societal engagement. Further work should also be promoted towards identifying marine litter sources more precisely. Cooperation and collaboration between the major marine litter partners in the region with common priority actions is also considered important.

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2) Quality Status Report (Biodiversity and Fisheries)

Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 1. Habitat distributional range and Common Indicator 2. Condition of the habitat’s typical species and communities

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 1 (CI1): Habitat distributional range Common Indicator 2 (CI2): Condition of the habitat’s typical species and communities
Indicator Assessment Factsheet Code	EO1CI1/EO1CI2

RATIONALE/METHODS

Background (brief)

Marine habitats are generally defined by physical features and characteristic species. Nonetheless, habitat types are not clearly distinct regions with clear boundaries in nature. Benthic habitats are considered as important drivers of diversity and therefore the modification or loss of habitats are considered as serious threat to marine ecosystems. Due to heterogeneity of habitats and limited available data, the monitoring of habitat status is a great challenge for ecological assessment programmes.

Monitoring, developing indicators, reporting on the state, trends and pressures on biodiversity and related issues are required under several policies and legislations.

This assessment presents a brief overview of the habitat distributional range and condition of the habitat’s typical species and communities based on published data issued from recent or ongoing research projects/studies. It will enable the identification of the progress elaborated towards the achievement of targets adopted regarding relatively known habitats types. Habitat types and parameters to be monitored are subject to revision as further knowledge and baseline data becomes available, on the basis of a risk-based approach.

Background (extended)

In the list of the IMAP Ecological Objectives and Common Indicators, *Habitat distributional range* and *Condition of the habitat's typical species and communities* belong to the Ecological Objective EO1 Biodiversity.

Habitat destruction is one of the most pervasive threats to the diversity, structure, and functioning of Mediterranean marine coastal ecosystems and to the goods and services they provide (Bazairi et al., 2010, Danovaro et al., 2010, Martin et al., 2014, Telesca et al., 2015, Boero, 2003, Claudet and Fraschetti, 2010 and Airoldi and Beck, 2007)). The 20% of the entire basin and 60-99% of the territorial waters of EU member states are heavily impacted by multiple interacting threats; less than 20% has low impact and very few areas and less than 1% remain relatively unaffected by human activities (Micheli et al., 2013, Coll et al., 2012, Coll et al., 2010).

The Alboran Sea, the Gulf of Lyons, the Sicily Channel and Tunisian Plateau, the Adriatic Sea, off the coasts of Egypt and Israel, along the coasts of Turkey, and within the Marmara and Black Sea are highly impacted. Low cumulative human impacts were found in offshore areas, and in several small coastal areas of some countries. These areas represent important opportunities for conservation aimed at preventing future degradation. Pollution, fisheries, urbanisation and invasive alien species (increasing temperature and UV, and acidification) are the most frequently cited pressures in the Red List of European Habitats (Gubbay *et. al.,* 2016) affecting the distribution range and the conditions of habitats. Climate change is also affecting some mediolittoral and infralittoral habitats, especially by altering the thermal structure of the water column, with extensive mass mortalities (Rivette et al., 2014).

The proliferation of coastal and marine infrastructures, such as breakwaters, ports, seawalls and offshore installations call for special concern, all being associated with loss of natural habitats and alteration of hydrographic conditions (Perkol-Finkel et al., 2012). New strategies aimed at elevating the ecological and biological value of coastal infrastructures are urgent.

Seabed trawling causes important changes in the ecosystem structure and the loss of shallow habitats of endemic populations and deeper soft bottom habitats (Harmelin-Vivien, 2000). Trawling has the most dramatic consequences on the Mediterranean seagrass beds *Posidonia oceanica*, which provides habitats and food resources for a diversified fish fauna and act as an important nursery area for many species. In this context, *Posidonia* medows and deep-sea habitats were protected from bottom trawling activities and other destructive practices. The continuous stirring, mixing, and resuspension of surface sediments by intensive and chronic trawling activities changes sediment dynamics and have permanently smoothed the seafloor morphology of the continental slope over large spatial scales in addition to having induced changes in the water column dynamics and properties.

Commercial interest in deep-sea mining is increasing, relating to the future exploitation of seafloor resources and care should be also taken to modifications of water column structures. The benthic communities in deep waters are often extremely vulnerable to physical disturbance and the recovery after impacts of trawling might take a long time in deep water. Thus, the environmental impacts of deep-sea mining could be significant, including physical disturbance, the creation of suspended sediment plumes, water mixing effects, and the impacts of mining ships and other infrastructure (Willamson et al., 2016). Another major threat for habitats, notably in the Mediterranean Sea, is the introduction and spreading of alien species (as detailed in EO2 Non-indigenous species assessment).

Policy context and targets

The Mediterranean continental shelf possesses rich and important habitats. Therefore it should be recognized how significant progress was achieved by development of a set of regulatory and policy frameworks and tools for the conservation of habitats in the framework of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BD, adopted in 1995).

In this context, a reference list of 27 major types of benthic habitat is particularly important. It was elaborated to help the Mediterranean countries in drawing up inventories of natural sites of conservation interest (UNEP-MAP RAC/SPA, 2002). The SAP BIO Programme adopted in 2003 by COP 13 of the Barcelona Convention had identified among its priority actions the elaboration of a complete and integral inventory of its Mediterranean habitats, including mapping the spatial distribution and the cohort of species associated with each habitat.

The most typical Mediterranean habitats are distributed in the coastal strip, made up of: i) *Lithophyllum byssoides* (e.g. L. Lichenoides) rims in the medio-littoral stage; ii) *Posidonia oceanica* meadows and Fucal forests (biocenoses with Cystoseira) in the infra-littoral stage; and iii) the coralligenous in the circa-littoral stage (Zenetos et al., 2002; Boudouresque, 2004). Added to these habitats are the Vermetid platforms and the Neogoniolithon brassica-florida concretion (Boudouresque, 2004).

The Contracting Parties to Barcelona Convention adopted the following Action Plans of relevance for protection of the Mediterranean habitats:

- The Action Plan for the conservation of marine vegetation in the Mediterranean which was updated in 2012. The main objectives of thus Action Plan are: (i) ensuring the conservation of macroscopic marine vegetation species and vegetal assemblages in the Mediterranean by implementing management and legal protection measures and improve knowledge of these species; (ii) avoiding loss and degradation of the seagrass meadows, and of other vegetal assemblages of importance for the marine environment, as marine habitats that are essential to the survival of many Mediterranean species, and keeping them in favourable conservation status; (iii) ensuring the conservation of marine vegetal assemblages that could be considered natural monuments, such as barrier reefs of Posidonia and organogenic surface formations, terraces (platforms with vermitids covered by soft algae) and certain Cystoseira belts.
- The Action Plan for the Conservation of the Coralligenous and Other Calcareous Bio-concretions in the Mediterranean Sea which was updated in 2016. In this Action plan, the coralligenous is considered as a typical Mediterranean underwater seascape comprising coralline algal frameworks that grow in dim light conditions and in relatively calm waters. Mediterranean maërl beds should be considered as sedimentary bottoms covered by a carpet of free-living calcareous algae (Corallinales or Peyssonneliaceae) also developing in dim light conditions
- The Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea (Dark Habitats Action Plan) in 2013. In fact, dark Habitats are considered as sensitive habitats requiring protection on, fragile and constitute veritable reservoirs of biodiversity that, therefore, must be protected and need further attention.

These Action Plans were adopted by the Contracting Parties as regional policy instruments setting the priorities and activities to be undertaken and for co-ordination of efforts to protect the species in question. This approach has been proved to be necessary to ensure conservation and sustainable management of the concerned species in every Mediterranean area of their distribution.

Marine Protected Areas (MPAs) are one of the most important effective area-based conservation measures having a potential to ensure the long-term conservation and sustainable use of the components of the marine and coastal Mediterranean biodiversity. Being committed under the Convention on Biological Diversity (CBD) to achieve the Aichi Targets, the Contracting Parties to the Barcelona Convention adopted a roadmap aimed at guiding and harmonizing their efforts towards achieving the Aichi Target 11 by 2020 (Decision IG.21/5). The Roadmap emanated from the "Regional Working Programme for the Coastal and Marine Protected Areas in the Mediterranean Sea including the High Sea" and build on the progress made so far in the Mediterranean to develop marine and coastal protected areas.

Additionally the EU Birds and Habitats Directives enable EU-Member States to work together within the same strong legislative framework in order to protect the EU's most vulnerable species and habitat types across their entire natural range by the creation of a Europe-wide ecological network of nature conservation areas – called the Natura 2000 Network

Following the recent "2016 status of Marine Protected Areas in the Mediterranean", 12.92% of Posidonia beds (European Nature Information System (EUNIS) class A5.5351) as mapped during the 2016 EMODnet seabed habitats project are covered by national designations and 31.37% by Natura 2000 designations. It is one of the objectives of the Natura 2000 network to target the posidonia habitat. Together, all MPAs and other effective area-based conservation measures (OECMs) cover 39.77% of this habitat. Although these figures are encouraging, they greatly depend on the quality and comprehensiveness of input data. 4.68% of Mediterranean coralligenous communities (EUNIS classes A4.26 or A4.32) are covered by national designations while 25.40% is covered by Natura 2000 sites. 32.78% of this habitat is covered by all MPAs and OECMs. Finer scale research is needed to assess the conservation benefits of these figures.

In addition, the large FRA established by GFCM, which prohibits the use of towed dredges and trawl nets at depths greater than 1,000 m, brings in a precautionary decision relevant both to the management of deep-sea bottom fisheries and the protection of deep-sea benthic ecosystems and covers 58.33% of the Mediterranean. The complementary regulations would be beneficial.

The Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) adopted in 2016 (UNEP/MAP, 2016) contains in its Appendix 1 a reference list of species and habitats to be monitored. The decision, noting that those Contracting Parties who have the necessary means and are willing to do so, can go beyond the monitoring requirements of this reference list. In addition, there are other institutional mandates such as the EU Directive establishing a framework for Maritime Spatial Planning (MSP) and the EU Blue Growth strategy requiring that areas and actions are prioritized to ensure that conservation and management efforts will produce biological and socioeconomic long-term benefits. However, at present, the lack of concrete application of MSP, even at small scale, limits the potential to solve hot spots of conflicts with consequent effects on marine biodiversity and the services it provides.

Assessment methods

Assessments of the status and the extension of marine habitats require the adoption of rigorous approaches (in terms of sampling design, selection of appropriate spatial and temporal scales, habitat classification, identification of vulnerable taxa) that can give a good image of the distributional range and the condition of marine systems and of their alteration by pressures from human activities. Following changes in space and time in the occurrence of target species/habitats (e.g. habitat formers) able to indicate the status of the systems, and including the consideration of appropriate control areas should be the way to go.

Ground-truth sampling from benthic and pelagic monitoring and assessment, and environmental data are required to assess condition of the habitat's typical species and communities occurring at a site scale (100's of meters to 10's of kilometres). Various methods exist to collect pelagos or benthos data (e.g. grabs, cores, visual imagery techniques, or trawl surveys (Van Hoey et al., 2010)). Each method has its advantages and disadvantages which should be taken into consideration (Underwood & Chapman, 2013). If sufficient data are available, broad scale, Special and biogenic habitat can then be predicted and mapped using this benthos data with the support of environmental data.

Habitat mapping is fundamental for the identification of hot spots of habitat diversity, if sufficient and recent ground-truth data are available to enable a relevant spatial and biological (communities) resolution. Maps permit to detect changes in habitat cover, and allow boundary demarcation of multiple-use zoning schemes. Large-scale maps visualise the spatial distribution of habitats, thus aiding the planning of networks of MPAs, identifying area highy exposed to pressure (risk-based approach), and allowing to monitor the degree of habitat fragmentation. Habitat mapping should be integrated using several univariate variables such as the number of species, their relative abundance and biomass together with the consideration of whole assemblages (structure and functions) to support the assessment status.

Direct (ROV, scuba diving) and indirect methods (side scan sonar, multibeam, sub bottom profiler, underwater camera) can be integrated to carry out proper assessments. The monitoring of the pressures is also necessary to the assessment of the ecological status. To this end, data of the distribution of human activities and mapping tools must be collated (eg. Distribution of habitats and changes in the habitat extent). It has to be stressed that assessments cannot disregard from appropriate sampling designs using replicated samplings in space and time and proper control areas for the identification of the status and the trends of marine systems. In this respect, the spatial identification of the Cells of Ecosystem Functioning can be the precondition to apply the assessment not only of the distribution patterns of some habitats and species, but also the processes that allow for the functioning of ecosystems.

The current assessment is based on literature, recent projects and initiatives in the Mediterranean, as work is still ongoing for all Mediterranean countries to update their national monitoring progammes to be aligned with the IMAP descision (UNEP/MAP 2016) and begin reporting comparable data.

Figure 1: Caracterisation of the seagrass habitat in Kuriat Island (Tunisia) © SPA/RAC, Arafet BEN MARZOU

RESULTS

Results and Status, including trends (brief)

The Mediterranean broad scale habitats were modeled using the same approach identified in Emodnet for the western Mediterranean. This consisted in first identifying the benthic assemblages (or groups of assemblages) whose extension is such that they can be portrayed at a broad scale level and then identifying the qualifying environmental factors that can be used to model each assemblage distribution (i.e. substrate classes, depth zones, estimated light reaching the sea bottom). This procedure was feasible because a regional benthic habitat classification scheme based on benthic zonation rules involving biological zones and substrate class combinations exists within the framework of the Barcelona convention (UNEP, 2006) and because the Barcelona Convention habitat categories have been included within the EUNIS 2007-2011 habitat classification scheme (Figure 2, Table 1).

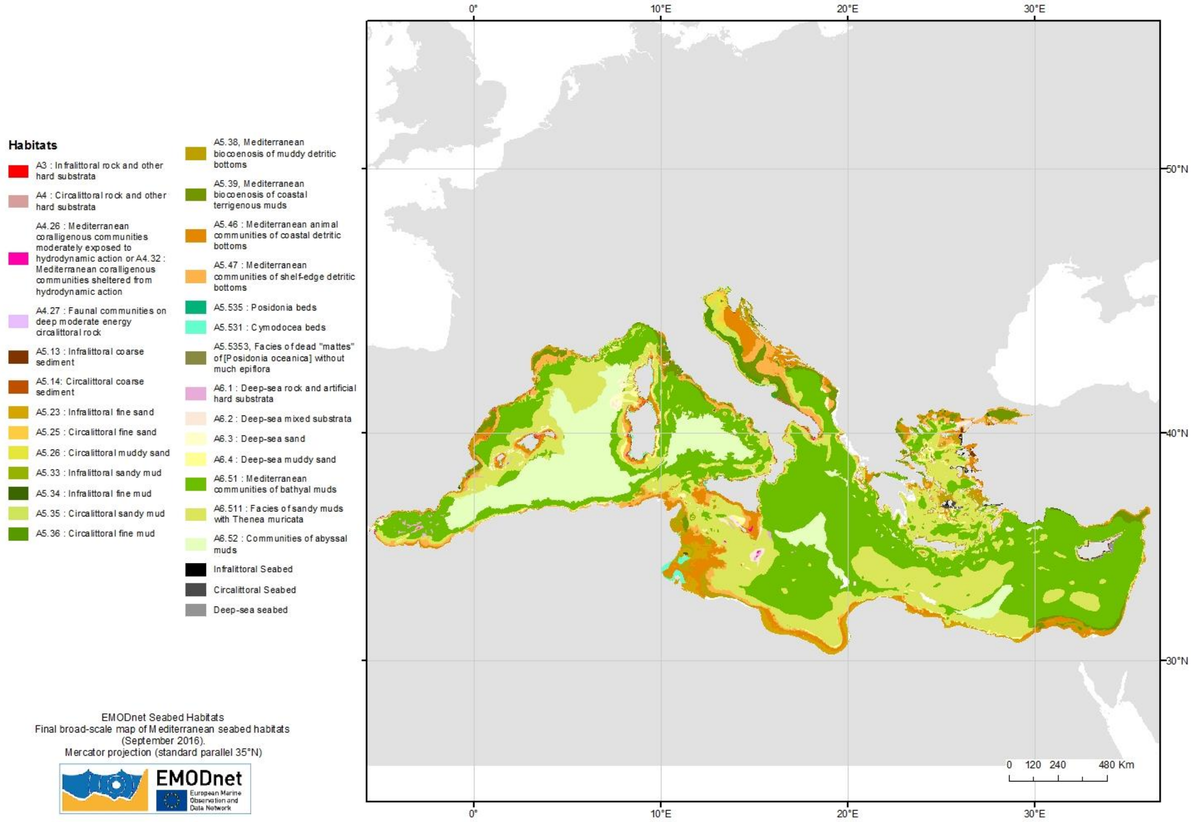

Figure 2: Final EUNIS habitat map for the Mediterranean.

Table 1: List of expected Mediterranean broad-scale habitat with a description of the associated biological assemblages

Broad scale habitat name	**Description of Mediterranean benthic assemblages and equivalent Barcelona convention habitat name**
A3 Infralittoral rock and other hard substrata	*III.6 Hard beds and rocks (contains Biocenosis of infralittoral algae)*
A5.13 Infralittoral coarse and mixed sediment	III.3 Coarse sands with more or less mud (contains Biocenosis of coarse sands and fine gravels mixed by the waves, Biocenosis of coarse sands and fine gravels under the influence of bottom currents)
A5.23 Infralittoral fine sand	III. 2. Fine sands with more or less mud (contains Biocenosis of fine sands in very shallow waters, Biocenosis of well sorted fine sands, Biocenosis of superficial muddy sands in sheltered waters *)*
A4.26 Mediterranean coralligenous communities moderately exposed to hydrodynamic action OR A4.32 Mediterranean coralligenous communities sheltered from hydrodynamic action	IV.3.1 Coralligenous biocenosis
A5.46 Mediterranean animal communities of coastal detritic bottoms	*IV.2.2 Biocenosis of the coastal detritic bottom*
A5.38 Mediterranean biocoenosis of muddy detritic bottoms	IV.2.1 Biocenosis of the muddy detritic bottom
A5.39 Mediterranean biocoenosis of coastal terrigenous muds	IV.1.1. Biocoenosis of coastal terrigenous muds
A4.27 Faunal communities on deep moderate energy circalittoral rock	IV.3.3 Biocenosis of shelf-edge rock
A5.47 Mediterranean communities of shelf-edge detritic bottoms	IV.2.3 Biocenosis of shelf-edge detritic bottoms
A6.11 Deep-sea bedrock	V.3 Hard beds and rocks (includes Biocenosis of deep sea corals, Caves and ducts in total darkness)
A6.3 Deep-sea sand	V. 2. SANDS (includes Biocenosis of bathyal detritic sands with Gryphus vitreus)
A6.511 Facies of sandy muds with Thenea muricata	V. 1. 1. 1. Facies of sandy muds with Thenea muricata (Biocenosis of bathyal muds)
A6.51 Mediterranean communities of bathyal muds	V. 1. 1. 2. Facies of fluid muds with Brissopsis lyrifera, V. 1. 1. 3. Facies soft muds with Funiculina quadrangularis and Aporrhais serresianus, V. 1. 1. 4. Facies of compact muds with Isidella elongata, V. 1. 1. 5. Facies with Pheronema grayi (Biocenosis of bathyal muds)
A6.52 Communities of abyssal muds	VI. 1. 1. Biocenosis of abyssal muds

Source: Populus J. 2017

Results and Status, including trends (extended)

The recent MedMAPnetwork3 and Medkeyhabitats4 Projects implemented by SPA/RAC produced severeal new data on the distribution of the most important marine key habitats in the Mediterranean.

The regional project "Towards an ecologically representative and efficiently managed network of Mediterranean Marine Protected Areas" (MedMPAnetwork project) builds on the achievements of the Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership project), including the Regional Project for the Development of a Mediterranean Marine and Coastal Protected Areas (MPAs) Network through the boosting of MPAs Creation and Management (MedMPAnet project) with the aim to contribute to the implementation of the Barcelona Convention and its Specially Protected Areas and Biological Diversity (SPA/BD) Protocol. The global objective of the project is to support achieving a network of Marine Protected Areas (MPAs) in the Mediterranean which ensures the long term conservation of key elements of the marine biodiversity and gives significant support to the sustainable development of the region, while specific objectives include: strengthening MPA Regional Coordination and Networking; developing the MPA network in the Mediterranean and improving MPA Management. Four Mediterranean riparian countries are beneficiary in this project: Egypt, Lebanon, Morocco and Tunisia

MedKeyHabitats project aims at establishing cartographic inventory of marine habitats of conservation interest to extend the Specially Protected Areas of Mediterranean Importance network (SPAMI), as required by Barcelona Convention's Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol). This will assist the countries partners to implement the appropriate mesures in relation to the priorities of the SAP-BIO and the recommendations of the Action Plans for the conservation of marine vegetation , the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea and the conservation of dark assemblages of the Mediterranean Sea (marine caves, canyons, etc. Eight Mediterranean riparian countries are beneficiary in this project: Albania, Algeria, Croatia, Egypt, Libya, Morocco, Montenegro and Tunisia. The results of key habitats mapping realized in Montenegro in the framework of MedKeyHabitats project are presented in Table 2 and related case study.

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[3] http://rac-spa.org/medmpanetwork

[4] http://rac-spa.org/medkeyhabitats

Table 2: Habitat Mapping in Montenegro (see related case study)

According to CAMP biodiversity Vulnerability study and "Rapid Assessment Survey of coastal habitats to help prioritize the suitable new areas needing a status of protection for the development of a network of Marine and Coastal Protected Areas in Montenegro" the following 23 benthic assemblages were selected a priori in Montenegro. Detailed habitat mapping was done in 3 areas: Boka Kotorska Bay (Kotorsko-Risan part), Platamuni and Ratac since. List of habitats:

1. Barren = encrusting coralline algae and sea urchins Arbacia lixula and Paracentrotus lividus,
2. Boulders_barren = same as above plus large boulders,
3. Caulerpa racemosa assemblage,
4. Cladocora caespitosa reefs = Cladocora caespitosa assemblage,
5. Coralligenous assemblages = Large boulders and vertical walls with dominance of Halimeda tuna, Parazoanthus axinellae and sponges,
6. Infralittoral algal turf assemblages,
7. Infralittoral gravel assemblages,
8. Infralittoral mud assemblages,
9. Infralittoral mud and gravel assemblages,
10. Infralittoral pebble assemblages,
11. Infralittoral sand assemblages,
12. Large sponge assemblage with Geodia, Aplysina and Petrosia,
13. Mussel bed assemblage,
14. Photophilic algae assemblage with Cystoseira spp. and Halopteris spp.,
15. Photophilic algae assemblage with Cystoseira spp.,
16. Photophilic algae assemblage with Padina pavonica,
17. Posidonia oceanica,
18. Rubble and turf assemblage with Codium sp.,
19. Sciaphilic algae assemblages on hard substrata = Rocky substrates dominated by Codium bursa and Flabellia petiolata,
20. Sciaphilic algae assemblages on hard vertical/subvertical substrata with Flabellia petiolata and Halimeda tuna,
21. Sciaphilic algae assemblages on hard substrata with Flabellia petiolata and Peyssonnelia spp.,
22. Submerged canyon,
23. Submerged caves.

Data on distribution of all habitats types are missing and detailed maps and data are available for 3 locations.

A total of 257 benthic marine habitat types were assessed in a recent overview of the degree of endangerment of marine, terrestrial and freshwater habitats in the European Union and adjacent regions (The European Red List of Habitats, 2016). In total, 19% and 18% of the evaluated habitats were assessed as threatened in categories Critically Endangered, Endangered and Vulnerable. The highest proportion of threatened habitats in the EU28 is in the Mediterranean Sea (32%), followed by the North-East Atlantic (23%), the Black Sea (13%) and then the Baltic Sea (8%). This report provides also an overview of the risk of collapse for 47 benthic habitats in the Mediterranean. Almost half of the Mediterranean habitats (23 habitats, 49%) were Data Deficient in countries. Of the remainder (24 habitats) 83% were of conservation concern (NT-CR) with 63% threatened to some degree (42% Vulnerable and 21% Endangered). A good proportion of habitats in infralittoral and mediolittoral environments were either Vulnerable or Endangered. They include algal-dominated communities on infralittoral sediments, and circalittoral sediments and rocks together with mussel and oyster beds. The criteria under which habitats were most frequently assessed as threatened and were in decline in extent and in quality.

The brown algae ***Cystoseira* spp**. form dense canopies along rocky intertidal and subtidal rocky coasts (CocoNet project, http://www.coconet-fp7.eu/). Conspicuous historical declines in extent and quality, for at least a century and especially of species thriving in rock-pools and in the infralittoral zone, are documented in many regions of the Mediterranean Sea (Adriatic Sea, Gulf of Lyon, Ligurian Sea, Strait of Sicily). Algal turfs replace canopies, with a shift from high- to low-diversity habitats. In many coastal rocky bottoms, a shift from canopy-forming algae dominated system to overgrazed sea urchin-dominated barrens (*Paracentrotus lividus* and *Arbacia lixula*) can also occur, mainly in consequence of the illegal destructive fishing of the rock-boring mollusk *Lithophaga lithophaga* and the overfishing of primary sea-urchin predator fishes. Despite the progressive expansion of **barren areas** replacing algal canopies and other rocky bottom assemblages is currently widely acknowledged (Western and Eastern Mediterranean Sea), no published work has been aimed at the assessment of the extension of barren (Mangialajo et al., 2013)

According to Telesca et al. (2015), the estimated lost area of ***Posidonia oceanica*** was 124,091 ha over the past 50 years, which corresponds to an average regression of 10.1% of the total Mediterranean basin. If we consider only those areas for which we had historical information (368,837 ha), the estimated loss of *P. oceanica* was 33.6% (see Table 3).

Table 3. Spatial extent of *Posidonia oceanica* meadows across the Mediterranean Sea (source: Telesca et al., 2015).

	Mediterranean Sea	Western basin	Eastern basin
Coastline length (km)	46,000	11.621 25%	34,379 75%
Coastline length with *P. oceanica* (km)	11,907	6,201 14%	5,706 12%
Coastline length without *P. oceanica* (km)	12,622	3,925 9%	8,697 19%
Coastline length without data (km)	21,471	1,494 3%	19,977 43%
Total area of *P. oceanica* (ha)	1,224,707	510,715 41.7%	713,992 58.3%

Kelps such as *Laminaria rodriguezii* are now confined to very deep areas of the Mediterranean Sea (Balearic and Alboran Islands). The few available temporal data from the Adriatic Sea, obtained in surveys undertaken between 1948–1949 and 2002, indicate that this species has become exceptionally rare or has completely disappeared from this area. Repeated surveys in 2010 showed no recovery of the species. These losses have been linked to intensive trawling. In other areas of France, Italy and Tunisia the species records date back mainly to the 1960–1970s, while in this work recent accessible information on the status of these populations was not found. Only two habitats were assessed as threatened considering the *area of occupancy*: **biogenic habitats of Mediterranean mediolittoral rock** represented by vermetid molluscs and by red algae such as *Lithophyllum byssoides* and *Neogoniolithon brassica-florida*, and **photophilic communities** dominated by calcareous, habitat forming algae, as they are found at only a few sites on the European side of the Mediterranean Sea.

Our knowledge of the pelagic habitats for the Mediterranean Sea is generally limited to coastal areas for which several long-term monitoring stations exist for both zooplankton (O'Brien et al., 2010) and phytoplankton. Our knowledge for the open-sea is scarcer but satellite data and associated modelling chl-*a* regionalisation (D'Ortenzio et al., 2009) are available, which can be used for the already developed OSPAR pelagic indicator which can be adapted to the Mediterranean (OSPAR, 2017). This data can be used as well for Ecologocal

Objective 5 on Eutrophication. Other studies applied to the whole Mediterranean basin considering additional components of the pelagic habitat do exist, such as the work of Berline et al. (2014) on larval dispersion. These studies can be used as a baseline for the indicator development related to pelagic habitats (pelagic habitats need to be considered at the ecohydrodynamic scale, i.e. Ostle et al., 2017), and notably for the consideration of plankton species distribution. This approach could also be already used for grouping existing MPAs or choosing new MPAs based on their importance in terms of plankton communities, and therefore, for the rest of the marine food-web.

Figure 3: *Posidonia oceanica* meadow in Corsica (France), © Sandrine RUITON

The distribution of **nursery areas (**see EO 3 Harvest of commercially exploited fish and shellfish) of 11 important commercial species of demersal fish and shellfish were assessed in the European Union Mediterranean waters using time series of bottom trawl survey data with the aim of identifying the most persistent recruitment areas (Colloca *et al.,* 2015). A high interspecific spatial overlap between nursery areas was mainly found along the shelf break of many sectors of the Northern Mediterranean, indicating a high potential for the implementation of conservation and management measures. The new knowledge on the distribution and persistence of demersal nurseries can further inform the application of spatial conservation measures, such as the designation of new no-take MPAs in EU Mediterranean waters and their inclusion in a conservation network. The establishment of no-take zones has to be consistent with the objectives of the Common Fisheries Policy applying the ecosystem approach to fisheries management and with the requirements of the IMAP and MSFD to maintain or achieve seafloor integrity and good environmental status.

The first continuous maps of **coralligenous and maërl habitats** across the Mediterranean Sea have been produced across the entire basin, by modelling techniques (Martin *et al.,* 2014). Important new information was gained from Malta, Italy, France (Corsica), Spain, Croatia, Greece, Albania, Algeria, Tunisia and Morocco, making the present datasets the most comprehensive to date. Still, there were areas of the Mediterranean Sea where data is scarce (Albania, Algeria, Cyprus, Israel, Libya, Montenegro, Morocco, Syria, Tunisia and Turkey) or totally absent (Bosnia and Herzegovina, Egypt, Lebanon and Slovenia).

A preliminary study of coralligenous benthic assemblages was performed in 2013 at 20 sites in Turkey, Greece and France within the framework of the EU-funded project CIGESMED. The study detected different coralligenous assemblages in the western and eastern Mediterranean Sea. In the western basin, Gorgonians were found to be dominant even in shallow-depths, whereas these animals were rare or absent in the first fieldwork session performed at the eastern Mediterranean sites. However, a number of algae and invertebrates were common in the different Mediterranean areas and could be useful for future monitoring programs and the implementation of biotic indices that have already been developed (e.g. Index-Cor).

Knowledge on maërl beds was somewhat limited compared to what was available for coralligenous outcrops; a significant update was nevertheless achieved. Previously unknown spatial information on maërl distribution became available for Greece, France (Corsica), Cyprus, Turkey, Spain and Italy. Malta and Corsica, in particular, had significant datasets for this habitat as highlighted by fine-scale surveys in targeted areas.

A fine-scale assessment of (i) the current and historical known distribution of ***P. oceanica***, (ii) the total area of meadows and (iii) the magnitude of regressive phenomena in the last decades is also available (6). The outcomes showed the current spatial distribution of *P. oceanica*, covering a known area of 1,224,707 ha, and highlighted the lack of relevant data in part of the basin (21,471 linear km of coastline). The estimated regression of meadows amounted to 34% in the last 50 years, showing that this generalised phenomenon had to be mainly ascribed to cumulative effects of multiple local stressors.

Our knowledge about the **deep-sea habitats** on the scale of the whole Mediterranean Basin is extremely scant and limited only to sites in the western Mediterranean which received much attention in the last decades (e.g., Cap de Creus Canyon, South Adriatic Sea, Santa Maria di Leuca Coral Province, Alboran Sea). The lack of information about deep-sea habitats in the North African and in the eastern side of the Mediterranean Sea is particularly evident.

A recent project, “Deep sea Lebanon” is underway where a one-month deep-sea expedition (October 2016) was conducted in the unstudied areas in Lebanon. In total, more than 200 species were observed, including new records for the Mediterranean Sea. The project will assist the Lebanese relevant authorities in the development of management guidelines of deep sea areas, identifying the deep sea potential areas to be protected and preparing the management plans for the selected MPA proposal.

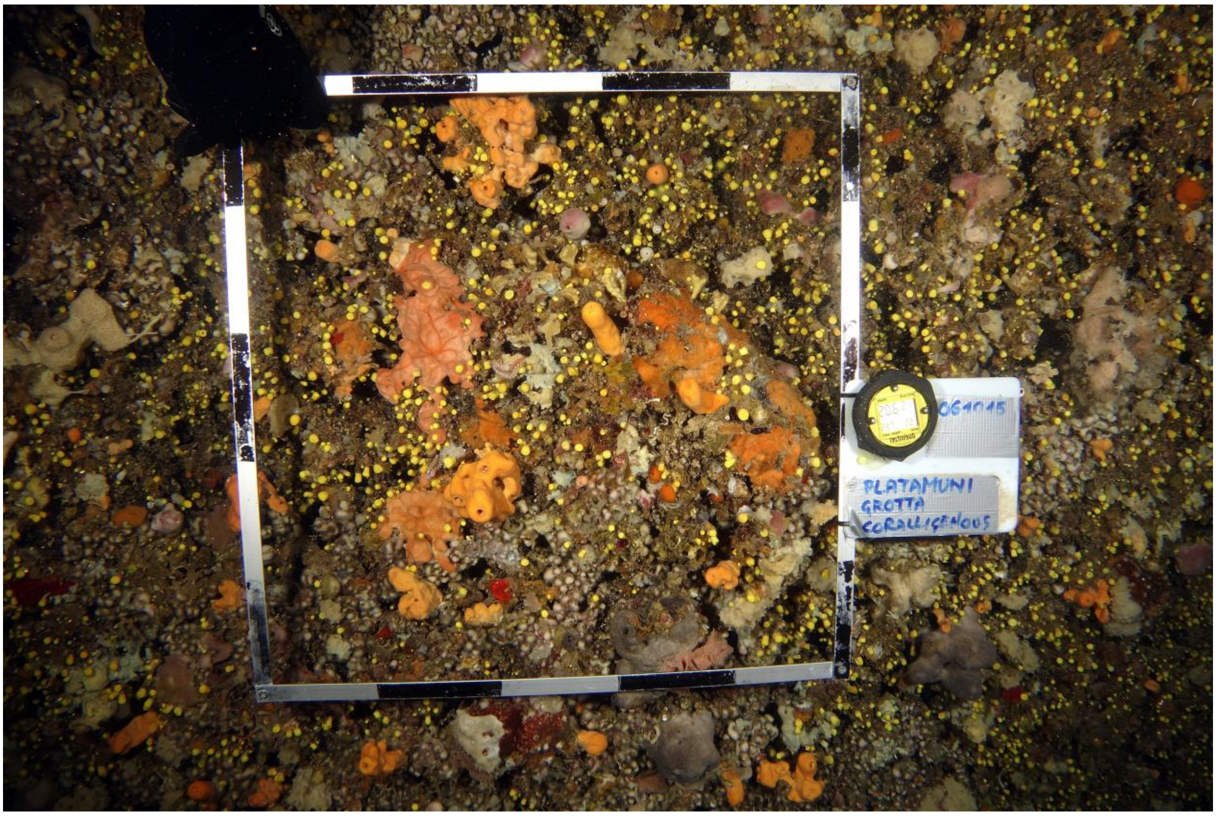

Figure 4: Monitoring system for coralligenous habitat in Platamuni cave (Montenegro) © SPA/RAC, Egidio TRAINITO

CONCLUSIONS

Conclusion (brief)

Regional expertise, research and monitoring programmes over the last few decades have tended to concentrate their attention on only a few specific Mediterranean habitats. The exploration of other habitats, such as bioconstructions, from very shallow to the deep-sea should be further supported, with a focus on threats and pressures in order to improve the conservation status as well as the policy assessments.

Despite the scientific importance of time series studies, the funding for many monitoring programmes is in jeopardy and much of the Mediterranean Sea remains not only just under-sampled, but also unsampled in many areas. Risk based monitoring should be coordinated and standardized so that results can be easily comparable at least for some, decided *a priori*, variables. Coordination and planning of works, notably by UNEP/MAP, is crucial to ensure coherence and synergies at regional or sub-regional scale.

Conclusions (extended)

Beside criteria such as reduction in quantity and in quality and the geographical distribution, more research should focus on processes leading to low diversity of habitats. Regime shifts are ubiquitous in marine ecosystems, ranging from the collapse of individual populations, such as commercial fish, to the disappearance of entire habitats, such as macroalgal forests and seagrass meadows. Lack of a clear understanding of the feedbacks involved in these processes often limits the possibility of implementing effective restoration practices. Moreover, these habitats are selected in the IMAP reference list and they will be monitored in this cycle of IMAP implementation.

There is a need to increase the geographical coverage of protection, establishing new arrays of MPAs (and then networks of MPAs) in the southern and eastern parts of the Mediterranean Sea, with the aim among others to achieve Aichi Target 11 (most MPAs are concentrated in the north-central Mediterranean Sea) since the IMAP Ecological Objectives 1, 3, 4 and 6 have been shown to evolve favorably in Mediterranean MPAs. The use of MPA networks as a reference where to assess the attainment of GES should be taken into account, but the need to reach GES (sustainable use), for the whole Mediterranean Sea area, should be kept in mind. This Regional scale objective is important to avoid moving, and thus increasing, pressure (by activities) outside MPAs, where sensitive habitats could be then more exposed. The GES should be achieved in all Mediterranean waters by 2020, but this current assessment clearly indicates that much more progress and management of pressures should be undertaken to progress towards this objective.

In addition, there is a need to establish MPAs in area beyond national jurdisction to protect deep-sea habitats. The procedures for the listing of SPAMIs are specified in detail in the SPA/BD Protocol (Art. 9). For instance, as regards the areas located partly or wholly in the high seas, the proposal must be made “by two or more neighbouring parties concerned” and the decision to include the area in the SPAMI List is taken by consensus by the Contracting Parties during their periodical meetings. Once the areas beyond national jurisdiction are included to SPAMI List, all contracting Parties agree “to recognize the particular importance of these areas for the Mediterranean”, and consequently “to comply with the measures applicable to the SPAMIs and not authorize nor undertake any activities that might be contrary to the objectives for which the SPAMIs were established”. This gives to the SPAMIs and the measures adopted for their protection an *erga omnes* effect, at least as far the parties to the protocol are concerned.

The coastal states are currently formulating their criteria and the associated monitoring protocols for determining GES. The monitoring guidance factsheets that have been developed for all the IMAP Common indicators significantly support this national endeavors, allowing for a reduction of the inconsistencies in interpretations of the Ecological Objectives and Indicators (not least in the ecological terminology used), as well as in their related national monitoring programmes which suffer of the same. The harmonization of criteria for implanting GES has been clarified with the adoption of a new EU legal act in 2017 (Decision 2017/848/EU) for most European countries. It should be noted that a significant work has been also carried out for the MSFD at the European level, through the OSPAR and HELCOM conventions notably, where monitoring guidelines have been produced.

Current assessment is mainly qualitative and based on compilation of published studies and assessments. Large-scale analyses have been critical to expand our knowledge about the *extent* of habitats and threats but are often biased by the extrapolation of either a few small-scale studies or low-resolution large-scale assessments. The massive lack of ground-truth data and standardized monitoring for most of offshore habitats compromise quantitative assessment of their condition. This limits the potential to assess the condition and the trajectories of change in Mediterranean habitats. Additional inputs (methods and case studies) from ongoing and recent projects like ActionMED project (http://actionmed.eu/) should also be considered for the 2019 State of Environment and Development Report.

Baseline data (‘reference’ with low or least disturbance) are lacking at the Mediterranean scale for many habitats exposed to abrasion by bottom-trawling fisheries. This compromises our ability to identify a sustainable condition for those habitats, which are under continuously high-pressure levels. 'Pristine' baselines (no disturbance) are lacking for most of the habitats; this compromises our knowledge of the potential best condition of natural habitat communities. It is not practical or feasible to use this pristine state as an environmental target everywhere, but it is useful for understanding the natural dynamic and recovery potential of a given habitat. Increasing the establishment and management of Marine Protected Areas (MPAs), notably including 'no take or low-pressure areas' could help provide data in the future, for the relevant habitat types.

Ocean warming, acidification, extreme climate events and biological invasions are expected to increase in the next years. These are difficult to be assessed and managed. More attention should be directed to those threats that can be more easily mitigated such as trawling, maritime traffic and nutrient loading from some land-based activities. In this framework, improve knowledge of the distribution and intensity of threats (e.g. fishery, bioinvasions, marine litter, seabed mining, coastal and non-coastal infrastructures) to reduce uncertainties on their effects should be also increased.

Many potentially relevant data exist but are not all available (e.g. fishing pressure data at fine spatial resolution, or biological data from marine research and marine industry).

Many biological datasets exist, but few have associated data on pressure at a compatible spatial and temporal scale.

Each country currently stores its own monitoring data, so common methodology (and tools) still needs to be developed/ further harmonized. The need for this should be anticipated and relevant work should be coordinated to ensure coherence and facilitate the computation of data for indicator assessment.

Promote open access to data is very critical, especially those deriving from EU projects, through institutional databases sustained under rules and protocols endorsed by EU. The data ensuing from EU projects are still much fragmented and are not stored in a single repository where data are available in a standard format with a stated access protocol. As regards the European Countries, the European Marine Observation and Data Network (EMODnet) is assembling marine data, products and metadata to make fragmented resources more available to public and private users relying on quality-assured, standardised and harmonised marine data which are interoperable and free of restrictions on use. At regional scale, a new platform on biodiversity has been developed by SPA/RAC (http://data.medchm.net) in order to integrate data on biodiversity cluster. This Mediterranean biodiversity platform is interoperable with EMODnet or any regional and or national spatial data infrastructure (SDI).

The process of Maritime Spatial Planning (MSP) across the Mediterranean should be largely supported, considering activities that are expected to increase in the future (e.g. aquaculture, maritime traffic, seabed mining).

Key messages

- The shift from Habitat conservation approaches to Biodiversity and Ecosystem Functioning approaches reflects much better the rationale which sustains the management and conservation of marine ecosystems.
- This shift calls for holistic, integrative and ecosystem based approaches, which are still under development and will require a reappraisal of the way we tackle ocean monitoring, assessment and management.

Knowledge gaps

The analysis of marine systems is mostly compartmentalised, with a series of approaches that should be complementary but that, instead, are developed with little connections with each other. The distinction between benthic systems and pelagic ones, for instance, is based on the patterns of distribution of biodiversity but does not consider processes much. Some of the main gaps that require further research include the following:

- Role of resting stage banks for plankton dynamics;
- Impact of gelatinous macrozooplancton on the functioning of ecosystems;
- Links between deep sea systems and coastal ones;
- Habitat identification for the pelagic habitats and mapping processes;
- Knowledge of connectivity processes;
- Development of innovative techniques such as remote sensing and acoustic for the study of seabed to cover large areas at high resolution.

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Ecological Objective 1 (EO1): Biodiversity

Note: The maps and illustrations are provisional

EO1: Common Indicator 3. Species distributional range (related to marine mammals)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 3 (CI3): Species distributional range (related to marine mammals)
Indicator Assessment Factsheet Code	EO1CI3

RATIONALE/METHODS

Background (short)

Robust information on species occurrence, distribution and ranges is the baseline to perform any further in depth investigation and to gain insights on the conservation status of the target populations. These are therefore pivotal to inform conservation and management at the diverse temporal and spatial scale. Cetaceans in the Mediterranean Sea are protected under statutory regulations (e.g. the Habitat Directive and the Marine Strategy Framework Directive) and by several international agreements such as ACCOBAMS among the others, which not only indicates to some extent the priorities in terms of conservation, but also clearly states the details of monitoring activities that should be in place. By consequence, these information and the process to gather them are necessary to abide to national and international regulations.

Background (extended)

The aim of this indicator is to provide information about the geographical area where marine mammal species occur, and to determine the range of cetaceans and seals that are present in the Mediterranean waters. The distribution of a given marine mammal species is usually described by a map, describing the species presence, distribution and occurrence. Geographical Information Systems (GIS) are commonly used to graphically represent monitoring data and species distributional range maps.

Data on distribution of marine mammals are usually collected during dedicated ship and aerial surveys, acoustic surveys, or opportunistically by whale watching operators, ferries, cruise ships, military ships.

Twelve species of marine mammals — one seal and 11 cetaceans — are regularly present in the Mediterranean Sea. All these 12 species belong to populations (or sub-populations, *sensu* IUCN) that are genetically distinct from their North Atlantic conspecifics. The Mediterranean monk seal (*Monachus monachus*) and the 11 cetacean species (fin whale, *Balaenoptera physalus*; sperm whale, *Physeter macrocephalus*; Cuvier's beaked whale, *Ziphius cavi*rostris; short-beaked common dolphin, *Delphinus delphis*; long-finned pilot whale, *Globicephala melas*; Risso's dolphin, *Grampus griseus*; killerwhale, *Orcinus orca*; striped dolphin, *Stenella coeruleoalba*; rough-toothed dolphin, *Steno bredanensis*; common bottlenose dolphin, *Tursiops truncatus*; harbour porpoise, *Phocoena phocoena relicta*) face several threats, due to heavy anthropogenic pressures throughout the entire Mediterranean basin.

The Mediterranean monk seal is considered the most endangered marine mammal in the Mediterranean and one of the world's most endangered pinnipeds, as its spatial distribution was drastically reduced and fragmented along last century. The species is found mainly along the mainland coasts of Greece, Cyprus, western and southern Turkey and around islands in the Ionian and Aegean Seas (UNEP/MAP RAC/SPA, 2013; National Oceanic and Atmospheric Administration
(NOAA), 2017).

Threats to the Mediterranean monk seal vary regionally, but the primary threats to the species are displacement and habitat deterioration, deliberate killing by humans, and fisheries bycatch (UNEP-MAP RAC/SPA, 2013; Karamanlidis et al. 2015).

The conservation status of marine mammals in the region is jeopardised by many human impacts, such as: (1) enhanced mortality by deliberate killing (mainly due to interactions with fisheries), naval sonar, ship strikes, fisheries bycatch, chemical pollution and solid debris ingestion and entanglement on it; (2) habitat degradation as a consequence of noise (vessel sonars use, seismic surveys, engines) vessel traffic disturbance, food depletion due to over fishing, habitat fragmentation, coastal development.

Two of these cetacean species have very limited ranges: the harbour porpoise, possibly representing a small remnant population in the Aegean Sea, and the killer whale, present only as a small population (around 50 individuals) in the Strait of Gibraltar.

Out of the 12 marine mammal species listed above, seven are listed under a Threat category on the IUCN's Red List, three are listed as Data Deficient and two need to be assessed.

Policy Context and Targets

Since 1985, the Mediterranean monk seal was recognised within the framework of the Barcelona Convention as a species to be protected as a matter of priority. In that year, during their fourth ordinary meeting, the Contracting Parties adopted a declaration, referred to as the Genoa Declaration, which included, amongst the priority targets to be achieved in the decade 1986-1995, the "protection of the endangered marine species" with a specific reference to the monk seal. Following the Genoa Declaration, an Action Plan for the Management of the Mediterranean Monk Seal (*Monachus monachus*) was adopted by the Barcelona Convention's Contracting Parties (UNEP-MAP-RAC/SPA & IUCN 1988, UNEP-MAP-RAC/SPA 2003). The main aims of the Barcelona Convention's Action Plan for the Management of the Mediterranean Monk Seal are: i) to reduce adult mortality; ii) to promote the establishment of a network of marine reserves; iii) to encourage research, data collection, and rehabilitation programmes; iv) to implement information programmes targeting fishing communities and various other stakeholders; and v) to provide a framework for the coordination, reviewand financing of relevant activities.

Aware of the scientific progress achieved, a Regional Strategy for the Conservation of Monk Seals in the Mediterranean (2014-2019) was adopted by the 18th Meeting of the Contracting Parties to the Barcelona Convention, that presents a new vision, with associated goals and targets that are SMART.

The Mediterranean monk seal is listed under the Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BD Protocol) of the Barcelona Convention. It has been classified as "Critically Endangered" by the International Union for the Conservation of Nature (IUCN; Karamanlidis and Dendrinos 2015) and is legally protected throughout its range via regional, national and international legislation, including the Convention on the Conservation of Migratory Species of Wild Animals, Convention on the Conservation of European Wildlife and Natural Habitats, Convention on Biological Diversity, and Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Additionally, the European Union's Habitats Directive (92/43/EEC) lists the Mediterranean monk seal in the Directive's Annexes II and IV as a species of Community interest whose conservation requires the creation of Special Areas of Conservation (SAC).

The Mediterranean cetaceans' populations are protected under the framework of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area), under the auspices of the UNEP Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS). The Pelagos Sanctuary is a large marine protected area, established by France, Italy and Monaco in the Corso-Ligurian-Provençal Basin and the Tyrrhenian Sea, where most cetacean species are regularly observed and benefit from its conservation regime.

All cetacean species in the Mediterranean Sea are also protected under the Annex II of the SPA-BD Protocol of the Barcelona Convention, under the Appendix I of the Bern Convention, under the Annex II of the Washington Convention (CITES), under the Appendix II of the Bonn Convention (CMS) and under the Annex IV of the EU Habitats Directive.

In 2016, the 19th Meeting of the Contracting Parties to the Barcelona Convention adopted the updated Action Plan for the Conservation of Cetaceans in the Mediterranean Sea. This Action Plan, firstly adopted in 1991, was prepared using the information available about the cetacean populations and the threats hanging over them as known in 1991. However, aware that many important aspects of cetacean biology, behaviour, range and habitats in the Mediterranean were poorly known, the list of "Additional Points for the Implementation of the Action Plan" (Appendix to the Action Plan) has been amended in 2015 in collaboration with the ACCOBAMS secretariat. The main objective of this Action Plan is to promote the protection and the conservation of cetacean habitats including feeding, breeding and calving grounds, as well as the recovery of cetacean populations in the Mediterranean Sea Area.

The short-beaked common dolphin, the sperm whale, the Cuvier's beaked whale and the monk seal are also listed under the Appendix I of the Bonn Convention (CMS). The common bottlenose dolphin, the harbor porpoise and the monk seal are also listed under the Annex II of the EU Habitats Directive.

Assessment methods

Visual and acoustic surveys. Before conducting any type of monitoring of animal populations aimed at assessing the species distribution, it is essential to define the main objectives of the programme, alongside with the collection of relevant information on the target study area and the species presence, occurrence and behaviour. These elements are critical to choose the right data collection methodology, survey design approach and analytical framework.

We can identify are at least five potential approaches to be undertaken when monitoring cetaceans:

1. Visual surveys from ship, aircraft or land observation platforms (LOP).
2. PAM carried out during ship surveys with towed hydrophones.
3. PAM performed by means of static acoustic monitoring, e.g. using T-PODs or EARS.
4. A combination of all or some of the above methodologies.
5. Satellite tagging and tracking.

Visual aerial and both acoustic and visual surveys offer several advantages, but present some limitation depending on the target species. Therefore, when deciding which monitoring method to implement, it is pivotal to consider the limitations of each approach and compare the different methodologies. In general, surveys from ship or aircraft have a low temporal resolution. Ship surveys may have bias due to responsive movements of animals, stationary acoustic systems often have low spatial resolution and are inherently problematic from a logistical point of view in terms of deployment of instruments.

Monk seals surveys are focused on coastal visual surveys from small boats, mainly concentrated in suitable caves. They can be done either through direct monitoring of seal presence evidences on cave beaches or by installing monitoring photo or video traps inside them. The data from the latter can be physically retrievable periodically or remotely accesible, even in real time.

Passive Acoustic Monitoring (PAM). Cetaceans, in particular odontocetes, are highly vocal animals that can produce vocalisations for over the 80% of the time (e.g. the sperm whale). The monitoring of these sounds allows, hence, for the collection of information on spatial and temporal habitat use. The collection of acoustic data for cetaceans has some significant advantages over visual methods. In fact, acoustic methods can be automated, data can be collected 24-hrs a day over long period of time, data collection is not dependent on observer's skills, is less sensitive to weather conditions and can detect the presence of diving animals not available for visual observations. The disadvantages of of PAM methods are that they rely on animals making sounds within a useful detection range and are identifiable to the species level.

Satellite tracking. Information on the distribution and movements of individual animals can help to identify critical habitats, migration routes and patterns, to define boundaries between populations, as well as, to identify and quantify potential threats during long distance migrations (i.e. ships strikes). Effective conservation of animal populations is enhanced by this information, which can also be valuable when designing monitoring programmes.

To make inferences about large populations ranging over a wide area, many animals must be tagged, especially in species with high individual variation in behaviour.

Many kinds of tags have been used in studies of cetaceans, including VHF transmitters, satellite tags and GPS data loggers. Satellite telemetry, being based on signal transmission between the tagged animals and the ARGOS satellite network, offers a virtually total coverage of the Earth's oceans and bodies of water and can be used to track animals even in remote location that difficult to reach. Furthermore, being the data downloaded to land-based server stations, they can be accessed, parsed and analysed without the need to physically retrieve the tags.

Each tagged animal can provide a wealth of information but the limitation is that typically only a few animals can be tagged in a study due to limited funding or access to live animals. General conclusions arising from these studies must be carefully evaluated especially if all members of the population are not equally available for tagging.

RESULTS

Results and Status, including trends (brief)

This assessment presents a brief overview of the key results and status of twelve species of marine mammals, one seal and 11 cetaceans that are regularly present in the Mediterranean Sea and face several threats due to heavy anthropogenic pressures throughout the entire Mediterranean basin.

Results and Status, including trends (extended)

Mediterranean monk seal – Regularly present only in the Ionian, Aegean and Levantine Seas, the Mediterranean monk seas breeds in Greece and parts of Turkey and Cyprus. Deliberate killing, habitat loss and degradation, disturbance and by-catch in fishing gear are the main threats.

Conservation efforts initiated over the past few decades seem to have at least partially stymied the population's decline, as the current overall abundance of eastern Mediterranean subpopulation is said to be substantially higher than the 350 monk seals estimated in 2004 (Güçlüsoy et al. 2004) and 2010 (Aguilar and Lowry, 2010)[5]. It is unclear when this recent small increases and signs of recovery began and if it will continue (Karamanlidis and Dendrinos, 2015).

This small and localized recovery is likely the result of four factors (Notarbartolo di Sciara

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[5] Although there have been improvements in the methodologies used to study monk seals (e.g., the remote use of infrared photo cameras in caves), it is unlikely that the estimated increase in population size was substantially influenced by differences in methodology as the methods used to calculate abundance (although different by location) have been largely similar across time (e.g., Pires and Neves 2001, Pires et al. 2008 and Karamanlidis et al. 2009).

and Kotomatas 2016): i) the decline of artisanal fishing in many economies and the reduce of number of negative interactions between fisheries and monk seals; ii) the shift in public opinion regarding environmental stewardship and animal welfare; iii) the good management of marine protected areas (MPAs) and generally thebuilt of public support for the species; and iv) the inaccessability of monk seal habitat to humans (this refuge may have enabled the population to avoid extinction).

Sporadic sightings of monk seal have been reported in other Mediterranean sub-regions, but there has not been systematic monitoring to discern the status of this population (Mo et al. 2011, UNEP-MAP-RAC/SPA, 2013, Karamanlidis et al. 2015). Vagrant individuals have also been recently sighted throughout the Mediterranean in areas where the species was thought to be extinct (e.g., in Albania, Croatia, Israel, Lebanon, Spain, etc.) (Karamanlidis et al. 2015) (Figure 1).

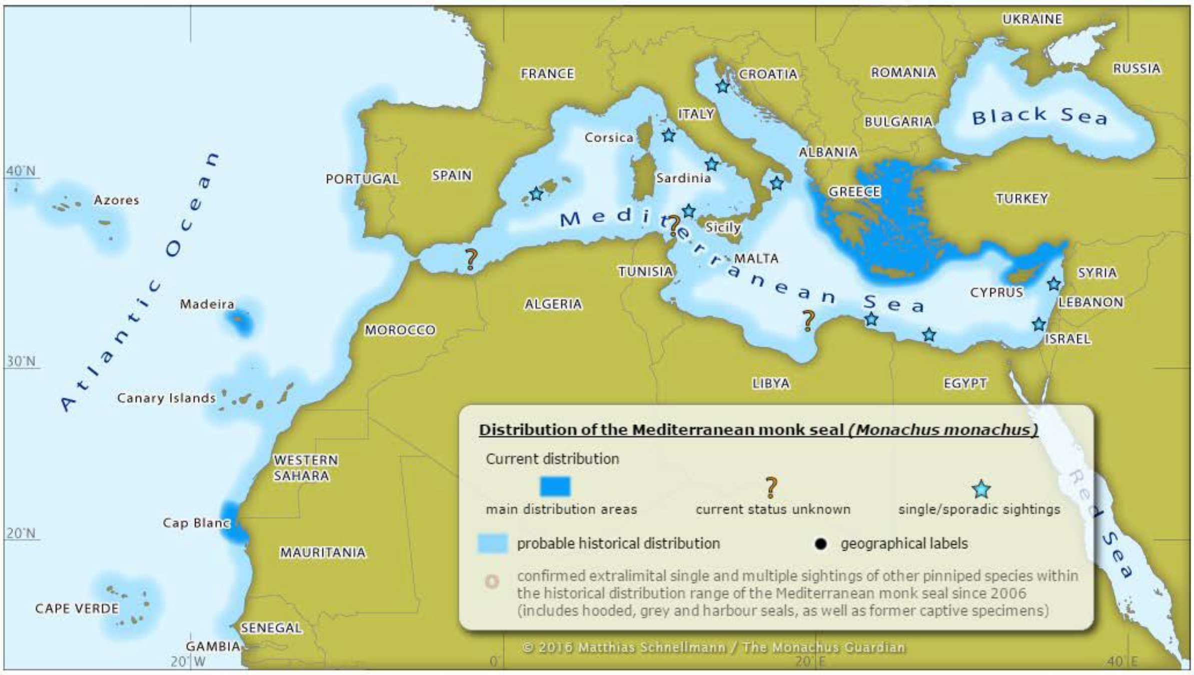

Figure 1: Current and historical distributions of the Mediterranean monk seal *Monachus monachus*. Source: NOAA, 2017.

Fin whale – This species is observed throughout the Mediterranean Sea, mainly in the western Basin. True Mediterranean fin whales range from the Balearic Islands to the Ionian and southern Adriatic seas, while North East North Atlantic (NENA) whales seasonally enter through the Strait of Gibraltar (Figure 2). The main anthropogenic threats include collisions with ships, disturbance, chemical and acoustical pollution.

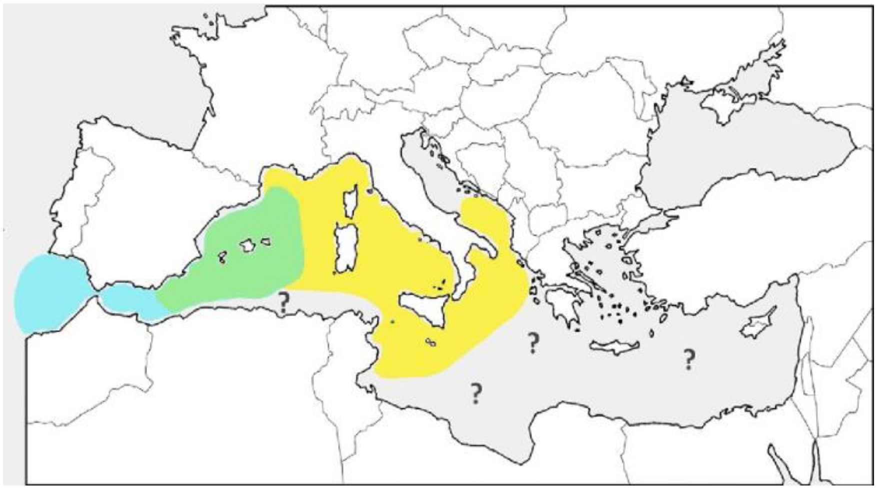

Figure 2: Presumed distribution of fin whale (*Balaenoptera physalus*) populations in the Mediterranean Sea. Blue: north-east North Atlantic population (NENA whales). Yellow: Mediterranean population (MED whales). In green the presumed overlap between the two populations (from: Notarbartolo di Sciara, G., Castellote, M., Druon , J.N., Panigada, S. 2016. Fin whales: at home in a changing Mediterranean Sea? Advances in Marine Biology Series, 75:75-101).

Sperm whale – Sperm whales prefer slope and deep waters all over the Basin, with localized hot spots in the Hellenic Trench, the Ligurian Sea, the Balearic area and the Gibraltar Strait. Human threats include ship strikes, occasional entanglement in driftnets, ingestion of plastic debris, anthropogenic noise and chemical contaminants.

Cuvier's beaked whale – This species is distributed throughout the Mediterranean Sea, mainly along the deep continental slope, in presence of underwater canyons. Cuvier's beaked whales are particularly vulnerable to military and industrial sonars, bycatch in fishing gears, ingestion of plastics.

Short-beaked common dolphin – Common dolphins significantly declined in the Mediterranean Sea over the last few decades and are now present in specific locations within the Alborán Sea, the Sardinian Sea, the Strait of Sicily, the eastern Ionian Sea, the Aegean Sea and the Levantine Sea. Prey depletion from overfishing and incidental mortality in fishing gear seem to be the main current threats for this species in the Mediterranean Sea.

Long-finned pilot whale – This species in present in the western Basin only, mainly in offshore waters. Current threats include bycatch in driftnets, ship strikes, disturbance from military sonar and chemical pollution.

Risso's dolphin – Risso's dolphins are present – in relatively low numbers – throughout the Mediterranean Sea, with a preference for slope waters. Known distributional range includes the Alborán, Ligurian, Tyrrhenian, Adriatic, Ionian, Aegean and Levantine seas and the Strait of Sicily.

Killer whale – This species is seasonally present in the Strait of Gibraltar and adjacent Atlantic and Mediterranean waters only and it is very rare in the rest of the Mediterranean Sea. Strong negative interactions with local artisanal bluefin tuna fisheries have been described.

Striped dolphin –The most abundant cetacean species in the Mediterranean Sea, mainly using offshore deep waters, from the Levantine Basin to the Strait of Gibraltar. Subject to a wide range of different threats that affect the Mediterranean population, such as morbillivirus epizootics and high levels of chemical pollutants.

Rough-toothed dolphin – It is regular in the eastern Mediterranean only, particularly in the Levantine Sea, at very low densities and limited range. Subject to similar human impacts as other dolphins, including bycatch, acoustic and chemical pollution.

Common bottlenose dolphin – One of the most common species all over the Mediterranean Sea, mainly found on the continental shelf. Human threats include mortality in fishing gear, occasional direct killings, habitat loss or degradation including coastal development, overfishing of prey and high levels of contamination.

Harbour porpoise – This cetacean subspecies, typically found in the Black Sea, is occasionally observed in the northern Aegean Sea. Main threats in the Black Sea include severe levels of bycatch in fishing gears, mortality events and habitat degradation.

CONCLUSIONS

Conclusions (brief)

Current knowledge about the presence, distribution, habitat use and preferences of Mediterranean marine mammals is limited and regionally biased, due to an unbalanced distribution of research effort during the last decades, mainly focused on specific areas of the Basin. Throughout the Mediterranean Sea, the areas with less information and data on presence, distribution and occurrence of marine mammals, are the south-eastern portion of the basin, including the Levantine basin and the North Africa coasts. In addition, the summer months are the most representative in the censuses and very few information have been provided for the winter months in the data pool, when conditions to conduct off-shore research campaigns are particularly hard due to meteorological adversity.

Conclusions (extended)

Marine mammals’ presence and distribution are mainly related to suitable habitats and availability of food resources, anthropogenic pressures, as well as climate change effects on preys, may cause changes and shifts in the occurrence of marine mammals, with potential detrimental effects at the population levels. Accordingly, in order to enhance conservation effort and inform management purposes, it is crucial to obtain detailed and robust descriptions of species’ range, movements and extent of geographical distribution, together with detailed information on the location of breeding and feeding areas.

Ongoing effort are running by ACCOBAMS to start a synoptic region-wide survey referred to as the ACCOBAMS Survey Initiative (ASI), to assess the presence distribution and to estimate density and abundance of cetaceans in the summer of 2018. Concurrently, local scientists are working on the identification of Cetacean Critical Habitats (CCHs) and Important Marine Mammal Areas (IMMAs) in the entire Mediterranean Sea. A gap analysis has also been conducted within the Mediterranean Sea, to provide an inventory of available data and to select areas where more information should be collected.

Key messages

- A risk based approach for monitoring should be carried out to assess the marine mammal distribution throughout the whole Mediterranean Sea.
- More effort should be devoted in poorly monitored areas.
- Those species which are listed as Data Deficient under the Red List criteria should be considered as a priority.

Knowledge gaps

- Most of the Mediterranean Sea has been surveyed to some extent to evaluate cetaceans' occurrence, distribution and ranges.
- Nonetheless, there is a great disparity in the overall distribution of research effort, with most research been done and still carried out in the north-western portion of the basin, where long time series of data, covering up to three decades, exist. In southern Mediterranean countries information on species occurrence and distribution mostly arises from anecdotal information and localized research projects. Systematic surveys in these areas are still scarce. Effort should be done to allocate research in those areas to consolidate baseline information and to eventually obtain long time series of data.
- The current gap in the availability of data, and by consequence of knowledge, is hampering the identification of protection measures towards the conservation of species at the regional level.

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 3. Species distributional range (marine reptiles)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	No national data was available for this assessment.
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 3 (CI3): Species distributional range (Marine reptiles)
Indicator Assessment Factsheet Code	EO1CI3

RATIONALE/METHODS

Background (short)

This assessment presents a brief overview of the known distribution range of loggerhead and green sea turtles at breeding, foraging and wintering grounds, based on published data. Sea turtles are an ideal model species to assess the selected indicator, as their populations are dispersed throughout the entire Mediterranean, as discrete breeding, foraging, wintering and developmental habitats (Casale & Margaritoulis, 2010), making the two sea turtle species a reliable indicator on the status of biodiversity across this region. Therefore, the objective of this indicator is to determine the species range of sea turtles that are present in Mediterranean waters.

Background (extended)

In biology, the range of a given species is the geographical area in which that occurs (i.e. the maximum extent). A commonly used visual representation of the total areal extent (i.e. the range) of a species is a range map (with dispersion being shown by variation in local population densities within that range). Species distribution is represented by the spatial arrangement of individuals of a given species within a geographical area. Therefore, the objective of this indicator is to determine the species range of sea turtles that are present in Mediterranean waters, especially the species selected by the Parties.

Sea turtles are an ideal model species to assess the selected indicator, as their populations are dispersed throughout the entire Mediterranean, as discrete breeding, foraging, wintering and developmental habitats (Casale & Margaritoulis 2010), making the two sea turtle species a reliable indicator on the status of biodiversity across this region. Three sea turtle species are found in the Mediterranean (leatherback, *Dermochelys coriacea*; green, *Chelonia mydas*; and loggerhead, *Caretta caretta*), but only the green and loggerhead turtles breed in the basin and have limited gene flow with those from the Atlantic, even though, turtles from the Atlantic do enter the western part of the basin (confirmed by genetic analyses: Encalada et al. 1998; Laurent et al. 1998). Green turtles are primarily herbivores, whereas loggerheads are primarily omnivores, resulting in their occupying important components of the food chain; thus, changes to the status in sea turtles, will be reflected at all levels of the food chain. However, the extent of knowledge on the occurrence, distribution, abundance and conservation status of Mediterranean marine species is uneven. In general, the Mediterranean states have lists of species, but knowledge about the locations used by these species is not always complete, with major gaps existing (Groombridge 1990; Margaritoulis et al. 2003; Casale & Margaritoulis 2010; Mazaris et al. 2014; Demography Working Group 2015). Even some of the most important programmes on this topic have significant gaps (e.g. Global databases do not reflect actual current knowledge in the Mediterranean region). It is therefore necessary to establish minimum information standards to reflect the known distribution of the two-selected species. Species distribution ranges can be gauged at local (i.e. within a small area like a national park) or regional (i.e. across the entire Mediterranean basin) scales using a variety of approaches.

Given the breadth of the Mediterranean, it is not feasible to obtain adequate information about the entire surface (plus, the marine environment is 3 dimensional, with sea turtles being present only briefly to breathe), so it is necessary to choose sampling methods that allow adequate knowledge of the distribution range of each species. Such sampling involves high effort for areas that have not been fully surveyed to date. Monitoring effort should be long term and should cover all seasons to ensure that the information obtained is as complete as possible.

Both nesting and foraging areas of marine turtles are vulnerable to anthropogenic pressures in the Mediterranean Sea, including an increase in the exploitation of resources (including fisheries), use and degradation of habitats (including coastal development), pollution and climate change (UNEP/MAP/BLUE PLAN, 2009; Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). These issues might reduce the resilience of this group of species, negatively impacting the ability of populations to recover (e.g. Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). The risk of extinction is particularly high in the Mediterranean because the breeding populations of both loggerhead and green turtles in this basin are demographically distinct to other global populations (Laurent et al., 1998; Encalada et al., 1998), and might not be replenished.

The main threats to the survival of loggerhead and green turtles in the Mediterranean have been identified as incidental catch in fishing gear, collision with boats, and intentional killing (Casale & Margaritoulis 2010). Casale (2011) estimated that there are more than 132,000 incidental captures per year in the Mediterranean, of which more than 44,000 are predicted to be fatal, although very little is known about post-release mortality (Álvarez de Quevedo et al.

2013). Wallace et al. (2010, 2011) grouped all species of sea turtles globally into regional management units (RMUs), which are geographically distinct population segments, to determine the population status and threat level. These regional population units are used to assimilate biogeographical information (i.e. genetics, distribution, movement, demography) of sea turtle nesting sites, providing a spatial basis for assessing management challenges. A total of 58 Regional Management Units (RMUs) were originally delineated for the seven sea turtle species. The Mediterranean contains 2 RMUs for loggerheads and 1 RMU for green turtles (Figure 1).

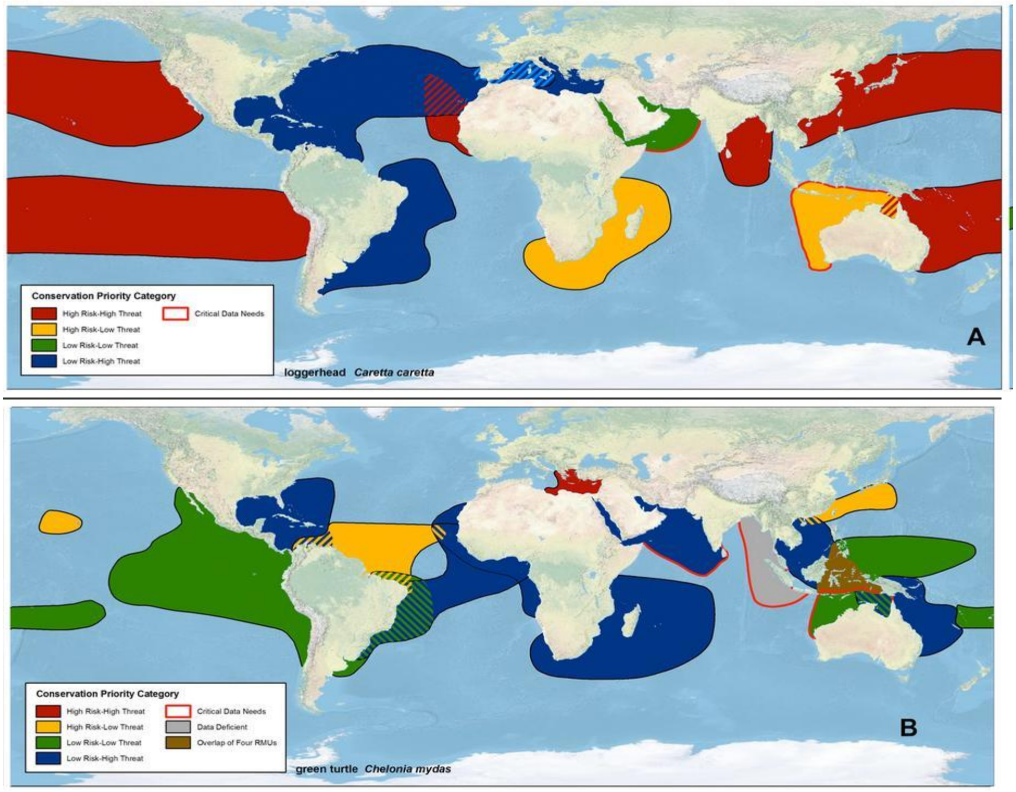


Figure 1*:* Regional Management Units of sea turtle populations globally (extracted from Wallace et al. 2010, 2011); (A) Showing the 2 loggerhead RMUs in the Mediterranean and (B) showing the 1 green turtle RMU in the Mediterranean.

These analyses showed that the Mediterranean has the highest average threats score out of all ocean basins, particularly for marine turtle bycatch (Wallace et al. 2011). However, compared to all RMUs globally, the Mediterranean also has the lowest average risk score (Wallace et al. 2011).

Other key threats to sea turtles in the Mediterranean include the destruction of nesting habitat for tourism and agriculture, beach erosion and pollution, direct exploitation, nest predation and climate change (Casale & Margaritoulis 2010; Mazaris et al. 2014; Katselidis et al. 2012, 2013 2014). Coll et al. (2011) also identified critical areas of interaction between high biodiversity and threats for marine wildlife in the Mediterranean. Within this analysis, the authors delineated high risk areas to both species, with critical areas extending along most coasts, except the south to east coastline (from Tunisia to Turkey) (Figures 2-4).

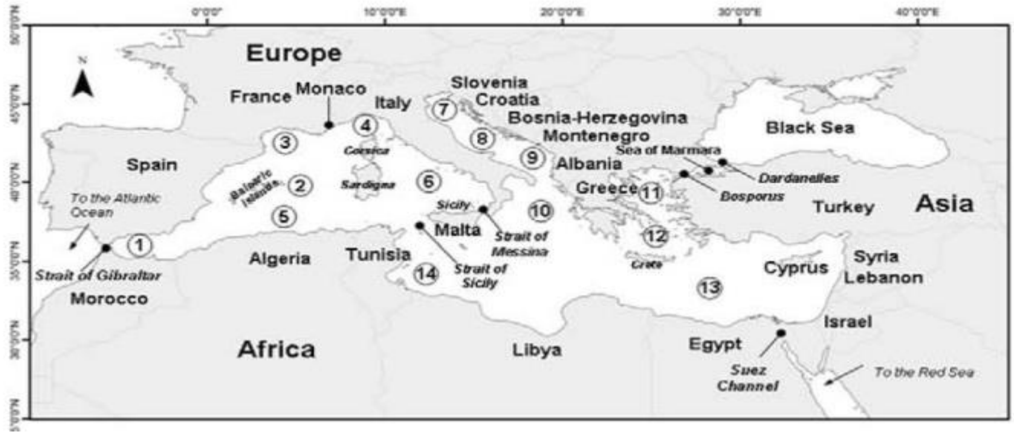


Figure 2*:* Main biogeographic regions of the Mediterranean Sea (extracted from Coll et al. 2011)

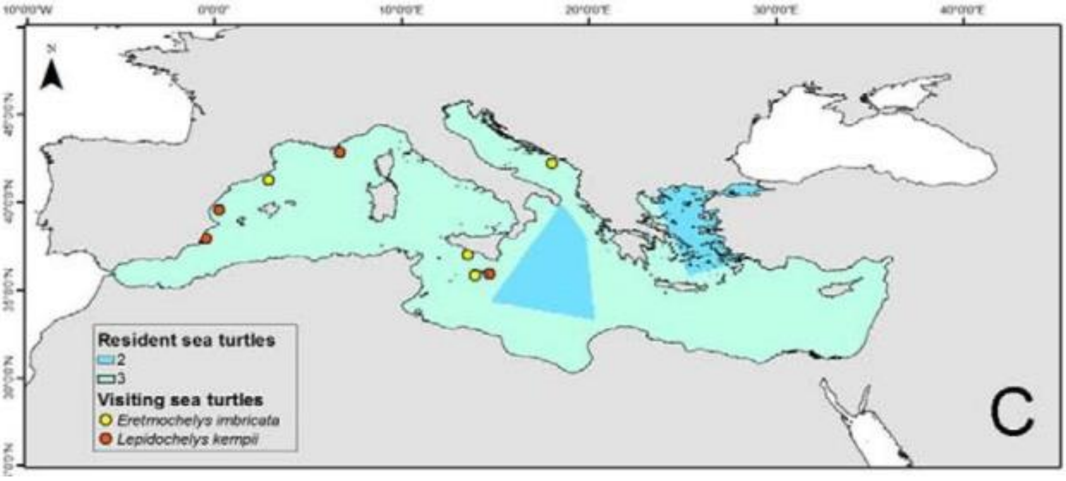


Figure 3*:* Modelled resident and sea turtle species richness (n = 3 species) in the Mediterranean (extracted from Coll et al. 2011*)*

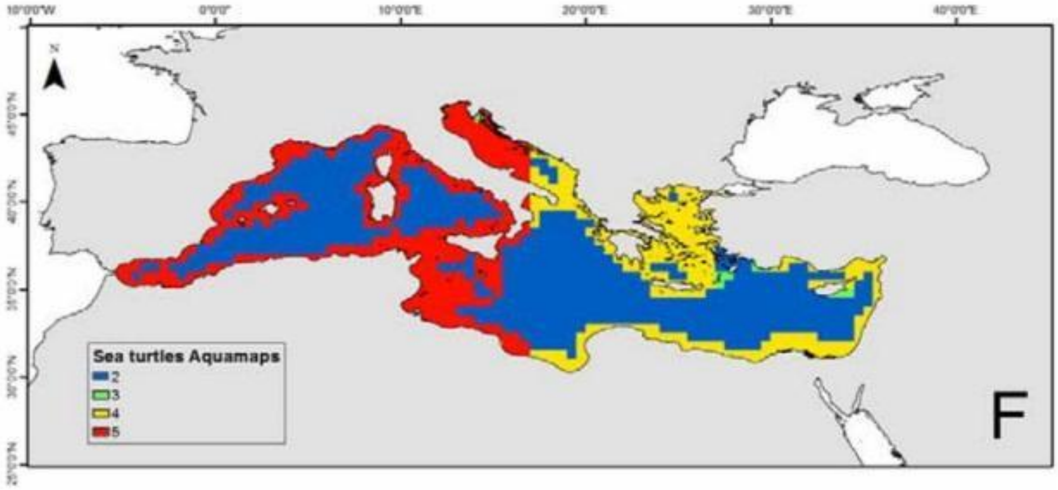


Figure 4: Aqua Map model of sea turtle distribution in the Mediterranean Sea (extracted from Coll et al. 2011). Note, this is primarily based on nesting beach data.

Policy context and Targets

The Parties to the Barcelona Convention included among their priority targets for the period 1985-1995 the protection of Mediterranean marine turtles (Genoa Declaration, September 1985). With this purpose, the Action Plan for the Conservation of Marine Turtles in the Mediterranean Sea was adopted by the Contracting Parties to the Barcelona Convention in 1989. Since that time, this Action Plan was revised three times: i) in 1999, when the updated version of the Action Plan was adopted at the 11th Meeting of the Contracting Parties to the Barcelona Convention; ii) in 2007 when a new update of the Action Plan was approved by the 15th COPs and iii) the last updated timetable for the period 2014-2019 was reviewed and adopted by the 18th COP .

The objective of this Action Plan is the recovery of the populations of *Caretta caretta* and *Chelonia mydas* in the Mediterranean (with priority accorded to *Chelonia mydas*, wherever appropriate) through: i) appropriate protection, conservation and management of marine turtle habitats, including nesting, feeding and wintering areas and key migration passages and ii) improvement of the scientific knowledge by research and monitoring.

Sea turtles are afforded additional legislative protection under a number of international conventions, including the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendices I and II of the Convention on Migratory Species (CMS), the Bern Convention (Council of Europe) and European Union regulation (Habitats Directive), several agreements and recommendations adopted by the Regional Fisheries Management Organizations (RFMOs) such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM).

Monitoring and assessing sea turtle populations, unveiling migratory patterns and identifying feeding areas, as well as faced threats, are fundamental to further design sound conservation strategies and policies. It will be ensured through the IMAP that includes three common indicators related to sea turtles within the Ecological Objective 1. This assessment will include information on marine reptile species that, at some point in their annual life cycle, are reliant on coastal and/or offshore marine areas. In this context, this indicator will allow a large-scale monitoring and assessment of sea turtles.

Assessment methods

This assessment presents a brief and general overview of the distributional range of two marine turtle species to identify existing knowledge and knowledge gaps for use in elaborating the national monitoring programmes for biodiversity. Published information by regional and national surveys and research projects were used to compile the review, but this overview does not present a comprehensive assessment of existing knowledge.

RESULTS

Results and Status, including trends (brief)

This general overview reconfirms that most nesting sites of loggerheads are located in the eastern and central basins of the Mediterranean, in particular in Greece, Turkey, Cyprus and Libya, while all green turtle nesting sites are located in the eastern basin, primarily Turkey, Syria and Cyprus. The number of nests found at different sites is not just dependent on climate, but other factors, like predation, sand type/structure etc. Most research has been conducted on nesting beaches; consequently, detailed information about marine habitat use at developmental, foraging and wintering grounds and how these areas connect with one another and the overlap in use by multiple populations is still missing.

Results and Status, including trends (extended)

Loggerhead sea turtles.

Nesting sites: Over 100 sites around the Mediterranean have scattered to stable (i.e. every year) nesting (Halpin et al., 2009; Kot et al. 2013; SWOT, 2006a, 2006b, 2008, 2009, 2010, 2011, 2012). Most sites are located in the eastern and central basins of the Mediterranean (Figure 5).

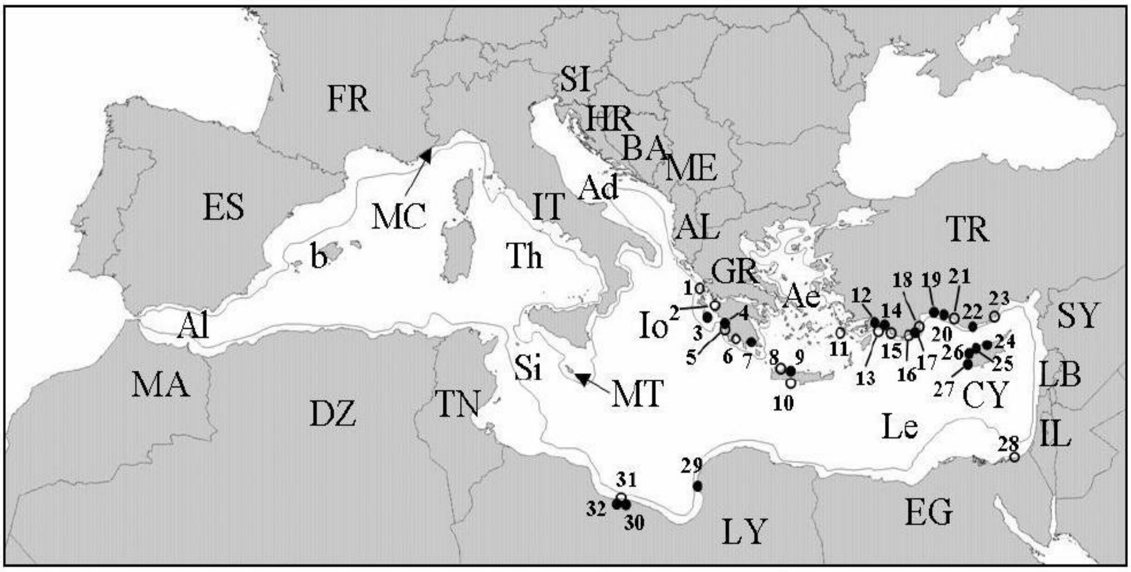


Figure 5: Map of the major loggerhead nesting sites in the Mediterranean (extracted from Casale & Margaritoulis), Black circles: >100 nests/year; white circles: 50-100 nests/year : Major nesting sites (>50 nests/year) of Loggerheads in the Mediterranean. 1 Lefkas; 2 Kotychi; 3 Zakynthos; 4 Kyparissia; 5 beaches adjacent to Kyparissia town; 6 Koroni; 7 Lakonikos Bay; 8 Bay of Chania; 9 Rethymno; 10 Bay of Messara; 11 Kos; 12 Dalyan; 13 Dalaman; 14 Fethiye; 15 Patara; 16 Kale; 17 Finike-Kumluca; 18 Cirali; 19 Belek; 20 Kizilot 21 Demirtas; 22 Anamur; 23 Gosku Delta; 24 Alagadi; 25 Morphou Bay; 26 Chrysochou; 27 Lara/Toxeftra; 28 Areash; 20 Al-Mteafla; 30 Al-Ghbeba; 31 Al-thalateen; 32 Al-Arbaeen. Country codes: AL Albania; DZ Algeria; BA Bosnia and Hersegovina; HR Croatia; CY Cyprus; EG Egypt; FR France; GR Greece; IL Israel; IT Italy; LB Lebanon; LY Libya; MT Malta; MC Monaco; ME Montenegro; MA Morocco; SI Slovenia; ES Spain; SY Syria; TN Tunisia; TR Turkey; Ad Adriatic; Ae Aegean; Al Alboran Sea; Io Ionian; Le Levantine basin; Si Sicily Strait; Th Thyrrenian; b Balearic.

Sporadic to regular nesting has been recorded in Cyprus, Egypt, Greece, Israel, Italy, Lebanon, Libya, Malta, Syria, Tunisia and Turkey (Margaritoulis et al. 2003; Casale & Margaritoulis 2010). Surveys have been conducted for tracks in Algeria (last surveyed 1980s), Croatia (last surveyed 1990s), France (last surveyed 1990s), Malta (last survey on 2015 through the LIFE+ MIGRATE project (LIFE11NAT/MT/1070)) Morocco (last surveyed 1980s) and Spain (last surveyed 1990s) (Margaritoulis et al. 2003; Casale & Margaritoulis 2010). Information on nesting has not been gathered for Albania, Montenegro, Monaco, Slovenia or Bosnia (Margaritoulis et al. 2003; Casale & Margaritoulis 2010). A recent IUCN analysissuggests that, when all Loggerhead nesting sites in the Mediterranean are considered together, the geographic distribution of loggerheads in the Mediterranean is broad, and is considered of Least Concern though conservation dependent, under current IUCN Red List criteria (Casale 2015).

Most nests are laid in Greece, Turkey, Cyprus and Libya (Margaritoulis 2003; Casale & Margaritoulis 2010; Almpanidou et al. 2016). An average of 7200 nests are made per year across all sites (Casale & Margaritoulis 2010), which are estimated to represent 2,280–2,787 females based on clutch frequency assumptions (Broderick et al. 2002). Greece and Turkey alone have more than 75% of the nesting in the Mediterranean; however, the smaller populations at other sites such as Libya and Cyprus are also of regional significance being at the edges of the species range (Demography Working Group, 2015). Of note, the beaches of the countries of North Africa have not been extensively surveyed, particularly Libya, so gaps on the numbers and distribution of nests still remain. Genetic analyses suggest low gene flow among groups of rookeries; thus, it is essential to preserve distinct genetic units (Carreras et al. 2006).

The number of nests held at different sites is not just dependent on climate, but other factors, like predation, sand type/structure etc. (Almpanidou et al. 2016). Thus, a recent study of all Mediterranean nesting sites showed that the climatic suitability of current stable sites will remain suitable in the future (Almpanidou et al. 2016). However, other factors may lead to the loss of these sites, such as sea level rise (e.g. Katselidis 2014). Furthermore, Almpanidou et al. (2016) showed that sites with sporadic nesting might be increasingly used, i.e. such sites might not be past sites that are infrequently used, but may reflect the exploratory nature of turtles to locate new alternative sites (Schofield et al. 2010a). Thus, it is worth ensuring that all current stable nesting sites are fully protected (with their use into the future being likely); however, it is also important to follow how the use of sporadic nesting sites changes over time, to detect new sites of importance in need of protection (Katselidis 2014; Almpanidou et al. 2016).

Foraging (adult and developmental) and wintering sites: Most research has been conducted on nesting beaches; consequently, detailed information about marine habitat use at developmental, foraging and wintering grounds is still missing (Figure 6).

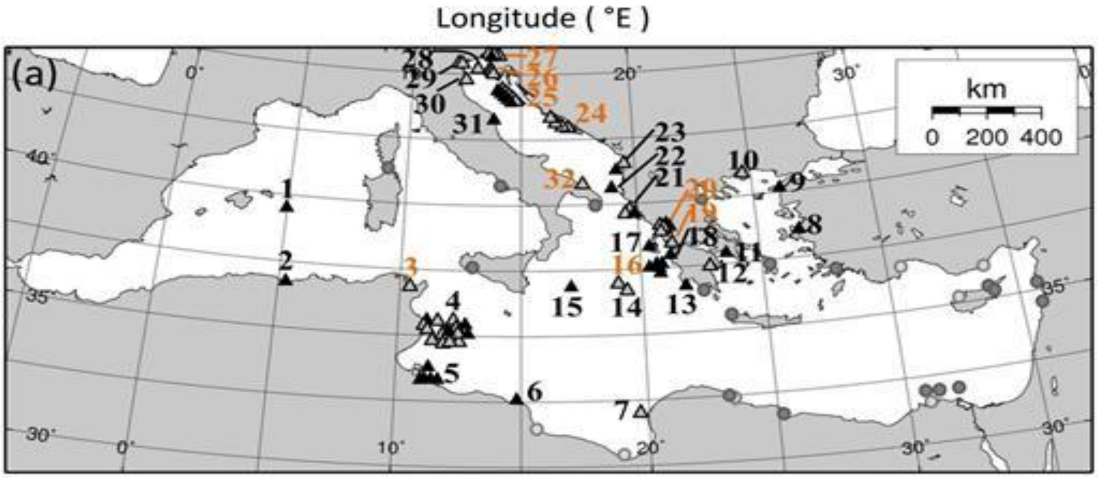


Figure 6: Foraging sites identified across the Mediterranean based on published papers (extracted from Schofield et al. 2013)

Discrete foraging sites frequented by male (black triangles) and female (grey triangles) loggerheads from Zakynthos (with some turtles frequenting more than one site). The foraging sites are indicated and numbered by open circles; orange circles = foraging sites overlapping or in close proximity to existing marine protected areas and/or national parks. Discrete foraging sites are arbitrary, and defined as a single site or group of overlapping sites that are separated from adjacent sites by a minimum distance of 36 km, which reflects the mean migration speed of loggerhead turtles (1.5 km h^{-1}; Schofield *et al.,* 2010) over a 24 h period. In addition, other known loggerhead (filled dark grey circles) and green turtle (filled light grey circles) foraging sites based on published datasets (Bentivegna, 2002; Margaritoulis *et al.,* 2003; Broderick *et al.,* 2007; Hochscheid *et al.,* 2007; Casale *et al.,* 2008). Note: solely juvenile foraging sites of the West Mediterranean have not been included here. The table below lists the different foraging sites, including the species, size class and genetic populations detected at these sites in various papers.

The way in which adult and newly hatched turtles disperse from breeding sites has been explored using a range of techniques in the Mediterranean, including genetics, stable isotope, satellite tracking, particle tracking and stable isotopes (e.g. Zbinden et al 2008, 2011; UNEP(DEPI)/MED. 2011; Schofield et al. 2013; Patel 2013; Luschi & Casale 2014; Casale & Patrizio 2014; Hays et al. 2014; Snape et al. 2016). These studies indicate that loggerheads probably forage throughout all oceanic and neritic marine areas of the west and east basins of the Mediterranean (Hays et al. 2014; Casale & Marianni 2014). Most satellite tracking studies have been conducted in Spain (of juvenile turtles), Italy (a mix of juvenile and adult turtles) and Greece (adult males and females) and Cyprus (adult females) (UNEP(DEPI)/MED. 2011; Casale & Patrizio 2014). Due to these biases, the results of tracking studies alone should be treated with caution.

Through combining studies using various techniques, loggerheads do not appea to be uniformly distributed (Clusa et al. 2014), with foraging in different sub basins affecting remigration rates, body size and fecundity (Zbinden et al. 2011; Cardona et al. 2014; Hays et al 2014). While most turtles that breed in the eastern basin tend to forage in the eastern and central areas, increasing numbers of satellite studies are showing that some individuals do disperse to and use the western basin too (Bentivegna 2002; Schofield et al. 2013; Patel 2013). The west Mediterranean primarily supports individuals from the Atlantic (Laurent et al. 1998; Carreras et al. 2006; Casale et al. 2008). Tracking studies of juvenile loggerheads in the western Mediterrnaean show that they are widely distributed throughout the entire region (UNEP(DEPI)/MED. 2011). As information on the distribution is not available on juvenile loggerheads in the central and east Mediterranean, it is likely that similarly ubiquitous distribution exists, but needs confirming (UNEP(DEPI)/MED. 2011).

The two most important neritic loggerhead foraging grounds for adults and juveniles appear to be the Adriatic Sea and the Tunisian Continental Shelf (including Gulf of Gabés) (Zbinden et al. 2010; Casale et al. 2012; Schofield et al. 2013; Snape et al. 2016). Important oceanic areas include the Alboran Sea, the Balearic Sea and different parts of the North African coasts, as well as the Sicily Channel. Large numbers of juvenile loggerheads have been documented in the south Adriatic too (Casale et al. 2010; Snape et al. 2016). Aerial and fishery bycatch data indicate that the highest density of turtles occur in the western basin Alboran Sea and Balearic islands, the Sicily Strait, the Ionian Sea, the north Adriatic, off Tunisia, Libya, Egypt and parts of the Aegean (Gómez de Segura et al. 2003, 2006; Cardona et al. 2005; Lauriano et al. 2011; Casale & Margaritoulis 2010). In Egypt, Bardawil Lake has been identified as an important foraging area for adult and juvenile loggerheads based on stranding records and tracking studies of turtles from Cyprus (Nada et al. 2013, Snape et al. 2016).

However, establishing the distribution of, even coastal, foraging sites has yet to be achieved. Certain sites, where high numbers of turtles of all size classes from different populations aggregate in confined areas, have been identified, such as Amvrakikos Bay, Greece (Rees & Margaritoulis 2008) and Drini Bay, Albania (White et al 2011). However, tracking studies also show that the foraging areas of individual turtles may extend from <10 km2 up to 1000 km2 in the open waters of the Adriatic and Gulf of Gabés (Schofield et al. 2013). Furthermore, knowledge of how foraging habitat differs between adult males and females, as well as how these sites overlap with juvenile developmental habitat remains limited across the various populations (Snape et al. in submission). Particle tracking has suggested that, within the Mediterranean, adults exhibit high fidelity to sites where they established use as juveniles (Hays et al. 2014).

Furthermore, various studies have shown that, while turtles exhibit high fidelity to certain sites (Schofield et al. 2010b), both juvenile and adult loggerheads use more than one foraging site (sometimes up to 5), spanning both neritic and oceanic sites, particularly in the Ionian and Adriatic (Casale et al. 2007, 2012; Schofield et al. 2013). Adults that forage in the Adriatic, tend to use sites seasonally, shifting to alternative sites in winter (Zbinden et al. 2011: Schofield et al. 2013), although some hibernate (Hoscheid et al. 2007). However, juveniles have also been documented shifting into the Adriatic in winter, suggesting that some sites may be used year-round by different components of loggerhead populations (Snape et al. in submission). The use of multiple sites and seasonal shifts in site use need to be documented to understand how different foraging, developmental and wintering sites are connected. In this way, groups of areas should be protected where connections are known to exist.

Green turtles.

Nesting sites: Most green turtle nests (99%) are laid in Turkey, Cyprus and Syria, with the remainder being found in Lebanon, Israel and Egypt (Figure 7; Kasparek et al. 2001; Casale & Margaritoulis 2010). An average of 1500 nests are documented each year (range 350 to 1750 nests), from which an annual nesting population of around 339–360 females has been estimated (Broderick et al. 2002), ranging from 115 to 580 females (Kasparek et al. 2001). The five key nesting beaches include: Akyatan, Samadağ, Kazanli (Turkey), Latakia (Syria) and Alagadi (northern Cyprus), with Ronnas Bay also being a priority area (Stokes et al. 2015). This allows the conservation effort of the nesting beaches for this species to be highly focused.

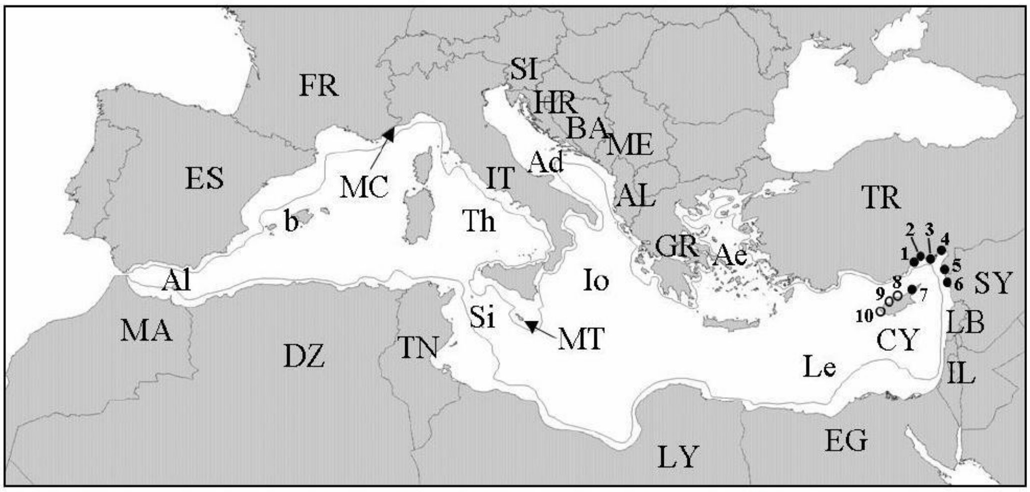
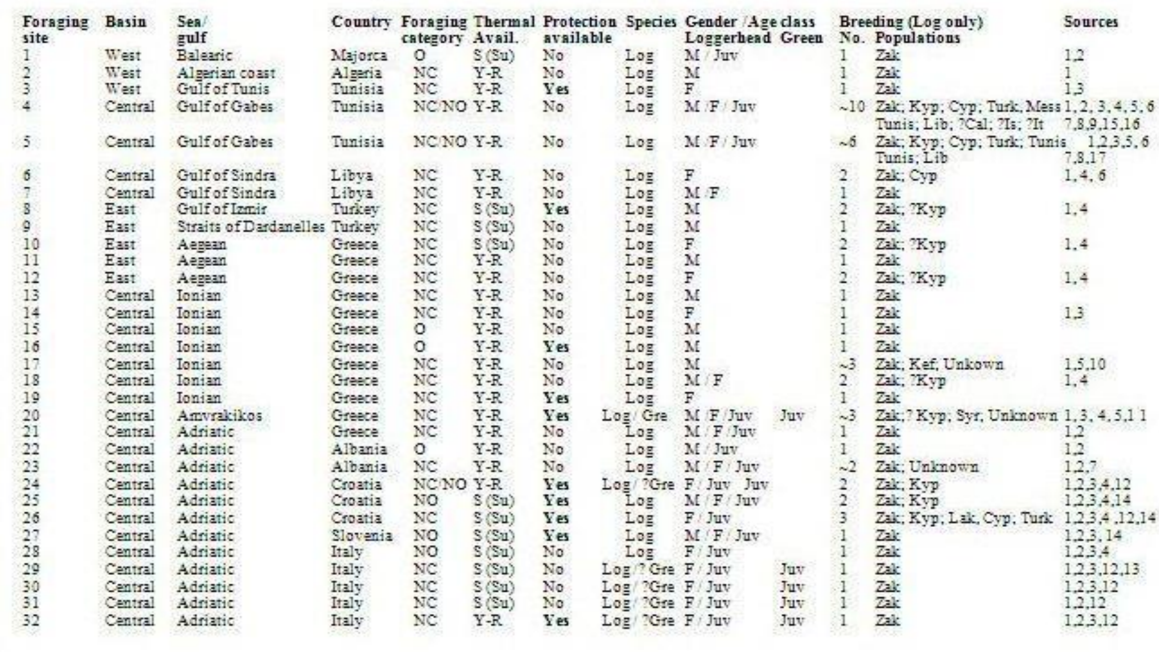


Figure 7: Map of the major green turtle nesting sites in the Mediterranean (extracted from Casale & Margaritoulis): Major nesting sites (>40 nests/year) of green turtles in the Mediterranean. 1 Alata; 2 Kazanli; 3 Akyatan; 4 Sugozu; 5 Samandag; 6 Latakia; 7 North Karpaz; 8 Alagadi; 9 Morphou Bay; 10 Lara/Toxeftra. Closed circles >100 nests/year; open circles 40-100 nests/year. Country symbols, see previous map.

Foraging (adult and developmental) and wintering sites: As with loggerheads, most information about green turtles is restricted to the nesting habitats, rather than developmental, foraging, and wintering habitats. Green turtles have been primarily documented foraging and wintering along the Levantine basin (Figure 8 and Table 1; Turkey, Syria, Cyprus, Lebanon, Israel, Egypt) (Broderick et al. 2007; Stokes et al. 2015). However, foraging areas have also been documented in Greece (particularly, Lakonikos Bay and Amvrakikos Bay; Margaritoulis & Teneketzis 2003) and along the north coast of Africa, primarily Libya and some sites in Tunisia (see Figure 8 and Table for published sources). Some turtles have been documented in the Adriatic Sea (Lazar et al. 2004) and around Italian waters (Bentivegna et al. 2011), with some records occurring in the western basin (see Figure 8 and Table for published sources). In addition, Broderick et al (2007) detected wintering behaviour for greens off of Libya, with high fidelity to the same sites across years; however, further documentation has not been recorded for the other populations or other areas of the Mediterranean. These wintering sites were detected based on a shift in location to deeper water from early November to March/April and reduced area use compared to summer months, which were assumed to be indicative of reduced activity during the colder months. Lakonikos Bay in Greece and Chrysochou Bay in southern Cyprus represent well documented foraging grounds of juvenile green turtles based on strandings and bycatch databases. Within Egypt, Bardawill Lake has been identified as an important foraging area for adult and juvenile green turtles based on stranding records and tracking studies of turtles from Cyprus (Nada et al. 2013). In Turkey, green turtles have been documented stranded in the Gulf of Iskenderun, and might represent foraging habitat, while juvenile green turtles have been confirmed inhabiting the coast along the Cukurova, with Samandag and Fethiye Bay also representing possible juvenile foraging grounds (see Casale & Margaritoulis 2010 for overview). Overall, the way in which the foraging grounds are distributed and the numbers and size classes that they support, or how frequently green turtles move among sites (i.e. connectivity), remains limited.

Table 1 (extracted from Schofield et al. 2013a): Published literature used to identify overlap in foraging sites (A) based on tracking datasets and (B) based on genetic data. Foraging category, NO = neritic open sea; NC = neritic coastal. Thermal state, Avail = availability; Use = recorded use; Y-R = year round; S (Wi) = Seasonal (Winter); S (Su) = Seasonal (Summer); Unconf. = unconfirmed. Species, Log = loggerhead; Gre = Green; Gender/Ageclass, M = adult male; F = adult female; Juv = juveniles, with gender not differentiated. Breeding populations, ? = unconfirmed; Zak = Zakynthos, Greece; Kyp = Kyparissia, Greece; Cyp = Cyprus; Syr = Syria; T = Turkey; Lib = Libya; Tunis = Tunisia; Mess = Messina; Cal = Calabria; Is = Israel; It = Italy. Sources: 1 = current study; 2 = Casale et al., (2007, 2010); 3 = Zbinden et al., (2008, 2011); 4 = Margaritoulis et al., (2003); 5 = Bentivegna (2002); 6 = Broderick et al., (2007); 7 = Hochscheid et al., (2007); 8 = Echwikhi et al., (2010); 9 = Chaeib et al., (in press); 10 = Houghton et al., (2000); 11 = Rees et al. (2008), Rees & Margaritoulis (2008); 12 = Lazar et al., (2004a,b); 13 = Vallini et al., (2006); 14 = Carreras et al., (2006); 15 = Casale et al., (in press); 16 = Casale et al., 2012 ; 17 = Saied et al., 2012.



Foraging site	**Basin**	**Sea/ gulf**	**Country**	**Foraging category**	**Thermal Avail.**	**Protection available**	**Species**	**Gender /Age class**		**Breeding (Log only)**		**Sources**
								Loggerhead	**Green**	**No.**	**Populations**	
1	West	Balearic	Majorca	O	S (Su)	No	Log	M / Juv		1	Zak	1,2
2	West	Algerian coast	Algeria	NC	Y-R	No	Log	M		1	Zak	1
3	West	Gulf of Tunis	Tunisia	NC	Y-R	**Yes**	Log	F		1	Zak	1,3
4	Central	Gulf of Gabes	Tunisia	NC/NO	Y-R	No	Log	M /F / Juv		~10	Zak; Kyp; Cyp; Turk, Mess Tunis; Lib; ?Cal; ?Is; ?It	1, 2, 3, 4, 5, 6 7,8,9,15,16
5	Central	Gulf of Gabes	Tunisia	NC/NO	Y-R	No	Log	M /F / Juv		~6	Zak; Kyp; Cyp; Turk; Tunis Tunis; Lib	1,2,3,5, 6 7,8,17
6	Central	Gulf of Sindra	Libya	NC	Y-R	No	Log	F		2	Zak; Cyp	1, 4, 6
7	Central	Gulf of Sindra	Libya	NC	Y-R	No	Log	M /F		1	Zak	
8	East	Gulf of Izmir	Turkey	NC	S (Su)	**Yes**	Log	M		2	Zak; ?Kyp	1, 4
9	East	Straits of Dardanelles	Turkey	NC	S (Su)	No	Log	M		1	Zak	
10	East	Aegean	Greece	NC	S (Su)	No	Log	F		2	Zak; ?Kyp	1, 4
11	East	Aegean	Greece	NC	Y-R	No	Log	M		1	Zak	
12	East	Aegean	Greece	NC	Y-R	No	Log	F		2	Zak; ?Kyp	1, 4
13	Central	Ionian	Greece	NC	Y-R	No	Log	M		1	Zak	
14	Central	Ionian	Greece	NC	Y-R	No	Log	F		1	Zak	1,3
15	Central	Ionian	Greece	O	Y-R	No	Log	M		1	Zak	
16	Central	Ionian	Greece	O	Y-R	**Yes**	Log	M		1	Zak	
17	Central	Ionian	Greece	NC	Y-R	No	Log	M		~3	Zak; Kef, Unkown	1,5,10
18	Central	Ionian	Greece	NC	Y-R	No	Log	M / F		2	Zak; ?Kyp	1, 4
19	Central	Ionian	Greece	NC	Y-R	**Yes**	Log	F		1	Zak	
20	Central	Amvrakikos	Greece	NC	Y-R	**Yes**	Log / Gre	M /F /Juv	Juv	~3	Zak;? Kyp; Syr, Unknown	1, 3, 4, 5,1 1
21	Central	Adriatic	Greece	NC	Y-R	No	Log	M / F /Juv		1	Zak	1,2
22	Central	Adriatic	Albania	O	Y-R	No	Log	M / Juv		1	Zak	1,2
23	Central	Adriatic	Albania	NC	Y-R	No	Log	M / F / Juv		~2	Zak; Unknown	1,2,7
24	Central	Adriatic	Croatia	NC/NO	Y-R	**Yes**	Log / ?Gre	F / Juv	Juv	2	Zak; Kyp	1,2,3,4,12
25	Central	Adriatic	Croatia	NO	S (Su)	**Yes**	Log	M / F / Juv		2	Zak; Kyp	1,2,3,4,14
26	Central	Adriatic	Croatia	NC	S (Su)	**Yes**	Log	F / Juv		3	Zak; Kyp; Lak, Cyp; Turk	1,2,3,4 ,12,14
27	Central	Adriatic	Slovenia	NO	S (Su)	**Yes**	Log	M / F / Juv		1	Zak	1,2,3, 14
28	Central	Adriatic	Italy	NO	S (Su)	No	Log	F / Juv		1	Zak	1,2,3,4
29	Central	Adriatic	Italy	NC	S (Su)	No	Log /? Gre	F / Juv	Juv	1	Zak	1,2,3,12,13
30	Central	Adriatic	Italy	NC	S (Su)	No	Log / ?Gre	F / Juv	Juv	1	Zak	1,2,3,12
31	Central	Adriatic	Italy	NC	S (Su)	No	Log / ?Gre	F / Juv	Juv	1	Zak	1,2,12
32	Central	Adriatic	Italy	NC	Y-R	**Yes**	Log / ?Gre	F / Juv	Juv	1	Zak	1,2,3,12

CONCLUSIONS

Conclusions (brief)

This general overview stresses the importance of assimilating all available information on the distribution of sea turtles at breeding, foraging, developmental sites and how these areas are connected to understand the distribution patterns of sea turtles at the size class, population and species level to select key areas for protection. Parallel mitigation strategies are required to build the resilience of existing populations.

Conclusions (extended)

Due to the importance of both breeding and foraging grounds, parallel mitigation strategies are required to build the resilience of existing populations; such as regulating coastal development at nesting areas and fishery bycatch at foraging areas. However, foraging grounds tend to be broadly dispersed over a range of 0 to 2000 km from the breeding areas, complicating the identification of key foraging grounds for protection. As a starting point, it is essential to assimilate all research material on sea turtles (e.g. satellite tracking, stable isotope, genetic, strandings aerial surveys) to make a comprehensive overview of the distribution of different species, populations and size classes (Figure 8, represents a starting point).

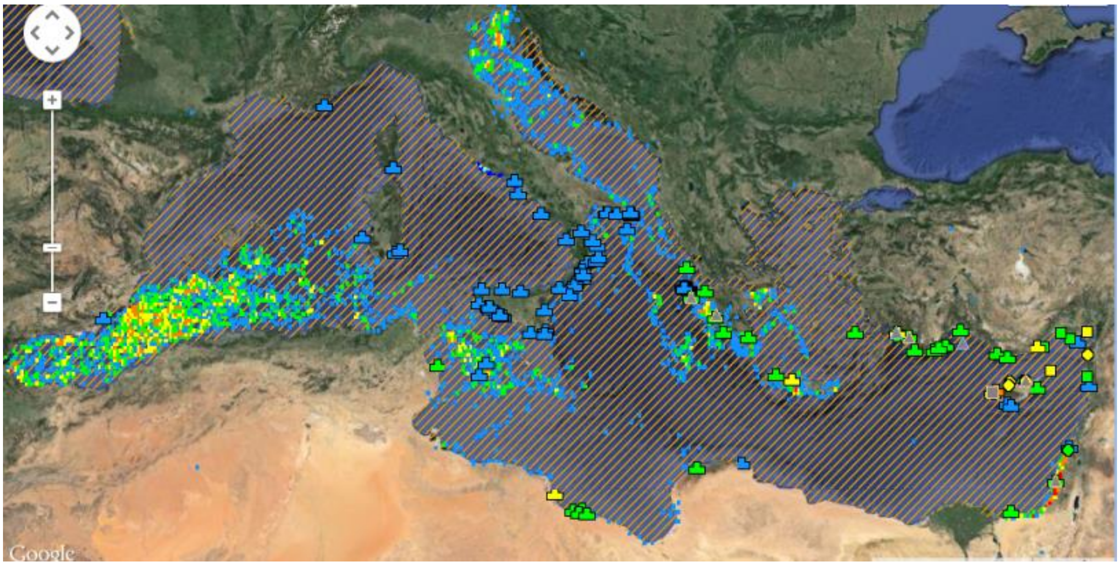


Figure 8: Image from OBIS-SEAMAP: State of the World's Sea Turtle (SWOT). The image presents an example for sea turtles, showing satellite tracking data (dots), nesting sites and genetic sampling sites (shapes) that have been voluntarily submitted to the platform by data holders. Many datasets are missing, including several known nesting sites and a considerable amount of satellite tracking from the eastern, central and western Mediterranean (over 195 routes have been published, and many remain unpublished; Luschi & Casale 2014, Italian Journal of Zoology 81(4): 478-495). The distribution range (lines) of the three sea turtles species present in the Mediterranean encompasses the entire basin. Big gaps exist; yet, this is the only information currently available in the form of an online database and mapping application.

Nesting sites.

In general, knowledge about currently used nesting sites of both loggerhead and green turtles in the Mediterranean is good. However, all potential nesting beaches need to be surveyed throughout the Mediterranean to fill gaps in current knowledge (e.g. nesting in north Africa, particularly Libya). This could be done via traditional survey methods, but also by aerial surveys (plane or drone) at the peak period of nesting (July), or even by high resolution satellite imagery, which is becoming commercially available.

Existing stable nesting beaches should be afforded full protection, in parallel to collecting key information on why turtles use them, including geographic location, beach structure, sand composition, sand temperature ranges, coastal sea temperatures etc. In parallel, sporadically used beaches should be monitored at regular intervals (i.e. every 5 years or so), to identify changes in use over time, and pinpoint sites where use changes from sporadic to stable. Again, all these sites should be assessed with respect to geographic location, beach structure, sand composition, sand temperature ranges, coastal sea temperatures etc. on the ground, which will help with identifying future viable beaches for nesting. Ideally, all sandy beaches, whether used or not should be subject to the same analyses, to identify any beaches that might be used in the future by turtles, due to range shifts under climate change, which will alter sand temperatures on beaches and in the water, as well as causing sea level rise, which will alter the viability of current beaches, forcing turtles to shift to alternative sites. In this way, future beaches of importance can be detected and protected from certain human activities.

Foraging (adult and developmental) and wintering sites.

It is necessary to determine how to focus protection effort of foraging (adult and developmental) habitats, i.e. protect easy-to-define areas where high numbers of turtles aggregate from different populations and size classes, protect protracted areas of coastline where 10-20 individuals may aggregate at intervals from different populations and size classes, but amounting to representative numbers over a large expanse.

The former is easier to design and protect, but the latter may be more representative of sea turtle habitat use in the Mediterranean. The latter is more at risk of loss too, as management studies for the development of e.g. marinas and hotels would assume that the presence of just 10-20 turtles was insignificant; however, if this action was repeated independently across multiple sites, one or more turtle populations could become impacted.

Thus, it is essential to determine how developmental, foraging and wintering grounds are distributed throughout the Mediterranean, as well as the numbers of turtles of different size classes and from different populations that frequent these sites, including the seasonality of use and connectivity across sites. Only with this information can we make informed decisions about which sites/coastal tracts to protect that incorporate the greatest size class and genetic diversity.

The aerial (plane or drone) surveys are recommended to delineate areas used by sea turtles in marine coastal areas, along with seasonal changes in use, by monitoring these sites at 2-4 month intervals. Following this initial assessment, representative sites should be selected and sampled on the ground (i.e. boat based surveys) to delineate species, size classes and collect genetic samples to determine the extent of population mixing. Where possible, stable isotope and tracking studies should be conducted (including PIT tagging) to establish the connectivity among sites.

Key messages

- This general overview stresses the importance of assimilating all information on the distribution of green and loggerhead sea turtles in the Mediterranean at breeding, foraging, developmental and wintering grounds to understand how these areas are connected when considering different size classes, populations and species for effective conservation management.
- Parallel mitigation strategies are required to build the resilience of existing populations.

Knowledge gaps

- Location of all breeding/nesting sites
- Location of all wintering, feeding, developmental sites of adult males, females, juveniles
- Connectivity among the various sites in the Mediterranean
- Vulnerability/resilience of these sites in relation to physical pressures
- Analysis of pressure/impact relationships for these sites and definition of qualitative GES
- Identification of extent (area) baselines for each site and the habitats they encompass
- Appropriate assessment scales
- Monitor and assess the impacts of climate change
- Assimilation of all research material on sea turtles (e.g. satellite tracking, stable isotope, genetic, strandings aerial surveys) in a single database

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 3. Species distributional range (Related to Seabirds)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 3 (CI3): Species distributional range (related to seabirds)
Indicator Assessment Factsheet Code	EO1CI3

RATIONALE/METHODS

Background (short)

The Mediterranean Sea is considered an important habitat for seabirds, including particularly the Critically Endangered Balearic shearwater (*Puffinus mauretanicus*), the endemic Yelkouan shearwater (*Puffinus yelkouan*) and the little tern (*Sterna alibifrons*). In addition to these species, a number of other seabird species are listed in the Annexes of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention (SPA-BD Protocol).

The Mediterranean region is a region of intensive human use. Many of the seabird species face threats on land and at sea. On land this includes high pressure from coastal developments affecting availability of breeding and wintering habitats, and predation at colonies from native and invasive species. At sea the main threats include interaction with fisheries (bycatch) and the lack of prey caused by depletion of fish stocks and from acute and chronic pollution (oil spills, chemical discharges, etc.) and disturbance from maritime traffic (Tarzia et al., 2015; Yesou et al., 2016).

The distribution range of a species is the first step to assess its status and potential changes over time. It is also the simplest indicator, but that does not mean that reliable information is available for the whole region. Overall, Mediterranean seabirds have reduced their distribution range across historical times, although there are few reliable sources of data to make a proper assessment of trends.

Background (extended)

Seabirds as a group occur in all seas and oceans worldwide, and their role as potential indicators of marine conditions is widely acknowledged. Many studies use aspects of seabird biology and ecology, especially productivity and population trends, to infer and/or correlate with aspects of the marine environment, particularly food availability.

Nevertheless, despite the importance of seabirds as indicators of many aspects of the functioning of marine systems, the most important current challenge is to ensure the survival and improve the status of the many seabird species which are already globally threatened with extinction and to maintain the remainder in favourable conservation status. Indeed, seabirds are among the most threatened bird groups globally. They are all endangered by a number of threats, including contamination by oil pollutants, direct and indirect depletion of food resources, non-sustainable forms of tourism, disturbance, direct persecution includingillegal hunting and the use of poison, mortalit y from bycatch, wind farms, loss of habitats, degradation of habitat, particularly wetlands and small, islands of high biological importance, introduction of and predation by alien species, climate change (Table 1).

Table 1: Threats to seabirds

		Threats inland				Threats at sea				
English name	**Scientific name**	**Predation by introduced mammals**	**Coastal development**	**Human disturbance**	**Poaching**	**Fisheries bycatch**	**Prey depletion**	**Pollution**	**Infrastructures**	**Environmental change**
Scopoli's shearwater	*Calonectris d. diomedea*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Cory's shearwater	*Calonectris d. borealis*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Balearic shearwater	*Puffinus mauretanicus*	na	na	na	na	🟥	🟧	🟧	🟧	🟧
Yelkouan shearwater	*Puffinus yelkouan*	🟥 ?	🟧	🟩	🟩	🟥	🟧	🟧	🟧	🟧
European storm-petrel	*Hydrobates pelagicus*	🟥 ?	🟧	🟩	🟩	🟩	🟧	🟧	🟧	🟧
Mediterranean shag	*Phalacrocorax a. desmarestii*	🟧	🟧	🟧	🟩 ?	🟧	🟧	🟧	🟧	🟧
Mediterranean gull	*Larus melanocephalus*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Slender-billed gull	*Larus genei*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧
Audouin's gull	*Larus audouinii*	🟩	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Sandwich tern	*Sterna sandvicensis*	na	🟧	🟧	na	🟧	🟥	🟧	🟧	🟧
Lesser-crested tern	*Sterna bengalensis*	na	🟧	🟧	na	🟧	🟧	🟧	🟧	🟧
Common tern	*Sterna hirundo*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Little tern	*Sterna albifrons*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧

The following factors are considered among the main responsible for the changes in distribution range:

- The introduction of terrestrial predators in islands has likely shaped the current distribution of many seabirds, particularly the shearwaters and the storm-petrel, restricting those to inaccessible areas of the main islands and to remote islets. Even so, in many cases these seabirds coexist with terrestrial predators (Ruffino et al. 2009), often resulting in population declining trends.
- Human development has led to the degradation and destruction of coastal habitats across the Mediterranean basin. Birds breeding in wetlands have been likely the most affected, due to the systematic drying of these habitats. Likewise, birds breeding in beaches and dunes have also experienced a severe decline of available habitat in good condition and free of disturbances, particularly with the boom of tourism in the last century. The latter are more acute in the northern side of the region, but the whole basin is affected.
- Human persecution and harvesting. This is a threat that has been largely reduced in the last century, particularly in the north, but might have been a major source of change in past centuries, and can be still a threat in some areas.

Other relevant pressures to consider are overfishing and climate change. These pressures might have a major influence on the distribution patterns of seabirds at sea, while their role at shaping breeding distributions is not clear within the Mediterranean region. Species with limited foraging ranges, such as the Mediterranean shag and the terns are the most prone to suffer from these alterations, as they cannot buffer the effects of local alterations of their (breeding) foraging grounds by switching to other (more distant) areas. On this regard, terns (and Audouin's gull) are adapted to cope with fluctuations on prey availability by changing their breeding location between years, if necessary.

Even if there are no proven changes in seabirds breeding distribution ranges due to food depletion and/or climate change (or, more widely, environmental change), they are likely to occur in the near future if the levels of fish overexploitation and environment degradation are maintained through time. Nevertheless, lacks of accurate data make it difficult to assess this type of changes, and it is necessary to set in place adequate monitoring programmes across the basin to make possible a proper assessment in the future.

Processes driving changes in distribution range can work both at local and regional level. For a local level approach, the protection of breeding sites is a first step to ensure the maintenance of the breeding range of seabirds. However, it is important to complement these efforts on land with the protection of the corresponding key habitats at sea. On this regard, the Mediterranean is in the process of building a representative and coherent network of Marine Protected Areas (e.g. Gabrié *et al*. 2012), that under proper management strategies will surely benefit the maintenance of the remaining seabird breeding populations, plus other visiting species. Moreover, promoting the protection of former/potential breeding sites, or even their restoration, could help recovering part of the lost distribution range for some species, through re-colonisation processes.

However, local measures might not suffice to fight pressures at sub-regional, regional or global level. Ensuring a healthy marine ecosystem requires sectorial policies adopting an ecosystem-based approach. Fisheries deserve particular attention, given the level of overexploitation of Mediterranean fish stocks. Current commitments by the General Fisheries Commission for the Mediterranean are a promising perspective, as well as the efforts of the EU Common Fisheries Policy in the European countries, but there is a long way ahead. Other issues to address are pollution (UNEP/MAP, 2015), river discharges (to ensure marine productivity), and climate/environmental change, which require an even wider approach (UNEP/MAP, 2016).

Policy Context and Targets

Given their imperilled conservation status, many seabirds have been highlighted for special conservation status and action under a range of international, regional and national agreements and mechanisms. However, because seabirds are highly mobile and migrate, they are exposed to vagaries of differing levels of protection across international (and non-governmental) regions.

The Barcelona Convention and its SPA-BD Protocol are the regulatory instruments of particular importance for seabirds protection in the Mediterranean, along with related policy frameworks and tools.

At the 12th COP of the Barcelona Convention, the Contracting Parties has requested SPA/RAC to draw up an Action Plan for the conservation of bird species listed in Annex II to the SPA-BD Protocol. After extensive consultation among international institutions, NGOs and experts throughout the Mediterranean, the first version was presented and adopted by the Contracting Parties to the Barcelona Convention at the 13th COP held in Catania, 2003. The development of this Action Plan followed various initiatives on the conservation of biological diversity, particularly with respect to birds and their important sites and habitats. Its main purpose is to maintain and/or restore the population levels of bird species listed in Annex II of the SPA-BD Protocol to a favourable conservation status and to ensure their long-term conservation.

The Implementation timetable of this Action Plan was updated for the first time in 2007, considering the results of the first Mediterranean Symposium held in 2005 and adopted during the 15th COP of the Barcelana convention held in Almeria in 2008.

The second update related to the period 2014-2019 was adopted by the 18th COP of the Barcelona Convention in 2013.

Moreover, Specific Action Plans for the 25 bird species listed in the Annex II of the SPA-BD Protocol are developed within the Barcelona Convention that should be implemented in all Mediterranean states where the species breed, winter or occur on migration.

Amongst other regulatory instruments, it is aslo relavnt to quote the EU Birds Directive (all seabirds in the EU), the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Convention on the conservation of European wildlife and natural habitats (Bern Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In addition to the above instruments, the Regional Fisheries Management Organisations (RFMOs) have also begun the adoption of the strategies that address incidental seabird bycatch. Level of regulation varies across RFMOs but includes combinations of the use of one or more bycatch mitigation measures in certain areas, data collection through observer programmes and use of monitoring, surveillance and compliance measures.

Assessment methods

The breeding distribution range of a seabird species may be assessed using a wide diversity of methodological approaches, most of them quite simple. For the most visible species, such as gulls and terns, simple visual inspection of the most suitable habitat might suffice, as these birds use open nests and have daily activity at the colony. Shags might be more difficult to confirm as breeders, as they often breed sparsely along coastal cliffs and islets and use crevices or caves that may be difficult to detect. In such cases, specific surveys from coastal vantage points or (even better) boats might be useful to confirm their breeding in some sites. For the secretive shearwaters, that breed in crevices and burrows and attend the nest at night, a combination of methods may be useful: vocalizations in suitable areas and the formation of rafts near the coast are indicators of breeding nearby, although other proofs are required to confirm breeding by direct prospection of the area and the location of occupied nests.

Assessing the distribution range of a species at sea may be trickier, as many areas remain largely un-prospected. A combination of coastal based counts at sea and boat surveys (e.g. using ferry lines or oceanographic cruises) might provide useful information. On the other hand, tracking technologies nowadays represent a highly valuable tool to understand the patterns of distribution of seabirds across their annual cycle. The latter are only limited by the type of device used (revealing different information for different time periods and at different precision), as well as by the age-groups tracked (most often adults) and the colonies of origin. Finally, citizen-science platforms are increasing and might provide very valuable, opportunistic information to refine seabird distribution patterns.

The assessment of seabirds spatial and temporal distribution and range is extracted mainly from time series data of ongoing monitoring activities. These monitoring activities are carried out sporadically in limited Mediterranean areas. However, these activities had resulted a small pool of data which make it difficult to do the assessment. The assessment of this indicator is important for seabird species, mainly endangered or threatened species included in the Annex II of the SPA-BD Protocol.

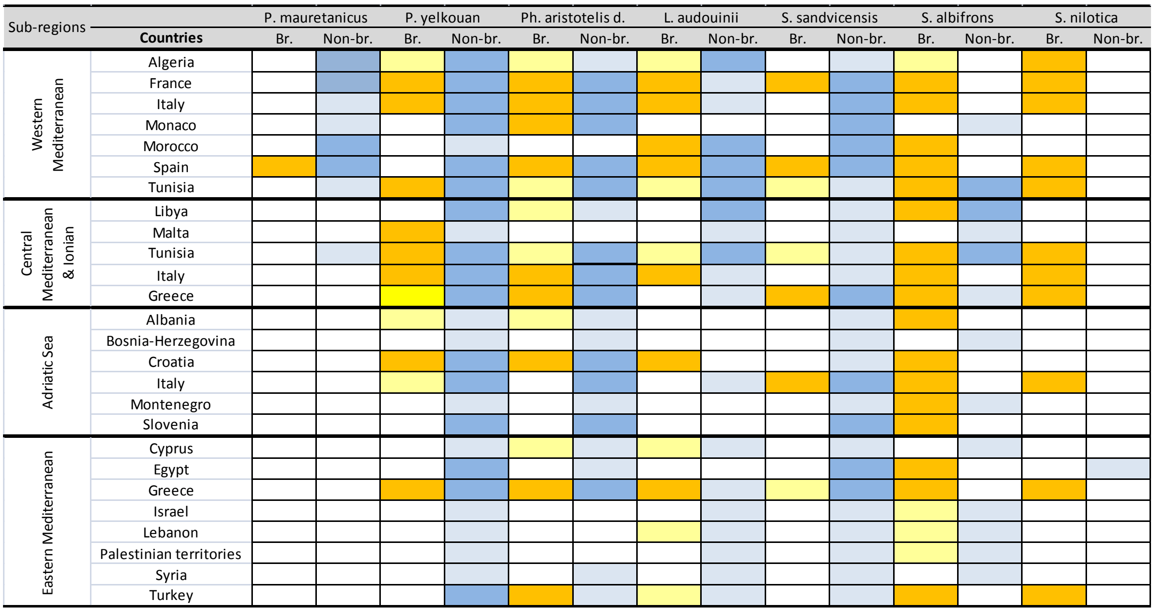
RESULTS

Results and Status, including trends (brief)

Important breeding or feeding grounds for the region's seabirds are difficult to define because there are only a few countries with active long-term seabird research programmes.

A summary of the presence/absence of the species selected for monitoring is shown in Table 1, per sub-region and country. As with other biodiversity components, seabirds show a higher diversity to the west and north of the Mediterranean basin (Coll *et al.*, 2008). This general pattern is in agreement with the marine productivity patterns in the region, but might also be related to other factors, such as better knowledge/monitoring programmes in the north and west. Species that breed in open nests, such as gulls and terns, seem to be more widely distributed, particularly the little tern. On the other hand, burrowing/crevice breeding species such as the shearwaters tend to concentrate in the north and west. These species might find more suitable habitat in these areas, but also the difficulty of finding their nests and their secretive behaviour near the colonies might have left them overlooked in some low-prospected areas.

Table 2: Presence of the different seabird species selected for monitoring per sub-region and country. Orange represents breeding and blue non-breeding (mainly winter, but this can also reflect the presence of birds during the breeding season and/or migration in countries where they do not breed). Dark colour is for regular and well-established species, while light colour is for scarce species. Question marks are introduced when the information deserves further corroboration or refinement.



Sub-regions		P. mauretanicus		P. yelkouan		Ph. aristotelis d.		L. audouinii		S. sandvicensis		S. albifrons		S. nilotica	
	Countries	Br.	Non-br.	Br.	Non-br.	Br.	Non-br.	Br.	Non-br.	Br.	Non-br.	Br.	Non-br.	Br.	Non-br.
Western Mediterranean	Algeria		🟦	🟨	🟦	🟨	▨	🟨	🟦		▨	🟨		🟧	
	France		🟦	🟧	🟦	🟧	🟦	🟧	▨	🟧	🟦	🟧		🟧	
	Italy		▨	🟧	🟦	🟧	🟦	🟧	▨		🟦	🟧		🟧	
	Monaco		▨		🟦	🟧	🟦				🟦		▨		
	Morocco		🟦		▨			🟧	🟦		🟦	🟧			
	Spain	🟧	🟦		🟦	🟧	🟦	🟧	🟦	🟧	🟦	🟧		🟧	
	Tunisia		▨	🟧	🟦	🟨	🟦	🟨	🟦	🟨	▨	🟧	🟦	🟧	
Central Mediterranean & Ionian	Libya				🟦	🟨	▨		🟦		▨	🟧	🟦		
	Malta			🟧	▨				▨		▨		▨		
	Tunisia		▨	🟧	🟦	🟨	🟦	🟨	🟦	🟨	▨	🟧	🟦	🟧	
	Italy			🟧	🟦	🟧	🟦	🟧	▨		▨	🟧		🟧	
	Greece			🟡	🟦	🟧	🟦		▨	🟧	🟦	🟧	▨	🟧	
Adriatic Sea	Albania			🟨	▨	🟨	▨				▨	🟧			
	Bosnia-Herzegovina				▨		▨				▨		▨		
	Croatia			🟧	🟦	🟧	🟦	🟧			▨	🟧			
	Italy			🟨	🟦		🟦		▨	🟧	🟦	🟧		🟧	
	Montenegro				▨		▨				▨	🟧	▨		
	Slovenia				🟦		🟦				🟦	🟧			
Eastern Mediterranean	Cyprus				▨	🟨	▨	🟨	▨		▨		▨		
	Egypt				🟦		▨				🟦	🟧			▨
	Greece			🟧	🟦	🟧	🟦	🟧	▨	🟨	🟦	🟧		🟧	
	Israel				▨				▨		▨	🟨	▨		
	Lebanon				▨			🟨	▨		▨	🟨	▨		
	Palestinian territories				▨				▨		▨	🟨	▨		
	Syria				▨		▨		▨		▨		▨		
	Turkey				🟦	🟧	▨	🟨	▨		▨	🟧		🟧	

Results and Status, including trends (extended)

Seabirds are a charismatic and ecologically important part of the Mediterranean’s biodiversity. Based on sporadic results regarding seabirds distribution in the Mediterranean sea, the UNEP/MAP-SPA/RAC has elaborated in 2010 a map (Figure 1) on distribution range of seabirds in the Mediterranean in order to: i) highlight heterogeneities in the marine environment that may reflect differences in habitat quality; ii) signal areas of high conservation value, particularly as habitat for seabirds.

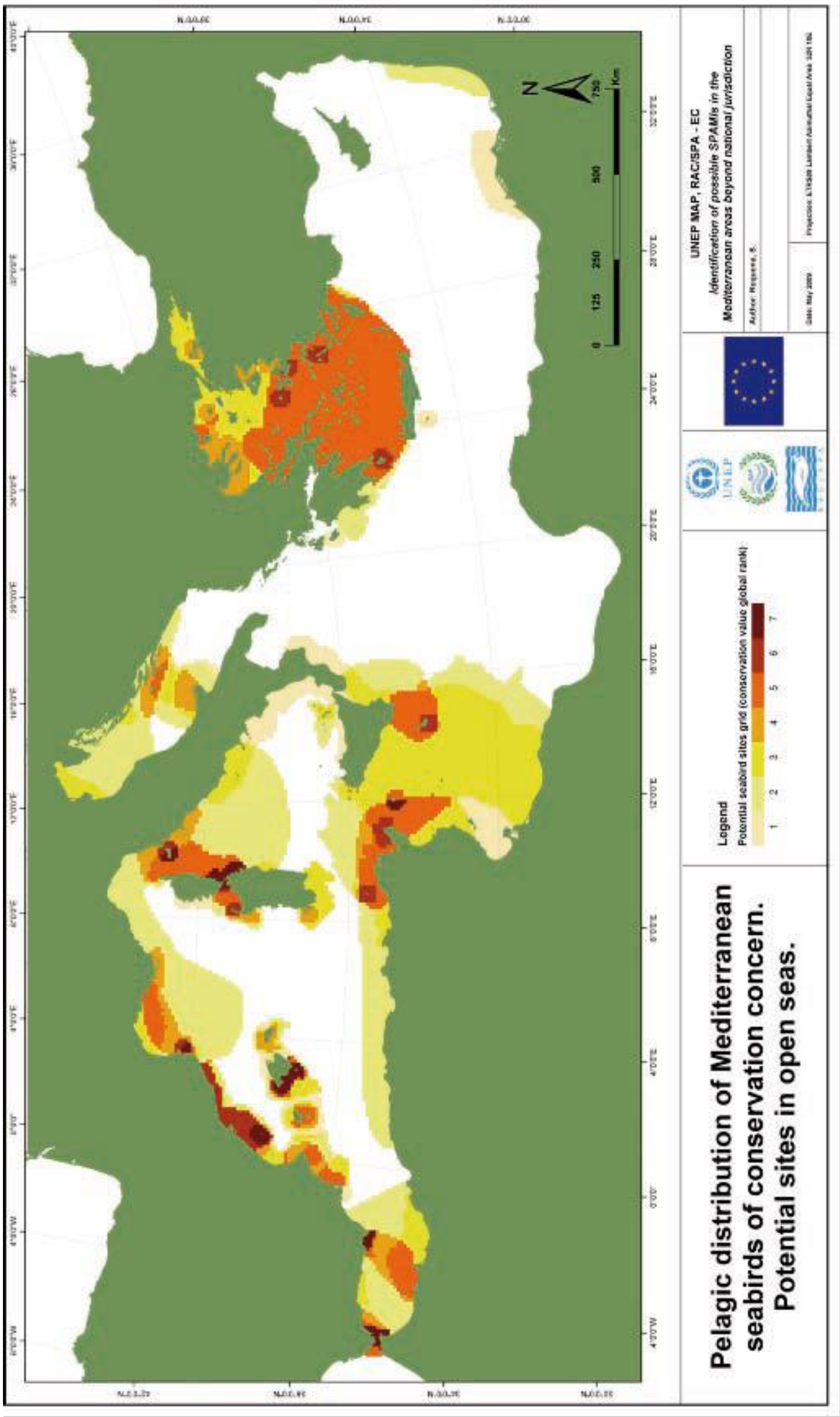


Figure 1: Distribution range of seabirds in the Mediterranean

Croatia's coastline is located in the Adriatic Sea, and includes over one thousand islands and islets. It is important for breeding Audouin's Gull, Yelkouan Shearwater and the Mediterranean Shag. It is also home to various gull and tern species.

There are only a few breeding sites for seabirds in Cyprus, including small colonies of Mediterranean Shag, Audouin's Gull and Yellow-legged Gull. Cyprus has a relatively large marine area, and its surrounding sea is likely to be important for pelagic seabird species, such as the Yelkouan Shearwater. The Government of Cyprus has designated seven SPAs which contain seabirds, four of which can be considered coastal.

Greece's marine area straddles both the Aegean and Ionian Seas. It has a large coastline, with over two thousand islands and islets. Its rocky coastline is important for breeding seabirds, such as endemic Mediterranean species: the Yelkouan and Scopoli's shearwaters and the Audouin's gull. It is also important for the Mediterranean Shag and the European Storm Petrel.

Italy's coastline and marine area extend into the Adriatic, the Ionian, the Tyrrhenian, the Ligurian Sea and the Central Mediterranean. Its coast includes many islands, such as the very large islands of Sicily and Sardinia as well as smaller islands and islets. Many of these islands are important for breeding pelagic seabirds such as the Yelkouan Shearwater and the European Storm Petrel. It is also important for the resident population of Audouin's Gull, various gull species and for the Mediterranean Shag. Its most threatened seabird is the Balearic Shearwater however this is only an occasional visitor to Italy's coast during its summer nonbreeding season.

The Gulf of Lions is one of the hotspots of productivity in the Mediterranean Sea. It offers ideal conditions for foraging seabirds, which concentrate on it over much of the year. Because the area offers few opportunities for rocky island-nesters, most of the birds present in the area come from colonies that are situated 150-500 km away (generally, a 4-16 hours' flight, depending on the species and wind conditions).

Situated in the central Mediterranean Sea, Malta has a relatively large marine area and is very important for a number of seabirds. It holds approximately 10% of the world's breeding population of the Yelkouan Shearwater, which is endemic to the Mediterranean and is considered threatened. It is also important for the Mediterranean subspecies of European Storm Petrel.

Slovenia`s cosatline is situated in the Adriatic Sea. Its shores are frequented by the Mediterranean Shag (*Phalacrocorax aristotelis desmarestii*), as well as by various gull and tern species.

Spain is extremely important for seabirds. A major breeding and feeding ground for many threatened and endemic species, including the most threatened seabird, the Balearic shearwater. The seabird community of the Alboran Sea is notoriously diverse, due to the influence of both Atlantic and Mediterranean basins. Moreover, the region acts as a migration corridor for any seabird movements between these two major basins, thus representing a huge migration bottleneck for hundreds of thousands of seabirds of several species. About 25 seabird taxa are regular in the region (Table 2), whereas several others occur there on an irregular basis or accidentally (UNEP/MAP-RAC/SPA 2014).

Along the coast of Montenegro there are several important coastline weatlands namely Ulcinj Salina (15 km^2), Skadar lake (300-550 km^2), Tivat salina (1.5 km^2) and Buljarica (2 km^2, beach length of 12 km). Out of 25 species of concearn in the SPA-BD Protocol, 19 are regulary observed in Montenergo, including 8 breeding species. In recent years important possitive changes were noted in the population of the Dalmatian Pelican, Pygmy Cormorant and Greater Flamingo. Status of pelagic bird species in Montenegro are unknown due to lack of researchies and monitoring (Saveljić, D (2015): Seabirds of Montenegro. 2nd Symposium of the conservation of marine and coastal birds in Mediterranean. Hammamet, Tunisia, 20-22 February 2015. Book of abstract. RAC-SPA Tunisia).

In the Moroccan and Algerian coasts information is more limited, and includes the recent finding of an important Audouin's gull colony in Al Hoceima islet (Afán et al. 2010) and the location of a few Yelkouan shearwaters in Kalah islet, in Algeria (Ledant et al. 1981, Bourgeois et al. 2012).

Table 2: List of species of seabirds occurring regularly in the Alboran Sea, indicating their occurrence status (abundant, A; common, C, sparse, S), its breeding status (yes/no), and its conservation status according to different lists and international agreements[6].

English name	Scientific name	Occurrence status	Breeding	SPA/BD	IUCN	EU Birds Directive	SPEC	ETS	Bonn	Bern	AEWA
Scopoli's shearwater	*Calonectris d. diomedea*	A	N	II	LC	I	SPEC 2	(VU)	-	II	-
Cory's shearwater	*Calonectris d. borealis*	S	Y	-	LC	I	SPEC 2	(VU)	-	II	-
Balearic shearwater	*Puffinus mauretanicus*	A	N	II	CR	I	SPEC 1	CR	-	II	-
Yelkouan shearwater	*Puffinus yelkouan*	S	?	II	VU	I	No-SPEC3	S	-	II	-
European storm-petrel	*Hydrobates pelagicus melitensis*	C	?	II	LC	I	No-SPECE	(S)	-	II	-
Northern gannet	*Morus bassanus*	C	N	-	LC	-	No-SPECE	S	-	III	-
Great cormorant	*Phalacrocorax carbo*	C	N	-	LC	-	-	S	-	III	-
Mediterranean shag	*Phalacrocorax aristotelis desmarestii*	S	Y	II	LC	I	No-SPECE	(S)	-	III	-
Pomarine skua	*Stercorarius pomarinus*	S	N	-	LC	-	No-SPEC	(S)	-	III	-
Arctic skua	*Stercorarius parasiticus*	S	N	-	LC	-	No-SPEC	(S)	-	III	-

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[6] SPA-BD Protocol of the Barcelona Convention. Priority species are listed under Annex II. EC Birds Directive (2009/147/EC). Annex I lists those species that require special conservation measures. Annex II and III refer to game and commercialised species, respectively. IUCN (global) threat status LC – Least Concern; NT – Near Threatened; VU - Vulnerable; EN – Endangered; CR – Critically Endangered. SPEC. European status as defined by BirdLife International. SPEC 1 – European species with global threat status; SPEC 2 - species which concentrates its population in Europe, where conservation status is not favourable; SPEC 3 – species widespread beyond Europe but with unfavourable conservation status there; Non-SPECE - species which concentrates its population in Europe, where conservation status is favourable; Non-SPEC: species widespread beyond Europe and with favourable conservation status there. ETS. European threat status, defined by BirdLife International following IUCN criteria. NE: not evaluated; S: secure; DD: data deficient; L: localized; H: harvested; R: rare; D: declining; VU: vulnerable; EN: endangered; CR: critically endangered. Bonn Convention. Annex I includes those species considered as threatened. Annex II is for those species whose habitats on migration require conservation improvement. Bern Convention. Annex II - strictly protected species; Annex III - protected species. AEWA (Agreement on the Conservation of African-Eurasian Waterbirds).

Great skua	*Stercorarius skua*	C	N	-	LC	-	No-SPECE	S	-	III	-
Mediterranean gull	*Larus melanocephalus*	A	Y	II	LC	I	No-SPECE	S	II	III	Y
Little gull	*Larus minutus*	S	N	-	LC	I	SPEC 3	(H)	-	III	-
Black-headed gull	*Chroicocephalus ridibundus*	A	Y	-	LC	II/2	No-SPECE	(S)	-	III	-
Slender-billed gull	*Chroicocephalus genei*	C	Y	II	LC	I	SPEC 3	L	II	III	Y
Audouin's gull	*Larus audouinii*	A	Y	II	NT	I	SPEC 1	L	I,II	III	Y
Lesser black-b. gull	*Larus fuscus*	A	N	-	LC	II/2	No-SPECE	S	-	-	-
Yellow-legged gull	*Larus michahellis*	A	Y	-	LC	II/2	No-SPECE	S	-	III	-
Black-legged kittiwake	*Rissa tridactyla*	S	N	-	LC	-	No-SPEC	(S)	-	III	-
Gull-billed tern	*Sterna nilotica*	C	Y	II	LC	I	SPEC 3	(VU)	II	III	Y
Sandwich tern	*Sterna sandvicensis*	C	N	II	LC	I	SPEC 2	H	II	III	Y
Lesser-crested tern	*Sterna bengalensis*	S	N	II	LC	-	SPEC 3	(S)	II	III	Y
Common tern	*Sterna hirundo*	C	Y	-	LC	I	No-SPEC	S	II	III	Y
Little tern	*Sternula albifrons*	C	Y	II	LC	I	SPEC 3	D	II	III	Y
Black tern	*Chlidonias niger*	C	N	-	LC	I	SPEC 3	(H)	II	III	Y
Razorbill	*Alca torda*	C	N	-	LC	-	No-SPECE	(S)	-	III	-
Atlantic puffin	*Fratercula arctica*	C	N	-	LC	-	SPEC 2	(H)	-	III	-

CONCLUSIONS

Conclusions (brief)

The southeast to northwest increasing diversity gradient might be partly influenced by prospection/monitoring effort. For many eastern and southern countries, as well as some Adriatic countries, the information on seabird breeding populations or occurrence at sea is patchy or completely lacking. This might be partly because the birds are actually rare or absent there, but could also be related to lack of data. Particularly little information is available for Algeria, Egypt, Israel, Lebanon, Syria, Cyprus and Turkey, as well as Albania. There is no information from Bosnia-Herzegovina, but this country has extremely limited coastal area, and most likely has no relevant seabird breeding populations. Information from Libya is also patchy, and focuses on terns.

The lack of information is not limited to the above countries, however. Most of the remaining countries have some important gaps, particularly at assessing population sizes, but also at properly inventorying all breeding colonies present in their territories, particularly in the case of the shearwaters. For instance, a colony of over 1,500 Yelkouan shearwaters was recently found in Greece, near Athens, although this area is reasonably well prospected. Likewise, the breeding of the storm-petrel in the Aegean Sea was not confirmed until a few years ago.

Conclusions (extended)

The waters off the Tunisian and Libyan coasts serve as a major foraging ground for Procellariiforms (shearwaters, storm-petrels) nesting in the Cap Bon – Strait of Sicily – Malta Important Area.

The world population of Audouin’s gull is estimated at <60,000 individuals; 90% of the breeding population is found in only 4 sites, and 70% concentrate in a single site (Ebro delta). The species scavenges around fishing vessels, and uses discards extensively and very efficiently. The species' association with fisheries is more pronounced in the western than in the central and eastern Mediterranean. The Sicily Channel / Tunisian Plateau area is a minor breeding area for *Larus audouinii*, with a small colony on the Galite archipelago, Tunisia (40 breeding pairs; BirdLife International 2013) and also on Zembra (10 pairs; BirdLife International 2013). Another colony is present on the Ionian island of Vendicari, Sicily. However, tracking has revealed that, although breeding only in small numbers, the waters off NW Tunisia are important foraging grounds for Audouin´s Gulls from colonies in southern Sardinia (Baccetti et al. 2014).

Information regarding seabirds in the Alboran Sea is patchy and requires of further research, particularly on the African side. This includes information on seabird breeding populations, as well as on distribution patterns at sea. But it is also necessary to improve the knowledge on human activities and their potential impact on seabirds. Information (and conservation action) regarding predation by introduced mammals in the colonies, and fisheries bycatch at sea, deserve particular attention.

Key messages

- Despite breeding distribution patterns are relatively easy to assess, information is patchy and often lacking.
- A southeast to northwest increasing diversity gradient has been observed, in agreement with productivity patterns in the region, but this might be confounded by larger data gaps in the southernmost and easternmost countries.

Knowledge gaps

- Information on gulls and terns seems reasonable good, although some southern and eastern countries might need updating their surveys. For the shearwaters, it is more difficult to find information for these same countries, which might be a combination of both small/inexistent breeding populations and lack of prospection.
- The priority actions needed involve: a) formal and effective site protection, especially for Important Bird Area (IBA) breeding sites and for marine IBA feeding and aggregation sites; b) removal of invasive, especially predatory, alien species as part of habitat and species recovery initiatives; and c) reduction of bycatch to negligible levels, as part of comprehensive implementation of ecosystem approaches to fisheries.

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 4. Population abundance of selected species (related to marine mammals)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 4 (CI4): Population abundance of selected species (related to marine mammals)
Indicator Assessment Factsheet Code	EO1CI4

RATIONALE/METHODS

Background (short)

Robust information on population parameters such as abundance and density is pivotal to inform conservation and management at the diverse temporal and spatial scale. They are also relevant to ensure that conservation measures, mitigation actions and management measures that are already in place are effective by providing a yardstick to evaluate their effectiveness (e.g. by evaluating population trends). Cetaceans in the Mediterranean Sea are protected under statutory regulations (e.g. the Habitat Directive and the Marine Strategy Framework Directive) and by several international agreements such as ACCOBAMS among the others, which not only dictate to some extent the priorities in terms of conservation but also clearly state the details of monitoring activities that should be in place. By consequence, this information and the process to gather it are necessary to abide national and international regulations.

Background (extended)

Background and rationale for the indicator, key pressures and drivers.

Population parameters such as abundance and density are essential components of the provision of science-based advice on conservation and management issues, both in terms of determining priorities for action and evaluating the success or otherwise of those actions. Such information is also often necessary to guarantee compliance with regulations at the national and international level.

By definition, population abundance refers to the total number of individuals of a selected species in a specific area in a given timeframe; while with density we refer to the number of animals per surface unit (e.g. number of animals per km^2). Monitoring density and abundance of cetaceans is particularly challenging and expensive. Cetaceans generally occur in low densities and are highly mobile; they are difficult to spot and to follow at sea, even during good survey conditions, because they typically only show part of their head, back and dorsal fin while surfacing and spend the majority of their time underwater.

In order to be able to assess potential trends over time, it is crucial to plan systematic monitoring programs, which are crucial components of any conservation strategy; unfortunately, such approach is neglected in many regions, including much of the Mediterranean. Monitoring at the regional level may require data collection throughout the year, to better understand seasonal patterns in distribution, whereas monitoring at the population level would mainly address inter-annual changes.

Changes in density and abundance in time and space - known as population trends – are usually caused by anthropogenic pressures and/or natural fluctuations, environmental dynamics and climate changes. It is strongly suggested that marine mammals' abundance is monitored systematically at regular intervals to suggest and apply effective conservation measures and assess /review the effectiveness of measures already in place.

This indicator aims at providing robust and quantitative indications on population abundance and density estimates for marine mammal species living in the Mediterranean Sea.

Policy Context and Targets

Since 1985, the Mediterranean monk seal was recognised within the framework of the Barcelona Convention as a species to be protected as a matter of priority. In that year, during their fourth ordinary meeting, the Contracting Parties adopted a declaration –referred to as the Genoa Declaration – which included, amongst the priority targets to be achieved in the decade 1986-1995, the "protection of the endangered marine species" with a specific reference to the monk seal. Following the Genoa Declaration, an "Action Plan for the Management of the Mediterranean Monk Seal (*Monachus monachus*)" was adopted by the Barcelona Convention's Contracting Parties (UNEP-MAP-RAC/SPA & IUCN 1988, UNEP-MAP-RAC/SPA 2003). The main aims of the Barcelona Convention'sAction Plan for the Management of the Mediterranean Monk Seal are:: i) to reduce adult mortality; ii) to promote the establishment of a network of marine reserves; iii) to encourage research, data collection, and rehabilitation programmes; iv) to implement information programmes targeting fishing communities and various other stakeholders; and v) to provide a framework for the coordination, reviewand financing of relevant activities.

Aware of the scientific progress achieved, a Regional Strategy for the Conservation of Monk Seals in the Mediterranean (2014-2019) was adopted by the 18th Meeting of the Contracting Parties to the Barcelona Convention, that presents a new vision, with associated goals and targets that are SMART.

The Mediterranean monk seal is listed under the Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BD Protocol) of the Barcelona Convention. It has been classified as "Critically Endangered" by the International Union for the Conservation of Nature (IUCN; Karamanlidis and Dendrinos 2015) and is legally protected throughout its range via regional, national and international legislation, including the Convention on the Conservation of Migratory Species of Wild Animals, Convention on the Conservation of European Wildlife and Natural Habitats, Convention on Biological Diversity, and Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Additionally, the European Union's Habitats Directive (92/43/EEC) lists the Mediterranean monk seal in the Directive's Annexes II and IV as a species of Community interest whose conservation requires the creation of Special Areas of Conservation (SAC).

The Mediterranean cetaceans' populations are protected under the framework of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area), under the auspices of the UNEP Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS). The Pelagos Sanctuary is a large marine protected area established by France, Italy and Monaco in the Corso-Ligurian-Provençal Basin and the Tyrrhenian Sea, where most cetacean species are regularly observed and benefit from its conservation regime.

All cetacean species in the Mediterranean Sea are also protected under the Annex II of the SPA-BD Protocol of the Barcelona Convention, under the Appendix I of the Bern Convention, under the Annex II of the Washington Convention (CITES), under the Appendix II of the Bonn Convention (CMS) and under the Annex IV of the EU Habitats Directive.

In 2016, the 19th Meeting of the Contracting Parties to the Barcelona Convention adopted the updated Action Plan for the Conservation of Cetaceans in the Mediterranean Sea. This Action Plan, firstly adopted in 1991, was prepared using the information available about the cetacean populations and the threats hanging over them as known in 1991. However, aware that many important aspects of cetacean biology, behaviour, range and habitats in the Mediterranean were poorly known, the list of "Additional Points for the Implementation of the Action Plan" (Appendix to the Action Plan) has been amended in 2015 in collaboration with the ACCOBAMS secretariat.

The main objective of this Action Plan is to promote the protection and the conservation of cetacean habitats including feeding, breeding and calving grounds, as well as the recovery of cetacean populations in the Mediterranean Sea Area.

The short-beaked common dolphin, the sperm whale and the Cuvier's beaked whale and the monk seal are also listed under the Appendix I of the Bonn Convention (CMS). The common bottle dolphin, the harbor porpoise and the monk seal are also listed under the Annex II of the EU Habitats Directive.

Assessment methods

Visual aerial and vessel surveys.

Before conducting any type of monitoring of animal populations aimed at assessing the species abundance and density, it is essential to define the main objectives of the programme, alongside with the collection of relevant information on the target study area and the species presence and occurrence. These elements are critical to choose the right data collection methodology, survey design approach and analytical framework. Visual aerial- and vessel-based surveys, as well as acoustic surveys from both static platforms and vessels, have proven to be successful to assess the density and abundance of many species, providing robust estimates. Monitoring at the regional level may require data collection throughout the year, to better understand seasonal patterns in distribution, whereas monitoring at the population level would mainly address inter-annual fluctuations.

We can identify are at least five potential approaches to be undertaken when monitoring cetaceans:

1. Visual surveys from ship, aircraft or land observation platforms (LOP).
2. PAM carried out during ship surveys with towed hydrophones.
3. PAM performed by means of static acoustic monitoring, e.g. using T-PODs or EARS.
4. Photo-identification and mark-recapture analysis.
5. A combination of all or some of the above methodologies.

Visual aerial and both acoustic and visual surveys offer several advantages, but present some limitation depending on the target species. Therefore, when deciding which monitoring method to implement, it is pivotal to consider the limitations of each approach and compare the different methodologies. In general, surveys from ship or aircraft have a low temporal resolution. Ship surveys may have bias due to responsive movements of animals, stationary acoustic systems often have low spatial resolution and are inherently problematic from a logistical point of view in terms of deployment of instruments. Photographic identification relies on visual differences between individuals and generally span over large time windows to obtain robust results. Finally, telemetry studies typically only allows small samples resulting in much inter-individual variation.

Line transect distance sampling, from both aircraft and ships, is a well-established approach used to estimate abundance and assess density for several species of cetaceans and mega-vertebrates. In line transect distance sampling, a survey area is defined and surveyed along pre-determined transects. The distance to each detected animal is measured and consequently used to obtain a detection function, from which an estimate of the effective width of the strip that has been searched can be calculated. Abundance is then calculated by extrapolating estimated density in the sampled strips to the entire survey area. This approach, despite being relatively easy to implement, relays on strong assumptions, of which one of the most significant is the assumption that all animals on the track line are detected, ie. probability to detect an animal or a group of animals is maximum ($g(0)=1$). This assumption is often invalidated by the so called perception and availability biases where the former implies that animals are not available to be seen during the period it is within visual range (e.g. the animal is underwater), and the latter implies that an observer misses an animal that is available at the surface. Both biases negatively affect abundance estimates. Therefore, estimates that do not take into account possible correction factors for these biases, represent underestimates of the real abundance. Both availability and perception biases vary with species, being generally small for large animals and larger for small sized species. Both biases can be overcome, and estimates corrected using a double platform approach, where the use of two independent platforms or sets of observers would allow for the estimation of the proportion of animals missed on the transect line, in conjunction with information on diving behaviour of the tagged species.

Relative abundance uncorrected for availability and/or perception biases may be sufficient for detecting population trends, reducing surveys cost considerably and may be used to monitoring the status of the target population between large-scale absolute abundance surveys based on larger budgets. It is important to underline that for these surveys correction factors for the availability and perception biases can be used *a posteriori* when available to obtain absolute estimates.

Passive Acoustic Monitoring.

Cetaceans, in particular odontocetes, are highly vocal animals that can produce vocalisations for over the 80% of the time (e.g. the sperm whale). The monitoring of these sounds allows, hence, for the collection of information on spatial and temporal habitat use, as well as estimation of relative density. The collection of acoustic data for cetaceans has some significant advantages over visual methods. In fact, acoustic methods can be automated, data can be collected 24-hrs a day over long period of time, data collection is not dependent on observer's skills, is less sensitive to weather conditions and can detect the presence of diving animals not available for visual observations. The disadvantages of PAM methods are that they rely on animals making sounds within a useful detection range and are identifiable to the species level, and usually not to the individual level.

Furthermore, with exception of some species such as the sperm whale and some Ziphiidae, methods to estimate abundance are not well established yet.

Photo-identification.

Photo-identification is a widely used technique in cetacean research. It can be used to obtain estimates of abundance and population parameters e.g. survival and calving rate for virtually all the species of cetaceans and it has been in use since the early 170s to monitor common bottlenose dolphins and killer whales since the 1970s. The technique uses good quality photos of animals' body parts that constitute unique recognizable and permanent markings.

Using photo-identification, it is sometimes possible to census the whole population when all individuals can be encountered at any given time in an area, all are well marked and no individuals seem to be moving in or out of the population. This is however unusual and has only been accomplished for a few populations of bottlenose dolphin, e.g. Sado Estuary, Portugal and Doubtful Sound, New Zealand, and for killer whales off Vancouver Island. More commonly, mark-recapture models must be applied to photo-identification data to estimate abundance (rather than a census of the whole population) for specific areas that populations or part of populations occupy during one or more seasons of the year. Information on the proportion of the population possessing recognisable markings is also required to allow estimation of population size.

RESULTS

Results and Status, including trends (brief)

This assessment presents a brief overview of the key results and status of twelve species of marine mammals, one seal and 11 cetaceans, hat are regularly present in the Mediterranean Sea and face several threats due to heavy anthropogenic pressures throughout the entire Mediterranean basin.

Results and Status, including trends (extended)

Mediterranean monk seal – Conservation efforts initiated over the past few decades seem to have at least partially stymied the population's decline, as the current overall abundance of eastern Mediterranean subpopulation is said to be substantially higher than the 350 monk seals estimated in 2004 (Güçlüsoy et al. 2004) and 2010 (Aguilar and Lowry, 2010) [7]. It is unclear when this recent small increases and signs of recovery began and if it will continue (Karamanlidis and Dendrinos, 2015).

Currently there are no population estimates for monk seals at the Mediterranean level; genetic analysis suggests that there may be two separate populations – genetically isolated – within the Basin, one in the Ionian Sea and one in the Aegean Sea. Previously listed as Critically Endangered by the IUCN Red List, the Mediterranean monk seal has been recently reassessed as Endangered, following an observed increase in individuals at localized breeding sites.

Fin whale – Comprehensive basin-wide estimates of density and abundance are lacking for all the species of cetaceans across the Mediterranean Region. Nonetheless, these parameters have been previously obtained for fin whales over large portions of the Central and Western Mediterranean Basin, highlighting seasonal, annual and geographical patterns. Line-transect surveys in 1991 yielded fin whale estimates in excess of 3,500 individuals over a large portion of the western Mediterranean (Forcada et al., 1996), where most of the basin's fin whales are known to live. Panigada et al. (2011, 2017) reviewed the existing density and abundance estimates in the Central and Western parts of the Basin and reported on a series of aerial surveys conducted in the Pelagos Sanctuary and in the seas around Italy, providing evidence of declining numbers in density and abundance since the 1990's surveys. These recent estimates provided values of 330 fin whales in July 2010 in the Pelagos Sanctuary area. Panigada and colleagues also reported on density and abundance estimates on a wider area, including the Pelagos Sanctuary, the Central Tyrrhenian Sea and portion of the sea west of Sardinia, with an estimated abundance of 665 fin whales in summer 2010. Laran et al. (2017) estimated approx. 460 (95% Confidence Interval 130-1 620) and 1,130 (95% CI 560-2 420) fin whales in the Pelagos sanctuary in winter 2011-2012 and summer 2012 respectively.

Sperm whale – There are no robust information on sperm whale population estimates for the entire Mediterranean Sea, while there are estimates obtained through photo-identification, line transect acoustic studies in localized specific areas. Given the values obtained in some Mediterranean areas (e.g. the Hellenic Trench, the Balearic islands, the Central Tyrrhenian Sea and the Ionian Sea), it has been suggested that the entire population may be around a few thousand animals, with possibly less than 2500 animals sexually mature and in a reproductive status (Notabartolo di Sciara et al., 2012). Laran et al. (2017) estimated approx. 560 (95% CI 120-2 650) and 370 (95% CI: 80-1 700) sperm whales in the North Western Mediterranean Sea in winter 2011-2012 and summer 2012 respectively.

Cuvier's beaked whale – No density or abundance estimates for this species are available for the whole Mediterranean Sea. The only available robust sub-regional estimates come from line-transect surveys in the Alborán Sea and from photo-identification studies in the Ligurian Sea. The most recent corrected estimates number 429 individuals (CV=0.22) from the Alborán Sea and around 100 individuals (CV=0.10) in the Ligurian Sea (Podestà et al., 2016). The lack of other estimates throughout the whole Mediterranean Sea precludes any inference on the numerical consistency of the entire population.

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[7] Although there have been improvements in the methodologies used to study monk seals (e.g., the remote use of infrared photo cameras in caves), it is unlikely that the estimated increase in population size was substantially influenced by differences in methodology as the methods used to calculate abundance (although different by location) have been largely similar across time (e.g., Pires and Neves 2001, Pires et al. 2008 and Karamanlidis et al. 2009).

Short-beaked common dolphin – Common dolphins used to be very common in the Mediterranean Sea, and during the 20th century the species was subject to a large decline, drastically reducing its population levels. No population abundance estimates are available for the Mediterranean Sea, apart from localized areas, such as for example the Gulf of Corinth and the Alborán Sea, thus making it difficult to assess the entire population.

Long-finned pilot whale – Two populations have been described in the Mediterranean Sea, one living in the Strait of Gibraltar and one in the area between the Alborán and the Ligurian Seas. The Gibraltar population has been estimated at less than 250 individuals, while there are few estimates for the other population, which seems to be declining (Verborgh et al., 2016). Laran et al. (2017) estimated approx. 300 (95% CI 90-950) and 650 (95% CI: 160-2 540) long-finned pilot whales in the North Western Mediterranean Sea in winter 2011-2012 and summer 2012 respectively.

Risso's dolphin – There are no population estimates for Risso's dolphin in the whole Mediterranean Sea, with information coming only from localized areas. Distance sampling was used to estimate winter and summer abundance of Risso's dolphins in the north-western Mediterranean (N=2550 (95% CI: 849–7658) in winter and N=1783 (95% CI: 849–7658) in summer). Systematic photo-identification studies allowed to estimate, through mark-recapture methods, an average population of about 100 individuals (95% CI: 60–220) summering in the Ligurian Sea (Azzellino et al., 2016). Laran et al. (2017) estimated approx. 2 050 (95% CI 700-5 850) and 1 410 (95% CI: 550-3 740) Risso's dolphins in the North Western Mediterranean Sea in winter 2011-2012 and summer 2012 respectively.

Killer whale – The most recent abundance estimate for this species is 39 individuals in 2011, representing one of the lowest levels compared to other killer whales population elsewhere in the world (Esteban et al., 2016).

Striped dolphin – Comprehensive basin-wide estimates of density and abundance are lacking for this species across the Mediterranean Region; nonetheless, ship and aerial surveys have provided abundance and density values for striped dolphins over large portions of the Central and Western Mediterranean Basin, highlighting seasonal, annual and geographical patterns. The overall higher density, and hence abundance, was observed in the North-Western Mediterranean Sea and estimated at 95,000 individuals (CV=0.11) (Panigada et al., 2017), with values clearly decreasing during the winter months and towards the Southern and Eastern sectors, reflects the general knowledge on the ecology of these species, described as the most abundant one in the Basin. Several estimates of abundance and density for this species have been provided for many areas of the Mediterranean, especially in the west. Laran et al. (2017) estimated approx. 57 300 (95% CI: 34 450-102 050) and 130 000 (95% CI: 76 750-222 100) striped dolphins in the North Western Mediterranean Sea in winter 2011-2012 and summer 2012 respectively. No baseline data are available for the whole basin however.

Rough-toothed dolphin – The very small number of authenticated records over the last 20 years (12 sightings and 11 strandings/bycatch) render any population estimate impossible and statistically unacceptable.

Common bottlenose dolphin – There are no density and abundance estimates for the entire Mediterranean Sea, with the only statistically robust estimates obtained from localized, regional research programmes in the Alborán Sea, the Balearic area, the Ligurian Sea, the Tunisian Plateau, the Northern Adriatic, Western Greece and Israel in the Levantine Basin. Laran et al. (2017) estimated approx. 13 410 (95% CI: 5 530-32 590) and 3 860 (95% CI: 1 040-15 020) common bottlenose dolphins in the North Western Mediterranean Sea in winter

2011-2012 and summer 2012 respectively.The IUCN assessment for the Mediterranean population implies that less than 10,000 common bottlenose dolphins are present in the Basin.

Harbour porpoise – This cetacean is not regularly present in the Mediterranean basin except in the Aegean Sea, where individuals from the Black Sea subspecies are occasionally observed and in the Alborán Sea, where individuals from the North Atlantic Ocean are rarely seen. No density and abundance estimates are available.

CONCLUSIONS

Conclusions (brief)

Some of the cetaceans species present in the Mediterranean Sea are migratory species, whit habitat ranges extending over wide areas. It is therefore highly recommended to monitor these species at regional or sub-regional scales for the assessment of their population abundance. Priority should be given to the less known areas, using online data sources, such as Obis Sea Map and published data and reports as sources of information.

Conclusions (extended)

There is general consensus among the scientific community that long-term systematic monitoring programmes, using techniques such as the photo-identification, provide robust and crucial data that can be used in assessing abundance at sub-regional levels and inform local conservation and mitigation measures. Establishing international collaborations between different research groups, merging existing data-sets allows performing robust analysis and estimating population parameters at larger scales.

The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) has been working for several years on defining an exhaustive program for estimating abundance of cetaceans and assessing their distribution and habitat preferences in the Black Sea, Mediterranean Sea and the adjacent waters of the Atlantic (the "ACCOBAMS Survey Initiative"). This initiative consists in a synoptic survey to be carried out in a short period of time across the whole Agreement area and it will combine visual survey methods (boat- and ship-based surveys) and passive acoustic monitoring (PAM).

Key messages

- Effort should be dedicated to provide density and abundance estimates at the Mediterranean level, with synoptic surveys, such as that currently ongoing with the ACCOBAMS Survey Initiative.
- The conservation priorities listed by the European Directives and the Ecosystem Approach should be implemented.

Knowledge gaps

- Gaps still exist on baseline information such as abundance and density for many species of cetaceans occurring in the Mediterranean Sea, especially in those sectors where research is carried out on limited resources and not systematically.
- Even though for some species such as the striped dolphin and the fin whale estimates have been obtained for a large portion of the Basin, for none of the species there are available estimates at the regional scale.

- The lack of these baseline critical information is therefore detrimental for conservation, slowing down the identification of potential and actual threats, the assessment of their effect on populations and eventually the evaluation of trends and the triggering of mitigation and conservation measures.

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 4. Population abundance of selected species (related to marine turtles)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 4 (CI4): Population abundance of selected species (related to marine turtles)
Indicator Assessment Factsheet Code	EO1CI4

RATIONALE/METHODS

Background (short)

This assessment presents a brief overview of the known abundance of loggerhead and green sea turtles at breeding, foraging and wintering grounds, based on published data, to determine what knowledge gaps need to be filled to realise the objective of this indicator. The objective of this indicator is to determine the population status of selected species by medium-long term monitoring to obtain population trends for these species. This objective requires a census to be conducted in breeding, migratory, wintering, developmental and feeding areas.

Background (extended)

Measurements of biological diversity are often used as indicators of ecosystem functioning, as several components of biological diversity define ecosystem functioning, including richness and variety, distribution and abundance. Abundance is a parameter of population demographics, and is critical for determining the growth or decline of a population. The objective of this indicator is to determine the population status of selected species by medium-long term monitoring to obtain population trends for these species. This objective requires a census to be conducted in breeding, migratory, wintering, developmental and feeding areas.

Effective conservation planning requires reliable data on wildlife population dynamics or demography (e.g. population size and growth, recruitment and mortality rates, reproductive success and longevity) to guide management effectively (Dulvy et al. 2003; Crick 2004). However, it is not possible to obtain such data for many species, especially in the marine environment, limiting our ability to infer and mitigate actual risks through targeted management. For sea turtles, nest numbers and/or counts of females are often used to infer population trends and associated extinction risk, because counts of individuals in the sea or when nesting on (often) remote beaches is tricky. Estimates of sea turtle abundance are obtained from foot patrols on nesting beaches counting either the number of females (usually during the peak 2-3 weeks of nesting) and/or their nests (Limpus 2005; Katselidis et al. 2013; Whiting et al. 2013, 2014; Pfaller et al. 2013; Hays et al. 2014). However, females may not be detected by foot patrols because they do not all initiate and end nesting at the same time and might not nest on the same beach or section of beach within or across seasons; consequently, monitoring effort could fail to detect turtles or miss them altogether on unpatrolled beaches. Consequently, it is assumed that females lay two (Broderick et al. 2001), three (Zbinden et al. 2007; Schofield et al 2013) or possibly as many as 5 or more clutches (Zbinden et al. 2007), depending on the beach being assessed in the Mediterranean. High environmental variability leads to overestimates of female population size in warmer years and under-estimates in cooler years (Hays et al. 2002). This is because sea turtles are ectotherms, with environmental conditions, such as sea temperature and forage resource availability, influencing the seasonality and timing of reproduction (Hays et al. 2002; Broderick et al. 2001, 2003; Fuentes et al. 2011; Schofield et al. 2009; Hamann et al. 2010; Limpus 2005). As a result, concerns have been raised about the reliability of using nest counts of females alone to infer sea turtle population trends (Pfaller et al 2013; Whiting et al. 2013, 2014).

Furthermore, nest counts cannot inform us about the number of adult males, the number of juveniles being recruited into the adult population, the longevity of nesting by individuals or mortality rates. Information is lacking on these components of sea turtle populations because males and juveniles remain in the water. Because turtles do not surface regularly, along with detection being difficult in low sea visibility of great sea depth conditions, a number of individuals are always missed from population surveys, requiring the use of certain statistical tools (such as distance sampling, Buckland et al. 1993) to be implemented to make up for the shortfall. Furthermore, for most populations the areas used by males and juveniles remain unknown (see the assessment for Common Indicator 1: Habitat distributional range). Yet, it is important to quantify the number of juveniles and males to guarantee successful recruitment into a population, as well as successful breeding activity to ensure population viability and health i.e. genetic diversity, within Indicator 3: Species distributional range, (Limpus 1993; Schofield et al. 2010; Demography Working Group 2015). This is because sea turtles exhibit temperature dependent sex determination, with the warming climate leading to heavily biased female production (Poloczanska et al., 2009; Katselidis et al. 2012; Saba et al., 2012). Therefore, we must quantify all of these parameters to understand sea turtle abundance trends and survival. Furthermore, factors impacting turtle population dynamics in the coming decades will not be detected from nest counts for another 30 to 50 years (Scott et al. 2011), because this is the generation time of this group and nest counts cannot predict how many juveniles are recruiting into the populations until they begin nesting themselves. This timeframe will likely be far too late to save many populations.

Gaps remain in assessing population abundance because it is not possible to survey all individuals in a turtle population either through in-water or beach-based surveys. It is therefore necessary to establish minimum information standards at key geographical sites to obtain reliable measures of population abundance of two selected species, taking into account all components of the population. To achieve this, first adequate knowledge about the distribution range of each species is required (Indicator 1). Monitoring effort should be long term and should cover all seasons to ensure that the information obtained is as complete as possible.

Key pressures and drivers.

Both nesting and foraging areas of marine turtles are vulnerable to anthropogenic pressures in the Mediterranean Sea, including an increase in the exploitation of resources (including fisheries), use and degradation of habitats (including coastal development), pollution and climate change (UNEP/MAP/BLUE PLAN, 2009; Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). These issues might reduce the resilience of this group of species, negatively impacting the ability of populations to recover (e.g. Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). The risk of extinction is particularly high in the Mediterranean because the breeding populations of both loggerhead and green turtles in this basin are demographically distinct to other global populations (Laurent et al., 1998; Encalada et al., 1998), and might not be replenished.

The main threats to the survival of loggerhead and green turtles in the Mediterranean have been identified as incidental catch in fishing gear, collision with boats, and intentional killing (Casale & Margaritoulis 2010). Casale (2011) estimated that there are more than 132,000 incidental captures per year in the Mediterranean, of which more than 44,000 are predicted to be fatal, although very little is known about post-release mortality (Álvarez de Quevedo et al. 2013). Wallace et al. (2010, 2011) grouped all species of sea turtles globally into regional management units (RMUs), which are geographically distinct population segments, to determine the population status and threat level. These regional population units are used to assimilate biogeographical information (i.e. genetics, distribution, movement, demography) of sea turtle nesting sites, providing a spatial basis for assessing management challenges. A total of 58 RMUs were originally delineated for the seven sea turtle species. The Mediterranean contains 2 RMUs for loggerheads and 1 RMU for green turtles. These analyses showed that the Mediterranean has the highest average threats score out of all ocean basins, particularly for marine turtle bycatch (Wallace et al. 2011). However, compared to all RMUs globally, the Mediterranean also has the lowest average risk score (Wallace et al. 2011).

Other key threats to sea turtles in the Mediterranean include the destruction of nesting habitat for tourism and agriculture, beach erosion and pollution, direct exploitation, nest predation and climate change (Casale & Margaritoulis 2010; Mazaris et al. 2014; Katselidis et al. 2012, 2013, 2014). Coll et al. (2011) also identified critical areas of interaction between high biodiversity and threats for marine wildlife in the Mediterranean. Within this analysis, the authors delineated high risk areas to both species, with critical areas extending along most coasts, except the south to east coastline (from Tunisia to Turkey).

Policy context and Targets

The Parties to the Barcelona Convention included among their priority targets for the period 1985-1995 the protection of Mediterranean marine turtles (Genoa Declaration, September 1985). With this purpose, the Action Plan for the Conservation of Marine Turtles in the Mediterranean Sea was adopted by the Contracting Parties to the Barcelona Convention in 1989. Since that time, this Action Plan was revised three times: i) in 1999, when the updated version of the Action Plan was adopted at the 11th Meeting of the Contracting Parties to the Barcelona Convention; ii) in 2007 when a new update of the Action Plan was approved by the 15th COPs and iii) the last updated timetable for the period 2014-2019 was reviewed and adopted by the 18th COP .

The objective of this Action Plan is the recovery of the populations of *Caretta caretta* and *Chelonia mydas* in the Mediterranean (with priority accorded to *Chelonia mydas*, wherever appropriate) through: i) appropriate protection, conservation and management of marine turtle habitats, including nesting, feeding and wintering areas and key migration passages; and ii) improvement of the scientific knowledge by research and monitoring.

Sea turtles are afforded additional legislative protection under a number of international conventions, including the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendices I and II of the Convention on Migratory Species (CMS), the Bern Convention (Council of Europe) and European Union regulation (Habitats Directive), several agreements and recommendations adopted by the Regional Fisheries Management Organizations (RFMOs) such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM).

Monitoring and assessing sea turtle populations, unveiling migratory patterns and identifying feeding areas, as well as faced threats, are fundamental to further design sound conservation strategies and policies. It will be ensured through the IMAP that includes three common indicators related to sea turtles within the Ecological Objective 1. This assessment will include information on marine reptile species that, at some point in their annual life cycle, are reliant on coastal and/or offshore marine areas. In this context, this indicator will allow a large-scale monitoring and assessment of sea turtles.

Assessment methods

This assessment presents a brief and general overview of the distributional range of two marine turtle species to identify existing knowledge and knowledge gaps for use in elaborating the national monitoring programmes for biodiversity. Published information by regional and national surveys and research projects were used to compile the review, but this overview does not present a comprehensive assessment of existing knowledge.

RESULTS

Results and Status, including trends (brief)

This general overview indicates that over 100 sites around the Mediterranean have scattered to stable (i.e. every year) nesting of loggerhead turtles. Greece and Turkey alone represent more than 75% of the nesting effort in the Mediterranean. Information on the size structure and abundance of individuals at oceanic and neritic marine areas has proven difficult. Most green turtle nests are laid in Turkey, Cyprus and Syria, with the remainder being found in Lebanon, Israel and Egypt. Information about the numbers of green turtles in various developmental, foraging and wintering habitats is limited.

Results and Status, including trends (extended)

Loggerhead sea turtles

Adult females at breeding areas: Over 100 sites around the Mediterranean have scattered to stable (i.e. every year) nesting (Halpin et al., 2009; Kot et al. 2013; SWOT, 2006a, 2006b, 2008, 2009, 2010, 2011, 2012), of which just 13 sites support more than 100 nests each (Casale & Margaritoulis 2010). Greece and Turkey alone represent more than 75% of the nesting effort in the Mediterranean; for details on nest numbers at the different sites in the Mediterranean see Casale & Margaritoulis (2010) and Figure 1. An average of 7200 nests are made per year across all sites (Casale & Margaritoulis 2010), which are estimated to be made by 2,280–2,787 females assuming 2 or 3 clutches per female (Broderick et al. 2002).

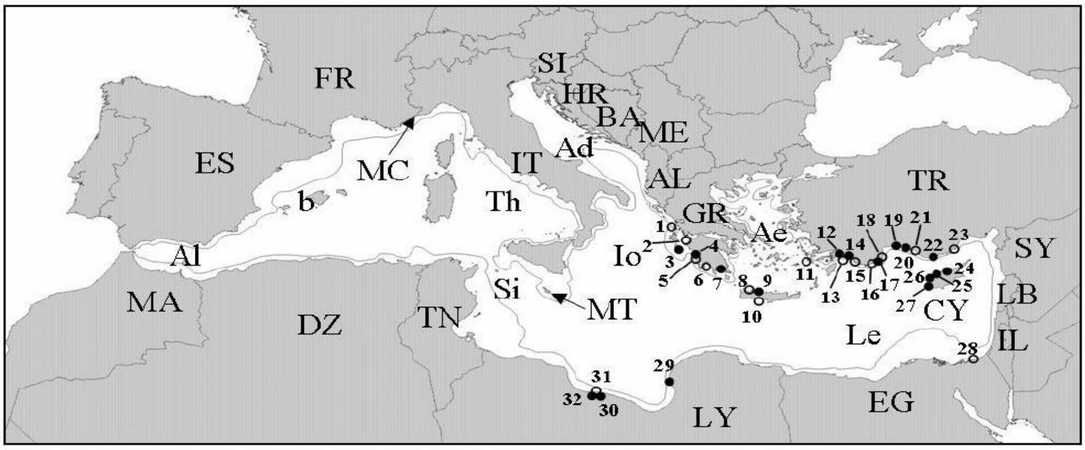

Figure 1: Map of the major loggerhead nesting sites in the Mediterranean (extracted from Casale & Margaritoulis, 2010); Major nesting sites (>50 nests/year) of Loggerheads in the Mediterranean. 1 Lefkas; 2 Kotychi; 3 Zakynthos; 4 Kyparissia; 5 beaches adjacent to Kyparissia town; 6 Koroni; 7 Lakonikos Bay; 8 Bay of Chania; 9 Rethymno; 10 Bay of Messara; 11 Kos; 12 Dalyan; 13 Dalaman; 14 Fethiye; 15 Patara; 16 Kale; 17 Finike-Kumluca; 18 Cirali; 19 Belek; 20 Kizilot 21 Demirtas; 22 Anamur; 23 Gosku Delta; 24 Alagadi; 25 Morphou Bay; 26 Chrysochou; 27 Lara/Toxeftra; 28 Areash; 20 Al-Mteafla; 30 Al-Ghbeba; 31 Al-thalateen; 32 Al-Arbaeen. Closed circles >100 nests/year; open circles 50-100 nests/year. Country codes: AL Albania; DZ Algeria; BA Bosnia and Hersegovina; HR Croatia; CY Cyprus; EG Egypt; FR France; GR Greece; IL Israel; IT Italy; LB Lebanon; LY Libya; MT Malta; MC Monaco; ME Montenegro; MA Morocco; SI Slovenia; ES Spain; SY Syria; TN Tunisia; TR Turkey; Ad Adriatic; Ae Aegean; Al Alboran Sea; Io Ionian; Le Levantine basin; Si Sicily Strait; Th Thyrrenian; b Balearic.

A recent IUCN analysis (Casale 2015) suggests that, when all Loggerhead nesting sites in the Mediterranean are considered together, the Mediterranean population size is relatively large, and is considered of Least Concern but conservation dependent under current IUCN Red List criteria. However, refer back to limitations of population analyses in the introductory section.

While tagging programs exist at some of the main nesting sites in the Mediterranean on nesting beaches, the loss of external flipper tags has proven problematic in maintaining long-term records of individuals (but see Stokes et al. 2014). However, these estimates of female numbers should be treated with caution because the Mediterranean represents one of the most temperate breeding regions of the world. Consequently, clutch frequency will vary from season to season depending on the prevailing weather conditions. For instance, in years with prevailing north winds, sea temperatures remain cooler, resulting in longer inter-nesting periods (Hays et al. 2002), and fewer clutches per individual, with the opposite trend being obtained in years with prevailing south winds. Even in tropical nesting sites, with relatively stable temperatures during breeding, clutch frequency can vary by as much as 3-12 clutches (Tucker 2010). Furthermore, the trophic status of foraging sites influences remigration frequency; thus, more turtles may return to breed in some years, again causing nest numbers to fluctuate (Broderick et al. 2001, 2002). Therefore, for programs that elucidate female numbers based on nest counts, the mean clutch frequency and breeding periodicity should be assessed at regular intervals by means of high resolution satellite tracking of individuals across years with different climatic conditions. Of note, knowledge about the numbers of females that nest on the beaches of the countries of North Africa remains limited and requires resolution.

Adult males at breeding areas: To date, no study globally has obtained an estimate of the number of males in a breeding population. This is because males remain in the marine area, making counts difficult to obtain. Within the Mediterranean, only Schofield et al. (2010) have attempted to estimate the numbers of males within a loggerhead rookery (Zakynthos) using photo-identification. Intensive capture-recapture over a three month period indicated a 1:3.5 ratio of males to females (based on a sample size of 154 individuals). Furthermore, Hays et al. (2014) showed that most males in this population breed annually (although some of those that forage off Tunisia/Libya and in western Greece return biannually; Hays et al. 2014; Casale et al. 2013), using a combination of long-term satellite tracking (over 1 year) and multi-year photo-identification records, with similar return rates being recorded in other populations globally (Limpus 1993). Based on this information, just 100 males might breed annually, with the same males breeding every year, in contrast to an estimated 600-800 females for this population (based on nest counts; Casale and Margaritoulis 2010). Therefore, it is imperative to ascertain the rate of recruitment and mortality of males in the population. If we assume 2,280–2,787 adult females loggerheads in the Mediterranean (Broderick et al. 2002), then there may be just 580 to 696 adult loggerhead males in total, with some populations potentially supporting very small numbers of males, especially when considering that Zakynthos is considered one of the largest breeding populations in the Mediterranean (Casale & Margaritoulis 2010; Katselidis et al. 2013; Almpanidou et al. 2016). Thus, counts of males across all breeding populations are required to ascertain the importance of protecting this component of sea turtle populations.

Developmental and adult foraging/wintering habitats: Because loggerheads probably forage throughout all oceanic and neritic marine areas of the west and east basins of the Mediterranean (Hays et al. 2014; Casale & Mariani 2014), combined with the fact that both adults and juveniles may frequent multiple habitats, counts of individuals in specific areas prove difficult.

Juvenile and immature turtles represent the greatest component of the population; thus, information on the size structure and abundance at foraging grounds is essential to understand changes in nest counts, based on changes in mortality and recruitment into adult breeding populations (Demography Working Group, 2015). However, because the juveniles of each nesting population may be dispersed across multiple habitats, and appear to use different sites across seasons, obtaining such counts is difficult requiring the complementary use of genetic sampling (Casale & Margaritoulis 2010).

Aerial and fishery bycatch data provide some information on turtle abundance in the western basin Alboran Sea and Balearic islands, the Sicily Strait, the Ionian Sea, the north Adriatic, off Tunisia-Libya, Egypt and parts of the Aegean (Gómez de Segura et al. 2003, 2006; Cardona et al. 2005; Lauriano et al. 2011; Casale & Margaritoulis 2010; Fortuna et al. 2015), with unpublished information existing for the Balearic Sea, the Gulf of Lions, the Tyrrhenian Sea, the Ionian Sea, and the Adriatic Sea (Demography Working Group 2015). There are also bycatch data available providing evidence of turtle numbers (e.g. Casale & Margaritoulis 2010; Casale 2011, 2012). Another source of information is in-water capture at focal sites such as Amvrakikos, Greece (Rees et al. 2013) and Drini Bay, Albania (White et al. 2013). At Drini Bay, Albania, 476 turtles of size class 20 cm to 80 cm were captured primarily May to October (Casale & Margaritoulis 2010). Furthermore, long-term studies (2002-present) have shown the presence of large juvenile to adult loggerheads (46-92 cm) in Amvrakikos Bay, Greece (Rees et al. 2013).

Thus, the data from existing sites needs to be assimilated and assessed for representativeness in providing abundance information on juvenile and adult turtles, so as to determine how to focus effort effectively across foraging and developmental sites across the Mediterranean. In parallel, techniques to obtain counts on a regular basis across a wide range of habitats need to be developed.

Green turtles.

Adult male and females in breeding habitats: Most green turtle nests (99%) are laid in Turkey, Cyprus and Syria, with the remainder being found in Lebanon, Israel and Egypt (Figure 2; Kasparek et al. 2001; Casale & Margaritoulis 2010). Out of 30 documented sites, just six host more than 100 nests per season (Stokes et al. 2014), with a maximum of just over 200 nests at two sites (both in Turkey). For details on nest numbers at the different sites in the Mediterranean see Stokes et al (2015) and Figure 2. An average of 1500 nests are documented each year (range 350 to 1750 nests), from which an annual nesting population of around 339–360 females has been estimated assuming two to three clutches (Broderick et al. 2002). Unlike loggerheads, green turtles globally strong exhibit interannual fluctuations in the number of nests, which has been associated with annual changes in forage resource availability (Broderick et al. 2001). Consequently, our knowledge about the population dynamics of green turtles in the Mediterranean remains insufficient.

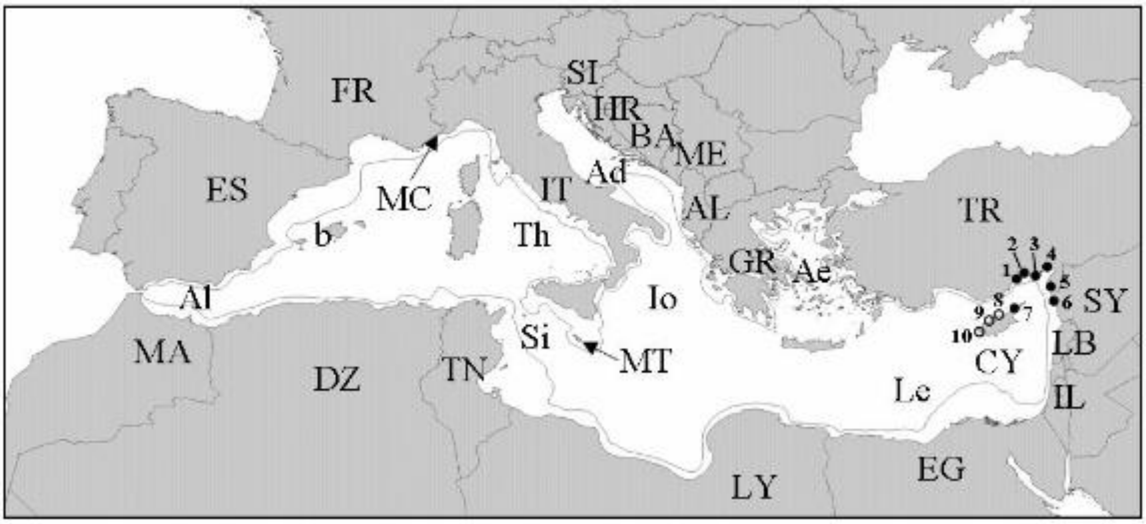

Figure 2: Map of the major green turtle nesting sites in the Mediterranean (extracted from Casale & Margaritoulis, 2010), Major nesting sites (>40 nests/year) of green turtles in the Mediterranean. 1 Alata; 2 Kazanli; 3 Akyatan; 4 Sugozu; 5 Samandag; 6 Latakia; 7 North Karpaz; 8 Alagadi; 9 Morphou Bay; 10 Lara/Toxeftra. Closed circles >100 nests/year; open circles 40-100 nests/year. Country symbols, see previous map.

Developmental and adult foraging/wintering habitats: Information about the numbers of green turtles in various developmental, foraging and wintering habitats is limited. While the greatest numbers of green turtles have been documented in the Levantine basin (Demography Working Group 2015), there are records of individuals using habitat in the Adriatic Sea (Lazar et al. 2004) and around Italian waters (Bentivegna et al. 2011), with some records occurring in the western basin; however, actual numbers, have not been obtained. It is essential to document the numbers of adults and juveniles that frequent developmental, foraging and wintering habitats in order to isolate key sites for management protection.

CONCLUSIONS

Conclusions (brief)

This general overview indicates that overall, programs at nesting sites need to place a strong focus on ensuring long-term recognition of unique female individuals and incorporate counts of males. The monitoring based on Common Indicator 1 will help with delineating developmental, foraging and wintering sites to make counts of adult vs. juvenile turtles and fluctuations in numbers over time. Information obtained through Common Indicator 2: Condition of the habitat’s typical species and communities will be intrinsically linked with Common Indicator 3: Species distributional range.

Conclusions (extended)

Major gaps exist in estimating the population abundance of sea turtles. First, the use of nest counts as a proxy for female numbers must be treated with caution, and variation in climatic factors at the nesting site and trophic factors at foraging sites taken into account. Counts of males at breeding grounds must be incorporated into programs at nesting sites. If just a total of 100 males frequent Zakynthos, which has around 1000 nests/season, then most sites throughout the Mediterranean (of which most have <100 nests) are likely to support very low numbers of males, making the protection of these individuals essential. Finally, with the delineation of developmental, foraging and wintering habitats (Indicator 1), it will be necessary to obtain counts of the number of individuals, particularly juveniles, that frequent these various habitats seasonally and across years. While information on the number of juveniles alone at given habitats does not reflect on any given nesting population, the relative numbers of immature to mature animals will provide baseline information about key juvenile developmental habitats and actual numbers relative to those obtained to adults.

Overall, programs at nesting sites need to place a strong focus on ensuring long-term recognition of female individuals and incorporate counts of males. The monitoring based on Common Indicator 1 will help with delineating developmental, foraging and wintering sites to make counts of adult vs. juvenile turtles and fluctuations in numbers over time. Information obtained through monitoring of Common Indicator 2 will be intrinsically linked with Indicator 3 (see this section).

Key messages

- This general overview indicates that major gaps exist in estimating the population abundance of sea turtles.
- Programs at nesting sites need to place a strong focus on ensuring long-term recognition of female individuals and incorporate counts of males.

- Programs need to be developed at foraging, wintering and developmental grounds, providing counts of individuals and linking them to their source breeding populations.

Knowledge gaps

- Seasonal and total numbers of adult males frequenting breeding sites
- Numbers of adult males and females frequenting foraging and wintering sites, including seasonal variation in numbers
- Vulnerability/resilience of documented populations and subpopulations in relation to physical and anthropogenic pressures;
- Analysis of pressure/impact relationships for these populations and subpopulations, and definition of qualitative GES;
- Identification of extent (area) baselines for each population and subpopulation with respect to adult females, adult males and juveniles to maintain the viability and health of these populations
- Appropriate assessment scales;
- Monitor and assess the impacts of climate change on nest numbers (clutch frequency) and breeding periodicity (remigration intervals) of females, as these paramaters are used as proxies for inferring female numbers.
- Monitor and assess the impacts of climate change on the breeding periodicity (remigration intervals) of males, as this provides an indication of total male numbers
- Assimilation of all research material on sea turtles (e.g. satellite tracking, stable isotope, genetic, strandings aerial surveys) in a single database

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 4. Population abundance of selected species (related to Seabirds)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 4 (CI4): Population abundance of selected species (related to seabirds)
Indicator Assessment Factsheet Code	EO1CI4

RATIONALE/METHODS

Background (short)

Background and rationale for the indicator, key pressures and drivers.

The Mediterranean Sea is considered an important habitat for seabirds, including particularly the Critically Endangered Balearic shearwater (*Puffinus mauretanicus*), the endemic Yelkouan shearwater (*Puffinus yelkouan*) and the little tern (*Sterna alibifrons*). In addition to these species, a number of other seabird species are listed in the Annexes of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention (SPA-BD Protocol).

The Mediterranean region is a region of intensive human use. Many of the seabird species face threats on land and at sea. On land this includes high pressure from coastal developments affecting availability of breeding and wintering habitats, and predation at colonies from native and invasive species. At sea the main threats include interaction with fisheries (bycatch) and the lack of prey caused by depletion of fish stocks, and from acute and chronic pollution (oil spills, chemical discharges, etc.) and disturbance from maritime traffic (Tarzia et al., 2015; Yesou et al., 2016).

Population size is the most straightforward indicator to assess the status and trends of seabirds. However, this information is subject to strong biases, particularly for species that attend colonies at night and/or breed in caves and crevices underground. Thus, for the gulls and terns there are often good count series in some regions, at least for some relevant local areas (particularly for protected sites). On the other hand, count data for “secretive” species such as shearwaters are often unreliable, even if prospection efforts have been reasonable. In the latter case, it is particularly important to take this type of data with extreme caution, and avoid drawing out trends except if there is a careful monitoring programme behind. Demographic information may result far more reliable in this type of situations (e.g. Genovart *et al.* 2016).

Assessment of abundance is a key parameter of population demographics, and is critical for determining the growth or decline of a population. The number of individuals within a population (population size) is defined as the number of individuals present in an animal aggregation (permanent or transient) in a subjectively designated geographical range.

Population density is the size of a population in relation to the amount of space that it occupies, and represents a complementary description of population size. Density is usually expressed as the number of individuals per unit area. The index of population abundance is a single species indicator that reflects the temporal variation in the breeding or the non-breeding (wintering) population of selected species compared to a base year (or reference level).

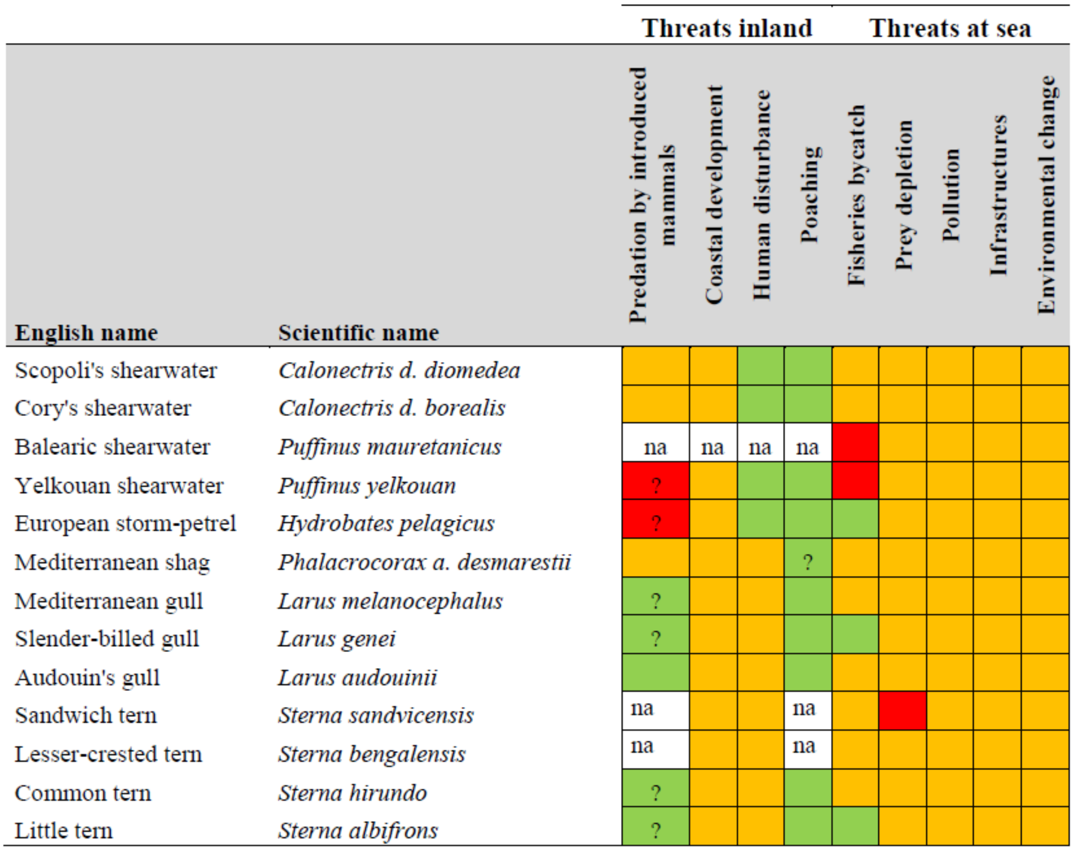
This indicator can be added into multi-species indices to reflect the variation over time of functional groups of species.

This assessment in the framework of the IMAP tends to to determine the population status of selected species by mediumlong term monitoring to obtain population trends for these species. This objective requires a census to be conducted in breeding, migratory, wintering, developmental and feeding areas.

Background (extended)

Seabirds as a group occur in all seas and oceans worldwide, and their role as potential indicators of marine conditions is widely acknowledged. Many studies use aspects of seabird biology and ecology, especially productivity and population trends, to infer and/or correlate with aspects of the marine environment, particularly food availability.

Nevertheless, despite the importance of seabirds as indicators of many aspects of the functioning of marine systems, the most important current challenge is to ensure the survival and improve the status of the many seabird species which are already globally threatened with extinction and to maintain the remainder in favourable conservation status. Indeed, seabirds are among the most threatened bird groups globally. They are all endangered by a number of threats, including contamination by oil pollutants, direct and indirect depletion of food resources, non-sustainable forms of tourism, disturbance, direct persecution includingillegal hunting and the use of poison, mortalit y from bycatch, wind farms, loss of habitats, degradation of habitat, particularly wetlands and small, islands of high biological importance, introduction of and predation by alien species, climate change (table 1).



		Threats inland				Threats at sea				
English name	Scientific name	Predation by introduced mammals	Coastal development	Human disturbance	Poaching	Fisheries bycatch	Prey depletion	Pollution	Infrastructures	Environmental change
Scopoli's shearwater	*Calonectris d. diomedea*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Cory's shearwater	*Calonectris d. borealis*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Balearic shearwater	*Puffinus mauretanicus*	na	na	na	na	🟥	🟧	🟧	🟧	🟧
Yelkouan shearwater	*Puffinus yelkouan*	🟥 ?	🟧	🟩	🟩	🟥	🟧	🟧	🟧	🟧
European storm-petrel	*Hydrobates pelagicus*	🟥 ?	🟧	🟩	🟩	🟩	🟧	🟧	🟧	🟧
Mediterranean shag	*Phalacrocorax a. desmarestii*	🟧	🟧	🟧	🟩 ?	🟧	🟧	🟧	🟧	🟧
Mediterranean gull	*Larus melanocephalus*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Slender-billed gull	*Larus genei*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧
Audouin's gull	*Larus audouinii*	🟩	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Sandwich tern	*Sterna sandvicensis*	na	🟧	🟧	na	🟧	🟥	🟧	🟧	🟧
Lesser-crested tern	*Sterna bengalensis*	na	🟧	🟧	na	🟧	🟧	🟧	🟧	🟧
Common tern	*Sterna hirundo*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Little tern	*Sterna albifrons*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧

Policy context and Targets

Given their imperilled conservation status, many seabirds have been highlighted for special conservation status and action under a range of international, regional and national agreements and mechanisms. However, because seabirds are highly mobile and migrate, they are exposed to vagaries of differing levels of protection across international (and non-governmental) regions.

The Barcelona Convention and its SPA-BD Protocol are the regulatory instruments of particular importance for seabirds protection in the Mediterranean, along with related policy frameworks and tools.

At the 12th COP of the Barcelona Convention, the Contracting Parties has requested SPA/RAC to draw up an Action Plan for the conservation of bird species listed in Annex II to the SPA-BD Protocol. After extensive consultation among international institutions, NGOs and experts throughout the Mediterranean, the first version was presented and adopted by the Contracting Parties to the Barcelona Convention at the 13th COP held in Catania, 2003. The development of this Action Plan followed various initiatives on the conservation of biological diversity, particularly with respect to birds and their important sites and habitats. Its main purpose is to maintain and/or restore the population levels of bird species listed in Annex II of the SPA-BD Protocol to a favourable conservation status and to ensure their long-term conservation.

The Implementation timetable of this Action Plan was updated for the first time in 2007, considering the results of the first Mediterranean Symposium held in 2005 and adopted during the 15th COP of the Barcelana convention held in Almeria in 2008.

The second update related to the period 2014-2019 was adopted by the 18th COP of the Barcelona Convention in 2013.

Moreover, Specific Action Plans for the 25 bird species listed in the Annex II of the SPA-BD Protocol are developed within the Barcelona Convention that should be implemented in all Mediterranean states where the species breed, winter or occur on migration.

Amongst other regulatory instruments, it is aslo relavnt to quote the EU Birds Directive (all seabirds in the EU), the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Convention on the conservation of European wildlife and natural habitats (Bern Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In addition to the above instruments, the Regional Fisheries Management Organisations (RFMOs) have also begun the adoption of the strategies that address incidental seabird bycatch. Level of regulation varies across RFMOs but includes combinations of the use of one or more bycatch mitigation measures in certain areas, data collection through observer programmes and use of monitoring, surveillance and compliance measures.

Assessment methods

Estimating breeding seabird populations might seem straightforward, but is often an extremely complex task, particularly with the nocturnal and burrowing species such as the shearwaters (e.g. Sutherland *et al*. 1994).

For gulls and terns, they tend to breed in aggregated colonies and their direct count may be relatively easy. Ideally a nest count is recommended, by visiting the colony and prospect systematically all the area occupied by the seabirds. Transects are the most used approach, dividing the colony in bands of a given width (which may depend on the visibility of the nests and the difficulty of the terrain) and counting every nest within each band. A slight modification consists of walking along transect lines and recording all nests detected, indicating the distance of each nest to the line; then a mathematical function of detectability allows to correct for the decreasing detectability of nests with distance and to get a whole estimate (distance-sampling) (Barbraud *et al*. 2014).

For shags, the direct count of nests often requires of boat-based counts following the rocky and cliff areas where the birds breed.

For the shearwaters, the direct count of nests is extremely complicated, although it may be attempted in accessible areas; call-playback may be of help in these cases (Perrins *et al*. 2012). However, it is often necessary to rely on indirect methods, as several areas remain inaccessible (e.g. Arcos et al. 2012b, Borg *et al*. 2016). These indirect methods are subject to potentially strong biases, and results must be taken with caution. Among them: counts of rafts and setting abundance out of vocalization rates. Capture-recapture methods may also be used, although the necessary assumption that populations are “closed” is often violated.

RESULTS

Results and Status, including trends (brief)

Derhé (2012) has assessed the global population of Puffinus yelkouan and estimated it to be 46,000-92,000 individuals. However, very high non-breeding season numbers reported in the

Bosporus suggest that there may be a large percentage of non-breeding birds in the population and estimates of breeding numbers at colonies may be underestimated. It is predicted that the global breeding population is suffering a rapid decline of c.50% over three generations (54 years) – a considerably higher rate of decline than was previously predicted. As such, the species' global Red List status has now been revised to Vulnerable based on the findings of Derhé (2012).

Information on seabird population sizes in the Mediterranean is patchy and often outdated, with some figures being repeated work after work while no real progress has been made. The different groups and species therefore deserve different considerations.

Results and Status, including trends (extended)

Balearic and Yelkouan shearwaters.

For the shearwaters, information on population size is particularly hard to get from the colonies, and most figures rely on indirect estimates subject to strong biases, and in occasions they just come from wild guesses. Comments on the trends of these species are therefore considered under common indicator 5 (demography). However, the upsurge of tracking technologies in the last decade and the increasing attention paid to marine protected areas for seabirds has led to an increase of monitoring work at the colonies, and the finding of new breeding sites. At the same time, the efforts of monitoring at sea (both direct counts from the coast or boats, and tracking studies) have led to an unprecedented knowledge of the patterns of distribution of these seabirds, which is essential to deal with the threats that occur at sea.

The Balearic shearwater is restricted to the Balearic Islands in the western Mediterranean as a breeder (Figure 1). There have been no proper counts of the breeding population at regional scale since 2001 (Ruiz & Martí 2004), although some colonies have been counted afterwards, and assumptions to infer estimates have changed for other colonies (Arcos 2011, 2016). All in all, the official estimate for the breeding population is of 3,200 breeding pairs. However, counts at sea suggest a larger population, with a global estimate of ca. 25,000 individuals (Arcos *et al*. 2012b, Arroyo *et al*. 2014), which could imply a breeding population of about 7,000 breeding pairs (Genovart *et al*. 2016). Trends based on this type of data should be considered as unreliable and therefore demographic data should be taken as the best reference (see common indicator 5).

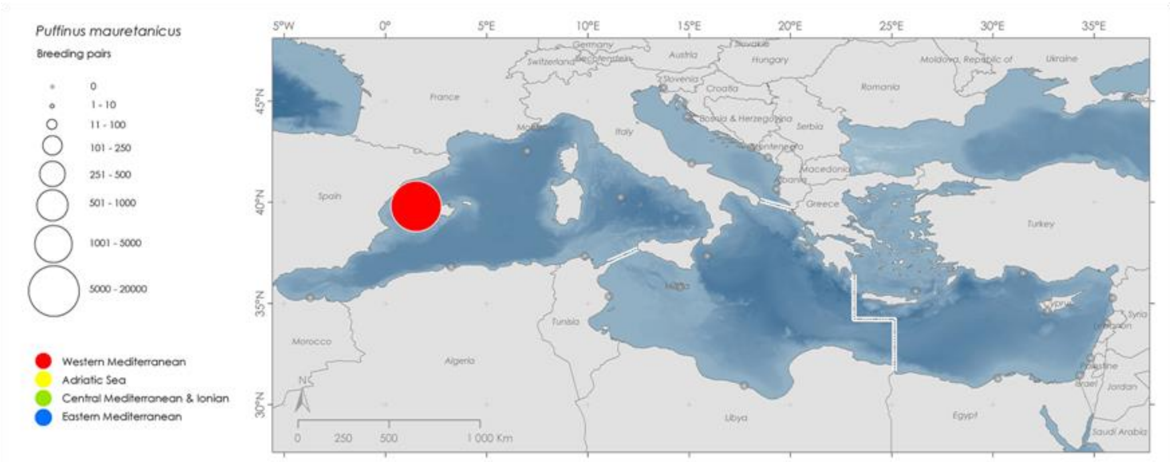


Figure 1. Distribution and relative size of the Balearic shearwater *Puffinus mauretanicus* breeding population, sorted by sub-region and country. In this case the species is limited as a breeder to the Balearic Islands (Spain), in the Western Mediterranean.

The Yelkouan shearwater keeps a wider distribution, with the bulk of birds breeding in Italy (mainly in Corsica), Greece and Malta, plus scattered colonies all across the Mediterranean, being scarcer in the south and east (Figure 2). Overall the breeding population is estimated at around 21,000-33,000 pairs (Bourgueois & Vidal 2008, Derhé 2012, García-Robles *et al*. 2016, Gaudard *in prep*.). It is also important to highlight the relevance of some congregation areas at sea, and particularly the flyway of the Bosphorus, where up to 90,000 individuals have been counted in a single day (Sahin 2016).

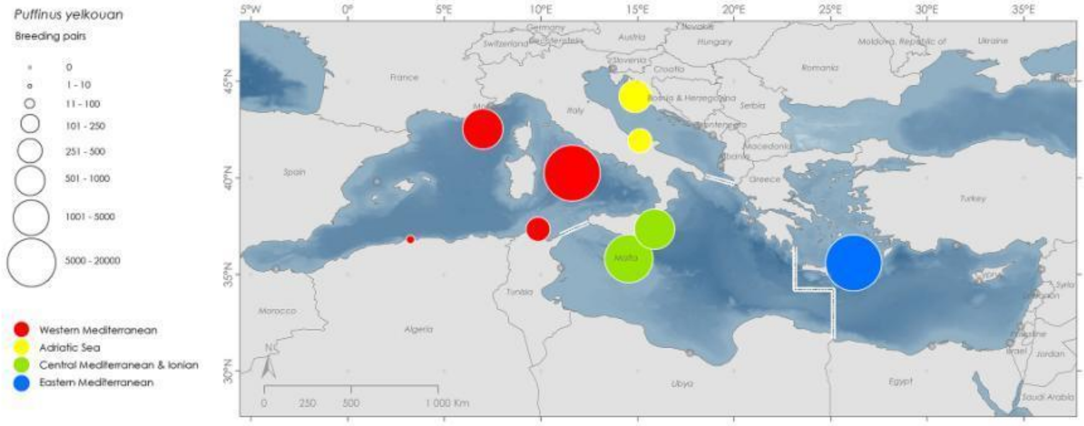


Figure 2. Distribution and relative size of the Yelkouan shearwater *Puffinus yelkouan* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

The information from the Bosphorus, coupled with the discovery of a few new breeding sites, and an inferred positive trend from colony estimates in Italy and Malta has led to infer a positive population trend in recent years, but this is most likely a misinterpretation of the available information, since: (1) the population of the Bosphorus has not increased, simply was not exhaustively counted before; (2) the discovery of new colonies should be related to increased effort of prospection, not to a real colonisation of new breeding sites; and (3) the perceived positive trend in some colonies is either limited to a few sites were rat control has permitted a real recovery at local level or the result of inferring trends out of unreliable figures. Demographic data suggest precisely the opposite, as explained under common indicator 5.

Mediterranean shag.

This species is easier to detect and count than the shearwaters, but maybe harder than the gulls and terns. Compared to the shearwaters, it is a diurnal species and it's easier to detect the nests. However, shags tend to breed in coastal cliffs, most often in inaccessible nests speared across long stretches of coastline, so counting them requires time and, most often, a boat to cover all areas. In comparison, gulls and terns tend (with exceptions) to nest in aggregated colonies in flat areas, easier to count.

According to the available information, the breeding population of this shag is spread across the Mediterranean basin, occupying the four sub-regions considered here, with the bulk of it in the north (Figure 3). The largest populations occur in the Balearic Islands and Corsica-

Sardinia, Croatia and the Aegean (both Greece and Turkey), with only a few small colonies in the north African coast, usually lacking reliable numerical data (Algeria, Tunisia, Lybia and Egypt). The global population of this subspecies endemic to the Mediterranean is estimated at below 10,000 breeding pairs, although proper prospection is lacking for some areas. Available data for Turkey and Cyprus is particularly old. Trends are unclear, with differences between countries, but either slight declines or stability seem the norm for those countries with most reliable data.

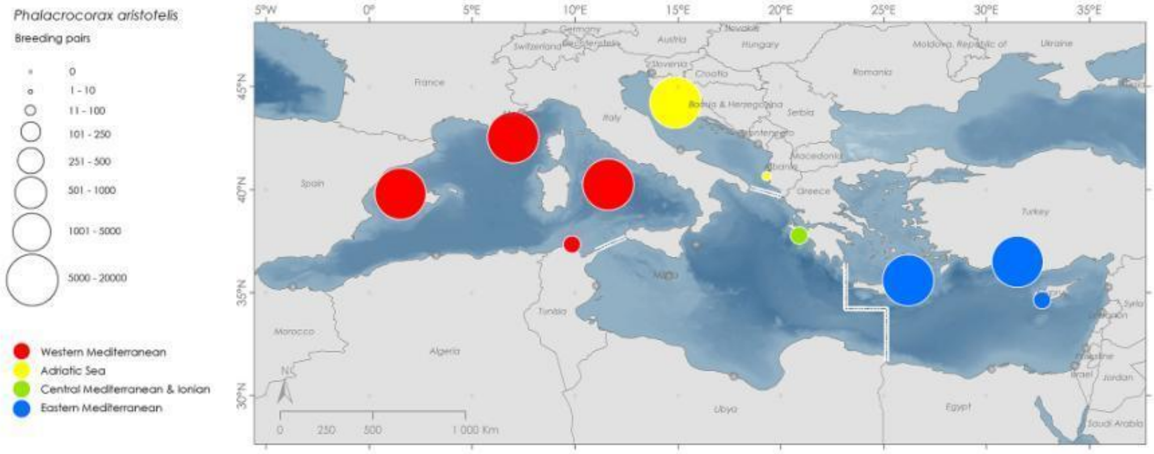


Figure 3. Distribution and relative size of the Mediterranean shag *Phalacrocorax aristotelis* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

Audouin's gull.

It is also a Mediterranean endemic species, spread across the basin with about 22,000 breeding pairs. The bulk of the population breeds in Spain, which concentrates over 90% of the total, although colonies extend eastwards to Turkey and southwards down to Morocco and Algeria (Figure 4). The species is adapted to changing the location of breeding colonies from year to year, if necessary (Oro, 2003), but overall the eastern population seems to have decreased significantly in recent years, particularly in Greece (where the estimates moved from 700-900 breeding pairs in 1995 to 350-500 in 2010, coupled with a decrease in breeding productivity; Saravia-Mullin *et al*. 2012) (see common indicator 5). On the other hand, the western population seems to be in better shape. However, recent declines of the major western colonies (such as the Ebro Delta), coupled with the colonisation of new breeding sites in areas of highly degraded habitat (e.g. ports), make it recommendable to keep alert to a potential decline in the near future. All in all, the recent uplisting of the species in the IUCN global list, from Near Threatened to Not Threatened might require further review in the near future.

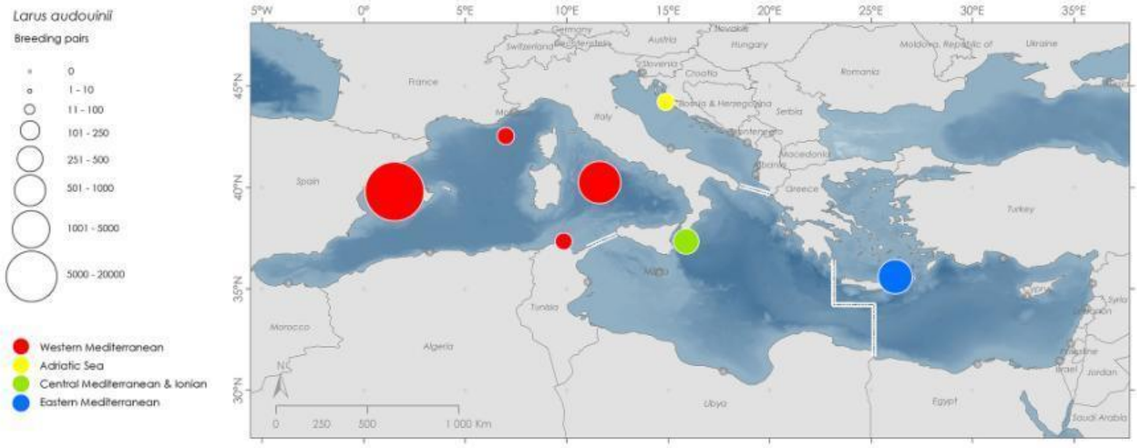


Figure 4. Distribution and relative size of Audouin's gull *Larus audouinii* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

Sandwich tern.

The bulk of the Mediterranean population is concentrated in the Western sub-region, where a few colonies sum up over 6000 breeding pairs between France and Spain. Italy also holds an important population in the Adriatic Sea, with about 800 breeding pairs, and Greece holds smaller colonies in the Central and Eastern sub-regions (Figure 5).

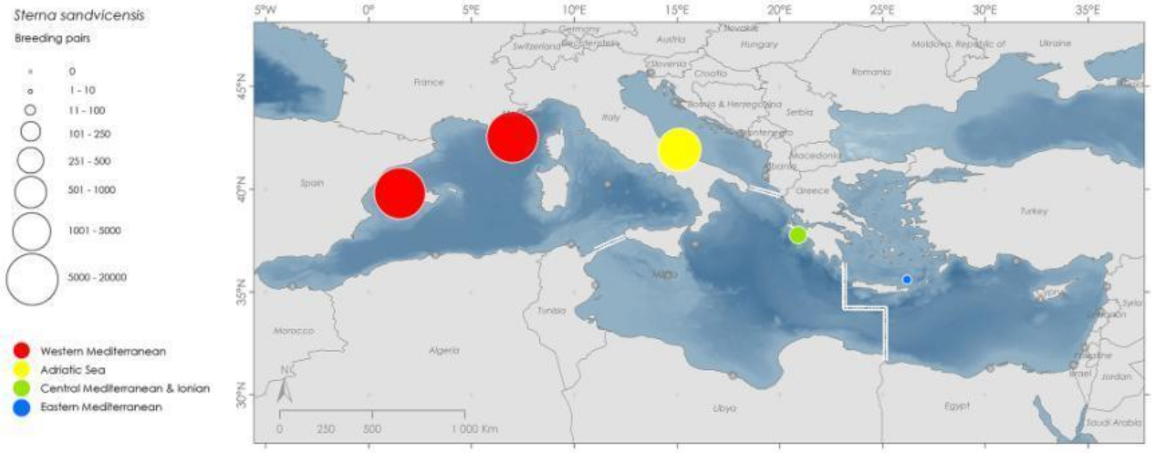


Figure 5. Distribution and relative size of Sandwich tern *Sterna sandvicensis* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

Little tern.

This is a widespread species across the region, breeding in wetlands and beaches in the four sub-regions considered (Figure 6). Numbers are lacking for Morocco, Libya and the easternmost countries. Turkey populations appear to be the largest ones, but the available information is poor, with 5,000-8,000 breeding pairs estimated (BirdLife International 2017b). Population trends vary between countries, with no clear trend at regional level.

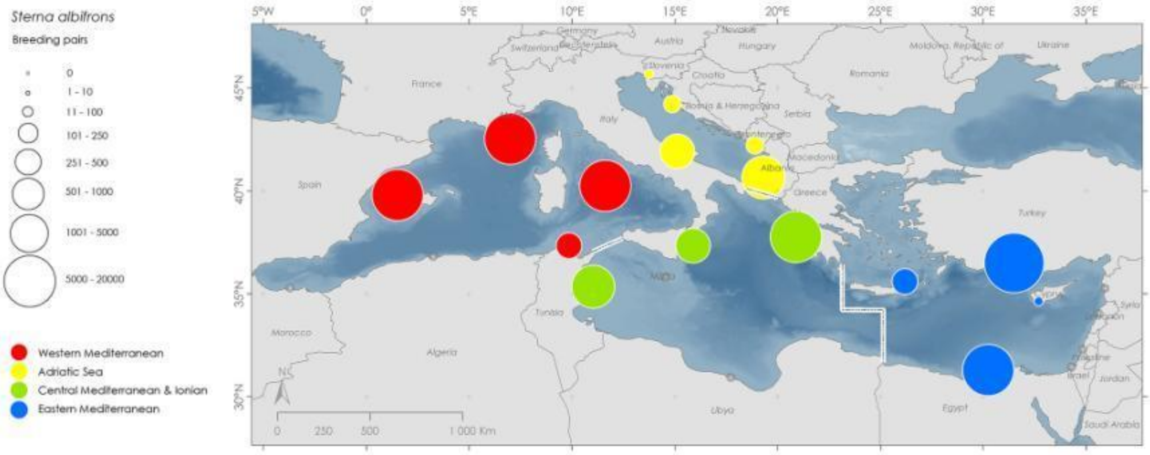


Figure 6. Distribution and relative size of the little tern *Sternula albifrons* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

Gull-billed tern.

The species is widespread across the whole Mediterranean, occupying the four sub-regions considered (Figure 7) and totalling over 4,000 breeding pairs. It is important to recall that most of the population inhabits in wetlands and makes little use of the sea.

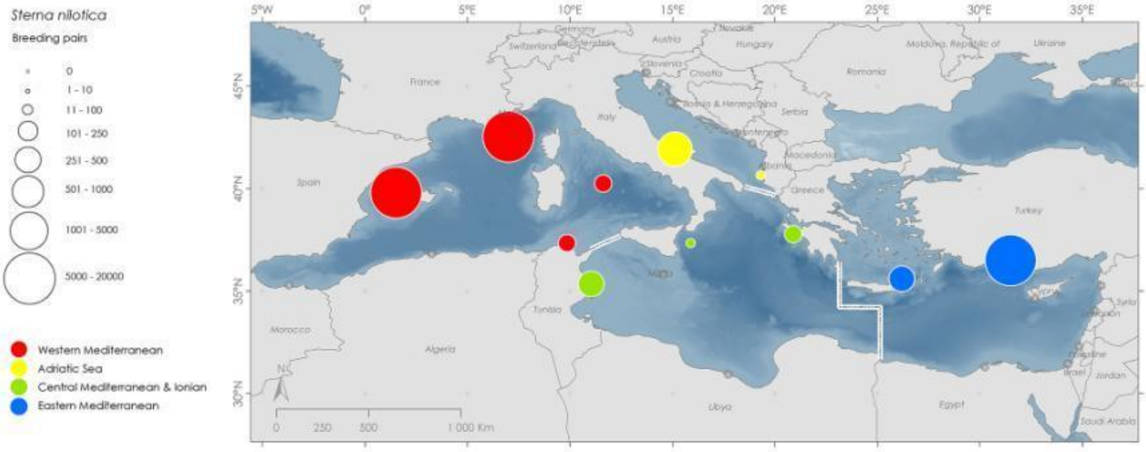


Figure 7. Distribution and relative size of the gull-billed tern *Sterna nilotica* breeding population, sorted by sub-region (each colour corresponds to a given sub-region, see map legend) and country.

CONCLUSIONS

Conclusions (brief)

The overall pattern of seabird abundance in the Mediterranean region is consistent with the results of common indicator 3 (distribution): seabirds tend to be more abundant in the north and west of the Mediterranean basin. This is particularly so in the case of the most marine species (shearwaters, Mediterranean shag and Audouin’s gull). As in the case of the distribution patterns, it remains to elucidate to which extent this pattern, that makes sense in terms of productivity and maybe also of suitable breeding habitat availability, is not confounded by prospection effort/data quality.

Conclusions (extended)

Obtaining reliable estimates of population size is harder than just confirming presence/absence (which is the basis for assessing distribution patterns), so there are more gaps regarding this common indicator. Information for some countries and species is old and just repeated from one publication to another, so it is important to break with this tradition and ensure that the different countries start implementing proper monitoring programmes. Information will be easier to collect and more reliable for the diurnal species breeding in open habitats, such as Audouin’s gull and the terns, whereas for the most “secretive” species (shearwaters) it might be important to rely on demographic studies of representative colonies to properly assess population trends (see common indicator 5).

Key messages

- Patterns of abundance roughly match those of distribution for seabirds, with a southeast to northwest increase.
- Information is patchy, often old and subject to potentially high biases, particularly in the case of the shearwaters. Establishing population trends for the latter is complicated without censuses.

Knowledge gaps

- The geographic gaps are similar to those described for Common Indicator 3.
- For many eastern and southern countries, as well as some Adriatic countries, the information on seabird breeding populations is patchy or completely lacking. Particularly little information is available for Algeria, Libya, Egypt, Israel, Lebanon, Syria, Cyprus and Turkey, as well as Montenegro, Bosnia-Herzegovina and Albania.

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Ecological Objective 1 (EO1): Biodiversity

Note: The maps and illustrations are provisional

EO1: Common Indicator 5. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 5 (CI5): Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals)
Indicator Assessment Factsheet Code	EO1CI5

RATIONALE/METHODS

Background (short)

The objective of this indicator is to focus on the population demographic characteristics of marine mammals within the Mediterranean waters. Demographic characteristics of a given population may be used to assess its conservation status by analysing demographic parameters as the age structure, age at sexual maturity, sex ratio and rates of birth (fecundity) and of death (mortality). These data are particularly difficult to obtain for marine mammals, thus relying on demographic models, all of which make assumptions that may be violated in practice.

Background (extended)

The populations of long-lived and slow reproducing cetaceans are among the most critical conservation units; a demographic approach can be therefore very useful for their management and conservation.

While some demographic studies have been conducted using industrial whaling data on Northeast Atlantic populations, little is known about the demography of their counterparts in the Mediterranean, where industrial whaling has never occurred.

Policy Context and Targets

Since 1985, the Mediterranean monk seal was recognised within the framework of the Barcelona Convention as a species to be protected as a matter of priority. In that year, during their fourth ordinary meeting, the Contracting Parties adopted a declaration, referred to as the Genoa Declaration, which included, amongst the priority targets to be achieved in the decade 1986-1995, the "protection of the endangered marine species" with a specific reference to the monk seal. Following the Genoa Declaration, an Action Plan for the Management of the Mediterranean Monk Seal (*Monachus monachus*) was adopted by the Barcelona Convention's Contracting Parties (UNEP-MAP-RAC/SPA & IUCN 1988, UNEP-MAP-RAC/SPA 2003). The main aims of the Barcelona Convention's Action Plan for the Management of the Mediterranean Monk Seal are: i) to reduce adult mortality; ii) to promote the establishment of a network of marine reserves; iii) to encourage research, data collection, and rehabilitation programmes; iv) to implement information programmes targeting fishing communities and various other stakeholders; and v) to provide a framework for the coordination, reviewand financing of relevant activities.

Aware of the scientific progress achieved, a Regional Strategy for the Conservation of Monk Seals in the Mediterranean (2014-2019) was adopted by the 18th Meeting of the Contracting Parties to the Barcelona Convention, that presents a new vision, with associated goals and targets that are SMART.

The Mediterranean monk seal is listed under the Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BD Protocol) of the Barcelona Convention. It has been classified as "Critically Endangered" by the International Union for the Conservation of Nature (IUCN; Karamanlidis and Dendrinos 2015) and is legally protected throughout its range via regional, national and international legislation, including the Convention on the Conservation of Migratory Species of Wild Animals, Convention on the Conservation of European Wildlife and Natural Habitats, Convention on Biological Diversity, and Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Additionally, the European Union's Habitats Directive (92/43/EEC) lists the Mediterranean monk seal in the Directive's Annexes II and IV as a species of Community interest whose conservation requires the creation of Special Areas of Conservation (SAC).

The Mediterranean cetaceans' populations are protected under the framework of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area), under the auspices of the UNEP Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS). The Pelagos Sanctuary is a large marine protected area, established by France, Italy and Monaco in the Corso-Ligurian-

Provençal Basin and the Tyrrhenian Sea, where most cetacean species are regularly observed and benefit from its conservation regime.

All cetacean species in the Mediterranean Sea are also protected under the Annex II of the SPA-BD Protocol of the Barcelona Convention, under the Appendix I of the Bern Convention, under the Annex II of the Washington Convention (CITES), under the Appendix II of the Bonn Convention (CMS) and under the Annex IV of the EU Habitats Directive.

In 2016, the 19th Meeting of the Contracting Parties to the Barcelona Convention adopted the updated Action Plan for the Conservation of Cetaceans in the Mediterranean Sea. This Action Plan, firstly adopted in 1991, was prepared using the information available about the cetacean populations and the threats hanging over them as known in 1991. However, aware that many important aspects of cetacean biology, behaviour, range and habitats in the Mediterranean were poorly known, the list of "Additional Points for the Implementation of the Action Plan" (Appendix to the Action Plan) has been amended in 2015 in collaboration with the ACCOBAMS secretariat.

The main objective of this Action Plan is to promote the protection and the conservation of cetacean habitats including feeding, breeding and calving grounds, as well as the recovery of cetacean populations in the Mediterranean Sea Area.

The short-beaked common dolphin, the sperm whale and the Cuvier's beaked whale and the monk seal are also listed under the Appendix I of the Bonn Convention (CMS). The common bottle dolphin, the harbor porpoise and the monk seal are also listed under the Annex II of the EU Habitats Directive.

Assessment methods

Monitoring effort should be directed to collect long-term data series covering the various life stages of the selected species. This would involve the participation of several teams using standard methodologies and covering sites of particular importance for the key life stages of the target species.

The preliminary classical tools for demographic analyses are life tables, accounting for the birth rates and probabilities of death for each vital stage or age class in the population. A life table can be set out in different ways:

1) following an initial age class (i.e. cohort) from birth to the death of the last individual; this approach allows to set out a cohort life table and is generally applied on sessile and short-lived populations;
2) counting population individuals grouped by age or by stages in a given time period; this approach allows to obtain a static life table, that is appropriate with long-lived or mobile species;
3) analysing the age or stage distribution of individuals at death; this approach allows to develop a mortality table, using carcasses from stranding data.

Photo-identification is one of the most powerful techniques to investigate cetacean populations. Information on group composition, area distribution, inter-individual behavior and short and long-term movement patterns can be obtained by the recognition of individual animals. Long-term datasets on photo-identified individuals can provide information on basic life-history traits, such as age at sexual maturity, calving interval, reproductive and total life span. Nevertheless, estimating age and length from free-ranging individuals may be rather difficult in practice: imprecise data will trickle down in model outputs and yield imprecise demographic parameter estimates. Long-term data sets on known individuals through photo-identification may overcome some of the potential biases.

RESULTS

Fin whale - Demographic models - commonly used in animal and plant populations - have been applied to marine mammals and cetaceans only in the recent years. Usually, two different approaches are used when dealing with demographic studies, based on static or cohort life-tables. A third approach refers to the use of mortality tables and provides detailed information about size/age and sex of dead individuals. This approach, based on stranding data, has for the first time been applied to cetaceans in the Mediterranean Sea, developing a demographic model for the Mediterranean fin whale population based on a life-history table (mortality table) using stranding records (Arrigoni et al., 2011). Dealing with stranded data implies several assumptions; the main one being that stranding data represent a faithful description of the real mortality by different life stages. This assumption, however, is true only if the probability of stranding is equal in all life stages.

This preliminary study described the structure of the Mediterranean sub-population by analyzing stranding records from the period 1986–2007, showing a strong impact, natural and anthropogenic, on calves and immature animals. These results, while confirm a common pattern to several mammals – characterized by high mortality in the youngest age classes - may prevent reaching sexual maturity, thus severely impacting the species at the population level. Proper conservation plans should therefore consider the discovery of breeding grounds, where calves may benefit from greater protection, to increase survival rates. Similarly, appropriate naval traffic regulations, aimed at reducing mortality rates from ship collisions, could enhance the survival of mature females and calves. In addition, mitigating other sources of mortality and stress, such as chemical and acoustic pollution, whale-watching activities and habitat loss and degradation, could further improve the population’s chances of survival.

Common bottlenose dolphin - The only Mediterranean area with quantitative historical information that can be used to infer population trends over time scales of more than a couple of decades is the northern Adriatic Sea. There, bottlenose dolphin numbers likely declined by at least 50% in the second half of the 20th century, largely as a consequence of deliberate killing initially, followed by habitat degradation and overfishing of prey species. For some other parts of the northern Mediterranean, e.g. Italy and southern France, the available information is less precise but suggests similar trends. In an area off southern Spain where the species has been studied intensively, abundance estimates have shown variability but no trend since the early 1990s.

Since there are no historical data on the density and abundance of bottlenose dolphins in the Pelagos Sanctuary, it is not possible to infer possible increase or decrease over time. The Groupe d’Etudes des Cétacés de Méditerranée has estimated – through direct counting and photo-identification - around 198–242 bottlenose dolphins around the island of Corsica in 2000, and 130–173 in 2003. These estimates appear to be lower than those assessed through mark recapture analysis in the same area in 2006, but any inference on potential trends is purely speculative, as a different approach has been used to for these estimated and this may lead to significant biases.

CONCLUSIONS

Conclusions (brief)

Available data on demography for Mediterranean marine mammals are rather scarce and fragmented and at present it is rather difficult to provide strong and robust evidence on baselines and changes over time in demographic parameters.

Conclusions (extended)

Data are available for localized regions only, where more effort has been devoted over the years allowing to estimate survival rates for specific species and time intervals.

Demographic studies can supply useful tools to the management and the conservation of threatened and overexploited species. Population models, based on life-history tables and transition matrices, allow to assess population performance, to project population trends overtime and thus to foster the conservation of the studied populations, suggesting specific measures for their protection.

Key messages

- Systematic and long-term photo-identification programs, jointly to the use of appropriate instruments to measure observed animals, would be essential tools to supply basic knowledge on population structure needed for conservation plans.

Knowledge gaps

- There is a strong need for systematic monitoring programmes over time, to collect time series and allow the assessment of trends over time and space.
- Monitoring programmes should be repeated at regular intervals, ideally every year for photo-identification using a risk-based approach and following international regulations (e.g.: Habitat and Marine Strategy Directives, Ecosystem Approach).

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Ecological Objective 1 (EO1): Biodiversity

Note: The maps and illustrations are provisional

EO1: Common Indicator 5. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine reptiles)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 5 (CI5): Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine reptiles)
Indicator Assessment Factsheet Code	EO1CI5

RATIONALE/METHODS

Background (short)

This assessment presents a brief overview of demographical parameters that are used to monitor loggerhead and green sea turtles at breeding, foraging and wintering grounds in the Mediterranean, based on published data, to determine what knowledge gaps need to be filled to realise the objective of this indicator. Demographic information helps to identify the stage(s) in the life cycle that affect(s) most population growth, and may be applied to (1) quantify the effectiveness of conservation measures or extent of exploitation (e.g. fisheries management), (2) understand the evolution of life history traits and (3) indicate fitness with respect to the surrounding environment. For sea turtle populations, some measures of demography are well documented, such as nest and/or female numbers (see Indicator 2), from which population trends are currently applied to infer population growth (or recovery) and, hence, threat status. Yet, without information about the number of juveniles recruiting into the population (e.g. Dutton et al. 2005; Stokes et al. 2014), or reliable estimates of mortality rates of both juveniles and adults, it is very difficult to predict future trends.

Background (extended)

Effective conservation planning requires reliable data on wildlife population dynamics or demography (e.g. population size and growth, recruitment and mortality rates, reproductive success and longevity) to guide management effectively (Dulvy et al. 2003; Crick 2004). However, it is not possible to obtain such data for many species, especially in the marine environment, limiting our ability to infer and mitigate actual risks through targeted management. Yet, demographic information helps to identify the stage(s) in the life cycle that affect(s) most population growth, and may be applied to (1) quantify the effectiveness of conservation measures or extent of exploitation (e.g. fisheries management), (2) understand the evolution of life history traits and (3) indicate fitness with respect to the surrounding environment.

For sea turtle populations, some measures of demography are well documented, such as nest and/or female numbers (see Indicator 2), from which population trends are currently applied to infer population growth (or recovery) and, hence, threat status. Yet, without information about the number of juveniles recruiting into the population (e.g. Dutton et al. 2005; Stokes et al. 2014), or reliable estimates of mortality rates of both juveniles and adults, it is very difficult to predict future trends. For instance, factors impacting turtle population dynamics in the coming decades will not be detected from nest counts for another 30 to 50 years (Scott et al. 2011), because this is the generation time of this group and nest counts cannot predict how many juveniles are recruiting into the populations until they begin nesting themselves.

Another parameter that is well established is the emergence success rate of hatchlings from the nests, along with offspring sex ratios at hatching. Globally, highly female-biased offspring sex ratios have been predicted (Witt et al. 2010; Hays et al. 2014). This high female bias is of concern because sea turtles exhibit temperature dependent sex determination, with the warming climate ultimately leading to even more biased female production (Poloczanska et al., 2009; Saba et al., 2012; Katselidis et al. 2012). Thus, it is essential to determine how the offspring sex ratio transforms into the adult sex ratio, to determine the minimum number of males needed to keep a population viable and genetically healthy, which are not necessarily the same. Because males tend to breed more frequently than females (i.e. every 1-2 years versus 2 or more years by females; Casale et al. 2013; Hays et al. 2014), fewer males might be needed in the population to mate with all females. However, biased sex ratios can induce deleterious genetic effects within populations with a decline in the effective population size and increasing the odds of inbreeding and random genetic drift (Bowen & Karl 2007; Girondot et al. 2004; Mitchell et al. 2010). However, most sea turtle populations exhibit high multiple paternity (i.e. the eggs of individual females are fathered by multiple males; for review see Lee et al. in submission). This behaviour is considered to be a strategy to enhance genetic diversity; thus, if male numbers further declined, this could have deleterious effects on the population (Girondot et al. 2004). Furthermore, differences in survival between the sexes might occur in different age classes (Sprogis et al. 2016); thus, it is essential to quantify sex ratios and sex-specific mortality across the different size/age classes. Strandings provide a useful source of information on the causes of mortality, but do not necessarily reflect the actual numbers of animals that are dying (Epperly et al. 1996; Hart et al. 2006). Bycatch data have also been used to estimate mortality rates (for overview see, Casale 2011), which are predicted to be around 44000 turtles/year in the Mediterranean. However, these values need confirmation.

Consequently, these knowledge gaps hinder our ability to generate representative demographic models to provide accurate assessments of the conservation status of loggerhead and green turtles in the Mediterranean. Yet, such information is vital to implement the most appropriate measures to conserve sea turtles.

Key pressures and drivers.

Both the nesting and foraging areas of marine turtles are vulnerable to anthropogenic pressures in the Mediterranean Sea, including an increase in the exploitation of resources (including fisheries), use and degradation of habitats (including coastal development), pollution and climate change (UNEP/MAP/BLUE PLAN, 2009; Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). These issues might reduce the resilience of this group of species, negatively impacting the ability of populations to recover (e.g. Mazaris et al. 2009, 2014; Witt et al. 2011; Katselidis et al. 2012, 2013, 2014). The risk of extinction is particularly high in the Mediterranean because the breeding populations of both loggerhead and green turtles in this basin are demographically distinct to other global populations (Laurent et al., 1998; Encalada et al., 1998), and might not be replenished.

The main threats to the survival of loggerhead and green turtles in the Mediterranean have been identified as incidental catch in fishing gear, collision with boats, and intentional killing (Casale & Margaritoulis 2010). Casale (2011) estimated that there are more than 132,000 incidental captures per year in the Mediterranean, of which more than 44,000 are predicted to be fatal, although very little is known about post-release mortality (Álvarez de Quevedo et al. 2013). Wallace et al. (2010, 2011) grouped all species of sea turtles globally into regional management units (RMUs), which are geographically distinct population segments, to determine the population status and threat level. These regional population units are used to assimilate biogeographical information (i.e. genetics, distribution, movement, demography) of sea turtle nesting sites, providing a spatial basis for assessing management challenges. A total of 58 RMUs were originally delineated for the seven sea turtle species. The Mediterranean contains 2 RMUs for loggerheads and 1 RMU for green turtles. These analyses showed that the Mediterranean has the highest average threats score out of all ocean basins, particularly for marine turtle bycatch (Wallace et al. 2011). However, compared to all RMUs globally, the Mediterranean also has the lowest average risk score (Wallace et al. 2011).

Other key threats to sea turtles in the Mediterranean include the destruction of nesting habitat for tourism and agriculture, beach erosion and pollution, direct exploitation, nest predation and climate change (Casale & Margaritoulis 2010; Mazaris et al. 2014; Katselidis et al. 2012, 2013, 2014). Coll et al. (2011) also identified critical areas of interaction between high biodiversity and threats for marine wildlife in the Mediterranean. Within this analysis, the authors delineated high risk areas to both species, with critical areas extending along most coasts, except the south to east coastline (from Tunisia to Turkey).

Policy context and Targets

The Parties to the Barcelona Convention included among their priority targets for the period 1985-1995 the protection of Mediterranean marine turtles (Genoa Declaration, September 1985). With this purpose, the Action Plan for the Conservation of Marine Turtles in the Mediterranean Sea was adopted by the Contracting Parties to the Barcelona Convention in 1989. Since that time, this Action Plan was revised three times: i) in 1999, when the updated version of the Action Plan was adopted at the 11th Meeting of the Contracting Parties to the

Barcelona Convention; ii) in 2007 when a new update of the Action Plan was approved by the 15th COPs and iii) the last updated timetable for the period 2014-2019 was reviewed and adopted by the 18th COP .

The objective of this Action Plan is the recovery of the populations of *Caretta caretta* and *Chelonia mydas* in the Mediterranean (with priority accorded to *Chelonia mydas*, wherever appropriate) through: i) appropriate protection, conservation and management of marine turtle habitats, including nesting, feeding and wintering areas and key migration passages and ii) improvement of the scientific knowledge by research and monitoring.

Sea turtles are afforded additional legislative protection under a number of international conventions, including the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendices I and II of the Convention on Migratory Species (CMS), the Bern Convention (Council of Europe) and European Union regulation (Habitats Directive), several agreements and recommendations adopted by the Regional Fisheries Management Organizations (RFMOs) such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM).

Monitoring and assessing sea turtle populations, unveiling migratory patterns and identifying feeding areas, as well as faced threats, are fundamental to further design sound conservation strategies and policies. It will be ensured through the IMAP that includes three common indicators related to sea turtles within the Ecological Objective 1. This assessment will include information on marine reptile species that, at some point in their annual life cycle, are reliant on coastal and/or offshore marine areas. In this context, this indicator will allow a large-scale monitoring and assessment of sea turtles.

Assessment methods

This assessment presents a brief and general overview of the distributional range of two marine turtle species to identify existing knowledge and knowledge gaps for use in elaborating the national monitoring programmes for biodiversity. Published information by regional and national surveys and research projects were used to compile the review, but this overview does not present a comprehensive assessment of existing knowledge.

RESULTS

Results and Status, including trends (brief)

Knowledge about the various demographic parameters of sea turtles remains patchy throughout the Mediterranean, with detailed information being available at some sites and no information at other sites. To develop comprehensive models, knowledge about all aspects of demography across a range of representative populations of different sizes is required.

Results and Status, including trends (extended)

Loggerhead and green sea turtles.

For this indicator, both species have been combined as the same gaps exist for both. Specific details for green turtles on Cyprus are provided by Broderick et al. (2002) and Stokes et al. (2014), with published data lacking for most other sites in the Mediterranean.

Internesting intervals of adult females (breeding grounds): It is essential to quantify the internesting interval within and across years because this influences clutch frequency and will influence estimates of population size (see Indicator 2, Species distributional range). The nesting interval is regulated by sea temperature (Hays et al. 2002), being longer when the sea temperature is cooler. Ranges from 12 to over 20 days have been detected within and across nesting sites in the Mediterranean (see Demography Working Group 2015 and Casale & Margaritoulis 2010 for ranges across Mediterranean populations).

Remigration intervals of adult males and females (breeding grounds): Knowledge on remigration rates (breeding periodicity) of known females and how this changes with time (i.e. maturation of younger nesters or aging of older nesters) is essential as this will affect our ability to predict the total adult sex ratio of populations. Knowledge on female remigration intervals is again limited to Greece, Turkey and Cyprus. Females in Greece and Cyprus tend to have remigration intervals of approximately 2 years (Demography Working Group 2015 and Casale & Margaritoulis 2010), but can be 1-3, or more years (Schofield et al. 2009). For males, remigration intervals have only been documented for males on Zakynthos, which are primarily 1 year, but with some individuals that forage near Tunisia/Libya and the western basin returning every 2 years (Hays et al. 2014; Casale et al. 2013). To determine the total number of adults in the population, clear knowledge about remigration frequency is required.

Clutch frequency (breeding grounds): This parameter is difficult to quantify due to difficulty in detection rates. Clutch frequencies of 1.2-2.2 have been suggested for green and loggerhead turtles on Cyprus (Broderick et al. 2002). However, on Zakynthos, loggerhead turtles have mean clutch frequencies of 2-3 nests, with up to 5 occurring, based on satellite tracking studies (Zbinden et al. 2011; Schofield et al. 2013a). As this parameter is critical for inferring the numbers of females at breeding sites, as most estimates of females are estimated from nest counts divided by the assumed clutch frequency, it is essential to understand this parameter. Furthermore, clutch frequency will vary with internesting period; i.e. in warmer years, a female could lay more clutches due to shorter internesting periods and vice versa. Again, this information will influence population estimates.

Sex ratios of adult male and females (breeding grounds): Once information on clutch frequency and remigration interval is robust, then estimates of the numbers of females can be obtained. However, to quantify adult sex ratios at the breeding grounds and overall for the adult component of sea turtle populations, counts of males in the marine environment during breeding must be made. Thus, at present, knowledge about the number of males that frequent breeding areas is non-existent. Therefore, we do not know how many males are currently breeding with females or what the sex ratios are for adults. Only on Zakynthos has a prediction been made of 1:3.3 males to females based on in-water photo-id surveys of a portion of the breeding population (Schofield et al. 2009). Thus, efforts are needed to quantify the number of males (See indicator 2 for more on this issue) in order to understand adult sex ratios and their potential implications on the conservation and persistence of the species.

Offspring sex ratios at breeding sites, including incubation (breeding grounds): Estimated hatchling sex ratios exist for several nesting sites in Greece, Turkey and North Cyprus, as well as Tunisia (Hays et al. 2014) (Figure 1), with all being strongly female biased. For all the other nations, there are no published accounts of estimated sex ratios (see Demography Working Group 2015). It is possible to infer offspring sex ratio from sand temperatures and incubation duration (e.g. Godley et al. 2001; Katselidis et al. 2012), which is relatively straight forward. Incubation duration has been recorded in most countries (see Demography Working Group 2015 and Casale & Margaritoulis 2010 for details).

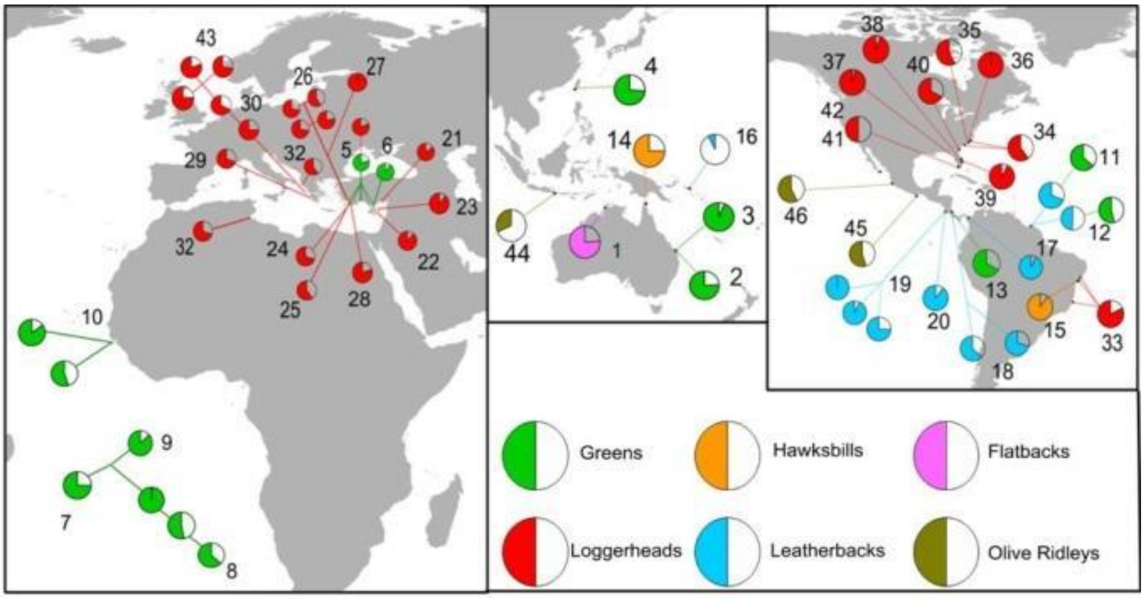

Figure 1: Offspring sex ratios globally, including the Mediterranean (extracted from Hays et al. 2014)

Breeding success of adult males and females (breeding grounds): Less is known regarding the breeding success of individual females and males. For females, breeding success should be measured generally and for individuals. General measures include the total number of female emergences versus successful nests. This information is generally collected by established beach-based monitoring programs in Greece, Turkey and North Cyprus. Furthermore, breeding success by females is reflected in fecundity (birth rates), i.e. the number of offspring an individual in a population produces. While information on emergence and hatching success is available for established beach-based monitoring programs in Greece, Turkey and North Cyprus, it is not linked to individual turtles in these programs. This is due to issues with tags falling off, knowledge about the successful production of offspring within and across years by individuals is not known, but could help towards indicating the fitness of individuals which could be used to infer the general health of the population.

With respect to males, just one study on multiple paternity has been conducted (Zbinden et al. 2007) on Zakynthos, showing higher than expected multiple paternity levels. Thus, some males might be more successful at mating with females than other males. Therefore, baseline data on the reproductive activity and success of individual males needs to be documented, again to ascertain their reproductive health and how this transforms to their contribution to the clutch (i.e. number of eggs represented by each male).

Hatchling success and emergence success (breeding grounds): Hatchling success (i.e. number of eggs that hatch; 60-80%) and hatchling emergence success (the number of hatchlings that make it out of the nest; 60-70%) has been documented for the major nesting countries of Greece, Turkey and Cyprus, but more information is required from the other countries (for more details see, Demography Working Group 2015 and Casale & Margaritoulis 2010).

Recruitment, mortality, longevity of breeding (breeding grounds): With the use of reliable tagging methods (i.e. use of 2 or more complementary techniques to ensure information on individuals is not lost; see Indicator 2), this information should be available for some nesting populations with long-term tagging programs (for example see, Dutton et al. 2005 and Stokes et al. 2014). At present recruitment is inferred by most tagging programs (i.e. in Greece, Turkey and Cyprus) from the absence of scars on flippers; however, this technique is not reliable. However, it is essential for existing and new programs to ensure continuous records of individual females, so that these key parameters can be assessed, which will help improve predictions of population recovery or decline.

Growth rates: A study of juvenile loggerheads sampled along the coast of Italy showed that growth rates differ between individuals of Atlantic and Mediterranean origin (Piovano et al. 2011). Casale et al. (2009, 2011) has assessed growth rates using skeletochronology and length-frequency analyses around Italian waters in the Adriatic. Studies of the growth rates of juveniles from different areas of the Mediterranean, however, are required, as these rates will vary depending on forage type. For instance, the size ranges of adult turtles tracked to the Adriatic, Ionian and Gulf of Gabes showed that those that migrated to the Adriatic were the largest, while those from the Ionian were intermediate in size and those from the Gulf of Gabes were the smallest (Schofield et al. 2013, supplementary literature); thus, the location of foraging sites likely influences the growth rates of juveniles. Because there is strong overlap in foraging site used by different populations, genetics analyses should be made in parallel to studies on growth rates. Genetic sampling is required to distinguish origin, with skeletochronology being the advised method to assess growth rates (Demography Working Group 2015); although, this can only be done on dead individuals at present. Studies of growth rate and age at first maturity of loggerhead sea turtles of Mediterranean origin are needed in the Adriatic Sea, the Aegean Sea, the Libyan Sea, the Levantine Sea, the Tyrrhenian Sea and the Balearic Sea (Demography Working Group 2015).

Sex ratios of juveniles and adults (developmental and foraging grounds): Estimates of juvenile and adult sex ratios at foraging grounds have been completed by only a few studies in the Mediterranean using capture-recapture or bycatch. Different adult sex ratios might be associated with different neritic areas; thus, estimates should be made at the level first, then at regional level. Generally balanced adult sex ratios have been documented for adults, ranging from 40-60% female bias, while 52-60% female bias has been documented for females (for overview see Casale et al. 2014). Studies on adults have been limited to the central Mediterranean, Italy, Greece (north-west section of Amvrakikos Gulf) and the southeast Tyrrhenian Sea to date (Casale et al. 2005, 2014; Rees et al. 2013). For juveniles, studies have been conducted at sites in the northwest Mediterranean, southwest Adriatic, north-east Adriatic and southeast Tyrrhenian (Casale et al. 1998, 2006; Maffucci et al. 2013). Of note, satellite tracking studies indicate that male loggerheads that breed on Zakynthos (Greece) forage along the entire Peloponnese mainland, whereas most females migrate at least 100 km away from the site (up to 1000 km) (Schofield et al. 2013b); thus, the Peloponnese might exhibit a strong male bias in terms of foraging habitat use. Furthermore, within the breeding area of Zakynthos, resident males occupied distinctly different foraging sites compared to breeding females (Schofield et al. 2013a), showing that sex specific differences might even occur on very small scales.

Therefore, existing values on sex ratios should be treated with caution. For instance, satellite tracking studies of turtles from Zakynthos (Greece) to Amvrakikos Gulf (Greece) (Zbinden et al. 2011; Schofield et al. 2013b) showed that males and females forage in all parts of the gulf, with females particularly using the southern and south-western areas. However, the study by Rees et al. (2013) was focused in a north-west section of the gulf, and so is not necessarily representative of the male:female ratios of this foraging ground. Thus, extensive surveys are required in most areas of the Mediterranean, with clarification on the area sampled related to the region and justification of its representativeness.

Physical parameters (breeding and foraging grounds): The carapace dimensions (curved [(CCL)] and straight [(SCL)] length and width [(CCW and SCW)]) tend to be measured in all programs that tag females on nesting beaches, as well as capture-recapture and bycatch studies of juveniles and adults in the marine environment. This information has shown that female loggerheads nesting in the Mediterranean are the smallest in the world, with those nesting on Cyprus being the smallest (Broderick and Godley 1996; Margaritoulis et al. 2003). However, variation in body size within populations has also been documented, and might be associated to foraging site use (Zbinden et al. 2011; Schofield et al. 2013b; Patel et al. 2015). For morphometric measurements across the different breeding sites see Casale & Margaritoulis (2010). Furthermore, capture-recapture studies of juvenile and adult turtles have shown that turtles in the Mediterranean mature at >70 cm CCL, respectively (Casale et al. 2005, 2013, Rees et al. 2013), with visual differentiation at <75-80 cm CCL (for smaller turtles, other techniques must be used to distinguish between males and females). However, White et al. (2013) found that in the Drini Bay population (Albania), tail elongation began at 60cm CCL. In Amvrakikos Gulf, which hosts loggerheads of similar demographic groups that also originate in Greek rookeries, tail elongation was considered to begin at 64.6 to 69.8cm CCL (Rees et al. 2013), with nesting females of 70 cm CCL regularly nest on beaches in Greece and Cyprus (Margaritoulis et al. 2003).

However, measures of biomass are less common, but are of importance. Furthermore, documenting the frequency of carapace injury to known individuals could provide an important means of inferring their exposure to boats. Indices of body fat status are rare (Heithaus et al. 2007). Furthermore, blood and tissue samples are only collected under certain conditions; thus, information on the actual health of individuals remains sparse. This information could be used for genetic analysis to determine the source population of individuals and stable isotope analyses to indicate general foraging areas used by the individuals.

Genetic parameters (breeding and foraging grounds): A large quantity of genetic information has been collected on sea turtles in the Mediterranean; however, information at specific foraging and breeding grounds is required. This information could be applied towards distinguishing the breeding site origin of mixed foraging and developmental stocks.

At present, genetic studies indicate the existence of six distinct loggerhead populations in the Mediterranean: Libya, Dalyan, Dalaman, Calabria, Western Greece and Crete and the Levant (central and eastern Turkey, Cyprus, Israel and Lebanon, and possibly Egypt) (Carreras et al. 2014; Saied et al. 2012; Yilmaz et al. 2012; Clusa et al. 2013; Demography Working Group 2015). In contrast, turtles nesting in Tunisia are not genetically distinct (Chaieb et al. 2010). No major genetic structuring has been detected for green turtles in the Mediterranean to date; however, as analyses evolve, updates may arise (Tikochinski et al. 2012).

Genetic analyses (e.g. mixed stock analysis and microsatellites) has shown the origin of turtles recorded at several Mediterranean foraging grounds (Maffucci et al. 2013; Giovannotti et al. 2010; Carreras et al. 2014; Yilmaz et al. 2012; Garofalo et al. 2013; Clusa et al. 2013). When combined with tracking datasets, these data reinforce the fact that turtles from different populations mix in the same foraging grounds (see Schofield et al. 2013b for overview; and details in Indicator 1).

However, at present it is difficult to assign individuals of unknown origin to distinct nesting populations using current genetic markers. Future studies need to build on this issue.

Furthermore, it is important to establish the genetic diversity within breeding populations, for both males and females, to evaluate health and potential changes in status. It is generally assumed that females and males return to breed at natal sites (Bowen et al. 2004). However, males have been shown to frequent multiple sites during the breeding period (Schofield et al. 2013; Casale et al. 2013). Moreover, genetic studies indicate high levels of multiple paternity on Zakynthos, which might be a mechanism to help enhance the genetic diversity of the population (Lee et al. in submission); although further examination of this phenomenon across different populations with different ratios of males and females and encounter rates (linked to how aggregated populations are) is needed.

Mortality including bycatch (breeding and foraging grounds): Several countries in the Mediterranean have stranding networks and rescue centres (MEDASSET 2016). Gaps exist in the Middle East and North Africa. Within this framework, genetic, blood and tissue samples are collected, as well as information on animal morphometrics, including skeletochronology, and cause of trauma. However, strandings represent a minimum estimate of mortality because carcasses decompose rapidly while drifting in currents and eddies and eventually sink (Epperly et al., 1996; Hart et al. 2006); consequently, many dead turtles probably never reach shore. By-catch information from different regions of the Mediterranean has been assimilated (for details see Demography Working Group 2015). Casale (2011) suggesting more than 132,000 incidental captures per year in the Mediterranean, of which more than 44,000 are predicted to be fatal; however, current knowledge on post-release mortality is restricted and needs further quantification (Álvarez de Quevedo et al. 2013). Of note, at least, 50% of small scale fisheries fleets are concentrated in the Aegean Sea, Gulf of Gabès, Adriatic and Eastern Ionian Sea, which represent the four major foraging grounds for loggerhead and green turtles in the region (for details see Demography Working Group 2015).

CONCLUSIONS

At present our knowledge on sea turtle demography is patchy at best for each component, with certain information being more widely available than other information. To understand the demography of loggerhead and green turtle populations in the Mediterranean, greater effort needs to be placed on filling existing gaps. Only then can we predict with any certainty the future viability of sea turtle populations in the Mediterranean.

Key messages

- This general overview, indicates that at present our knowledge on sea turtle demography is patchy at best for each component and that effort needs to be placed on filling existing gaps in order to predict with any certainty the future viability of sea turtle populations in the Mediterranean.

Knowledge gaps

- Knowledge on the sex ratios within different components (breeding, foraging, wintering, developmental habitats), age classes and overall within and across populations.
- Knowledge about recruitment and mortality into different components of the population
- Knowledge about the physical and genetic health status of these groups.
- Vulnerability/resilience of these populations/sub-populations in relation to physical pressures;
- Analysis of pressure/impact relationships for populations/sub-populations and definition of qualitative GES;
- Identification of extent (area) baselines for each population/subpopulation and the habitats they encompass;
- Monitor and assess the impacts of climate change on offspring sex ratios.

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Ecological Objective 1 (EO1): Biodiversity

EO1: Common Indicator 5. Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to Seabirds)

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO1: Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
IMAP Common Indicator	Common Indicator 5 (CI5): Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to seabirds)
Indicator Assessment Factsheet Code	EO1CI5

RATIONALE/METHODS

Background (short)

The Mediterranean Sea is considered an important habitat for seabirds, including particularly the Critically Endangered Balearic shearwater (*Puffinus mauretanicus*), the endemic Yelkouan shearwater (*Puffinus yelkouan*) and the little tern (*Sterna alibifrons*). In addition to these species, a number of other seabird species are listed in the Annexes of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention (SPA-BD Protocol).

The Mediterranean region is a region of intensive human use. Many of the seabird species face threats on land and at sea. On land this includes high pressure from coastal developments affecting availability of breeding and wintering habitat, and predation at colonies from native and invasive species. At sea the main threats include interaction with fisheries (bycatch) and the lack of prey caused by depletion of fish stocks, and from acute and chronic pollution (oil spills, chemical discharges, etc.) and disturbance from maritime traffic (Tarzia et al., 2015; Yesou et al., 2016).

An indepth knowledge of the demography of seabirds is important to understand their population dynamics and trends, and to put any threat in context. This is particularly relevant for the most “secretive species”, particularly the shearwaters, for which reliable information on population size is most often either unavailable or unreliable, and the only way to assess trends is through demographic studies. These are also species with particularly low flexibility on breeding performance, as they only lay one egg (compared to the shag, gulls and terns, which usually lay 2-3+ eggs), and are highly philopatric (so they cannot change their breeding location from one year to the other). Therefore, they have limited buffer mechanisms to face adverse conditions, particularly to compensate increases of mortality, which is their most sensitive demographic parameter. On the other hand, their large foraging ranges do provide some buffering ability to react against local food shortages, as they can search a huge area in search of food.

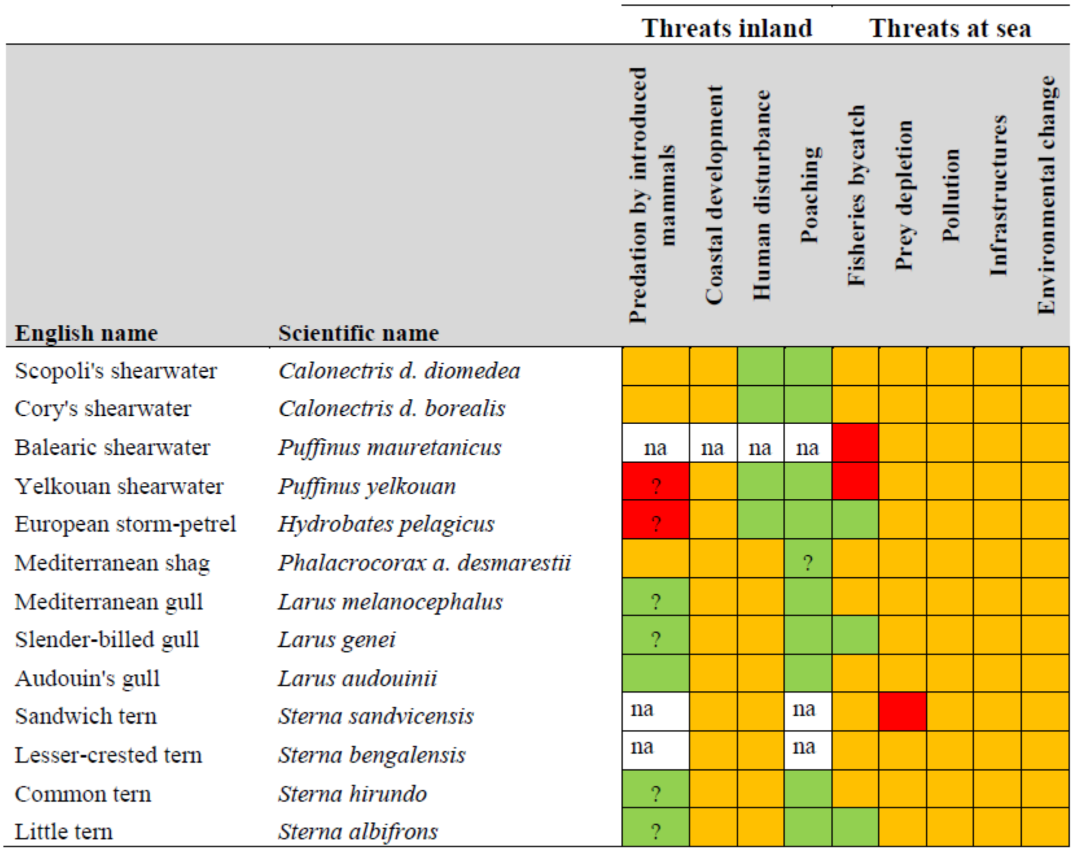
Background (extended)

Seabirds as a group occur in all seas and oceans worldwide, and their role as potential indicators of marine conditions is widely acknowledged. Many studies use aspects of seabird biology and ecology, especially productivity and population trends, to infer and/or correlate with aspects of the marine environment, particularly food availability.

Nevertheless, despite the importance of seabirds as indicators of many aspects of the functioning of marine systems, the most important current challenge is to ensure the survival and improve the status of the many seabird species which are already globally threatened with extinction and to maintain the remainder in favourable conservation status.

Indeed, seabirds are among the most threatened bird groups globally. They are all endangered by a number of threats, including contamination by oil pollutants, direct and indirect depletion of food resources, non-sustainable forms of tourism, disturbance, direct persecution includingillegal hunting and the use of poison, mortalit y from bycatch, wind farms, loss of habitats, degradation of habitat, particularly wetlands and small, islands of high biological importance, introduction of and predation by alien species, climate change (Table 1).

Table 1: Threats to seabirds



		Threats inland				Threats at sea				
English name	**Scientific name**	**Predation by introduced mammals**	**Coastal development**	**Human disturbance**	**Poaching**	**Fisheries bycatch**	**Prey depletion**	**Pollution**	**Infrastructures**	**Environmental change**
Scopoli's shearwater	*Calonectris d. diomedea*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Cory's shearwater	*Calonectris d. borealis*	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧	🟧
Balearic shearwater	*Puffinus mauretanicus*	na	na	na	na	🟥	🟧	🟧	🟧	🟧
Yelkouan shearwater	*Puffinus yelkouan*	🟥 ?	🟧	🟩	🟩	🟥	🟧	🟧	🟧	🟧
European storm-petrel	*Hydrobates pelagicus*	🟥 ?	🟧	🟩	🟩	🟩	🟧	🟧	🟧	🟧
Mediterranean shag	*Phalacrocorax a. desmarestii*	🟧	🟧	🟧	🟩 ?	🟧	🟧	🟧	🟧	🟧
Mediterranean gull	*Larus melanocephalus*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Slender-billed gull	*Larus genei*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧
Audouin's gull	*Larus audouinii*	🟩	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Sandwich tern	*Sterna sandvicensis*	na	🟧	🟧	na	🟧	🟥	🟧	🟧	🟧
Lesser-crested tern	*Sterna bengalensis*	na	🟧	🟧	na	🟧	🟧	🟧	🟧	🟧
Common tern	*Sterna hirundo*	🟩 ?	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟧
Little tern	*Sterna albifrons*	🟩 ?	🟧	🟧	🟩	🟩	🟧	🟧	🟧	🟧

Policy Context and Targets

Given their imperilled conservation status, many seabirds have been highlighted for special conservation status and action under a range of international, regional and national agreements and mechanisms. However, because seabirds are highly mobile and migrate, they are exposed to vagaries of differing levels of protection across international (and non-governmental) regions.

The Barcelona Convention and its SPA-BD Protocol are the regulatory instruments of particular importance for seabirds protection in the Mediterranean, along with related policy frameworks and tools.

At the 12th COP of the Barcelona Convention, the Contracting Parties has requested SPA/RAC to draw up an Action Plan for the conservation of bird species listed in Annex II to the SPA-BD Protocol. After extensive consultation among international institutions, NGOs and experts throughout the Mediterranean, the first version was presented and adopted by the Contracting Parties to the Barcelona Convention at the 13th COP held in Catania, 2003. The development of this Action Plan followed various initiatives on the conservation of biological diversity, particularly with respect to birds and their important sites and habitats. Its main purpose is to maintain and/or restore the population levels of bird species listed in Annex II of the SPA-BD Protocol to a favourable conservation status and to ensure their long-term conservation.

The Implementation timetable of this Action Plan was updated for the first time in 2007, considering the results of the first Mediterranean Symposium held in 2005 and adopted during the 15th COP of the Barcelana convention held in Almeria in 2008.

The second update related to the period 2014-2019 was adopted by the 18th COP of the Barcelona Convention in 2013.

Moreover, Specific Action Plans for the 25 bird species listed in the Annex II of the SPA-BD Protocol are developed within the Barcelona Convention that should be implemented in all Mediterranean states where the species breed, winter or occur on migration.

Amongst other regulatory instruments, it is aslo relavnt to quote the EU Birds Directive (all seabirds in the EU), the Convention on the Conservation of Migratory Species of Wild Animals (CMS), the Convention on the conservation of European wildlife and natural habitats (Bern Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In addition to the above instruments, the Regional Fisheries Management Organisations (RFMOs) have also begun the adoption of the strategies that address incidental seabird bycatch. Level of regulation varies across RFMOs but includes combinations of the use of one or more bycatch mitigation measures in certain areas, data collection through observer programmes and use of monitoring, surveillance and compliance measures.

Assessment methods

The basic methodology to gain information on seabird demography consists on the regular monitoring of nests at their colonies, coupled with ringing schemes and capture-recapture studies. In this case it is easier to monitor shearwaters, as they often breed in well-defined nests where it is easy to capture and ring both the adults and their chick, and adults are highly faithful to the same colony (and usually also the same nest) year after year. This allows to easily get information on breeding success (as the chicks remain at the nest until fledging) and, after a few years, other demographic parameters such as adult survival, age of recruitment, rate of sabbatical years, etc. These demographic parameters can be then used to model population trends, and to identify the most sensitive parameters influencing such trends. A similar approach may be used with shags, although nests tend to be even less accessible, and adults are difficult to capture. For a proper monitoring scheme, at least 2 visits per year should be conducted (incubation + chick-rearing periods) to ensure the assessment of breeding success, the ringing of chicks and the ringing/control of adults.

The gulls and terns present more difficulties, as they tend to nest in densely aggregated colonies and it is difficult to associate any nest with their adults and chicks. Moreover, adult birds can change their breeding location from one year to another. However, with some dedicated effort it is possible to assess breeding success (e.g. by fencing some areas and counting how many chicks fledge relative to the number of nests), and ringing schemes may allow to estimate other demographic parameters, particularly when using darvic rings that can be read at some distance.

Information from colonies may be complemented with data from other sources, particularly from ringed birds: sightings outside the colony, corpses collected by recovery centers (providing information on causes of mortality), bycatch information, etc.

RESULTS

Results and Status, including trends (brief)

Information on seabird demographic parameters is scarce and very sparse in the Mediterranean region. For most species, there is some available information on productivity (breeding success and average number of chicks fledged per pair), whereas there is far less information for demographic parameters that require quality data and elaborate analysis (e.g. survival). Results provided here focus on the two shearwater species, as this type of information is essential to understand their population dynamics. In both cases adult survival is the most sensitive parameter, and current estimates are well below the expected rates. Ongoing threats causing adult mortality, such as predation by introduced species and fishing bycatch, thus deserve urgent attention to ensure the long-term viability of these populations. Of the remaining species, the best studied case is that of Audouin's gull, where the regular census of most colonies and the establishment of a long-term colour-ringing scheme in the region have facilitate high quality studies, particularly in the western sub-region.

Results and Status, including trends (extended)

Balearic shearwater.

This species poses a good example of how demographic data can help understanding the population dynamics of certain seabird species with more reliability than census data. Indeed, as nests are difficult to locate, and many of them remain inaccessible, estimating the breeding population of such a species requires the use of indirect methods, often subject to high potential biases, such as raft counts at sea, habitat mapping and vocalisation rates at the colonies. Using a combination of these approaches, the estimate for the breeding population of Balearic shearwaters has ranged from about 1,700 to 4,500 breeding pairs in the last 30 years, with no clear trends (Ruiz & Martí 2004, Arcos 2011). Moreover, recent estimates at sea suggest that the global population might approach 25,000 individuals (Arcos *et al*. 2012b, Arroyo *et al*. 2014), which suggests an even larger breeding population, up to possibly 7,000 breeding pairs (Genovart *et al*. 2016). These last figures led to criticize the global status of the species, which was based on a population viability analysis conducted in 2004 under the assumption that the breeding population was of 2,000 breeding pairs. However, a review of the demographic analysis, with updated information and improved analytical tools, showed an even sharper decline than previously expected, of 13% per year, and set the average extinction time of the species in 60 years (Genovart *et al*. 2016). Such an assessment would have been not possible without a demographic approach, and the species might still be regarded as in good shape if it were for population counts alone.

The available demographic information for the species is very limited, however, and efforts should be directed to ensure the establishment of breeding monitoring programmes in a few representative colonies. Current work in Ibiza, Cabrera and Formentera might make help attaining this objective in the near future. So far information on breeding success is available for several colonies, ranging from 0.33 to 1.00 chicks fledged/year, with average values around 0.60-0.70 (out of a unique egg laid, as occurs with all shearwaters). On the other hand, other parameters more difficult to estimate come from a unique colony in Mallorca, Sa Cella, where adult survival is estimated at 0.81, immature survival at 0.43, the rate of sabbaticals is of 0.26, and age of breeding recruitment is concentrated between 3 and 6 years. This colony is free of predators, so demographic estimates out of there should be taken as "optimistic", as some colonies do have predators (rats, cats and others). This also suggests that the main mortality occurs at sea, where bycatch is the main concern (ICES 2013, Genovart *et al*. 2016).

Yelkouan shearwater.

For this species, there is very limited information on demography, mainly from Malta and France (Oppel *et al*. 2011, Borg *et al*. 2016, Gaudard 2017). Adult survival for Malta has been estimated at 0.74, whereas in France there are interesting differences between breeding birds (0.82) and non-breeding adult birds (0.95), suggesting that breeding represents a burden (which could be related with predation, but also with added foraging effort at sea and/or segregation leading to differential bycatch risk). Breeding success has been reported to be influenced by rats throughout; in Italy, this parameter ranged from 0.09 to 0.41 in islands with rats, and 0.75-0.90 in islands where rats had been eradicated (Gaudard 2017).

Audouin's gull.

For this species, demographic studies conducted in the Mediterranean region, particularly in the western sub-region, have allowed to study in depth several aspects of seabird ecology, including the relative influence of different factors on the breeding performance, survival and dispersal rates of birds (e.g. Oro *et al*. 1999, Oro & Pradel 2000, Oro & Ruxton 2001, Oro *et al*. 2004). Current work is being directed at understanding the recent disaggregation of the Spanish colonies, resulting in the colonisation of sub-optimal areas such as ports. On the other hand, the species is undergoing a steady decline in the eastern sub-region, including low breeding success, which has declined from 0.9 cicks per pair in 1997 to 0.3-0.4 chicks per pair afterwards (Saravia-Mullin *et al*. 2012).

CONCLUSIONS

Conclusions (brief)

Information for this common indicator is far scarcer than that for common indicators 3 (distribution) and 4 (population size). However, for some species this type of information is essential to properly understand population trends, as well as to assess the relevance of different threats in context. This is particularly so for the Procellariiformes, represented here by the Balearic and Yelkouan shearwaters. The good news is that collecting this type of information might be quite simple and less resource-consuming than conducting exhaustive population counts. It only requires of the selection of a few, representative colonies where breeding monitoring schemes could be conducted on a year-basis. These schemes would require the follow-up of standard protocols that might be simple enough, with 2-3 visits per year to ensure the assessment of breeding success, the ringing of chicks and the ringing/control of adults. The very limited schemes in place suggest that Balearic and Yelkouan shearwaters are undergoing a severe decline.

Conclusions (extended)

- For the remaining species, although population counts already provide relevant information, it is important to systematically collect demographic data as to better understand their population dynamics, and to put the different threats that they face in context.
- Colour-ringing schemes such as that of Audouin's gull, coupled with the detailed monitoring of a few, representative breeding colonies might provide high quality data on this regard. In addition, a systematic compilation of information from dead birds, particularly from wildlife recovery centres, might greatly help to understand the impact of different threats.

Key messages

- Demographic information is essential to properly assess the trends of certain seabirds, particularly shearwaters.
- The limited information available for Balearic and Yelkouan shearwaters suggests that both species are undergoing a severe decline, which threatens them with extinction. Introduced predators and fishing bycatch deserve particular attention on this regard.

Knowledge gaps

- Information on seabird demographic parameters is extremely scarce in the Mediterranean region, except for Audouin's gull. It is essential to set in place breeding monitoring programmes, particularly for the Balearic and Yelkuoan shearwaters, as well as ensure the continuity of the few already existing.
- Special attention must also be paid to their main threats, particularly predation by introduced mammals in the colonies and fishing bycatc at sea.

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Ecological Objective 2 (EO2): Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.

EO2: Common Indicator 6. Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species

GENERAL

Reporter:	SPA/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	EO2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
IMAP Common Indicator	Common Indicator 6 (CI6): Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (in relation to the main vectors and pathways of spreading of such species)
Indicator Assessment Factsheet Code	EO2CI6

RATIONALE/METHODS

Background (short)

The trend of new introductions of alien species in the Mediterranean has been increasing. About 1000 marine alien species have been reported in the Mediterranean Sea up to now, of which more than half are considered established. Many of these species have become invasive with serious negative impacts on biodiversity, human health, and ecosystem services.

The invasive alien species, including as a side effect of climate change, are seen as being among the main threats to marine biodiversity in the Mediterranean. The adopted Ecosystem Approach (EcAp) to management of human activities with a view to conserve natural marine heritage and protecting vital ecosystem services recognises that to achieve good environmental status “non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem”.

Background (extended)

There are many routes and mechanisms by which new alien species arrive in the Mediterranean Sea. Identification and assessment of the pathways of introduction is essential for predicting future trends of new introductions, identifying management options to mitigate invasions and to prevent new introductions, and communicating related risks and costs to policy makers and high-level administration. Among the many important pathways by which human actions have introduced alien invasive species into the Mediterranean Sea are shipping (by means of ballast waters and hull fouling), corridors, maritime transport and water ways, aquaculture, trade in live marine organisms (aquarium trade and fishing bait) and others (e.g. fishing activities and aquarium exhibits). Other additional factors such as global warming may enhance alien species to spread in the Mediterranean.

In the Mediterranean Sea, despite the variability in monitoring and reporting effort among countries and the gaps in our knowledge of alien species distribution, there is an enormous amount of information scattered in various databases, institutional repositories, and the literature. By harmonizing and integrating information that has often been collected based on different protocols and is distributed in various sources, the needed knowledge basis to assess the distribution and status of marine alien species can be built.

Policy context and targets

The CBD’s Aichi Biodiversity Target 9 is that “by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment”. This is also reflected in Target 5 of the EU Biodiversity Strategy (EU 2011). The new EU Regulation 1143/2014 on the management of invasive alien species seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have. The international Convention for the control and management of ships' ballast water and sediments was adopted the 13th of February 2004 and entered in force the 8th of September 2017. This is an important step and usefull management tool to be considered to limit alien species introduction through this vector and pathways.

In 2016, the 19th Meeting of the Contracting Parties to the Barcelona Convention adopted the Updated Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea, as well as the Integrated Monitoring and Assessment Programme (IMAP) which recognizes the introduction of marine alien species as a major threat to biodiversity and ecosystem health of the Mediterranean Sea, and stresses the need for updated national monitoring programmes on NIS and baseline asessments, which should be based on existing regional databases such as the Marine Mediterranean Invasive Alien Species database, (MAMIAS), the “Andromeda” invasive species database for the Mediterranean and Black Sea, and the European Alien Species Information Network (EASIN). Monitoring Guidance factsheets were developed in 2017 and adopted by the Meeting of the Ecosystem Approach Coordination Group and MAP Focal Points in September 2017. The Marine Strategy Framework Directive (MSFD), requires EU Member States to include alien species in the definition of GES and to set environmental targets to reach it.

Assessment methods

To estimate Common Indicator 6, a trend analysis (time series analysis) of the available monitoring data needs to be performed, aiming to extract the underlying pattern, which may be hidden by noise. A formal regression analysis is the recommended approach to estimate such trends. This can be done by a simple linear regression analysis or by more complicated modelling tools (when rich datasets are available), such as generalized linear or additive models. To monitor trends in temporal occurrence, two indicators are estimated on a yearly basis. The first is about the number of non-indigenous species at the current year that were not present at the previous year. To calculate this indicator the non-indigenous species lists of both years are compared to check which species were recorded in year n, but were not recorded in year n-1 regardless of whether or not these species were present in earlier years. The second indicator is estimated as the total number of known non-indigenous species at Tn minus the corresponding number of non-indigenous species at Tn-1, where Tn stands for the year of reporting. It is recommended to use standard monitoring methods traditionally being used for marine biological surveys, including, but not limited to plankton, benthic and fouling studies described in relevant guidelines and manuals. Standard methods for monitoring marine populations include plot sampling, distance sampling, mark-recapture, removal methods, and repetitive surveys for occupancy estimation. As a complimentary measure and in the absence of an overall IAS NIS targeted monitoring programme, rapid assessment studies may be undertaken, usually but not exclusively at marinas, jetties, and fish farms. The compilation of citizen scientists input, validated by taxonomic experts, can be useful to assess the geographical ranges of established species or to early record new species.

The current assessment is based on literature, recent projects and initiatives in the Mediterranean, as work is still ongoing for all Mediterranean countries to update their national monitoring plans to be aligned with the IMAP descision (UNEP/MAP 2016) and begin reporting comparable data.

RESULTS

Results and Status, including trends (brief)

Among the recent studies on NIS, two basin-wide inventories of the marine alien species of the Mediterranean have been published by Zenetos et al. (2010, 2012) and Galil (2012). Furthermore, many national lists of marine NIS have been published in the scientific literature, most of them during the last decade, including Croatia, Cyprus, Greece, Israel, Italy, Libya, Lebanon, Malta, Slovenia, Tunisia and Turkey.

Results and Status, including trends (extended)

Species migration is a global phenomenon take place all over the word, the drivers behind migration process are often of global nature despite the impacts being observed on local scale. During 1955 sea temperature rose in Mediterranean by 1.0 to 1.5 C. The increases of water temperature due to Climate change have accelerated the increase in number of alien species a phenomenon called tropicalization. All known alien species introductions have been compiled in the Marine Mediterranean Invasive Alien Species online database (MAMIAS; www.mamias.org), developed by SPA/RAC in collaboration with the Hellenic Centre for Marine Research (HCMR). According to MAMIAS, 1057 non-indigenous species have been reported in the Mediterranean Sea (excluding vagrant species and species that have expanded their range without human assistance through the Straits of Gibraltar), of which 618 are considered as established. Of those established species, 106 have been flagged as invasive. Among the four

Mediterranean sub-regions, the highest number of established alien species has been reported in the eastern Mediterranean, whereas the lowest number in the Adriatic Sea (Table 1).

In terms of alien species richness, the dominant group is Mollusca, followed by Crustacea, Polychaeta, Macrophyta, and Fish (Figure 1). The taxonomic identity of alien species differs among the four sub-basins, with macrophytes being the dominant group in the western and central Mediterranean and in the Adriatic Sea (Table 1).

Table 1: Summarized information for each Mediterranean sub-region about the status of alien invasions. Sources: MAMIAS (http://www.mamias.org/)

	Eastern Mediterranean	**Central Mediterranean**	**Adriatic**	**Western Mediterranean**
Number of established NIS	468	183	135	215
Richest taxons in NIS biota	Mollusca, Crustacea	Macrophyta, Polychaeta	Macrophyta, Mollusca	Macrophyta, Crustacea
Trend in the rate of new introductions (based on the last 3 decades)	increasing	decreasing	decreasing	decreasing

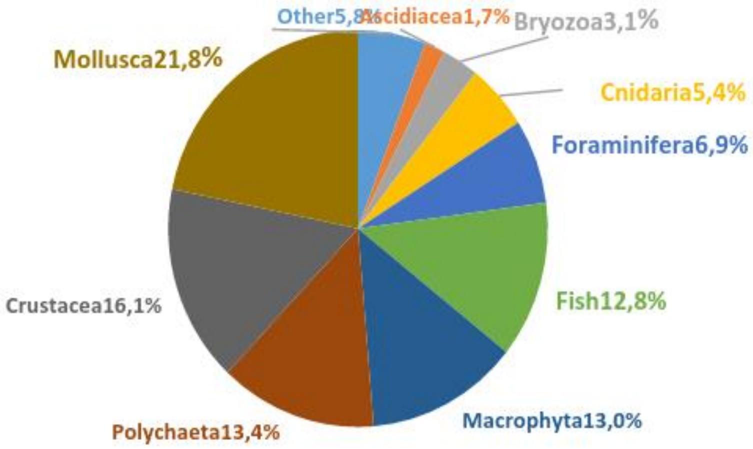

Figure 1: Contribution of the major taxa in the NIS marine biota of the Mediterranean Sea. Modified from Zenetos et al. (2012).

NIS in the Mediterranean Sea is linked to four main pathways of introduction: the corridors, shipping (ballast waters and hull fouling), aquaculture, and aquarium trade. Overall in the Mediterranean, corridors are the most important pathway, contrary to the situation in Europe, where shipping is the most important (Figure 2). Nevertheless, the importance of pathways of introduction of NIS varies among the four Mediterranean sub-regions, with shipping being the most important pathway in the western and central Mediterranean and the Adriatic (Table 1). An assessment of the 'gateways' (i.e. countries of initial introduction) to alien invasions in the European Seas (Nunes et al. 2014) revealed marked geographic patterns depending on the pathway of introduction.

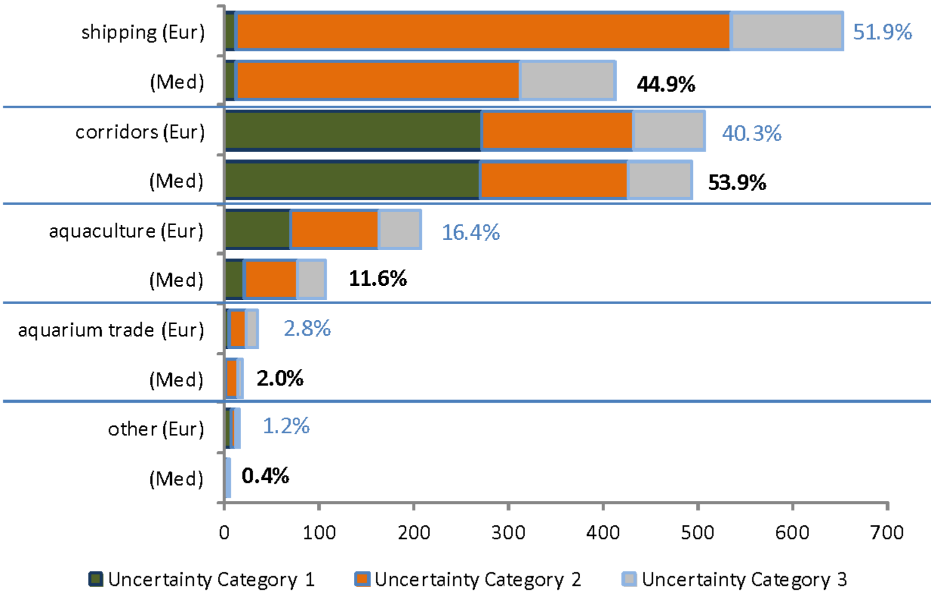

Figure 2: Number of marine alien species known or likely to have been introduced by each of the main pathways, in Europe (Eur) and the Mediterranean (Med). Percentages add to more than 100% as some species are linked to more than one pathway (blue percentages refer to the European total, while black percentages to the Mediterranean total). Uncertainty categories: (1) there is direct evidence of a pathway/vector; (2) a most likely pathway/vector can be inferred; (3) one or more possible pathways/vectors can be inferred; (4) unknown (not shown in the graph). Modified from Katsanevakis et al. (2013), Zenetos et al. (2012).

New introductions of alien species in the Mediterranean Sea have an increasing trend in the rate of new introductions by 30.7 species per decade, and the current (as of the 2000s) rate of new introductions exceeds 200 new species per decade (Figure 3).

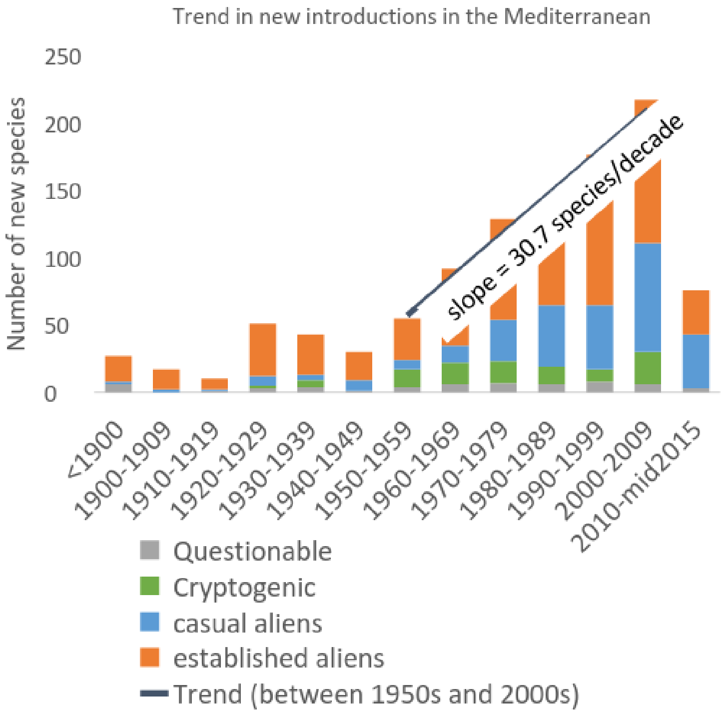

Figure 3: Trend in new introductions of alien marine species per decade in the Mediterranean Sea. Source: MAMIAS

However, this increasing trend in the rate of new introductions mainly reflects new introductions in the eastern Mediterranean, while in the other sub-regions the rate of new introductions is decreasing (Figure 4). However, the fewer numbers of new introduction in the last decade can also be due to an artefact, caused by the delay (often several years) between the date of introduction, observation and reporting of the species. Thus, the downwards tendencies of the last years cannot yet be firmly asserted.

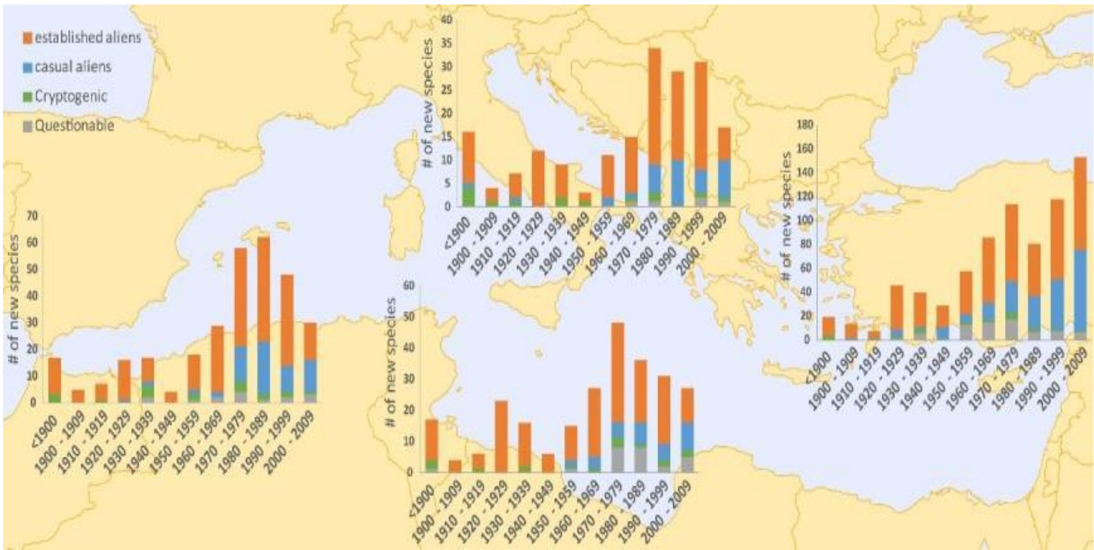

Figure 4: Trend in new introductions of NIS per decade in the Mediterranean sub-regions (eastern, central, western Mediterranean, and Adriatic Sea). Source: MAMIAS

The cumulative impact of alien species on the Mediterranean marine habitats was recently assessed and mapped, using the CIMPAL index, a conservative additive model, based on the distributions of alien species and habitats, as well as the reported magnitude of ecological impacts and the strength of such evidence (Katsanevakis et al. 2016). The CIMPAL index showed strong spatial heterogeneity, and impact was largely restricted to coastal areas (Figure 5).

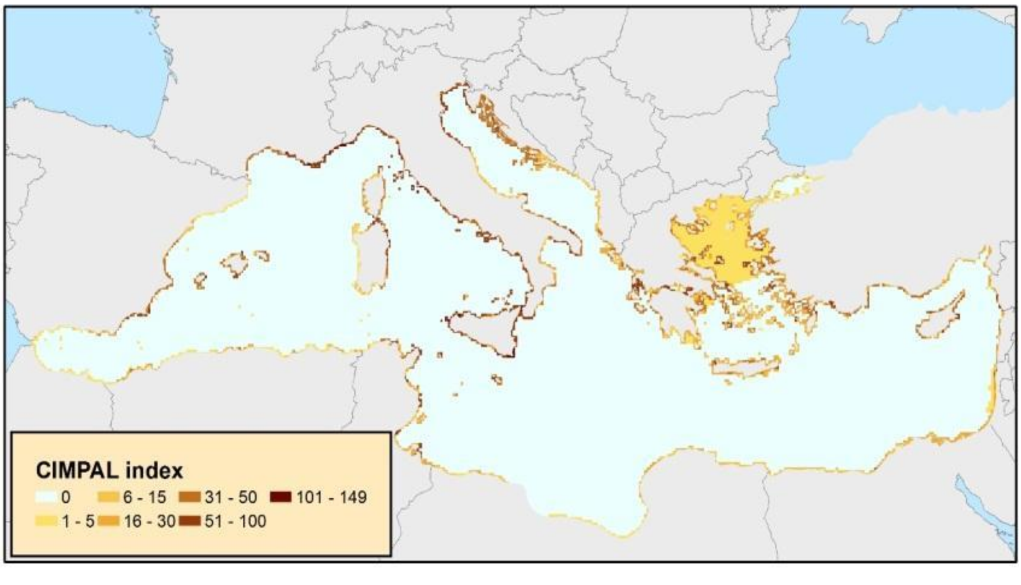

Figure 5: Map of the cumulative impact score (CIMPAL) of invasive alien species to marine habitats. Modified from Katsanevakis et al (2016)

CONCLUSIONS

Conclusions (brief)

Important progress has been made the last decade in creating inventories of non-indigenous species (NIS), and on assessing pathways of introduction and the impacts of invasive alien species on a regional scale. The development and regular updating of MAMIAS (data partner of EASIN) substantially contributes to address Common Indicator 6. SPA/RAC is establishing formal exchange of information with relevant information system (such AquaNIS) as provided for in the Mediterranean Action Plan concerning Species introduction and invasive species.

Conclusions (extended)

Nevertheless, monitoring and research effort currently greatly varies among Mediterranean countries and thus on a regional basis current assessments and comparisons may be biased. Thus, the implementation of the IMAP at national level, following the IMAP recommendations, will enable obtaining much more consistent results.

The lack of dedicated and coordinated monitoring at national and regional scale implies a low confidence in this assessment, even if the continuous and regular occurring of new introductions are demonstrated. This lack of standardized monitoring and data currently compromises representability and comparability between assessment cycles, and thus complicate assessment of effects of management measures on these trends.

Key messages

- Progress has been made in creating national and regional inventories of alien species and assessing their pathways and impacts.
- There is an increasing trend in the rate of new alien species introductions in the Mediterranean Sea.
- Corridors are the most important pathways of new introductions in the Mediterranean, followed by shipping and aquaculture.
- There is a need for better coordination at national and sub-regional level on NIS monitoring.

Knowledge gaps

- Evidence for most of the reported impacts of alien species is weak, mostly based on expert judgement; a need for stronger inference is needed based on experiments or ecological modelling. The assessment of trends in abundance and spatial distribution is largely lacking.
- Regular dedicated monitoring and long time-series will be needed so that estimation of such trends is possible in the future. NIS identification is of crucial importance, and the lack of taxonomical expertise has already resulted in several NIS having been overlooked for certain time periods. The use of molecular approaches including bar-coding are often usefull besides traditional species identification.

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Ecological Objective 3 (EO3): Commercially exploited fish

EO3: Common Indicator 7. Spawning stock Biomass

GENERAL

Reporter:	GFCM
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	GFCM Contracting and Cooperating Non Contracting Parties
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	E03: Populations of commercially exploited fish and shellfish are within biologically safe limits.
IMAP Common Indicator	Common Indicator (CI7) Spawning stock Biomass (EO3)
Indicator Assessment Factsheet Code	EO3CI7

RATIONALE/METHODS

Background (short)

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management measures (Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

The assessment of the size and state of exploited fish stocks is one of the pillars of fisheries management. Generally, stock status is determined by estimating both current levels of fishing mortality and spawning-stock biomass (*see EO3CI7*), and comparing these with reference points, which are typically associated with maximum sustainable yield (MSY - Brooks *et al*., 2010).

The GFCM provides regular reports on main indicators of relevance for fisheries management, and in 2016 has launched its flagship publication "The state of Mediterranean and Black Sea fisheries – SoMFi" [8] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of fishing mortality (GES indicator EO3CI9), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

Background (extended)

The GFCM, as the responsible Regional Fisheries Management Organization (RFMO) in the Mediterranean and Black Sea provides regular reports on main indicators of relevance for fisheries management, and in 2016 has launched its flagship

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[8] http://www.fao.org/gfcm/publications/en/

publication “The state of Mediterranean and Black Sea fisheries – SoMFi”[9] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of fishing mortality included below (GES indicator EO3CI9), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

Mediterranean countries, within the context of the GFCM, have recently updated and adopted new specific binding recommendations related to the mandatory requirements for data collection and submission, underpinned by the launch of the GFCM Data Collection Reference Framework (DCRF – GFCM, 2017a). The DCRF is the first GFCM comprehensive framework for the collection and submission of fisheries-related data, as requested through GFCM recommendations in place and necessary for relevant GFCM subsidiary bodies to formulate advice in accordance with their mandate. It encompasses all the necessary indications for the collection of fisheries data (i.e. global figure of national fisheries, catch; incidental catch of vulnerable species; fleet; effort; socio-economics; biological information) by GFCM members in a standardized way, in order to provide the GFCM with the minimum set of data needed to support fisheries management decision-making processes. In addition, the GFCM works through its permanent Working Groups on Stock Assessment (WGSAs) - on demersal and small pelagic fish species - where fisheries scientists perform their analysis and provide the best scientific advice to better manage fisheries and fish stocks. Several analytical methods, based on the population dynamics of different stocks of demersal and small pelagic species, have been applied within the GFCM-WGSAs. In order for the advice on the status of stocks to be reliable, the data and information used in the analysis should be timely available and accurate. Data for the assessment of stocks are collected through stock assessment forms (SAFs), which also contain information on reference points and the outcomes of the assessment (e.g. fishing mortality, exploitation rate, spawning stock biomass, recruitment etc.).

Following the decision of the GFCM to work on indicators of Good Environmental Status (GES) of Mediterranean and Black Sea species, habitats and ecosystems, so further embracing the FAO Ecosystem Approach to Fisheries (EAF) and within the framework of the Memorandum of Understanding signed with UNEP-MAP, a number of activities have been undertaken in the framework of the GFCM Scientific Advisory Committee on Fisheries (SAC) in recent years. In 2014, the first outputs of the MedSuit project (A Mediterranean Cooperation for the Sustainable Use of Marine Biological Resources - funded by the Italian Ministry of Environment) were presented to the sixteenth session of the SAC (GFCM, 2014a) together with a first proposal of indicators and targets for the assessment of the status of stocks, developed in collaboration with and within the framework of the UNEP-MAP Ecosystem Approach (EcAp) Process, in particular, its Ecological Objective 3 (Harvest of commercially exploited fish and shellfish). Indicators and targets were further discussed during the “First MedSuit Regional Workshop on indicators and targets to ensure GES of commercially exploited marine populations” (GFCM, 2014b), endorsed by the seventeenth session of the SAC (GFCM, 2015), and were finally incorporated in the GFCM Data Collection Reference Framework (DCRF) adopted by the GFCM (GFCM, 2017a).

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management

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[9] http://www.fao.org/gfcm/publications/en/

measures (Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

Spawning stock biomass is the combined weight of all individuals in a fish stock that are capable of reproducing. It reflects the reproductive stock capacity (GFCM, 2017b**)**. Generally, stock status is determined by estimating both current levels of fishing mortality (see also EO3CI9) and spawning-stock biomass and comparing these with reference points, which are typically associated with MSY (Brooks *et al.*, 2010).

The assessment of the size and state of exploited fish stocks is one of the pillars of fisheries management. The most recent studies assessing the status of fisheries in the world show an important decline in the status of stocks. Also, some ecosystems show clear signals of stress due to anthropogenic pressure, and others are threatened to be pushed to a point of no return if the marine resources will continue to be exploited at current levels (Tsikliras *et al.,* 2015).

Assessment methods

The complete set of main fishery indicators adopted to assess current status of Mediterranean stocks as well as their temporal trend is reported in the last SAC Report (FAO, 2017). Below are listed the ones, for which a common methodology has been already developed (GFCM, 2017b) and discussed during the meeting of the Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (UNEP/MAP, 2017a) as well as the 6th meeting of the Ecosystem Approach Coordination Group (UNEP/MAP, 2017b):

i. Spawning Stock Biomass (SSB) (Indicator assessment factsheet code *EO3CI9*).
ii. Fishing mortality (F) and/or Exploitation rate (E) (Indicator assessment factsheet code *EO3CI7*).
iii. Total Landing (TL) (Indicator assessment factsheet code *EO3CI8*).

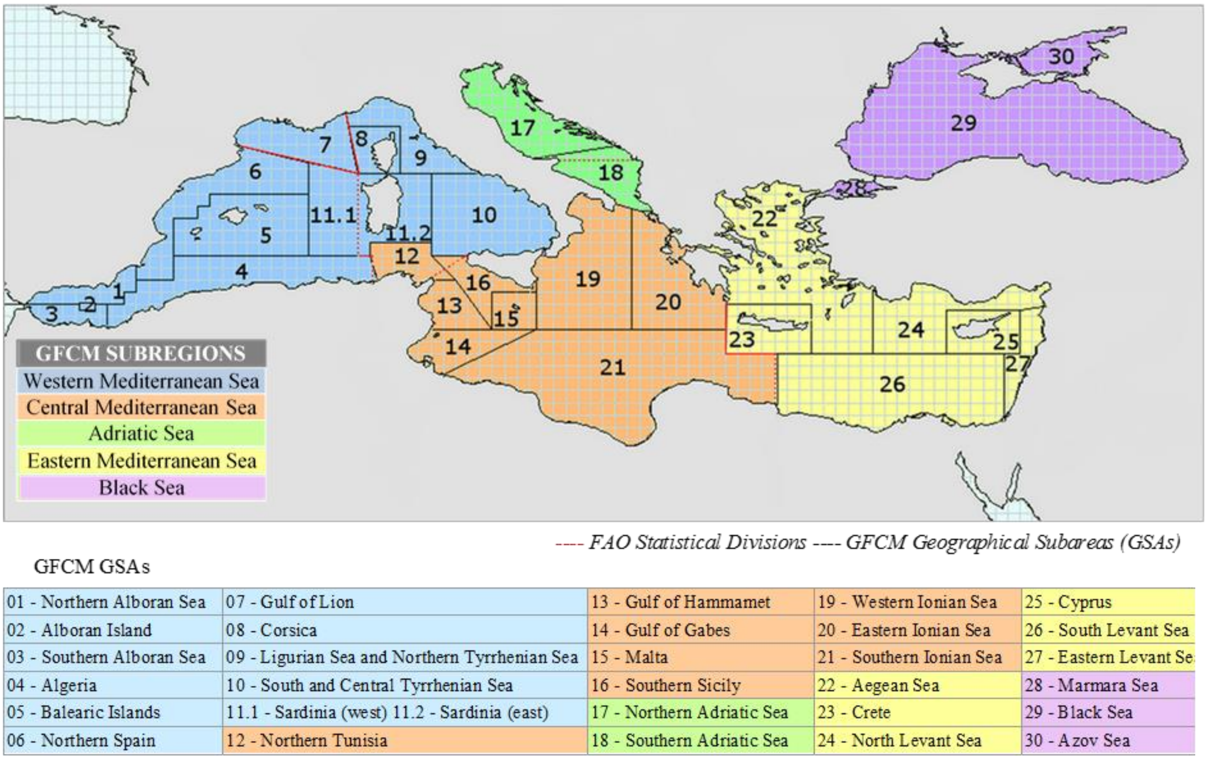
SSB is estimated regularly on a stock-–by-stock basis for those stocks assessed during the WGs on Stock Assessment, and is included in the stock specific SAFs. To calculate the spawning stock biomass, it is necessary to have estimates of the number of fish by length/age group, estimates of the average weight of the fish in each length/age group and an estimate of the amount of fish in each length/age group that are mature. SSB and its associated reference point, i.e. the SSB at Maximum Sustainable Yield (SSB_{MSY}) need to be estimated from appropriate quantitative assessments based on the analysis of catch at-age or/and at length (to be taken as all removals from the stock including discards). Where possible, reference points relative to SSB should be established for each stock.

Description of current indicator.

SSB refers to the total weight (biomass) of the part of the stock that has already spawned at least once, or that is ready to spawn during the reference year. The assessment of SSB helps in detecting potential situations of “recruitment overfishing”. Recruitment overfishing happens when the parental biomass is reduced by fishing, resulting in a reduction in the production of new individuals, which in turn may end up in a reduced amount of reproductive individuals, jeopardizing the capacity of the stock to self-renovate. It is characterized by a decreasing proportion of older fish in the catch as well as a large reduction of spawning stock biomass and recruitment.

Area.

For the present analysis, the study area is corresponding to GFCM area of application (FAO major fishing area 37): the Mediterranean Sea from the Straits of Gibraltar to Bosphorus, which englobes 27 Geographical Sub-Areas (GSAs). The Mediterranean GSAs were then aggregated by GFCM into four sub-regions, namely; (i) the Western, (ii) Central and (iii) Eastern Mediterranean and (iv) the Adriatic Sea (Fig. 1).



01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant Sea
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Se
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - Southern Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 1. Map of the GFCM area of application (Subregions and GSA- Geographical Subareas)

Sources of data.

Data used for the analysis of this indicator are mainly based on information available in SAFs as well as the GFCM capture production online database (both available in the GFCM webpage: http://www.fao.org/gfcm). Stocks assessments carried out from 2009 to 2016 were compiled, and the most recent stock assessment for each stock was used in the analysis. Only those stocks validated by the SAC at the time of preparation of this analysis have been included in the analysis. Information from these sources has also been complemented with information publicly available, including from the European Union Scientific, Technical and Economic Committee for Fisheries (STECF) website (https://stecf.jrc.ec.europa.eu).

SAFs include data on fisheries (e.g. fishing gear, fleet), and historical trends on catches, biological parameters of growth and maturity, as well as the set of reference points used and results obtained (i.e. F, SSB etc.). They also include information on the stock assessment methods used within the study area, the indicators of stock status and the set of established reference points.

Reference points.

FAO (1997) and Fletcher *et al*., (2002) define a fishery reference point as "*a benchmark against which to assess the performance of management in achieving an operational objective*". The reference points are crucial elements for assessing stock status and provision advice for fisheries management (GFCM, 2014a). In general, the reference points serve to compare the current value of estimated indicators with the target ones, which allows quantify how far or near the estimated indicator from the desirable situation.

When possible the quality assessment on the different indicators on the status of exploited population of fish has been carried out in relation to reference points as validated by the SAC. Biomass reference points are nearly always based on SSB, which is one of the most important stock status indicators and the primary indicator for the reproductive capacity of the stock. Achieving or maintaining good environmental status requires that SSB values are equal to or above SSB_{MSY} (the level capable of producing maximum sustainable yield).

While MSY reference points (or proxies) for the indicator on mortality (EO3CI9) exist for most of the stocks assessed, validated biomass reference points only exist for a few stocks. In the absence of validated MSY reference points, the WGSA often carry out an empirical analysis of the time series of biomass estimates coming from a validated stock assessment or in its absence from direct estimation based on surveys at sea. Two different approaches are currently used by the WGs:

1. For the case of demersal species, the 33rd and 66th percentiles of the SSB time series are used to classify current stock biomass as low, intermediate or high.

2. For the case of small pelagic species, and when the time series show a recovery after a historical low value, the lowest biomass from which a recovery is observed is considered B_{LOSS} and a precautionary limit is estimated as $2*B_{Loss}$

Methodology.

In the presence of analytical reference points linked to MSY, i.e. B_{MSY}, the ideal way to carry out a regional indicator-based stock assessment is to calculate an Exploitation Biomass Ratio (EBR, i.e. relative biomass) for each stock as follows:

$$EBR = \frac{SSB_{current}}{SSB_{MSY}}$$

This could be done by species and Geographical Sub-Area (GSA) initially but can then be aggregated at different levels by using different descriptors e.g. the mean or median for the whole region or sub-region or by functional group (e.g. small pelagics, demersal bony fish and crustaceans) thus allowing the exploration of temporal changes for different units (Table 1).

Indicator	GES definition	Related Operational Objective	Reference level	Spatial Coverage
Spawning Stock Biomass	Achieving or maintaining good environmental status requires that SSB values are equal to or	The Spawning Stock Biomass is at a level at which reproduction	-SSB_{MSY} or its proxy	At regional,

🟦	above SSB_{MSY}, the level capable of producing maximum sustainable yield (MSY).	capacity is not impaired	-Decreasing or increasing trend with relative level $SSB/SSB_{33\%} = 1$	sub-regional and stock level.

Table 1. Spawning Stock Biomass fishery indicator and the corresponding assessed criteria

In the absence of a validated reference point related to MSY (see above) one of the two options described above as reference points are used to estimate proxies for a limit and precautionary biomass reference points (i.e. B_{LIM} = 33% or B_{Loss}; B_{PA} = 66% or 2 * B_{LOSS}), and the overall status of the stock is described based on a traffic light approach in relation to the existing proxy reference points. Current biomass (SSB_{cur}) of a stock can thus be categorised into low, intermediate and high with respect to B_{LIM} and B_{PA} as follows:

$$SSB_{cur} \leq SSB_{LIM} \rightarrow Low\ biomass$$
$$SSB_{LIM} < SSB_{cur} \leq SSB_{PA} \rightarrow Intermediate\ biomass$$
$$SSB_{cur} > SSB_{PA} \rightarrow High\ biomass$$

Under this approach, when indicators based on SSB were not available, current total biomass was compared to indicators based on total biomass.

The status of a stock is ideally based on a validated stock assessment model, from which indicators of stock status (e.g. biomass, fishing mortality, recruitment) are obtained, and reference points are agreed for the chosen indicators. When possible, analytical stock assessment models that incorporate both fishery-dependent (e.g. catches) and independent information (e.g. surveys) are used, although direct surveys are used for some stocks. Different stock assessment models are used in the GFCM area of application, including variations of virtual population models (from pseudo-cohort based models, such as VIT, to tuned versions, such as extended survivor analysis – XSA), statistical catch at age analysis (e.g. state-space assessment model – SAM or stock synthesis – SS3) and biomass models (BioDyn, two-stage biomass models, etc.). Some stock assessment methods are only based on information from scientific surveys at sea (e.g. survey-based assessment – SURBA, or acoustic estimates of biomass).

When no analytical assessment model or reference points are validated by the SAC, advice can still be provided on a precautionary basis, in cases where there is evidence that the stock may be threatened (high fishing pressure, low biomass, habitat loss, etc.). When possible, advice on stock status should be based both on biomass and on fishing pressure, using indicators and reference points for both quantities.

Concerning the spatial analysis, the stock assessment is often conducted by management units based on the mentioned GSAs (Figure 1). This method does not ensure that the whole stock is assessed, since stocks may cover several different management units. In some cases, when there is scientific evidence of a stock spreading through different GSAs, as well as information on species from different GSAs, existing information is combined across GSAs. This is then defined as a “joint stock assessment of a shared stock”.

RESULTS

Results and Status, including trends

Analysis of the information at hand from both the GFCM and the STECF, revealed that estimates of biomass (SSB or total) with corresponding proxies for B_{LIM} and B_{PA} were available for 60 stocks in the Mediterranean Sea (Table 2). Of these, 25 (42%) were found to be in a situation of low biomass, 22 (37%) at intermediate biomass and 13 (22%) at high biomass (Figure 2).

In terms of the status of biomass of single species stocks, the species with the highest number of validated assessments with estimated biomass indicators were European hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*) (Figure 3, Tables 2 and 3). None of the hake stocks were in a state of high biomass, while red mullet, giant red shrimp (*Aristeomorpha foliacea*) sand red blue and red shrimp (*Arsiteus antennatus*) stocks were more evenly distributed in terms of biomass status (Fig. 3). Most stocks of deepwater rose shrimp (*Parapenaeus longirostris*) were in a state of low biomass. Coverage of small pelagic species (*Sardina pilchardus* and *Engraulis encrasicolus*) was lower and their status mostly intermediate to high, with the exception of *E. encrasicolus* in GSA 7 (Figure 3, Table 3).

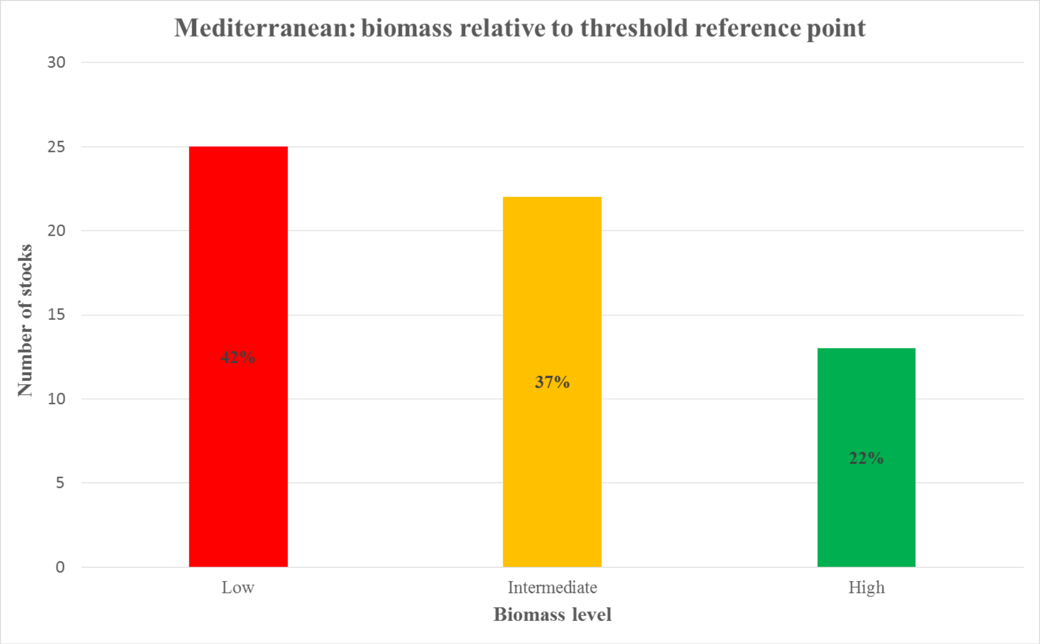


Figure 2. Number of stocks (and percentage in brackets) at low, intermediate and high biomass levels in the Mediterranean Sea based on the information available for 60 stocks over a combination of 15 GSAs and 14 species (Tables 3 and 4)

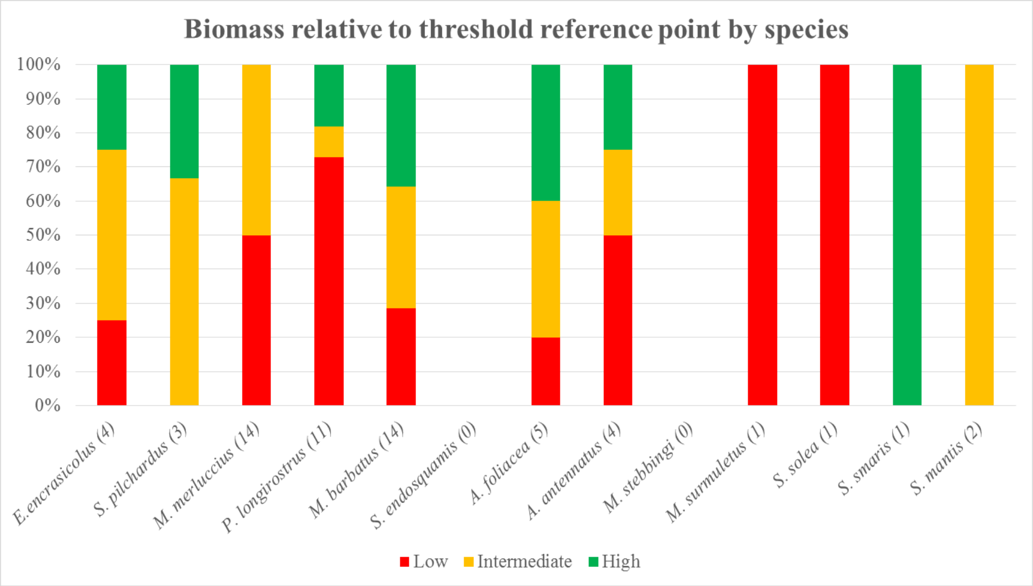


Figure 3. Percentage of stocks of each species (and number of stocks in brackets) at low, intermediate and high biomass levels in the Mediterranean Sea based on the information available for 60 stocks (Tables 3 and 4)

Table 2. Stocks considered in the analysis of biomass indicators, by species and GSA: for these stock proxies for B_{LIM} and B_{PA} were available. The number in the cells refers to the reference year of the most recent validated assessment and the fill colour refers to its source: light gray – GFCM assessments, light blue – STECF assessments.

Species/GSA	1	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	22	25	26
A. foliacea							2015	2014	2014							2014	2014			
A. antennatus	2015			2015	2015		2015													
E.encrasicolus						2015								2012	2015	2015				
M. merluccius	2015	2015		2015	2015	2015	2015	2013		2015	2015	2015	2015	2015	2015	2015				
M.stebbingi																				
M. barbatus	2014	2014	2014	2012	2015	2015		2013			2015	2015	2015	2015		2015	2012		2015	
M.surmuletus				2015																
N. norvegicus																				
P. longirostris				2012	2014		2015			2015	2015	2015	2015	2015	2015	2015	2015			
S. pilchardus														2014	2015	2015				
S. undosquamis																				
S. solea															2015					
S. smaris																			2015	
S. mantis															2014	2014				

Table 3. Stock status of each stock considered in the analysis of biomass indicators. Red - low biomass, yellow – intermediate biomass, red – high biomass.

tot = 60 stocks	Western Mediterranean									Central Mediterranean						Adriatic Sea		Eastern Med.	
Species /GSA	1	3	4	5	6	7	9	10	11	12	13	14	15	16	19	17	18	25	26
E.encrasicolus						🟥								🟩		🟨	🟨		
S. pilchardus														🟩		🟨	🟨		
M. merluccius	🟥	🟥		🟨	🟥	🟥	🟥	🟨		🟨	🟨	🟨	🟨	🟨		🟥	🟥		
P. longirostrus				🟨	🟩		🟩			🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		
M. barbatus	🟨	🟨	🟨	🟩	🟩	🟩		🟨			🟥	🟥	🟥	🟥	🟨		🟩	🟩	
S. endosquamis																			
A. foliacea							🟨	🟥	🟨						🟩		🟩		
A. antennatus	🟨			🟥	🟩		🟥												
M. stebbingi																			
M. surmuletus				🟥															
S. solea																🟥			
S. smaris																		🟩	
S. mantis																🟨	🟨		

The sub-regional level analysis revealed that in the Western and Central Mediterranean, and in the Adriatic Sea, most stocks were at low or intermediate biomass levels, with a small representation of high biomass stocks (23%, 16% and 15%, respectively). The coverage of Eastern Mediterranean stocks was very low (2 stocks) but these were both at high biomass levels (Figure 4).

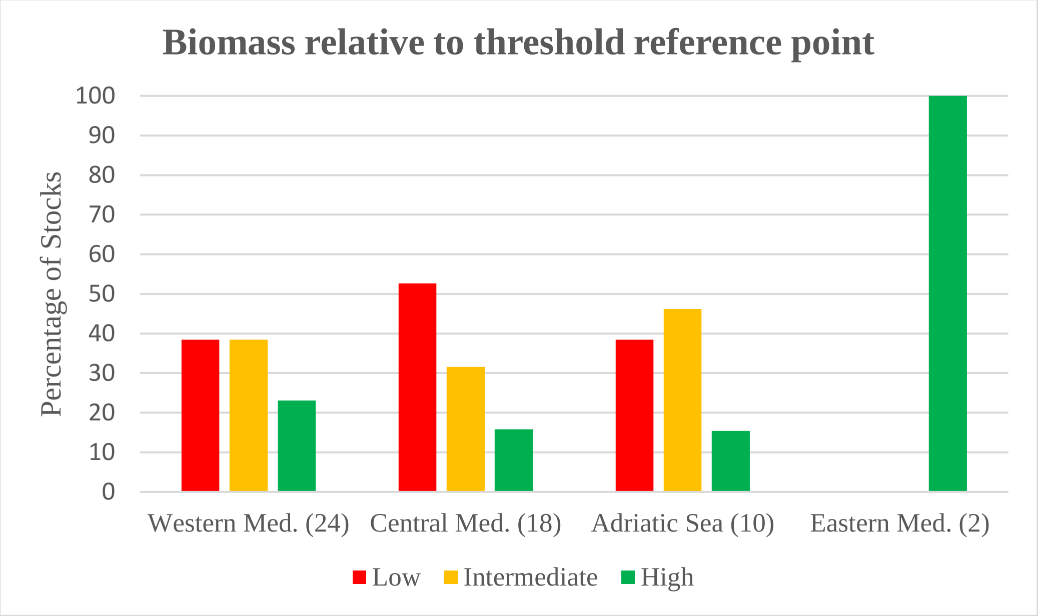


Figure 4. Percentage of stocks (and number of stocks in brackets) in each sub-region of the Mediterranean Sea at low, intermediate and high biomass levels based on the information available for 60 stocks (Tables 3 and 4).

CONCLUSIONS

Conclusions (brief)

Validated reference points for Spawning Stock Biomass are only available for a few stocks, and therefore the quality assessment included in this report is based on the empirical approach taken by the GFCM Working Groups on Stock Assessment that compares current biomass with the historical series of biomass as estimated from a validated stock assessment or directly from validated surveys at sea. The analysis of 60 different stocks, along the Mediterranean Sea, shows that around 42% show low biomass, 37% were considered to show an intermediate biomass and 22% showed high biomass.

Conclusions (extended)

With the aim to provide a spatio-temporal analysis of Mediterranean stock status, based not only on the most reliable recent data but also on indicators and reference points as most certain as possible, this analysis was conducted only on the endorsed assessments by either SAC of GFCM or STECF of European commission. Despite that many obstacles were fixed, some limitations, which can be a scope of improvement in the future, still persist. Amongst them, (i) the spatio-temporal coverage of stocks considered in the analysis, (ii) the shortness of indicator time series used, (iii) the absence of analytical biomass reference points and, (iv) the issue of standardized data and methodologies at regional level.

In terms of the relative biomass indicator, the analysis of 57 different stocks, along the Mediterranean Sea, shows that around 42% of the reviewed stocks were found to be in a situation of low biomass, 37% were considered to show an intermediate biomass and 22% showed high biomass.

Recently Froese *et al*., (2016) analyzed the status of European stocks and found that in the Mediterranean and the Black Sea region the average biomass is less than half (44%) of the sustainable level. Overall, this finding is in line with the present analysis with some slight difference that can be explained by the fact that the present analysis concerns all the Mediterranean stocks, taking into account the European and no European fisheries, whereas in Froese *et al*., (2016) only the European stocks were included. Furthermore, the proportion of stocks with biomass above or below the reference point was used to inform about the regional status, while the other study adopted the average biomass as a regional indicator of stock status.

Concerning the stock status by sub-region, most stocks in the Western and Central Mediterranean and the Adriatic Sea are at low or intermediate levels (i.e. below the precautionary reference point or B_{PA} proxy), while the Eastern Mediterranean is poorly covered with only two stocks having the necessary reference points for the analysis.

The low biomass levels observed in some of Mediterranean key stocks (specially on some important small pelagic stocks), together with the high fishing pressure (see Indicator EO3_CI08) has been repeatedly pointed out by the GFCM SAC, which has requested to initiate recovery plans for the stocks considered to be depleted, and to reduce fishing mortality to levels considered to be sustainable. Mediterranean countries are recently taking measures to correct these problems that jeopardize the sustainability of fisheries in the area, including through the implementation of the mid-term (2017-2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries adopted in 2016, which includes as one of its targets to *reverse the declining trend of fish stocks through strengthened scientific advice in support of management*[10]. Furthermore, the GFCM has recently adopted two dedicated subregional management plans and several riparian countries have reported a significant reduction of their fishing capacity, in line with the adopted GFCM resolution on the management of fishing capacity[11]. These measures are expected to be complemented with additional fisheries management measures within the mid-term strategy, with the objective to reduce fishing mortality and to increase biomass levels for low biomass stocks, especially those of priority species, before 2020.

Notwithstanding the above, it should be considered that the level of overfishing as well as the current biomass levels depends on the productivity of the stocks, which is affected by variables other than fishing itself. The reference point used in the assessment (F_{MSY} or its proxies) as well as the carrying capacity of the ecosystem, which relates to the maximum biomass that can be sustained, are affected by issues such as climate change or anthropogenic effects other than fisheries, including pollution and habitat destruction (Colloca *et al*., 2014). The combination of all these effects generates a strong biological stress and can be the cause of major ecological alterations, which in turn may affect the productivity of fisheries and therefore jeopardize Mediterranean fisheries and the production of local seafood for coastal communities.

Key messages

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[10] http://www.fao.org/gfcm/activities/fisheries/mid-term-strategy

[11] Resolution GFCM/37/2013/2 on Guidelines on the management of fishing capacity in the GFCM area

- Up to 42% of the stocks assessed in the Mediterranean show a low biomass in comparison with the existing time series, and only for 22% of the stocks the biomass is considered to be relatively high in relation to the time series
- Riparian states have recently explicitly recognized low biomass of key stocks in the Mediterranean as a key challenge in the context of blue growth and food security for coastal communities, and have included a specific target in the mid-term (2017-2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries aimed at reversing the declining trend of fish stocks through strengthened scientific advice in support of management
- The increase of biomass for key stocks requires the adoption of subregional management plans in the context of the GFCM, to complement those already in place for the Adriatic small pelagics and the Strait of Sicily demersal fisheries, as well as the adoption of measures that ensure the efficient management of fishing capacity.
- Although examples of recovery/increase of spawning stock biomass exist elsewhere in the world, it is also known that stock recovery/rebuilding may depend on factors other than fishing, and that in some cases stocks may require some time to rebuild after management measures are taken.

Knowledge gaps

- The advice on the status of Mediterranean commercially exploited stocks, as provided by the GFCM SAC have largely improved in recent years, as recognized by Mediterranean riparian states. However, the level of information differs between species and geographical areas, with information concentrating on a few stocks and lacking or being fragmented in other commercially exploited stocks.
- Even if stock assessments and advice are now available for an increasing number of stocks, the number of stocks for which MSY-based SSB reference points (or its proxy) exist is still very limited. Thus, it is not possible to establish reproductive potential levels relative to MSY, and the indication on current biomass levels is often based (as in this assessment) on an empirical analysis of often short time series.
- The update and adoption of new specific binding recommendations related to the mandatory requirements for data collection and submission, underpinned by the operationalization of the GFCM Data Collection Reference Framework (DCRF)[12] is expected to improve the quality of the data in support of advice, in line with the need expressed by riparian states. The mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries is also expected to contribute in this endeavour through specific actions such as, for example, the execution of harmonized scientific surveys-at-sea.

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[12] http://www.fao.org/gfcm/data/dcrf/en/

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ACRONYMS

CORMON	Correspondence Group on Monitoring
CWP	Coordinating Working Party on Fishery Statistics
DCRF	Data Collection Reference Framework
E	Exploitation rate
EAF	FAO Ecosystem Approach to Fisheries
EBR	Exploitation Biomass Ratio
EcAp	Ecosystem Approach
F	Fishing mortality
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean
GSA	Geographical Sub Areas
IUU	Illegal, Unreported and Unregulated (fishing estimates)
MSY	Maximum Sustainable Yield
RFMO	Regional Fisheries Management Organization
SAC	GFCM Scientific Advisory Committee on Fisheries
SAFs	Stock Assessment Forms
SoMFi	The State of Mediterranean and Black Sea fisheries
SSB	Spawning Stock Biomass
STECF	European Union Scientific, Technical and Economic Committee for Fisheries
TL	Total Landing
WGSAs	Working Groups on Stock Assessment

Ecological Objective 3 (EO3): Populations of commercially exploited fish and shellfish are within biologically safe limits

EO3: Common Indicator 8. Total landings

GENERAL

Reporter:	GFCM
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	GFCM Contracting and Cooperating Non Contracting Parties
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	E03: Populations of commercially exploited fish and shellfish are within biologically safe limits.
IMAP Common Indicator	Common Indicator (CI8): Total landings
Indicator Assessment Factsheet Code	EO3CI8

RATIONALE/METHODS

Background (short)

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management measures (Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

Total catch refers to the total amount of fish of a commercially exploited fish and shellfish species taken by any fishing gear, while total landing is the total amount of fish and shellfish landed and officially registered. Total catch is composed of total landings plus discards and unreported catches. As information on the latter quantities is fragmented, total landing is often used as a proxy indicator of fisheries production as well as of the removal of organisms from the ecosystem, although for areas where the latter are important a sizeable shift from real values may occur.

The GFCM provides regular reports on main indicators of relevance for fisheries management, and in 2016 has launched its flagship publication “The state of Mediterranean and Black Sea fisheries – SoMFi” [13] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of Total landings (GES indicator EO3CI8), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

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[13] http://www.fao.org/gfcm/publications/en/

Background (extended)

The GFCM, as the responsible Regional Fisheries Management Organization (RFMO) in the Mediterranean and Black Sea provides regular reports on main indicators of relevance for fisheries management, and in 2016 has launched its flagship publication "The state of Mediterranean and Black Sea fisheries – SoMFi" [14] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of fishing mortality included below (GES indicator EO3CI9), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

Mediterranean countries, within the context of the GFCM, have recently updated and adopted new specific binding recommendations related to the mandatory requirements for data collection and submission, underpinned by the launch of the GFCM Data Collection Reference Framework (DCRF – GFCM, 2017a). The DCRF is the first GFCM comprehensive framework for the collection and submission of fisheries-related data, as requested through GFCM recommendations in place and necessary for relevant GFCM subsidiary bodies to formulate advice in accordance with their mandate. It encompasses all the necessary indications for the collection of fisheries data (i.e. global figure of national fisheries, catch; incidental catch of vulnerable species; fleet; effort; socio-economics; biological information) by GFCM members in a standardized way, in order to provide the GFCM with the minimum set of data needed to support fisheries management decision-making processes. In addition, the GFCM works through its permanent Working Groups on Stock Assessment (WGSAs) - on demersal and small pelagic fish species - where fisheries scientists perform their analysis and provide the best scientific advice to better manage fisheries and fish stocks. Several analytical methods, based on the population dynamics of different stocks of demersal and small pelagic species, have been applied within the GFCM-WGSAs. In order for the advice on the status of stocks to be reliable, the data and information used in the analysis should be timely available and accurate. Data for the assessment of stocks are collected through stock assessment forms (SAFs), which also contain information on reference points and the outcomes of the assessment (e.g. fishing mortality, exploitation rate, spawning stock biomass, recruitment etc.).

Following the decision of the GFCM to work on indicators of Good Environmental Status (GES) of Mediterranean and Black Sea species, habitats and ecosystems, so further embracing the FAO Ecosystem Approach to Fisheries (EAF), and within the framework of the Memorandum of Understanding signed with UNEP-MAP, a number of activities have been undertaken in the framework of the GFCM Scientific Advisory Committee on Fisheries (SAC) in recent years. In 2014, the first outputs of the MedSuit project (A Mediterranean Cooperation for the Sustainable Use of Marine Biological Resources - funded by the Italian Ministry of Environment) were presented to the sixteenth session of the SAC (GFCM, 2014a) together with a first proposal of indicators and targets for the assessment of the status of stocks, developed in collaboration with and within the framework of the UNEP-MAP Ecosystem Approach (EcAp) Process, in particular, its Ecological Objective 3 (Harvest of commercially exploited fish and shellfish). Indicators and targets were further discussed during the "First MedSuit Regional Workshop on indicators and targets to ensure GES of commercially exploited marine populations" (GFCM, 2014b), endorsed by the seventeenth session of the SAC (GFCM, 2015), and were finally incorporated in the GFCM Data Collection Reference Framework (DCRF) adopted by the GFCM (GFCM, 2017a).

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[14] http://www.fao.org/gfcm/publications/en/

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management measures (Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

The most obvious impact that fishing has on the ecosystem is the removal (i.e. catch) of organisms from the environment. Catch (i.e. retained fraction + bycatch) represents the amount of marine biological resource, taken by the fishing gear, that reaches the deck of the fishing vessel (Figure 1). This should ideally include landings by commercial fleets, national landings in foreign ports, and foreign landings in domestic ports, bycatch, recreational fishing and illegal, unreported and unregulated (IUU) fishing estimates. However, most current statistics do not take into account those organisms that are caught but not landed (i.e. bycatch), thus causing the total catch of fishing vessels and the impact on the ecosystem to be underestimated. For this reason, when catch data are not available, landing data could be used as a proxy for catch.

For the purpose of this indicator, and as reported in the DCRF (GFCM, 2017a) the following definitions are used (Figure 1):

- Catch: amount of marine biological resource taken by the fishing gear which reaches the deck of the fishing vessel. This includes catches of individuals of the target species, which are usually kept on board and retained, and bycatch, which refers to catches of species that are not targeted by the fishery, with or without commercial value.
- Landing: Part of the catch retained on board and brought ashore
- Bycatch: Bycatch is the part of the catch that is unintentionally captured during a fishing operation in addition to target species. It may refer to the catch of other commercial species that are landed, commercial species that cannot be landed (e.g. undersized, damaged individuals), non-commercial species, as well as to incidental

catch of endangered, vulnerable or rare species (e.g. turtles, sharks, marine mammals etc.).

- Discards: Part of the catch not retained on board and discarded at sea. It may include the catch of target species or any other species (both commercial and non-commercial) discarded at sea.

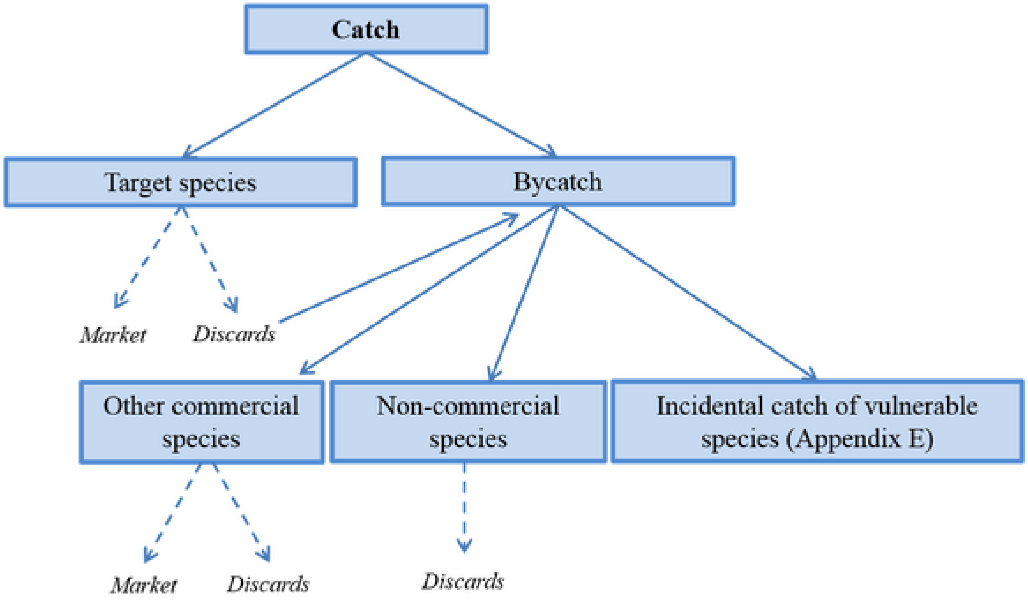


Figure 1. Scheme representing the different components of the catch

It is worth noting that Mediterranean fisheries show large diversity in terms of fishing effort, as well as in fishing gears and operations. According to the most recent data submitted to the GFCM (FAO, 2016), the fishing fleet operating in the Mediterranean consists of about 80.000 vessels. This number is an underestimate of the real size of the fleet, given the lack of data on some parts of the fleet (especially small-scale fleets) from some Mediterranean riparian States or non-State actors. The country with the largest fleet is Greece (20 percent of the total reported number), followed by Tunisia and Italy with around 15% of the fleet each one. The Eastern Mediterranean and the Ionian Sea have the largest share of vessels, with 28% and 27% respectively, followed by the western subregion, which accounts for 19% of the total.

Assessment methods

The complete set of main fishery indicators adopted to assess current status of Mediterranean stocks as well as their temporal trend is reported in the last SAC Report (FAO, 2017). Below are listed the ones, for which a common methodology has been already developed (GFCM, 2017b) and discussed during the meeting of the Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (UNEP(DEPI)/MED WG.430/3) as well as the 6th meeting of the Ecosystem Approach Coordination Group (UNEP(DEPI)/MED WG.444/6/Rev.1):

i. Spawning Stock Biomass (SSB) (Indicator assessment factsheet code *EO3CI9*)
ii. Fishing mortality (F) and/or Exploitation rate (E) (Indicator assessment factsheet code *EO3CI7*)
iii. Total Landing (TL) (Indicator assessment factsheet code *EO3CI8*).

The indicator on Total Landing monitor the catch and/or the landed fraction. It is of paramount importance in order to evaluate the trends in fish populations and, more generally, trends in the fishery.

Description of current indicator.

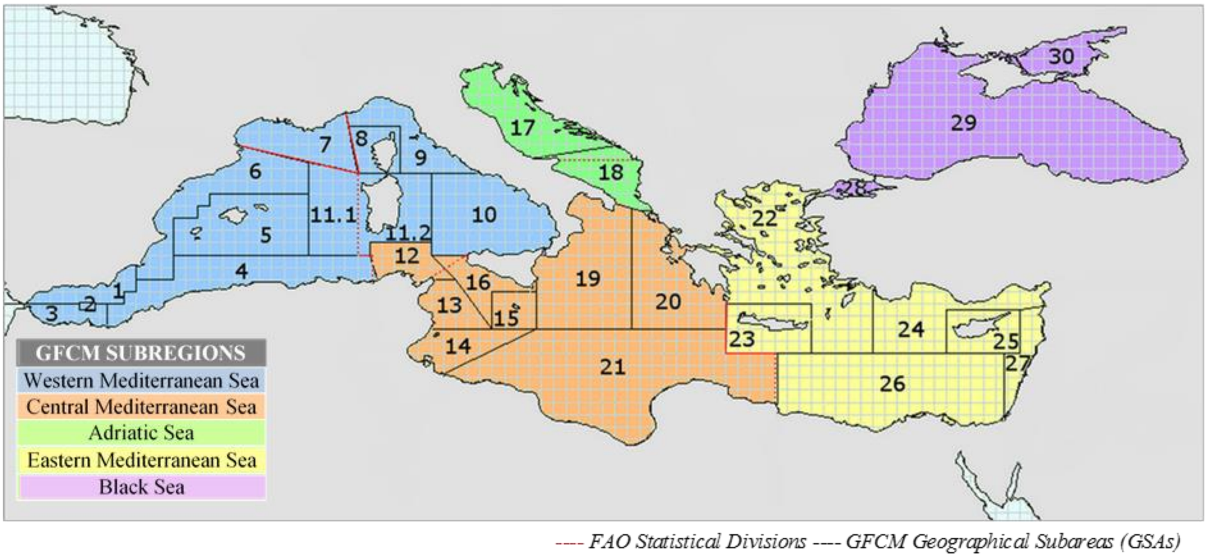
Catch represents the amount of marine biological resource, taken by the fishing gear, which reaches the deck of the fishing vessel. This includes catches of individuals of the target species, which are usually kept on board and brought ashore (the landed fraction), and bycatch, which refers to catches of species that are not targeted by the fishery, with or without commercial value (including discards and incidental catch of vulnerable species). Based on scientific advice, fishing must be adjusted to bring exploitation to levels that maximize yields (or catch) within the boundaries of sustainability.

Landing data coupled with information on fishing effort and prices, can in principle facilitate to:

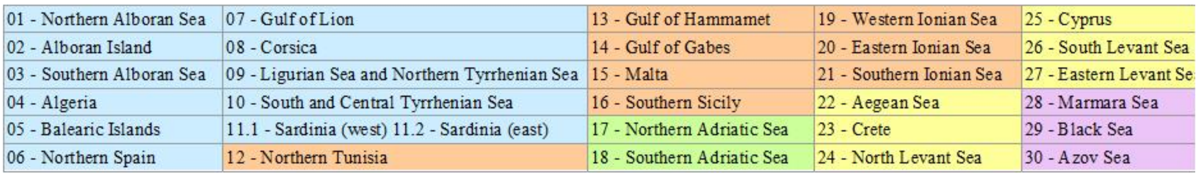
- keep track of the state and growth of a fishing fleet,
- identify potential changes in the status of the resources;
- perform basic analysis of the economic performance of the fisheries;
- estimate level of exploitation or total fishing pressure on an ecosystem (including IUU catch and discards).

Area.

For the present analysis, the study area is corresponding to GFCM area of application (FAO major fishing area 37): the Mediterranean Sea from the Straits of Gibraltar to Bosphorus, which englobes 27 Geographical Sub-Areas (GSAs). The Mediterranean GSAs were then aggregated by GFCM into four sub-regions, namely; (i) the Western, (ii) Central and (iii) Eastern Mediterranean, as well as (iv) the Adriatic Sea (Fig. 2).



GFCM GSAs



01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant Sea
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Se
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - Southern Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 2. Map of the GFCM area of application (Subregions and GSA- Geographical Subareas)

Sources of data.

Reliable landing and/or catch data are fundamental to perform the assessment of the different stocks. In each country landing/catch may come from different sources and are usually derived from a combination of catch reports, logbooks, observers on board, observers at market and/or at landing place, market and/or landing survey, and landing statistics from port authorities. Countries then report their annual catch by species and subdivision, into which FAO major fishing area 37, coinciding with the GFCM area of competence, has been divided for statistical purposes.

National catch data in the GFCM area of application are mainly collected through the FAO/GFCM STATLANT 37A questionnaire. This form is part of the STATLANT system of questionnaires developed by the Coordinating Working Party on Fishery Statistics (CWP) and dispatched by FAO on behalf of regional fisheries management organizations (RFMO) to the relevant national authorities.

Methodology.

The results provided for the total landing indicator (Table 1) are uploaded and extracted yearly from GFCM capture production online database.

Indicator	GES definition	Related Operational Objective	Reference level	Spatial Coverage
Total Landing	Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	Total landing and/or catch of commercial species does not exceed the Maximum Sustainable Yield (MSY) and the bycatch is reduced.	Decreasing or increasing trend using linear regression and percentage of change.	Regional and sub-regional

Table 1. Total landing fishery indicator and the corresponding assessed criteria

Data analysis can vary from simple averages of historical catch to more sophisticated methods like depletion-corrected average catch. Other approaches look at the trend in catch to determine if it has been sustainable and, in simple terms, treat a decline in catch as an indication that the population is over-exploited. However, catch-based methods need a time series of catch data going back to when exploitation began, which prevents their use in some cases.

RESULTS

Results and Status, including trends (brief)

Mediterranean catches are composed by a variety of species, with up to 30 species contributing to 90% of the catches, but the bulk of catches comes from small pelagic species, mainly anchovy and sardine.

Total landing in the Mediterranean steadily increased from about four hundred thousand tons in 1970 to around l million tons in 1994, but subsequently declined irregularly, to a figure of around 800.000 tons in 2015. The decrease in catches since 1994 is obvious in all Mediterranean subregions. However in the Adriatic, the declining trend was observed between mid 80's and early 90's, and catches have remained low since.

Results and Status, including trends (extended)

The Mediterranean production was increased strongly from the 50s to the beginning of the 80s raising from 420.000 tones to approach 1.000.000 tons. Then, it continued increasing until reaching its historical peak about 1.100.000 tons in 1994 (Sauzade and Rousset, 2013). Since that time, however, the catches follow a continuous and irregular decline except in 2006 when a peak was recorded, especially due to an exceptional catch of small pelagic. In 2015, total catch for the Mediterranean was around 800.000 tons (FAO, 2016) (Figure 3).

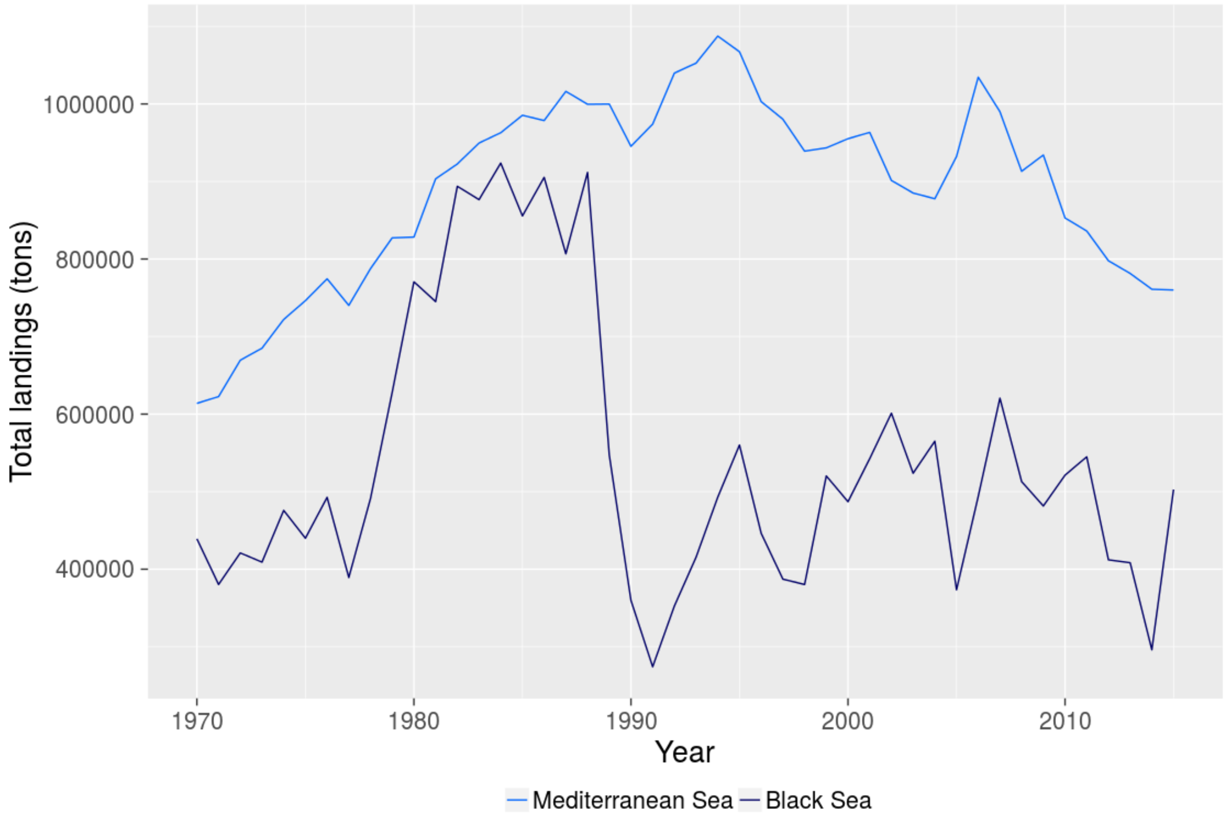


Figure 3. Trends in cumulative landings in the Mediterranean and the Black Sea between 1970 and 2015 (updated from FAO, 2016-a).

An analysis by sub-regions (including data up to 2014), shows as in the Western Mediterranean, marine landings, by main group of species, were about 320.000 tons in the beginning of 70s, and then it raised steady reaching a value of about 381.624 tons in 1987 (Figure 4). Afterwards, apparent fluctuations were observed that continued until 2004. A peak of about 432.493 tons was reached in 2006 followed by a significant downward trend. This peak is observed notably in the small pelagic landing group, which includes sardines and anchovies. This species group contributes with about 60% to total Western Mediterranean landings (Figure 5a) following exactly the same overall trend as this sub-regions total landing.

From the start of the examined period until the beginning of the 80s, the total Adriatic Sea marine production showed an upward trend, except in 1987 when a drop is observed (Figure 4). The Adriatic production stabilized in an average value of about 359.037 tons from 90s onwards. In that period, the production of the species groups of herrings, sardines and anchovies was raised apparently, on the contrary the production of molluscs group has showed a decline (Figure 5b).

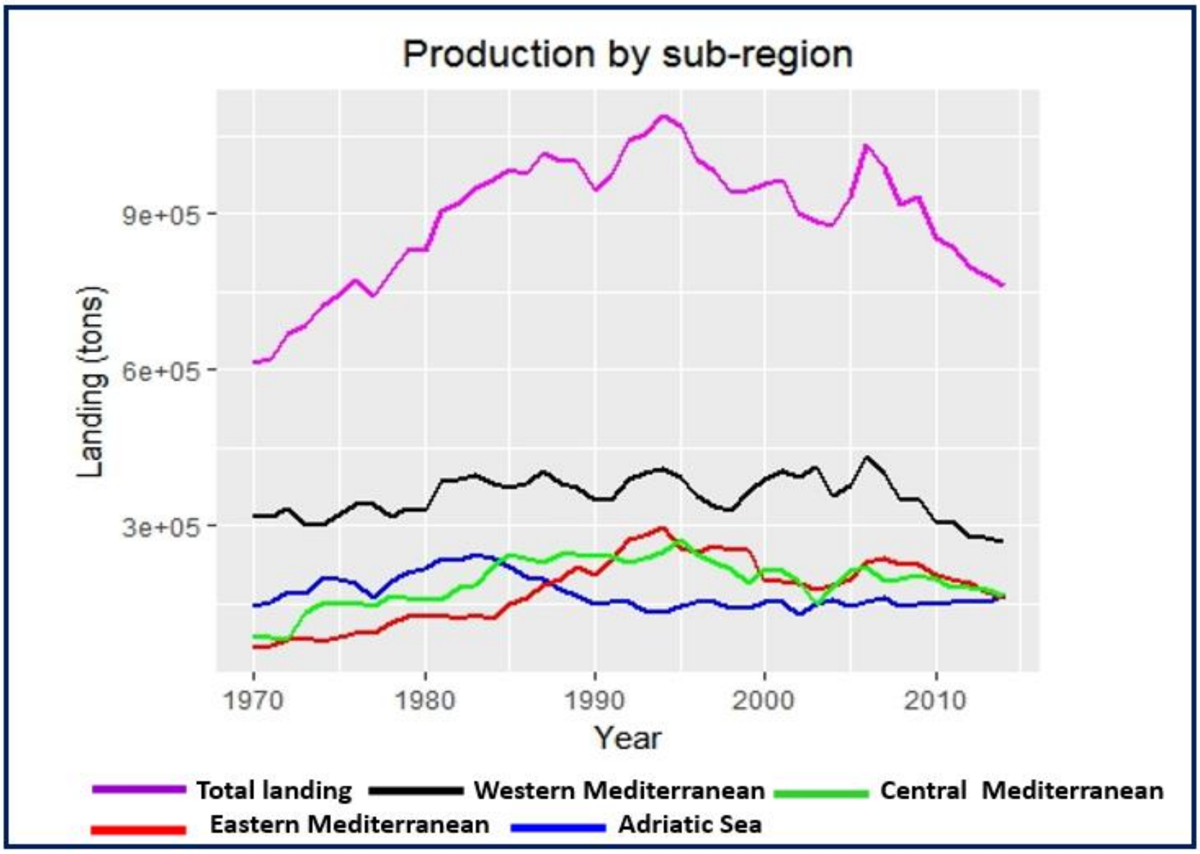


Figure 4. Trend in regional and sub-regional Mediterranean Total Landings (TL) indicator between 1970 and 2014.

The Central Mediterranean landing increased steadily from its minimum reported production of about 83.884 tons in 1970 to its historical level of about 273.872 tons recorded in 1995 (Fig. 4). Afterwards, the marine reported landing was decreased progressively until reaching a minimum value of about 149.652 tones. An improvement in the catch, mainly due to the increasing amount of the species groups of herrings, sardines and anchovies was detected in the following years especially in 2006 (Figure 5c). Recently (from 2009), the central Mediterranean production returned to decrease.

Likewise, the Eastern Mediterranean marine production follow an upward trend from the beginning of the time series to 1994 (Figure 4). Also in this case, this increase is specially observed in the groups of herrings, sardines, and anchovies and in the miscellaneous coastal fish (Figure 5d). Since 1994, a relevant decrease is shown.

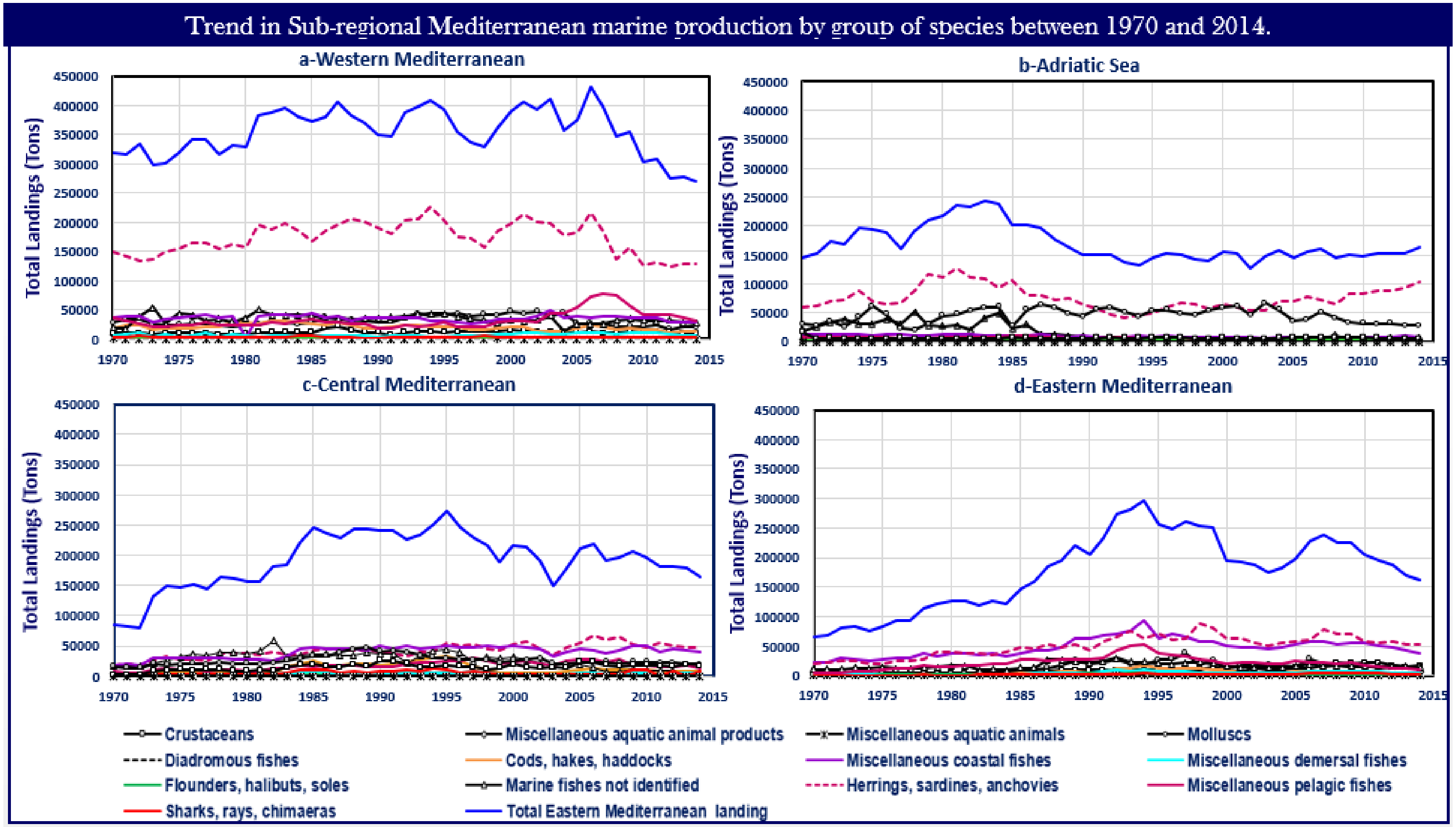


Figure 5. Trend in the Mediterranean sub-regions landings by group of species for the period 1970-2014.

An analysis by countries (Figure 6; FAO, 2016) shows that, in the western Mediterranean, Algeria, Spain and Italy, together account for 75 percent of landings, with Morocco and Tunisia also making sizeable contributions. Landings in the Adriatic Sea are dominated by Italy and Croatia, with almost equal volumes, together representing more than 99 percent of catches. In the Ionian Sea, Italy and Tunisia together account for 75 percent of landings, with Libya accounting for another 19 percent. In the eastern Mediterranean, Egypt makes the largest contribution (38%), followed by Greece (29%) and Turkey (27%), each of these making almost equal contributions.

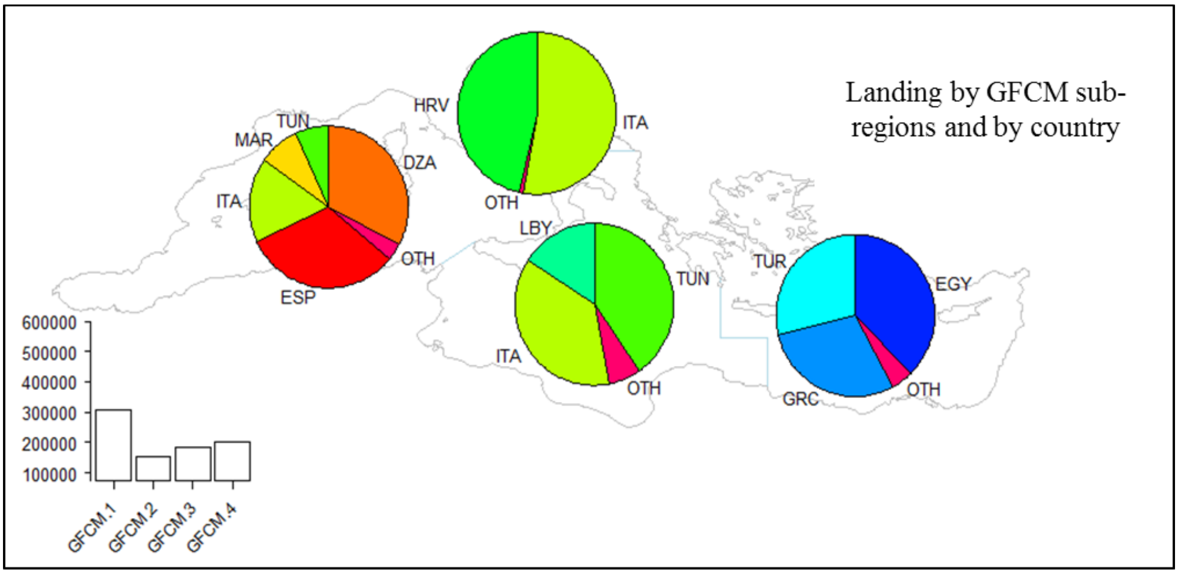


Figure 6. 2013 landings by Mediterranean GFCM sub-regions and by country. Pie charts reflect the percentage of the landings by country (in three letters alpha-code, with OTH meaning sum of other countries not explicitly mention in the chart) in the different sub-regions (GFCM.1 = western Mediterranean, GFCM.2 = Adriatic Sea, GFCM.3 = central Mediterranean, GFCM.4 = eastern Mediterranean). Bar plot on the bottom left represent the absolute values of landings (t) by GFCM sub-regions.

In general, the Mediterranean catches are composed of a variety of species. However, they are dominated by small pelagic group: anchovy (393.500 tons) and sardine (~186.000 tons) are by far the dominant species, representing almost the 38% of total landing in the GFCM area of application (Table 2). Other species account for about 55 percent of landings. Clams (~56.000 tons) and mussels (~20.000 tons) account for substantial landings, as do the species group of squid, cuttlefish and octopus (58.000 tons), which are mainly characteristic and endemic of the Mediterranean.

Code	Species	Average landings	Percentage
ANE	*Engraulis encrasicolus*	393 500	26.21
PIL	*Sardina pilchardus*	186 100	12.4
JAX	*Trachurus spp*	74 900	4.99
SPR	*Sprattus sprattus*	62 100	4.14
SIX	*Sardinella spp*	57 400	3.82
SVE	*Chamelea gallina*	52 600	3.5
BOG	*Boops boops*	27 000	1.8
HKE	*Merluccius merluccius*	24 900	1.66
MUL	*Mugilidae*	22 600	1.51
BON	*Sarda sarda*	22 200	1.48
MSM	*Mytilus galloprovincialis*	20 000	1.33
BFT	*Thunnus thynnus*	17 700	1.18
CLA	*Clupeonella cultriventris*	17 500	1.17
MOL	*Unallocated mollusca*	15 200	1.01
MZZ	*Unallocated osteichthyes*	66 600	4.44
OTH	*Other species**	451 000	30.04

Table 2. Average landings by species (years 2000-2013) that at least contribute to 1 percent of the total landings, sorted in decreasing order. **sum of species with average landing below 1% of the total*

The analysis by sub-regions (Figure 7) reveals as almost 30 species contribute to 90 percent of the total landings. The only exception is represented by the Adriatic Sea, where catches are dominated by less than 15 species.

Also in this case, the most important species in all Mediterranean sub-regions are sardine (*Sardina pilchardus*), and anchovy (*Engraulis encrasicolus*): the percentage contribution of both species being very similar in the Ionian, western and central Mediterranean Sea. In the Adriatic Sea, those species contributed up to 60% of total landing, followed by the clam (*Chamelea gallina*) with a contribution up to 20% and by different demersal coastal fish that accounted for about 6%.

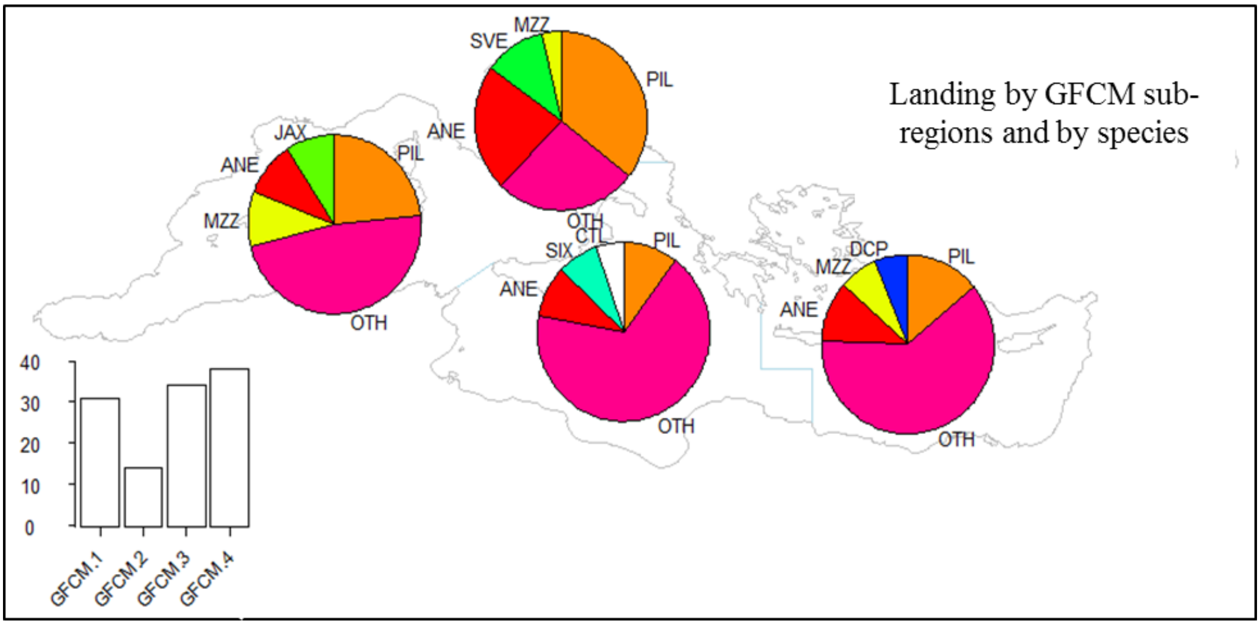


Figure 7. 2013 landings by Mediterranean GFCM sub-regions and by species. Pie charts reflect the percentage of landings by species (in three letters alpha-code, with OTH meaning the sum of other species not explicitly mentioned in the chart) in the different sub-regions (GFCM.1 = western Mediterranean, GFCM.2 = Adriatic Sea, GFCM.3 = Ionian Sea, GFCM.4 = eastern Mediterranean). Bar plot on the bottom, left represents the number of species or groups of species that account for 90% of the total catch in the respective GFCM sub-regions.

CONCLUSIONS

Conclusions (brief)

The temporal trend in annual production of demersal fish, crustaceans, cephalopods and small pelagic showed a rapid increase from the 70s to the beginning of the 90s, followed by a declining trend since then, obvious in all Mediterranean sub-regions with the exception of the Adriatic, where the decrease started in the mid-80s and the production has remained stable at low levels since the 90s. Small pelagics (composed of few species like anchovy, sardine and other clupeids) are by far the dominant group, representing almost the 38% of total landings in the GFCM area of application. On the contrary, the landings of demersal species show large differences among sub-regions, mainly due to different species and fishing activities. The western Mediterranean is the area with the highest annual production, amounting to around 270.000 tons, whereas the other three Mediterranean sub-regions show a similar yield (160.000 tons).

The maintenance of a sustainable and as large as possible yield of fish and shellfish is a priority for Mediterranean riparian countries in the context of food security and blue growth. In this respect, riparian countries recognize that it is important to maintain, and when necessary rebuild, the biomass of fish stocks in order to ensure Maximum Sustainable Yield. In this context, they are committed to implementing the mid-term (2017-2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries adopted in 2016, which includes as one of its targets to *reverse the declining trend of fish stocks through strengthened scientific advice in support of management*[15]. Furthermore, the GFCM has

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[15] http://www.fao.org/gfcm/activities/fisheries/mid-term-strategy

recently adopted two dedicated subregional management plans and several riparian countries have reported a significant reduction of their fishing capacity, in line with the adopted GFCM resolution on the management of fishing capacity[16]. These measures are expected to be complemented with additional fisheries management measures within the mid-term strategy, with the objective to efficiently manage key fisheries by 2020.

Conclusions (extended)

Catch in numbers or weight represents the removal of biomass and individuals from the ecosystem. Data based on landings, when accurately reported, can be a fair indicator of the status of Mediterranean fisheries' stocks and, the trend analysis can provide evidence of how well target populations are performing in response to fishing pressure (i.e. the impact that fishing has on fish populations).

Currently, the Mediterranean Sea is exploited by about 80.000 vessels, most of which are small-scale boats using many different fishing gears. The small-scale fishing component of the fleet is still extremely important for its socio-economic implications on many coastal communities, in addition to being a source of food and representing an important cultural heritage with relevant repercussions on activities related to tourism, for example.

It is worth noting that official landings statistics selectively represent landings from the commercial fisheries sector and do not provide an indication of all that is being harvested from the sea. Furthermore, landing/catch data should be associated to stock assessment analysis, in order to provide detailed information regarding the biological characteristics of a species or stock under fisheries' management.

Based on scientific advice, fishing must be adjusted to bring exploitation to levels that maximize yields (or catch) within the boundaries of sustainability.

Key messages

- The maintenance of a steady production of fish from Mediterranean fisheries is a priority in the context of blue growth and food security for coastal communities.
- Mediterranean catches are stagnant, with current yields at around 800.000 tons, below the maximum yield of around 1 million tons, obtained in the mid-90's.
- The current fishing pressure (see Indicator EO3CI9), the biomass levels of some key species (see Indicator EO3CI7) and other pressures on Mediterranean ecosystems jeopardize the sustainability of catches of fish and shellfish, and riparian states have agreed to undertake necessary management measures to revert the status of Mediterranean fisheries, including through the implementation of the *mid-term (2017 – 2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries*.

Knowledge gaps

- The correct estimation of total landings requires a precise knowledge of the fishing activities carried out by the active fishing fleet operating in the Mediterranean. The specificities of the Mediterranean fleet, composed by a large majority of small scale polyvalent vessels, as well as the existing variety of landing sites, and the different

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[16] Resolution GFCM/37/2013/2 on Guidelines on the management of fishing capacity in the GFCM area

capacity of Mediterranean riparian states to accurately monitor the landings in such sites, make difficult an accurate estimation of landings in the region. Furthermore, Illegal, Unregulated or Unreported (IUU) fishing activities in the area also affects the estimates.

- Ultimately, the ideal indicator for the production of fisheries as well as the removal of organisms due to fisheries should be total catch, but information on discards is fragmented.
- The GFCM has proposed a number of solutions to improve the quality of the estimation of total catch. On one hand, the GFCM DCRF[17] is expected to provide the technical elements to improve and harmonize the collection of information on fisheries throughout the Mediterranean. Also, the mid-term strategy towards the sustainability of Mediterranean and Black Sea fisheries foresees specific activities such as a bycatch monitoring programme or a survey of small-scale fisheries, as well as the implementation of dedicated actions to assess and curb IUU fishing, which are expected to largely improve the quality of the estimates for this indicator.
- Care needs to be taken in interpreting trends in the indicator for total landings because variations in total catch/landing may be a result of various factors, including the state of the stock, changes over time in the selectivity of fishing gear, changes in the species targeted by fishing activities, as well as inconsistencies in the reporting.

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[17] http://www.fao.org/gfcm/data/dcrf/en/

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ACRONYMS

CORMON	Correspondence Group on Monitoring
CWP	Coordinating Working Party on Fishery Statistics
DCRF	Data Collection Reference Framework
EAF	FAO Ecosystem Approach to Fisheries
EcAp	Ecosystem Approach
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean
GSA	Geographical Sub Areas
IUU	Illegal, Unreported and Unregulated (fishing estimates)
MSY	Maximum Sustainable Yield
RFMO	Regional Fisheries Management Organization
SAC	GFCM Scientific Advisory Committee on Fisheries
SAFs	Stock Assessment Forms
SoMFi	The State of Mediterranean and Black Sea fisheries
STECF	European Union Scientific, Technical and Economic Committee for Fisheries
WGSAs	Working Groups on Stock Assessment

Ecological Objective 3 (EO3): Populations of commercially exploited fish and shellfish are within biologically safe limits

EO3: Common Indicator 9. Fishing Mortality

GENERAL

Reporter:	GFCM
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	GFCM Contracting and Cooperating Non Contracting Parties
Mid-Term Strategy (MTS) Core Theme	2-Biodiversity and Ecosystems
Ecological Objective	E03: Populations of commercially exploited fish and shellfish are within biologically safe limits.
IMAP Common Indicator	Common Indicator (CI9).: Fishing Mortality
Indicator Assessment Factsheet Code	EO3CI9

RATIONALE/METHOD

Background (short)

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management measures (Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

The assessment of the size and state of exploited fish stocks is one of the pillars of fisheries management. Generally, stock status is determined by estimating both current levels of fishing mortality and spawning-stock biomass (*see EO3CI7*), and comparing these with reference points, which are typically associated with maximum sustainable yield (MSY - Brooks *et al*., 2010).

The GFCM provides regular reports on main indicators of relevance for fisheries management, and in 2016 has launched its flagship publication “The State of Mediterranean and Black Sea fisheries – SoMFi” [18] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of fishing mortality (GES indicator EO3CI9), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

Background (extended)

The GFCM, as the responsible Regional Fisheries Management Organization (RFMO) in the Mediterranean and Black Sea provides regular reports on main indicators of relevance for

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[18] http://www.fao.org/gfcm/publications/en/

fisheries management, and in 2016 has launched its flagship publication "The state of Mediterranean and Black Sea fisheries – SoMFi" [19] that includes a comprehensive analysis of salient issues of relevance in the area. The assessment on the status of commercially exploited fish, included in relation to the indicator of fishing mortality included below (GES indicator EO3CI9), emanates from the information published in SoMFi 2016 and anticipates some of the findings that will be presented in detail in SoMFi 2018.

Mediterranean countries, within the context of the GFCM, have recently updated and adopted new specific binding recommendations related to the mandatory requirements for data collection and submission, underpinned by the launch of the GFCM Data Collection Reference Framework (DCRF – GFCM, 2017a). The DCRF is the first GFCM comprehensive framework for the collection and submission of fisheries-related data, as requested through GFCM recommendations in place and necessary for relevant GFCM subsidiary bodies to formulate advice in accordance with their mandate. It encompasses all the necessary indications for the collection of fisheries data (i.e. global figure of national fisheries, catch; incidental catch of vulnerable species; fleet; effort; socio-economics; biological information) by GFCM members in a standardized way, in order to provide the GFCM with the minimum set of data needed to support fisheries management decision-making processes. In addition, the GFCM works through its permanent Working Groups on Stock Assessment (WGSAs) - on demersal and small pelagic fish species - where fisheries scientists perform their analysis and provide the best scientific advice to better manage fisheries and fish stocks. Several analytical methods, based on the population dynamics of different stocks of demersal and small pelagic species, have been applied within the GFCM-WGSAs. In order for the advice on the status of stocks to be reliable, the data and information used in the analysis should be timely available and accurate. Data for the assessment of stocks are collected through stock assessment forms (SAFs), which also contain information on reference points and the outcomes of the assessment (e.g. fishing mortality, exploitation rate, spawning stock biomass, recruitment etc.).

Following the decision of the GFCM to work on indicators of Good Environmental Status (GES) of Mediterranean and Black Sea species, habitats and ecosystems, so further embracing the FAO Ecosystem Approach to Fisheries (EAF), and within the framework of the Memorandum of Understanding signed with UNEP-MAP, a number of activities have been undertaken in the framework of the GFCM Scientific Advisory Committee on Fisheries (SAC) in recent years. In 2014, the first outputs of the MedSuit project (A Mediterranean Cooperation for the Sustainable Use of Marine Biological Resources - funded by the Italian Ministry of Environment) were presented to the sixteenth session of the SAC (GFCM, 2014a) together with a first proposal of indicators and targets for the assessment of the status of stocks, developed in collaboration with and within the framework of the UNEP-MAP Ecosystem Approach (EcAp) process, in particular, its Ecological Objective 3 (Harvest of commercially exploited fish and shellfish). Indicators and targets were further discussed during the "First MedSuit Regional Workshop on indicators and targets to ensure GES of commercially exploited marine populations" (GFCM, 2014b), endorsed by the seventeenth session of the SAC (GFCM, 2015), and were finally incorporated in the GFCM Data Collection Reference Framework (DCRF) adopted by the GFCM (GFCM, 2017a).

The indicators of Good Environmental Status of Commercially Exploited fish are quantitative proxies to describe the status of a specific fish stock (i.e. the fish population from which catches are taken in a given fishery) as well as the anthropogenic pressure imposed on it through fishing activities. Those indicators are regularly used in fisheries management to assess the sustainability of fisheries, as well as the performance of management measures

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[19] http://www.fao.org/gfcm/publications/en/

(Miethe *et al*., 2016), by monitoring how far the indicator is from previously agreed targets (i.e. reference points).

Fishing mortality (F) is considered an essential component of fishery stock status and a fundamental variable in stock assessment. F reflects all deaths in the stock that are due to fishing per year (not only what is actually landed). Generally, stock status is determined by estimating current levels of fishing mortality and spawning-stock biomass (see also EO3CI8) and comparing these with reference points, which are typically associated with Maximum Sustainable Yield (MSY) (Brooks *et al.*, 2010). When F is higher than maximum sustainably fishing mortality (F_{MSY}) (i.e. the fishing mortality rate that produces the maximum sustainable yield) the yield decreases.

The assessment of the size and state of exploited fish stocks is one of the pillars of fisheries management. The most recent studies assessing the status of fisheries in the world show an important decline in the status of stocks. Also, some ecosystems show clear signals of stress due to anthropogenic pressure, and others are threatened to be pushed to a point of no return if the marine resources will continue to be exploited at current levels (Tsikliras *et al.,* 2015).

Assessment methods

The complete set of main fishery indicators adopted to assess current status of Mediterranean stocks as well as their temporal trend is reported in the last SAC Report (FAO, 2017). Below are listed the ones, for which a common methodology has been already developed (GFCM, 2017b) and discussed during the meeting of the Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (UNEP(DEPI)/MED WG.430/3) as well as the 6th meeting of the Ecosystem Approach Coordination Group (UNEP(DEPI)/MED WG.444/6/Rev.1):

i. Spawning Stock Biomass (SSB) (Indicator assessment factsheet code *EO3CI9*)
ii. Fishing mortality (F) and/or Exploitation rate (E) (Indicator assessment factsheet code *EO3CI7*)
iii. Total Landing (TL) (Indicator assessment factsheet code *EO3CI8*).

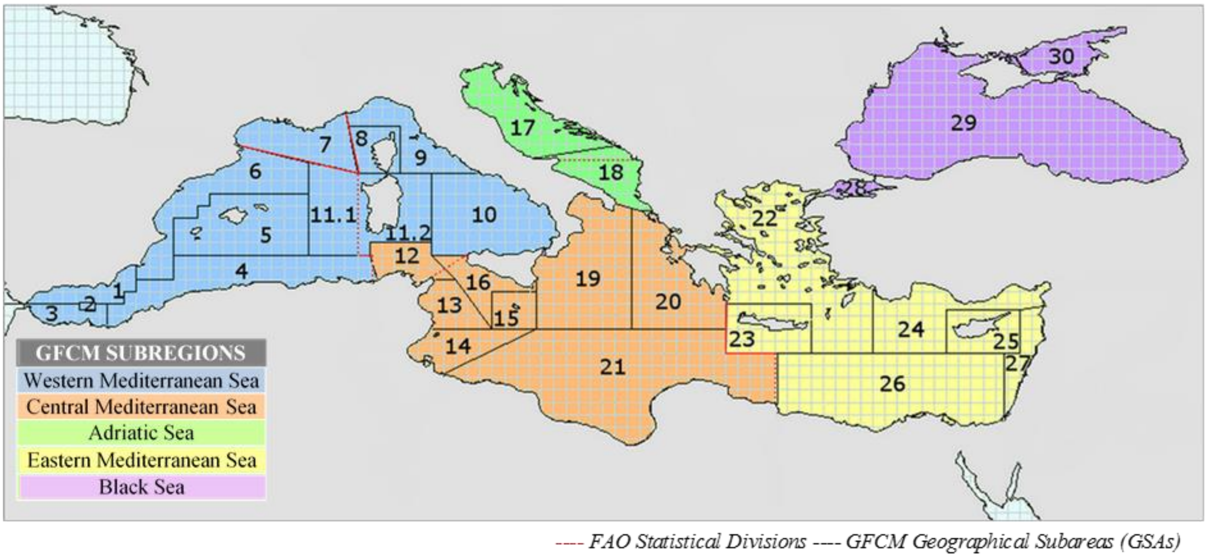
The indicator on fishing mortality is estimated as a regularly basis and submitted to GFCM through the SAFs. The results provided for this indicator are mainly based on information contained in the metadata database of SAF, and only those stocks validated by the SAC at the time of preparation of this analysis have been used.

Description of current indicator.

Fishing mortality is considered an essential component of fishery stock status and a fundamental variable in stock assessment. Generally, fishing mortality is defined as the instantaneous mortality rate (i.e. the individuals that die) due to fishing, and can be defined in terms either of numbers of fish or in terms of biomass of fish. It is usually expressed as a rate ranging from 0 (for no fishing) to high values (1.0 or more). F (fishing mortality) and M (natural mortality) together make up the total mortality rate Z. This indicator is intrinsically linked to the optimum catch that can be harvested from a stock in a sustainably way; a sustainable yield is one that will leave enough fish in the water to keep on breeding, so new generations of fish are created (i.e. where inputs to the fishery do not exceed what is coming out of the fishery). The Maximum Sustainable Yield (MSY) is the maximum yield that can be obtained from a species in a sustainable way, and it is associated with a maximum sustainably fishing mortality (F_{MSY}).

Area.

For the present analysis, the study area is corresponding to GFCM area of application (FAO major fishing area 37): the Mediterranean Sea from the Straits of Gibraltar to Bosphorus, which englobes 27 Geographical Sub-Areas (GSAs). The Mediterranean GSAs were then aggregated by GFCM into four sub-regions, namely; (i) the Western, (ii) Central and (iii) Eastern Mediterranean and (iv) the Adriatic Sea (Fig. 1).



GFCM GSAs

01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant Sea
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Se
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - Southern Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 1. Map of the GFCM area of application (Subregions and GSA- Geographical Subareas)

Sources of data.

Data used for the analysis of this indicator are mainly based on information available in SAFs as well as the GFCM capture production online database (both available in the GFCM webpage: http://www.fao.org/gfcm). Stocks assessments carried out from 2009 to 2016 were compiled, and the most recent stock assessment for each stock was used in the analysis. Only those stocks validated by the SAC at the time of preparation of this analysis have been included in the analysis. Information from these sources has also been complemented with information publicly available, including from the European Union Scientific, Technical and Economic Committee for Fisheries (STECF) website (https://stecf.jrc.ec.europa.eu).

SAFs include data on fisheries (e.g. fishing gear, fleet), and historical trends on catches, biological parameters of growth and maturity, as well as the set of reference points used and results obtained (i.e. F, SSB etc.). They also include information on the stock assessment methods used within the study area the indicators of stock status and the set of established reference points.

Reference points.

FAO (1997) and Fletcher *et al*., (2002) define a fishery reference point as "*a benchmark against which to assess the performance of management in achieving an operational objective*". The reference points are crucial elements for assessing stock status and provision advice for fisheries management (GFCM, 2014a). In general, the reference points serve to compare the current value of estimated indicators with the target ones, which allows quantify how far or near the estimated indicator from the desirable situation.

When possible the quality assessment on the different indicators on the status of exploited population of fish has been carried out in relation to reference points as validated by the SAC.

The fishing mortality reference point conceptually preferred by most RFMOs, including the GFCM, is F_{MSY}, as the value of F expected to produce the long-term maximum sustainable yield. F_{MSY} can be estimated from analytical models with a variety of approaches, either based on model assumptions or through simulations analyzing the long-term sustainability of the stock under different fishing mortality. When F_{MSY} is not available, a proxy that is considered similar can be used. The SAC uses mainly two different proxies for F_{MSY}, one is $F_{0.1}$, defined as the fishing mortality at which the slope of the Yield per Recruit (YPR) curve is 10 percent of its slope at the origin (FAO, 2014). Another proxy is based on exploitation rate (the rate between fishing mortality and total mortality $E=F/Z$), for which a value of 0.4 ($E_{Patterson}$ =0.4) have been shown to provide an approximation of maximum sustainable yields for small pelagic species worldwide. $F_{0.1}$ can be estimated for a wider number of stocks and is considered a conservative proxy for F_{MSY}, and is widely used in the context of the GFCM, especially for demersal stocks. $E_{0.4}$ is on the other hand used for small pelagics when no robust analytical estimate of F_{MSY} or $F_{0.1}$ can be obtained (GFCM, 2016).

For the purpose of this work, $F_{0.1}$ and $E_{0.4}$ are considered adequate proxies for F_{MSY} and therefore all information presented compares current F with any of the three reference points indistinctly and in general terms called F_{MSY}.

Methodology.

From the indicator based-stock-assessment F and using the associated reference points the exploitation (F/F_{MSY}) was estimated and used to assess the stock status. This indicator measures how far or near is the examined stock from its target level, i.e. the associated reference point (Table 1).

For the purpose of this analysis, the exploitation ratio (F/F_{MSY}) aggregated time series was also broken down by functional groups, i.e. (i) small pelagic, (ii) demersal bony fish and (iii) crustacean. This allowed exploring the temporal change in each functional groups and detect which of the Mediterranean species group status is improving. In addition, the functional groups temporal trend were further analyze by species to explore what is occurring at inside the groups of species.

Indicator	GES definition	Related Operational Objective	Reference level	Spatial Coverage
Fishing Mortality	Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	Fishing mortality in the stock does not exceed the level that allows MSY ($F \leq F_{MSY}$).	- F_{MSY} or its proxy - Decreasing or increasing temporal trend of exploitation ratio with relative level $F/F_{MSY} = 1$ using linear regression and percentage of change.	At regional, sub-regional and stock level.

Table 1. Fishing mortality fishery indicator and the corresponding assessed criteria

The status of a stock is ideally based on a validated stock assessment model, from which indicators of stock status (e.g. biomass, fishing mortality, recruitment) are obtained, and reference points are agreed for the chosen indicators. When possible, analytical stock assessment models that incorporate both fishery-dependent (e.g. catches) and independent information (e.g. surveys) are used, although direct surveys are used for some stocks. Different stock assessment models are used in the GFCM area of application, including variations of virtual population models (from pseudo-cohort based models, such as VIT, to tuned versions, such as extended survivor analysis – XSA), statistical catch at age analysis (e.g. state-space assessment model – SAM or stock synthesis – SS3) and biomass models (BioDyn, two-stage biomass models, etc.). Some stock assessment methods are only based on information from scientific surveys at sea (e.g. survey-based assessment – SURBA, or acoustic estimates of biomass).

When no analytical assessment model or reference points are validated by the SAC, advice can still be provided on a precautionary basis, in cases where there is evidence that the stock may be threatened (high fishing pressure, low biomass, habitat loss, etc.). When possible, advice on stock status should be based both on biomass and on fishing pressure, using indicators and reference points for both quantities.

Concerning the spatial analysis, the stock assessment is often conducted by management units based on the mentioned Geographical Sub Areas (GSAs -Figure 1). This method does not ensure that the whole stock is assessed, since stocks may cover several different management units. In some cases, when there is scientific evidence of a stock spreading through different GSAs, as well as information on species from different GSAs, existing information is combined across GSAs. This is then defined as a “joint stock assessment of a shared stock”.

RESULTS

Results and Status, including trends (brief)

In total 78 stocks were considered in this analysis, 11 among them are small pelagic stocks, mainly sardine and anchovy, and 67 are demersal stocks pertaining to 19 different species.

According to the indicator of exploitation status (F/F_{MSY}), the majority of examined stocks (86%) are harvested above sustainable levels, while only a minority (14%) of stocks are exploited sustainably. By species groups, the demersal fish suffer the highest overexploitation level. In terms of aggregated stocks at species level, according to the average F/F_{MSY}, almost all the Mediterranean assessed species are subjected to the overexploitation. Hake is the species subject to the highest fishing mortality: on average, across the Mediterranean, the fishing mortality rate for hake is up to 7 times higher than the target fishing mortality level. Only two species (sprat and picarel) have average fishing mortality rates that are lower than the target, but in both cases the estimate is based on a single management unit and on few stock assessments.

Results and Status, including trends (extended)

With the aim to carry out an overall analysis of Mediterranean current stocks status, the most recent endorsed stock assessments by both SAC of GFCM and STECF of European commission were consulted and included in the analysis.

In total 78 stocks are considered in this analysis, 11 from them are small pelagic stocks, mainly sardine and anchovy, and 67 are demersal stocks pertaining to 19 different species. Among the total included stocks, 63 are from SAC endorsed assessments (Table 2)

According to the indicator of exploitation status (F/F_{MSY}), the majority of examined (86%) stocks are harvested above the level that can ensure the stock sustainably, while only a minority (14%) of stocks are exploited sustainably. The overfishing intensity varies from $1.01 \leq F/F_{MSY} \leq 1.10$ to $F/F_{MSY} > 3$ (Figure 2).

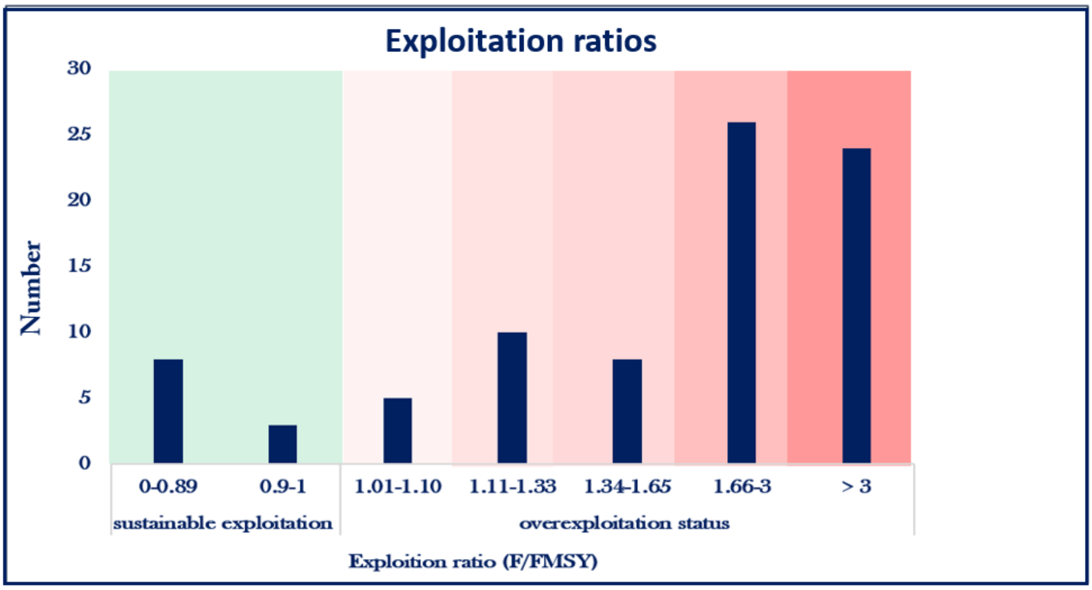


Figure 2. Exploitation ratios range. The colored area indicates the exploitation status. Green area: sustainable exploitation, gradual red color area: from very low (clear red) to high (dark red) overexploitation status.

By species groups, the demersal fish suffer the highest overexploitation level. On average, across all the Mediterranean assessed stocks, the exploitation ratio for demersal fish is about 3.7 times greater than the maximum sustainable yield, followed by the demersal crustacean that are exploited 1.8 time more than the target level. The small pelagic stocks are subjected to the lowest average fishing mortality, showing an average exploitation ratio estimated at around 1.66. (Figure 3).

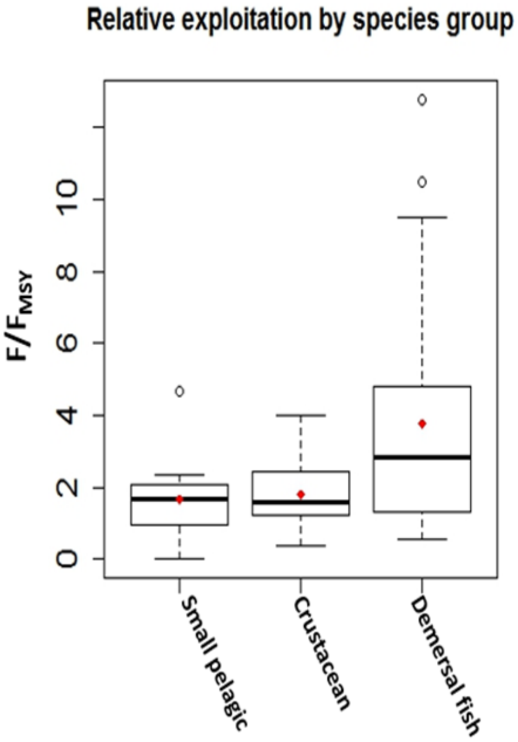


Figure 3. Distribution of the exploitation ratio (F/F_{MSY}) by species group. The red points indicates the mean.

At species level, according to the average F/F_{MSY}, almost all the Mediterranean assessed species are subjected to the overexploitation and at the forefront appear the European hake stocks with an average exploitation ratio up to 6.97 (Table 3 and Figure 4).

Table 2. The latest validated stock assessments by SAC (in blue) and by STECF (in purple) included in the overall analysis of current Mediterranean stock status

Species / GSA	1	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	22	25	26
A. foliacea							2015	**2014**	**2014**				2010	2010		**2014**	**2014**			
A. antennatus	2015			2015	2015		2015													
B. boops		2009																	2010	
D. labrax						**2015**														
E.encrasicolus	2009				**2015**	2015	**2015**							2012	2015	2015				
G.melastomus							2010													
G. seabream						**2015**														
L. piscatorius	**2015**			**2015**	**2015**	**2015**														
L. budegassa	**2013**			**2013**	**2013**								2010	2010						
M. poutassou					**2013**		**2013**													
M. merluccius	2015	2015		2015	2015	2015	2015	2013	**2014**	2015	2015	2015	2015	2015	2015	2015	**2014**			
M.stebbingi																				2015
M. barbatus	2014	2014	2014	2012	2015	2015	**2010**	**2013**	**2012**		2014	2014	2015	2015	2015	2015	2012		2015	
M.surmuletus	**2014**			2015			**2015**						2012	2012					2010	2013
N. norvegicus				2011	**2015**		**2015**						2012	2012	**2015**	**2015**				
P. bogaraveo	2011	2011																		
P.erythrinus													2011	2011						
P. longirostris	**2015**	2011	2011	2012	2014		2015	**2015**		2015	2015	2015	2015	2015	2015	2015	2015			
P. maxima																				
S. pilchardus	2015	2015			2015	2015								2014	2015	2015				
S. undosquamis																				2013
S. solea															2015					
S. smaris																			2015	
S. mantis							**2010**								2011	**2014**				
T. trachurus							**2015**	**2015**	**2015**											

Table 3. Exploitation ratio estimated (F/F_{MSY}) for latest validated assessments (for which a FMSY proxy is available) by the SAC of GFCM and STECF of Commission European. A grad red-orange-yellow was used to class the exploitation ratio from the more (dark red) to the less overexploitation status. The ratio $F/F_{MSY} \leq 1$ are colored in green.

Species	Western Mediterranean									Central Mediterranean						Adriatic sea		Eastern Med	
	1	3	4	5	6	7	9	10	11	12	13	14	15	16	19	17	18	25	26
E.encrasicolus	2.33				1.08		1.48							1.05		1.79	1.79		
S. pilchardus	0.90	0.90			4.69	0.01								0.53		2.07	2.07		
M. merluccius	8.50	8.50		7.88	8.00	12.80	4.50	4.63	9.41	6.92	6.92	6.92	6.92	6.92	4.83	2.29	2.29		
P. longirostrus	2.38	2.38	2.38	1.24	2.80		0.96	0.96	0.96	1.46	1.46	1.46	1.46	1.46	1.53	2.51	2.51		
M. barbatus	3.42	3.42	3.42	6.64	1.24	3.23	1.13	1.00	7.90		3.52	3.52	1.24	1.24	3.08	1.30	0.70	0.81	
P.bogaraveo	1.73	1.73																	
S. endosquamis																			2.20
A. foliacea							0.41	1.40	1.60				2.73	2.73	1.10		1.10		
A. antennatus				1.03	2.15		1.31												
B. boops		1.48																1.54	
G. melastomus							2.69												
L. budegassa	1.56			10.5	6.5								2.06	2.06					
M. stebbingi																			2.94
M. surmuletus	3.41			3.85			0.88						4.11	4.11				2.13	2.13
N. norvegicus				3.46	4.00		1.79		2.05				0.75	0.75		1.26	1.26		
P. erythrinus							1.31						2.40	2.40					
S. solea																1.35			
S. smaris																		0.64	
S. mantis							2.34									1.31	2.44		
T. trachurus							1.68	1.68	1.68										
L. piscatorius	3.00			3.00	3.00	3.00													
S. aurata						2.00													
M. poutassou					9.50		1.19												
D. labrax						3.00													

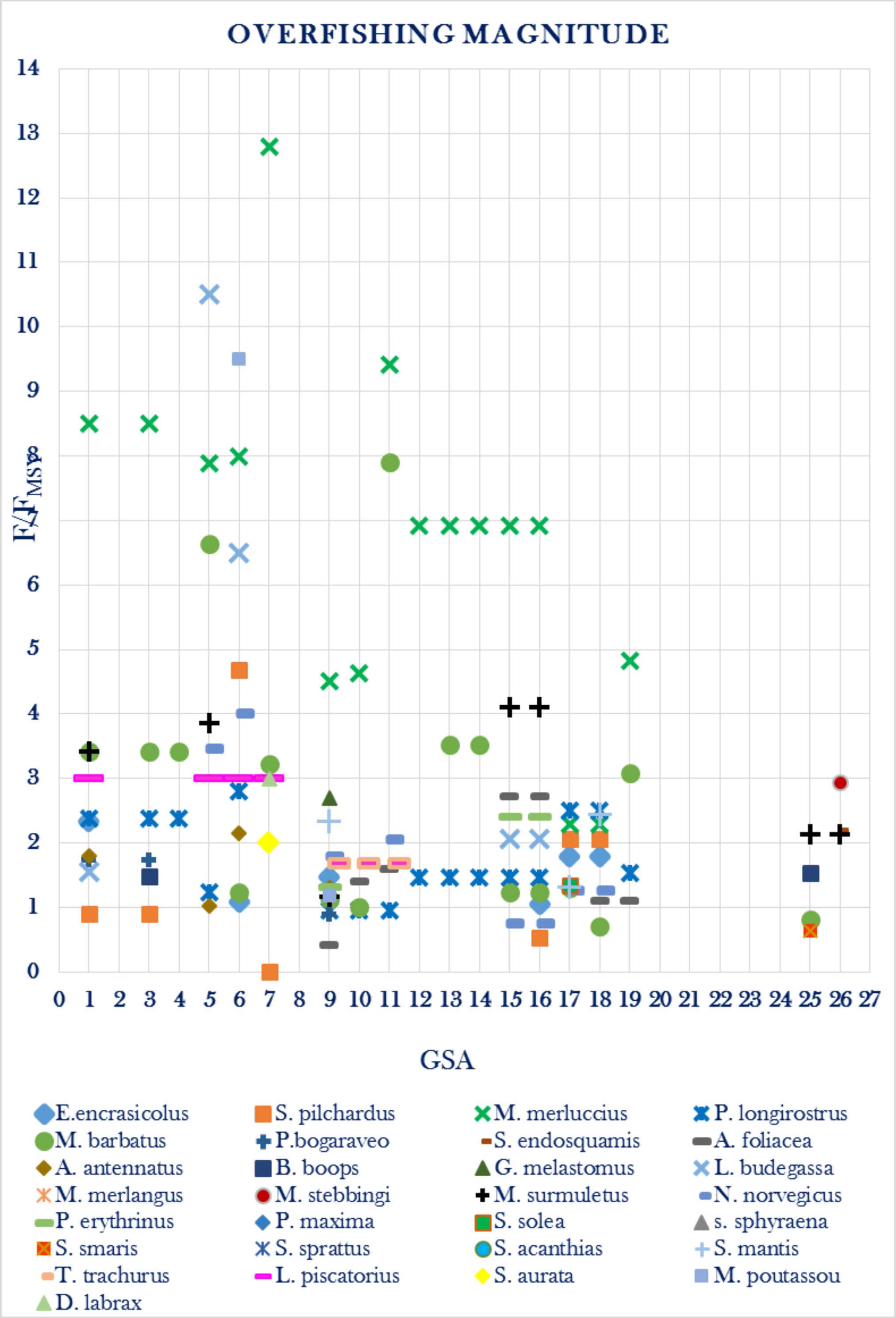
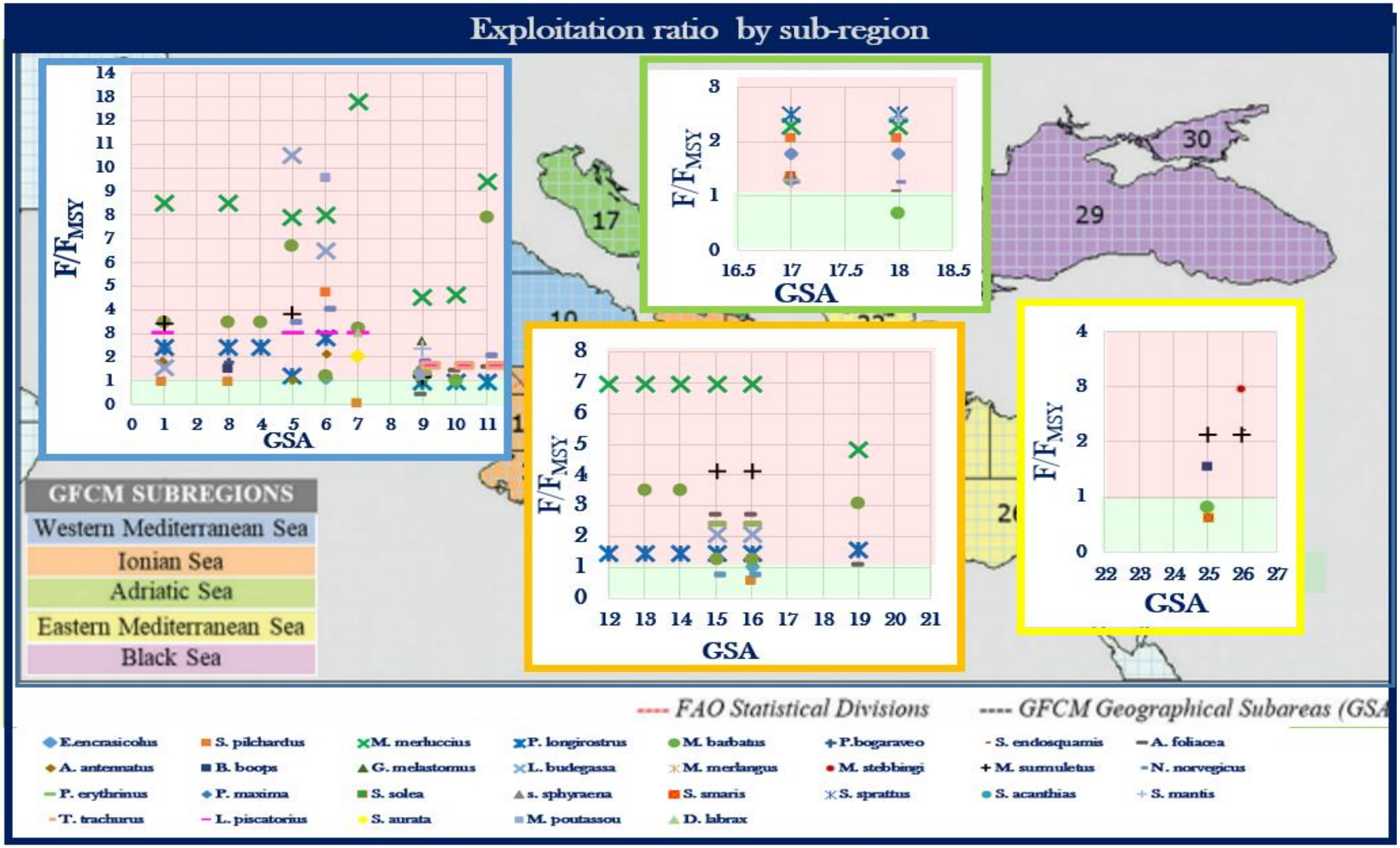


Figure 4. Estimated Exploitation ratio (F/F_{MSY}) of Mediterranean assessed stocks in different GSA

Figure 5. Fishing mortality relative to F_{MSY} by Mediterranean sub-region



CONCLUSIONS

Conclusions (brief)

In the Mediterranean, the majority (around 85 percent) of stocks for which a validated assessment exists are subject to overfishing. Current fishing mortality rates can be up to 12 times higher than the target for some stocks. In general, demersal species suffer higher exploitation rates than small pelagic species, with the latter showing average fishing mortality rates that are lower than the target.

The level of overfishing in the Mediterranean has been repeatedly pointed out by the GFCM SAC, which has requested fishing mortality to be reduced through adequate management measures. Mediterranean countries are recently taking measures to correct this problem that jeopardize the sustainability of fisheries in the area, including through the implementation of the mid-term (2017-2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries adopted in 2016, which includes as one of its targets to *reverse the declining trend of fish stocks through strengthened scientific advice in support of management*[20]. Furthermore, the GFCM has recently adopted two dedicated subregional management plans and several riparian countries have reported a significant reduction of their fishing capacity, in line with the adopted GFCM resolution on the management of fishing capacity[21]. These measures are expected to be complemented with additional fisheries management measures within the mid-term strategy, with the objective to reduce fishing mortality, especially for priority species, before 2020.

Conclusions (extended)

In the Mediterranean, the majority of stocks, for which a validated assessment exists, are fished outside biologically sustainable levels, either in terms of biomass (see also fishery indicator EO3CI7), exploitation or both criteria, with the degree varying among stocks, functional groups and geographical sub-areas. The ratio F/F_{MSY} illustrates that on average Mediterranean stocks are exploited three times greater than the target level and the biomass is lower than the reference point, which confirm a regional status of overexploitation. Current fishing mortality rates can be up to 12 times higher than the target for some stocks.

All Mediterranean sub-regions, without exceptions, are subject to high overfishing status, as the majority of their assessed stocks are not within biologically sustainable levels in terms of either stock size or fishing mortality. The Western Mediterranean stocks are in the worst shape compared to other sub-regions, with an average fishing mortality around three times higher than the target level, followed by the Central Mediterranean stocks with an average exploitation rate of about 2.9. Adriatic Sea and the Eastern Mediterranean stocks have shown an average exploitation rate of about 1.75 and 1.77, respectively.

Among the stocks listed in overexploitation status ($F > F_{MSY}$), 33% are close to reach the target level. Those stocks could only need as little as 10% of fishing mortality reduction to shift their status from overfishing to a sustainable exploitation. In general, demersal species suffer higher exploitation rates than small pelagic species, with the latter showing average fishing mortality rates that are lower than the target. Most stocks fished within biologically sustainable levels are of small pelagic species (e.g. sardine and anchovy), while only a few stocks of demersal species, such as whiting, some shrimp species, picarel and red mullet, are estimated to be fished at or below the reference point for fishing mortality. In light of this

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[20] http://www.fao.org/gfcm/activities/fisheries/mid-term-strategy

[21] Resolution GFCM/37/2013/2 on Guidelines on the management of fishing capacity in the GFCM area

review, it was concluded that around of 85% of the examined stocks (for which F_{MSY} or its proxy is available) are fished unsustainably (FAO, 2016).

Notwithstanding the above, it should be considered that the level of overfishing depends on the productivity of the stocks, which is affected by variables other than fishing itself. The reference point used in the assessment (F_{MSY} or its proxies) are affected by issues such as climate change or anthropogenic effects other than fisheries, including pollution and habitat destruction (Colloca *et al*., 2014). The combination of all these effects generates a strong biological stress and can be the cause of major ecological alterations, which in turn may affect the productivity of fisheries and therefore jeopardize Mediterranean fisheries and the production of local seafood for coastal communities.

Key messages

- The majority of Mediterranean stocks (~85%) are subject to overfishing.
- Riparian states have recently explicitly recognized overfishing in the Mediterranean as a key challenge in the context of blue growth and food security for coastal communities, and have included a specific target in the mid-term (2017-2020) strategy towards the sustainability of Mediterranean and Black Sea fisheries aimed at reversing the declining trend of fish stocks through strengthened scientific advice in support of management.
- The reduction of fishing mortality requires the adoption of subregional management plans in the context of the GFCM, to complement those already in place for the Adriatic small pelagics and the Strait of Sicily demersal fisheries, as well as the adoption of measures that ensure the efficient management of fishing capacity.

Knowledge gaps

- The advice on the status of Mediterranean commercially exploited stocks, as provided by the GFCM SAC have largely improved in recent years, as recognized by Mediterranean riparian states. However, the level of information differs between species and geographical areas, with information concentrating on a few stocks and lacking or being fragmented in other commercially exploited stocks.
- The correct estimation of fishing mortality requires a precise understanding of riparian states' fishing capacity. Due to the specificities of the Mediterranean fleet, composed of a large majority of small scale polyvalent vessels, information on fishing capacity is sometimes incomplete or inaccurate. Furthermore the estimation of robust reference points for fishing mortality requires the use of long time series and the incorporation of environmental and ecosystem variables, as well as the design of robust methods that can integrate information from different sources.
- The update and adoption of new specific binding recommendations related to the mandatory requirements for data collection and submission, underpinned by the operationalization of the GFCM Data Collection Reference Framework (DCRF)[22] is expected to improve the quality of the data in support of advice, in line with the need expressed by riparian states. The mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries is also expected to contribute in this endeavour through specific actions such as, for example, the execution of harmonized scientific surveys-at-sea.

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[22] http://www.fao.org/gfcm/data/dcrf/en/

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ACRONYMS

CORMON	Correspondence Group on Monitoring
DCRF	Data Collection Reference Framework
E	Exploitation rate
EcAp	Ecosystem Approach
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean
GSA	Geographical Sub Areas
F	Fishing mortality
F_{MSY}	Maximum Sustainably Fishing Mortality
MSY	Maximum Sustainable Yield
RFMO	Regional Fisheries Management Organization
SAC	GFCM Scientific Advisory Committee on Fisheries
SAFs	Stock Assessment Forms
SoMFi	The State of Mediterranean and Black Sea fisheries
SSB	Spawning Stock Biomass
STECF	European Union Scientific, Technical and Economic Committee for Fisheries
TL	Total Landing
WGSAs	Working Groups on Stock Assessment
YPR	Yield per Recruit

3) Quality Statur Report (Coast and Hydrography)

Ecological Objective 7 (EO7): Hydrography

EO7: Location and extent of the habitats impacted directly by hydrographic alterations

GENERAL

Reporter:	PAP/RAC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Mediterranean assessment based on research and publications
Mid-Term Strategy (MTS) Core Theme	3-Land and Sea Interaction and Processes
Ecological Objective	Ecological Objective 7(EO7): Alteration of hydrographical conditions
IMAP Common Indicator	Common Indicator 15 (CI15): Location and extent of the habitats impacted directly by hydrographic alterations
Indicator Assessment Factsheet Code	EO7CI15

RATIONALE/METHODS

Background (short)

Large-scale coastal and off-shore developments have the potential to alter the hydrographical regime of currents, waves and sediments in marine environment (UNEP/MAP/PAP, 2015). To address this, UN Environment/MAP has included the Ecological Objective 7 (“Alteration of hydrographical conditions”) as part of the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast (UNEP/MAP, 2016a). EO7’s Common Indicator 15 - 'Location and extent of habitats impacted directly by hydrographic alterations’ considers marine habitats which may be affected or disturbed by changes in hydrographic conditions due to new developments. The main target of this indicator is to ensure that all possible mitigation measures are taken into account when planning the construction of new structures, in order to minimize the impact on coastal and marine ecosystem and its services, integrity, and cultural/historic assets. The Good Environmental State (GES) regarding EO7 Hydrography is achieved when negative impacts due to new structures are minimal with no influence on the larger scale coastal and marine systems.

There are clear links between EO7 and other ecological objectives, especially EO1 (Biodiversity), and these need to be determined on a case-by-case basis.

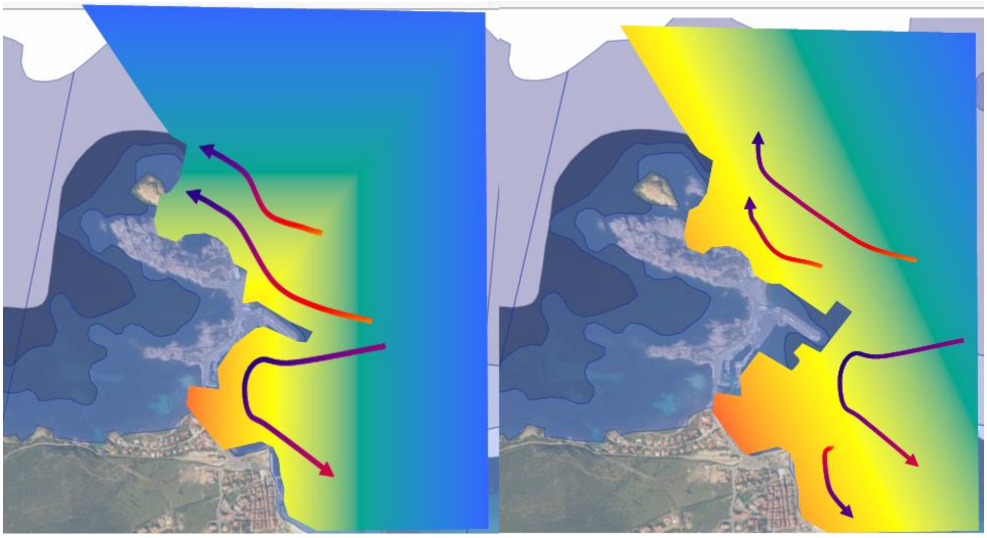

Figure 1. Illustration of hydrodynamic conditions without and with structure (image developed and provided by O. Brivois)

Background (extended)

Ecological Objective 7 is dedicated to assess permanent alterations in the hydrographic conditions due to new developments. By definition the term ‘hydrography’ is meant to include depth, tidal currents and wave characteristics of marine waters, including the topography and morphology of the seabed.

EO7 Common Indicator 15 considers only new developments, since existing structures have already changed the hydrographic conditions and potentially impacted the habitats. Since the baseline conditions before the construction of existing structures are unknown, the monitoring of CI15 for existing structures is not possible.

There is a clear link between EO7 and other ecological objectives, especially EO1 (Biodiversity). By definition of functional habitats under EO1, the priority benthic habitats for consideration in EO7 are to be selected. Ultimately, the assessment of impacts, including cumulative impacts, is a cross-cutting issue for EO1 and EO7.

The guidance document on how to reflect changes in hydrographical conditions in relevant assessments was prepared in 2015, aiming to define a methodological approach for assessing alterations of hydrographical conditions and the impact this may have on habitats due to permanent constructions and activities on the coast or at sea (UNEP/MAP/PAP, 2015).

As for Protocols of the Barcelona Convention relevant for the EO7, the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (UNEP/MAP/PAP, 1999) calls to Contracting Parties of the Barcelona Convection for continuous monitoring of ecological processes, population dynamics, landscapes, as well as the impacts of human activities (Article 7b). In addition, it calls to Contracting Parties to evaluate and take into consideration the possible direct or indirect, immediate or long-term impacts, including the cumulative impact of the projects and activities, on protected areas, species and their habitats (Article 17).

Another Protocol of the Barcelona Convention, the Protocol on the Integrated Coastal Zone Management in the Mediterranean (UNEP/MAP/PAP, 2008), in its Article 9, calls for Parties to minimize negative impacts on coastal ecosystems, landscapes and geomorphology, from infrastructure, energy facilities, ports and maritime works and structures; or where appropriate to compensate these impacts by non-financial measures. In addition, the Article 9 demands maritime activities to be conducted “in such a manner as to ensure the preservation of coastal ecosystems in conformity with the rules, standards and procedures of the relevant international conventions.

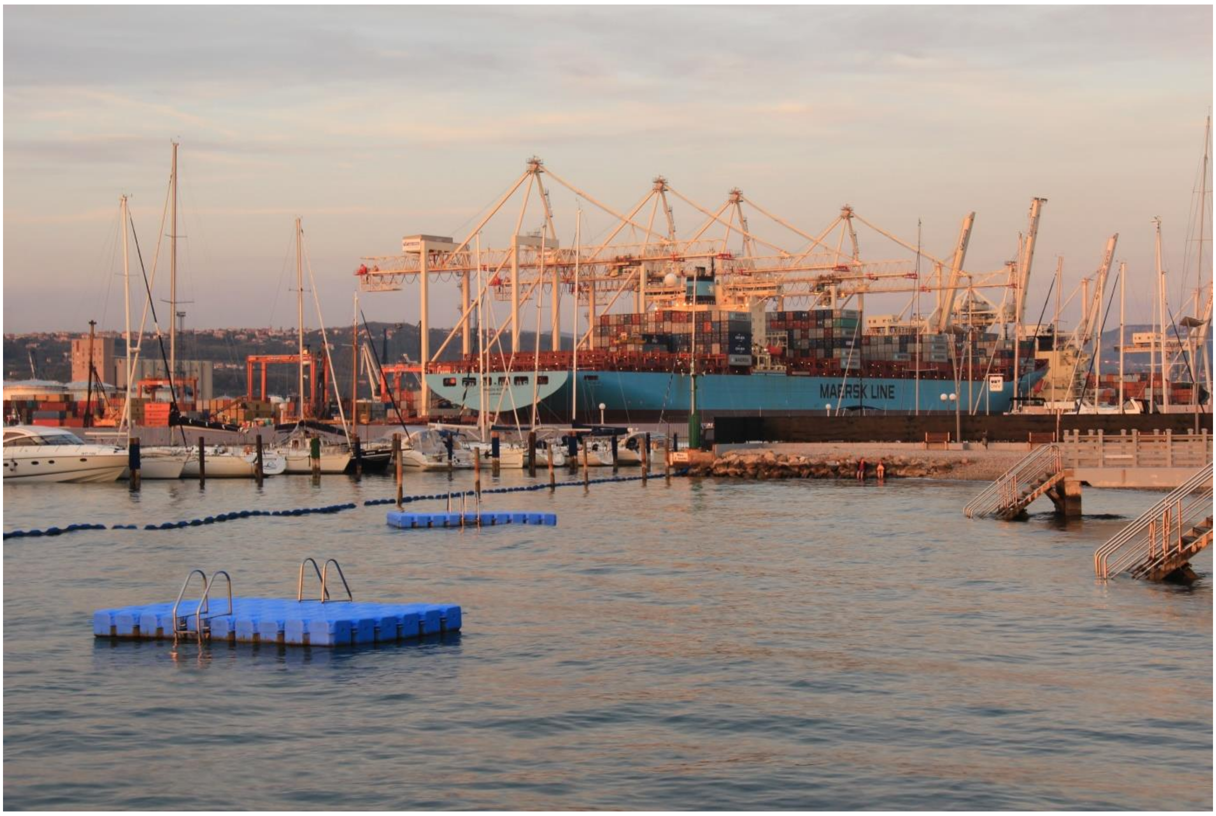

Photo by Marko Prem

Assessment methods

The methodology for assessment of this indicator is described in detail in Indicator Guidance Fact Sheet on Common Indicator 15.

In brief, the methodology to assess the indicator can be divided in three main steps:

(i) Baseline hydrographical conditions characterisation (Monitoring and modelling of actual conditions without structure);
(ii) Assessment of hydrographical alterations induced by new structure (comparing baseline conditions and with structure conditions, using modelling tools); and
(iii) Assessment of habitats impacted directly by hydrographic alterations (by crossing hydrographical alterations and habitat maps).

Among hydrographical conditions, at least waves and currents changes should be assessed, with changes in sediment transport processes and turbidity in case of sandy sites, and salinity and/or temperature changes in case of structures that involve water discharge, water extraction or changes in fresh water movements.

The monitoring should focus on habitats of interest around new permanent constructions (lasting more than 10 years). At first, the spatial scale (in cross-shore and long-shore directions) to be used should be about 10 to 50 times the characteristic length of the structure, and should be enlarged depending on the first results obtained for this area.

To correctly assess changes in time on habitats induced by constructions, the monitoring should be performed: before construction (baseline conditions); during construction; and after construction - short term changes 0 to 5 years after (at least yearly up to 5 years), midterm changes 5 to 10 years after (at least biennium to 10 years), and long-term changes (10 to15 years after construction).

Since there has been no systematic monitoring on this particular indicator at the regional level until now, examples of intersection of modeled area of hydrographic alterations with habitat area were not found. The methodology applied in some partial examples consisted mostly in measurement of trends for certain hydrographic parameters (temperature, salinity, waves, currents, marine acidification etc.) and limited, mostly qualitative, analysis on impacts on habitats at a national level.

The data presented in the results section are mainly from the European Union (EU) countries. It needs to be highlighted that the information presented here is extracted from technical assessments of the European Commission of submissions on Descriptor 7 by the EU countries. It should be noted that this information is from 2012 and is not fully in line with the Indicator Guidance Fact Sheet for the CI15.

There are case studies, namely, LNG terminal in Monfalcone Port, Italy; and container terminal Haifa Bay in Israel presented, which better correspond to the requirements of the h CI15 Guidelines fact sheets.

RESULTS

Results and Status, including trends (brief)

A brief overview of initial assessments of the current environmental status of marine waters belonging to Mediterranean-based EU countries is summarized. It needs to be highlighted that the information presented here is extracted from the technical assessment of the European Commission of submissions on Descriptor 7 by the EU countries. This information is up to 2012 and is not fully in line with the Indicator Guidance Fact Sheet for the CI15.

Nearly all of the EU Member States focused on coastal zones in their report, with most Member States (e.g. France, Greece, Italy Spain) expressed the readiness to address the existing knowledge gaps.

Results and Status, including trends (extended)

Many countries have focused on specific hydrographic parameters, most of them on temperature and salinity (e.g. Croatia, Cyprus, Italy), while some countries also assessed other parameters such as wave/current regime (e.g. Malta, France) and marine acidification (e.g. Cyprus, Greece). The proportion of the assessment area affected by hydrological processes was reported for some countries (Cyprus, Greece, Italy, Slovenia, Spain) although numbers quite varied due to the different methodologies used. For example, this proportion varied from less than 1% in Cyprus and Spain to 75-100% in Greece. However, in case of

Greece the high percentage is justified by the fact that changes due to climate change were also taken into account.

Several countries indicated different drivers behind pressures on hydrographic conditions (France, Greece, Malta, Slovenia). In addition, countries also estimated the impact of hydrographic alterations on marine habitats, such as Cyprus (impacts on macroalgae), Greece (impacts on seabed habitats), and Malta (impacts on algae and seagrass).

Photo by Marko Prem

CONCLUSIONS

The EO7 Common Indicator 15 reflects location and extent of the habitats impacted directly by hydrographic alterations due to new developments. The major challenge on deriving concluding remarks for this indicator at the regional level is that the national monitoring programmes are currently being developed for most Mediterranean countries. Therefore, assessment results on this indicator (as proposed in indicator guidance fact sheet) were not available at the national, nor regional level.

The findings here were mostly based on literature review of technical assessments on EU countries' reports on hydrographic alterations. However, these reports mainly focus on measurement of trends for certain hydrographic parameters, which is not completely in line with requirement for common Indicator 15. However, the measurement of baseline hydrographic conditions can serve as a baseline for more detailed assessments in the future. Two local scale projects are presented as case studies namely, LNG terminal in Monfalcone Port, Italy; and container terminal Haifa Bay in Israel.

Key messages

- The EO7 Common Indicator 15 considers marine habitats which may be affected or disturbed by changes in hydrographic conditions (currents, waves, suspended sediment loads) due to new developments.
- The national monitoring in Mediterranean countries regarding EO7 has not been initiated yet (except for the Contracting Parties that are EU member states, and their obligation of implementing Descriptor 7 of the Marine Strategy Framework Directive), or it is just being initiated.
- There is no sufficient data to derive conclusions/observe trends on Common Indicator 15 on regional, sub-regional or even national level.

Photo by Marko Prem

Knowledge gaps

- There are significant knowledge gaps on implementation of the Common Indicator 15. It is a complex multi-parameter indicator. The main knowledge gaps are related to insufficient surveys and monitoring of this indicator on all geographical levels, and lack of sound assessment methodologies. Assessments that estimate the extent of hydrographic alterations (knowing conditions before and after construction) and its intersection with marine habitats are currently rare in the Mediterranean, except for some local studies of Environmental Impact Assessment (EIA) /Strategic Environmental Assessment (SEA).
- There is certainly a lack of hydrographic data with detailed temporal and spatial scale in the Mediterranean Sea (bathymetric data, seafloor topography, current velocity, wave exposure, turbidity, salinity, temperature, etc.), which is one of the main challenges to implement this indicator, in particular to define the base-line conditions. To identify these gaps, a clear inventory of existing and available data in Mediterranean Sea should be done.
- Other difficulties come from the use of numerical model to assess hydrographic alterations before the structure is built. These tools need substantial data (bathymetry, offshore hydrodynamics data, field data); which can be costly and time-consuming; and their use requires experience and knowledge about the processes and theories involved.

- The link to EO1 is so essential, as map of benthic habitats in the zone of interest (broad habitat types and/or particular sensitive habitats) is required. Therefore, identifying the priority benthic habitats for consideration in EO7 together assessment of impacts, including cumulative impacts, is a cross-cutting issue of high priority for EO1 and EO7. In addition, effort needs to be given to detect the cause-consequence relationship between hydrographic alterations due to new structures and habitat deterioration.
- To conclude, such an integrated assessment of impacts calls for additional research efforts on habitat modelling, pressure mapping and cumulative impacts, along with monitoring of potentially affected areas.

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Ecological Objective 8 (EO8): Coastal Ecosystems and Landscapes

EO8: Common Indicator 16. Length of coastline subject to physical disturbance due to the influence of manmade structures

GENERAL

Reporter:	PAP/RAC
Geographical scale of the assessment:	Mediterranean, with a focus on France, Italy, Montenegro
Contributing countries:	France, Italy, Montenegro
Mid-Term Strategty (MTS) Core Theme:	3-Land and Sea Interaction and Processes
Ecological Objective	Ecological Objective 8 (EO8): Coastal Ecosystems and Landscapes
IMAP Common Indicator	Common Indicator 16 (CI16): Length of coastline subject to physical disturbance due to the influence of manmade structures
Indicator Assessment Factsheet Code	EO8CI16

RATIONALE/METHODS

Background (short)

The Mediterranean coastline is approximately 46000 km long, with around 40% of the coastal zone being under some form of artificial land cover (Plan Bleu, 2005). Mediterranean coastal areas are threatened by development that modifies the coastline through the construction of buildings and infrastructure that are needed to sustain residential, tourism, commercial, transport and other activities. This development can cause irreversible damage to landscapes; habitats and biodiversity; and shoreline configuration. This Ecological Objective 8 (EO8): Coastal Ecosystems and Landscapes, does not have a precedent in other regional ecosystem approach initiatives, such as Helcom or OSPAR, neither in the Marine Strategy Framework Directive (MSFD).

The UN Environment/MAP emphasizes the integrated nature of the coastal zone, particularly through consideration of marine and terrestrial parts as its constituent elements required by the Integrated Coastal Zone Management (ICZM) Protocol. The aim of monitoring the EO8 common indicator 16 “Length of coastline subject to physical disturbance due to the influence of manmade structures” is twofold: to quantify the rate and the spatial distribution of the Mediterranean coastline artificialisation; and to provide a better understanding of the impact of those structures to the shoreline dynamics.

GES for Common Indicator 16 can be achieved by minimizing physical disturbance to coastal areas close to the shoreline induced by human activities. Definition of targets, measures and interpretation of results regarding this common indicator is left to the countries, due to strong socio-economic, historic and cultural dimensions in addition to specific geomorphological and geographical conditions.

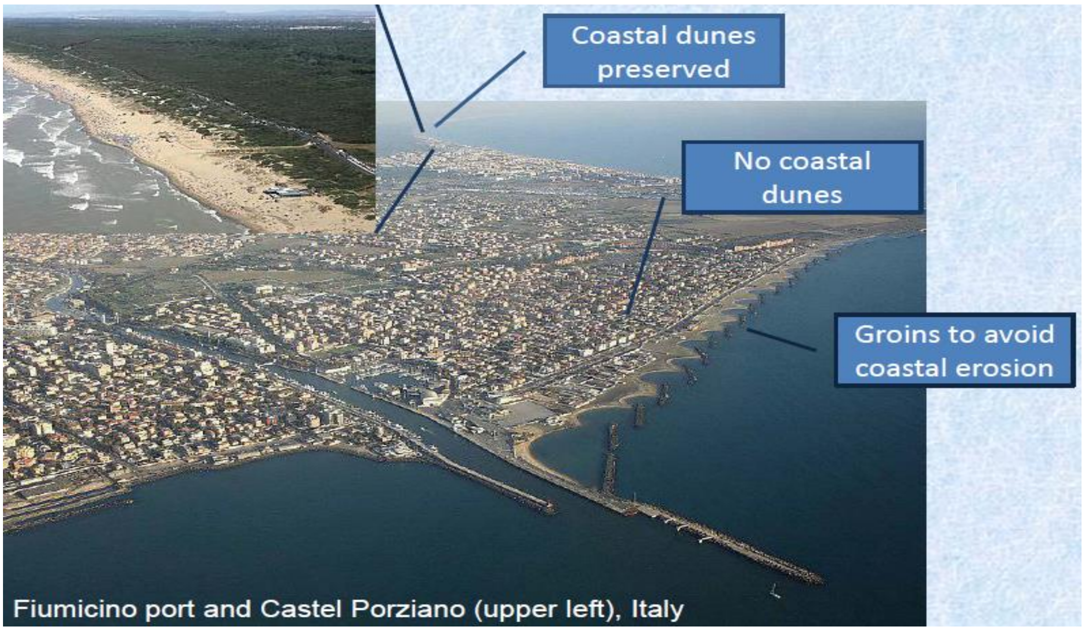

Figure 1. Example of urbanized coastline (photo provided by G.Giorgi)

Background (extended)

The land, inter-tidal zone and near-shore estuarine and marine waters in Mediterranean are increasingly altered by the loss and fragmentation of natural habitats and by the proliferation of a variety of built structures, such as ports, marinas, breakwaters, seawalls, jetties and pilings. These coastal manmade infrastructures cause irreversible damage to landscapes, losses in habitat and biodiversity, and strongly influence the configuration of the shoreline. Indeed, physical disturbance in particular in sandy coasts due to the development of artificial structures in the coastal fringe can disrupt the sediment transport, reduce the ability of the shoreline to respond to natural forcing factors, and fragment the coastal space. The modification of emerged beach and elimination of dune system contribute to coastal erosion phenomena by lessening the beach resilience to sea storms. Coastal defence infrastructures have been implemented to solve the problem together with beach nourishment, but preserving the natural shoreline system with adequate sediment transport from river has proved to be the best solution.

Around 40% of Mediterranean coastal zone is already under some form of artificial land cover. This share is expected to grow, especially since urban population in Mediterranean coasts is expected to increase by 33 million (30 million of that increase in the south and east) between 2000 and 2025 (UNEP/MAP, 2012). In addition, importance of tourism in these areas should be considered as well, since tourists can double the number of permanent dwellers in peak periods in some areas. That is why the construction of holiday homes is one of the important drivers of land consumption.

In the Mediterranean, the linear nature of coastal urbanization and the speed of the phenomenon is significant (Plan Bleu, 2005). The consequence of the growth in population growth, infrastructure and facilities results in increase in artificial land cover in the coastal zone. Monitoring the length of coastline subject to physical disturbance due to the influence of manmade structures and its trend is therefore of paramount importance, in order to preserve habitat, biodiversity and prevent coastal erosion phenomena. Also, access to the coast, beaches, visual qualities of coastal landscapes, decreasing potentials for other users to develop, such as tourism etc. are important elements to take into account.

The EO8 also reflects the aim of the Barcelona Convention to include coastal areas in the assessment, which became a legal obligation upon the entry into force of its Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol). In the Article 16 of the Protocol, the Contracting Parties are required to “set out an agreed reference format and process to collect appropriate data in national inventories “regarding the state and evolution of coastal zones.

Photo by Marko Prem

Assessment methods

Monitoring of the Common Indicator 16 focuses on measuring the length of artificial coastline and its share in total country’s coastline, on a proper geographical scale. An example of artificial vs. natural coastline can be seen in example on breakwaters in Figure 2.

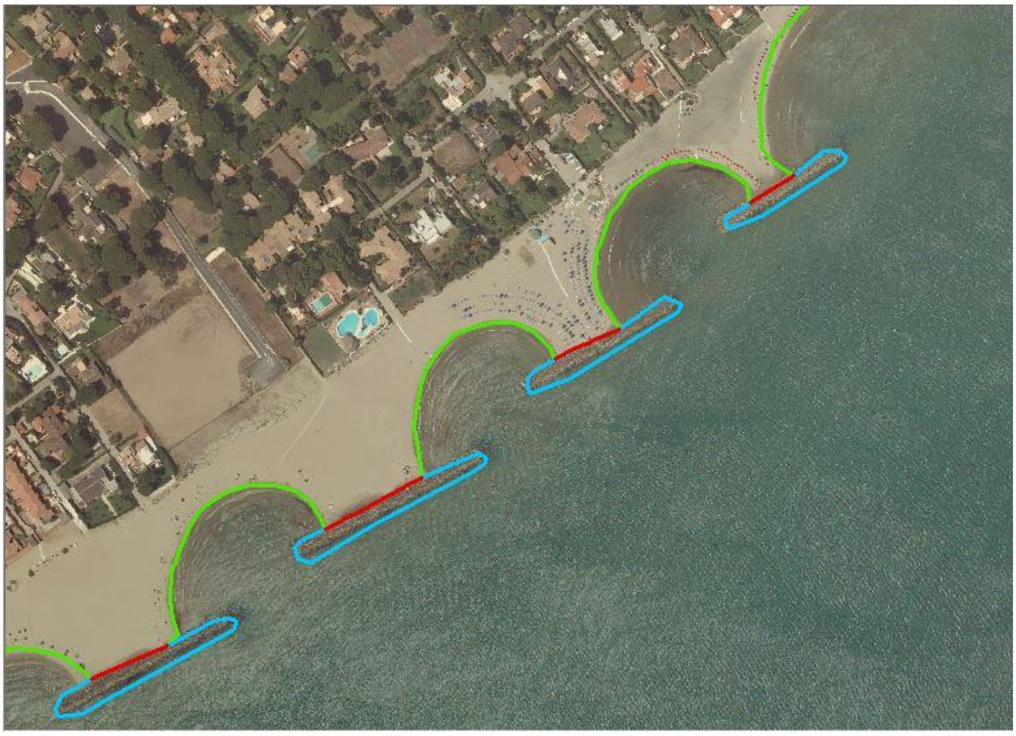

Figure 2. Image showing coastal defence structure (blue), artificial coastline (red) and natural coastline (green) (image developed by G.Giorgi)

The monitoring of this Common Indicator entails an inventory of:

(i) the length and location of manmade coastline (hard coastal defence structures, ports, marinas. Soft techniques e.g. beach nourishment is not included.
(ii) land claim, i.e. the surface area reclaimed from the 1980's onward (ha); and
(iii) the Impervious surface in the coastal fringe (100m from the coastline).

With regard to the coastline to be considered: the fixed reference official coastline as defined by responsible Contracting Party should be available throughout monitoring (initial, and all consequent monitoring should use the same official coastline). The optimal resolution should be 5 m or 1: 2000 spatial scale. The monitoring should be done every 6 years, and so every CP should fix a reference year in the time interval 2000-2012 in order to eliminate the bias due to old or past manmade infrastructures and coastal processes such as coastal erosion.

The length of artificial coastline should be calculated as the sum of segments on reference coastline identified as the intersection of polylines representing manmade structures with reference coastline ignoring polylines representing manmade structures with no intersection with reference coastline. The minimum distance between coastal defence structures should be set to 10 m in order to classify such segments as natural, i.e. if the distance between two adjacent coastal defence structures is less than 10 m, all the segment including both coastal defence structures is classified as artificial.

RESULTS

Results and Status, including trends (brief)

Until now there has been no systematic monitoring in Mediterranean regarding the Length of coastline subject to physical disturbance. The only country that has implemented the monitoring of this indicator on a national level, at the moment, is Italy. There were also assessments on national level in France and Montenegro, but these assessments, although quite similar, do not fully resemble the implementation of the common indicator 16, since they pre-date it. However, they still provide a deep insight on the state of Montenegrin and French coastlines regarding length of artificialized coastline.

Italy, for now, is the only country to implement the monitoring of the EO8 common indicator 16 on a national level. Almost 16 % of the coastline was classified as built-up in 2006, with strong regional (sub-national) differences, for example between Continental Italy (20.5%) and Sardinia (4.5%). The share of built-up coastline slightly increased in 2012 in the whole country (+0.36%), again with higher increase in Continental Italy (+0.51%) than in Sardinia (0.06%).

In Montenegro, the assessment in 2013 showed around 32% of built-up coastline on national level with notable differences between coastal counties (e.g. 11.6% in Ulcinj County and 40.4% in Tivat County).

The rate of artificalization of the whole of the French Mediterranean coast is around 11 %, with differences apparent from region to region: from the 19.5% for the coast of Languedoc-Roussillon to around 2 % for the coast of Region of Corsica (MEDAM Project).

It is important to note that in Montenegro and France the inventories of length of built-up coastline took place before the implementation of national Integrated Monitoring Assessment Programmes. However, methodology for delineating built-up coastline is quite similar to IMAP's monitoring guidelines.

Results and Status, including trends (extended)

The assessment results for Italy on the length of artificialized coastline are summarized in Table 1.

Table 1. Length of built-up coastline in Italy in 2006 (provided by Project EcAp-ICZM Italian Ministry of Environment/ISPRA)

	LENGTH (KM) *2006*			**PERCENTAGE *2006***		**PERCENTAGE *2012***		***TREND 2006-2012***
	total	natural	artificial	natural	artificial	natural	artificial	artificial
ITALY – continental	3844.985	3058.103	786.882	79.53	20.47	79.02	20.98	+0.51%
SICILIY	1177.769	1003.140	174.629	85.17	14.83	85.01	14.99	+0.16%
SARDINIA	1512.145	1444.395	67.749	95.52	4.48	95.46	4.54	+0.06%
TOTAL	6535.899	5505.638	1029.261	**84.25**	**15.75**	**83.89**	**16.11**	**+0.36%**

The total length in Table 1 is referred to a reference coastline for year 2006, and does not include islands except Sardinia and Sicily. Built-up coastline includes coastal defense structures, ports and marinas. The spatial extension of impervious surfaces on land side has not been considered in the calculation of the length of built-up coastline. The above results show that meaningful trends as for ex. 2012 over 2006 or 2018 over 2012, have to be calculated considering Sardinia and Sicily separated by the continental part of Italy as they both have share percentage completely different from each other and from the continental part. The high level of artificialisation in Sicily is mainly due to little ports and marinas for touristic and fishery activities that have been built or expanded in the last 30-20 years.

In Montenegro, the built-up assessment of coastal zone was carried out within the frame of Coastal Area Management Program (CAMP), which served as a basis for Spatial plan for six coastal counties and latter National strategy for integrated coastal zone management for Montenegro. The length of built-up coastline in Montenegro was assessed for each of the six coastal counties (Table 2). The indicator was calculated by overlapping the built-up areas with generalized coastline to get the share of the built-up coastline in the whole coastline. The coastline was generalized in order to avoid unrealistic length of anthropogenic coastline (e.g. to avoid undulations by marinas, ports, were groins, etc.). The built-up coastline is shown in Figure 3.

Table 2. Length of built-up coastline in Montenegro (provided by G. Berlengi)

County	Natural coastline (km)	Built-up coastline (km)	Total (km)	Share (built-up/total) (%)
Bar	23.615	12.549	36.164	**34.7**
Budva	24.505	7.305	31.810	**23.0**
Herceg Novi	32.883	19.715	52.597	**37.5**
Kotor	39.596	23.819	63.415	**37.6**
Tivat	19.008	12.885	31.893	**40.4**
Ulcinj	32.158	4.236	36.393	**11.6**
Total	**171.764**	**80.509**	**252.273**	**31.9**

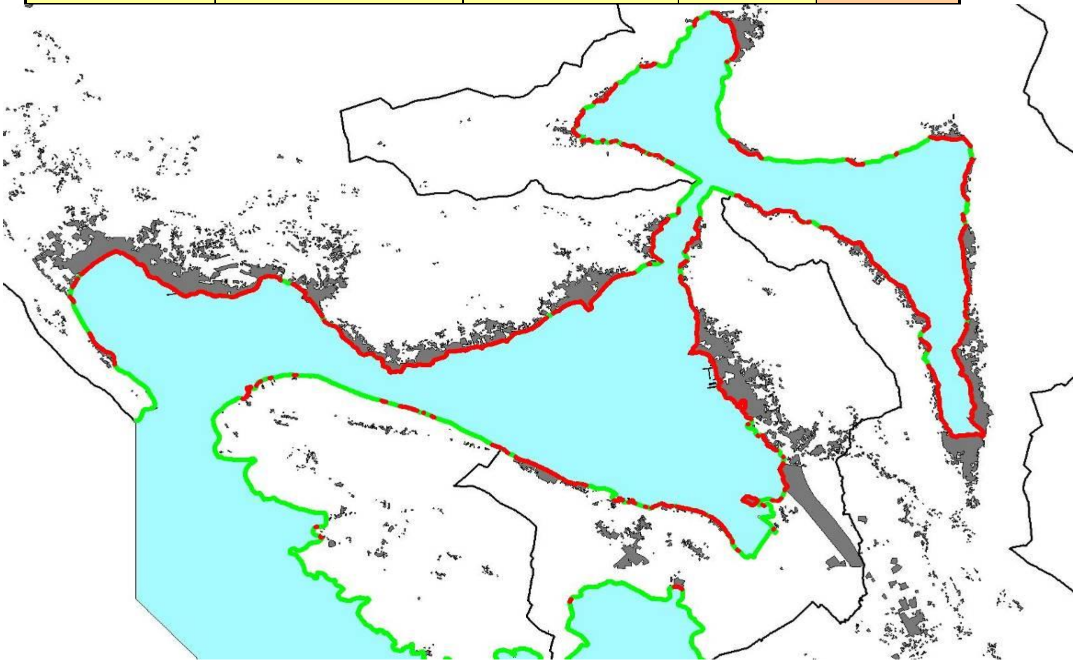

Figure 3. Map showing built-up coastline (in red) and natural coastline (in green) in Montenegro (provided by G. Berlengi)

In France, the MEDAM inventory (i.e. database) was established as a project that monitors the sources of artificial and development pressure on the French Mediterranean Coast, entailing features such as: the total length of coastline; coastline 'artificialised' by reclamation; rate of 'artificialisation' of coastline (linear), etc.

The rate of artificalisation of the whole of the French Mediterranean coast, according to MEDAM, is 11.1 %, with differences apparent from region to region: from the 19.5% for the coast of Languedoc-Roussillon to around 2 % for the coast of Region of Corsica (MEDAM Project).

In 1960-1985 period, the number of reclamations from the sea tripled along the French Mediterranean, followed by a distinct slow-down of these redevelopments between 1985 and 2010. The slowing down was to a large extent the result of enforcement of an Act (arrêté) that banned the destruction of marine phanerogams (*Posidonia oceanica* and *Cymodocea nodosa*) (Arrêté of 19 July 1988).

CONCLUSIONS

The inclusion of the EO8 Common Indicator aims to address the need for a systematic monitoring in Mediterranean regarding the physical disturbance of coastline due to the influence of manmade structures. On the other hand, it offers very few examples to follow, especially since this indicator has no operational precedents in regional ecosystem approach initiatives, such as Helcom or OSPAR, neither in Marine Strategy Framework Directive.

Some countries, such as Italy, France and Montenegro, have developed the inventories of the share of their urbanized coastline, while some countries of South and East Mediterranean will begin to do so in frame of the EcAp MED II project.

Key messages

- Mediterranean coastal areas are threatened by intensive construction of buildings and other infrastructure that can impact landscapes, habitats and biodiversity. The national reporting on state and evolution of coastal zones is required by the ICZM Protocol
- There was no systematic monitoring in Mediterranean regarding coastal artificialization by now. The only country that has implemented the monitoring of the EO8 common indicator on a national level by this moment is Italy, with Montenegro and France performing similar inventories;
- Targets, GES thresholds, measures and interpretation of results regarding this indicator should be left to the countries due to strong nation-specific socio-economic, historic and cultural dimensions and geographical conditions.

Photo by Marko Prem

Knowledge gaps

- It is difficult to point out the knowledge gaps in this phase since there are so few examples of implementation of the EO8 Common Indicator. However, there are some "known" knowledge gaps that could hinder successful implementation of this indicator.
- First, it is a choice of a fixed reference coastline that each Contracting Party should select in order to assure comparability of results between successive reporting exercises. Unfortunately, it is not unusual to find out that more than one 'official' coastline exists for the same Contracting Party produced with different technological techniques. In addition, coastlines change due to coastal erosion, sea level rise and morphological modifications. If spatial resolution is too low or time period is too long, manmade structures could be poorly identified or completely missed with heavy consequences on the calculation of length of artificial coastline.

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4) Quality Status Report (QSR) Cross-cutting and horizontal issues

Quality Status Report (QSR) Cross-cutting and horizontal issues

1. Environmental characteristics

1.1. The Mediterranean marine and coastal environment

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 socio-politically – twenty-one countries border this heavily used sea (UNEP/MAP, 2012).

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.

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.

The Mediterranean Sea stretches from the Atlantic Ocean on the west to the Asian continent on the east, and separates Europe from Africa. The basin expands up to 2.6 million square kilometres with an average depth of 1, 4600 meters, and a maximum depth of 5,267 meters, making it the largest enclosed sea on Earth (Coll et al, 2010). The Mediterranean has a narrow continental shelve and a large area of open sea. The Mediterranean has narrow continental shelves and a large area of open sea. Therefore, a large part of the Mediterranean basin can be classified as deep sea and includes some unusual features such as variation of temperatures from 12.8°C–13.5°C in the western basin to 13.5°C–15.5°C in the eastern and high salinity of 37.5–39.5 psu.

The coasts of the western Mediterranean, just as those of the eastern basin, have been subjected in recent geologic times to the uneven action of deposition and erosion. This action, together with the movements of the sea and the emergence and submergence of the land, resulted in a rich variety of types of coasts. The Italian Adriatic coast, revealing the Apennines, is typical of an emerged coast. The granite coast of north eastern Sardinia and the Dalmatian coast where the eroded land surface has sunk, producing elongated islands parallel to the coast, are typical submerged coasts. The deltas of the Rhône, Po, Ebro, and Nile rivers are good examples of coasts resulting from silt deposition.

Figure 1.1. Geographical characteristics of the Mediterranean region (UNEP/MAP, 2012)

Circulation and water masses.

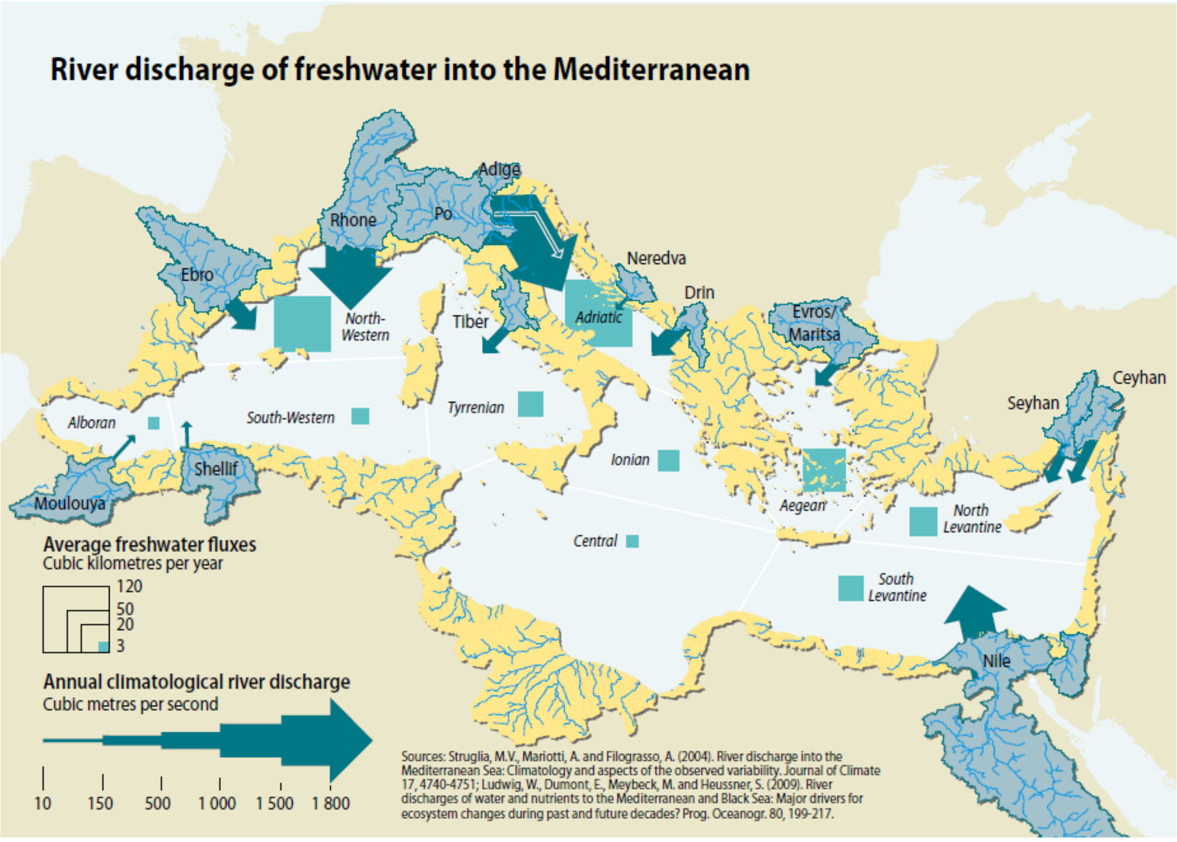
The Mediterranean Sea is a semi-enclosed sea characterized by high salinities, temperatures and densities. The net evaporation exceeds the precipitation, driving an anti-estuarine circulation through the Strait of Gibraltar, contributing to very low nutrient concentrations. The Mediterranean Sea has an active overturning circulation, one shallow cell that communicates directly with the Atlantic Ocean, and two deep overturning cells, one in each of the two main basins (Tanhua et al. 2013). It acts like an ocean system in which several temporal and spatial scales (basin, sub-basin and mesoscale) interact to form a highly complex and variable circulation. It is one of the few locations in the world where deep convection and water mass formation take place. The Mediterranean is also an important marginal basin to the North Atlantic producing very saline waters, the outflow of which through the Strait of Gibraltar may play an indirect role in the deep circulation of the North Atlantic. The inflowing waters are altered by an excess of evaporation over precipitation and slight cooling within the Mediterranean basin during their 100-year-long journey before returning back to the Atlantic (El-Geziry & Bryden 2010).

The Mediterranean hydrodynamics are driven by three layers of water masses: a surface layer, an intermediate layer, and a deep layer that sinks to the bottom. The Mediterranean Sea receives from the rivers that flow into it only about one-third of the amount of water that it loses by evaporation. In consequence, there is a continuous inflow of surface water from the Atlantic Ocean. After passing through the Strait of Gibraltar, the main body of the incoming surface water flows eastward along the north coast of Africa. This current is the most constant component of the circulation of the Mediterranean. It is most powerful in summer, when evaporation in the Mediterranean is at a maximum. This inflow of Atlantic water loses its strength as it proceeds eastward, but it is still recognizable as a surface movement in the Sicilian channel and even off the Levant coast. A small amount of water also enters the Mediterranean from the Black Sea as a surface current through the Bosporus, the Sea of Marmara, and the Dardanelles (Coll et al., 2010).

Hydrological and climatic setting.

The Mediterranean region is characterized by winter dominated rainfall and hot dry summers. Even though large spatial climate variability and diversity exist within the Mediterranean basins, many areas can be classified as arid or semiarid. The Mediterranean is an area of transition between a temperate Europe with relatively abundant and consistent water resources, and the arid African and Arabian deserts that are very short of water. The Mediterranean region is experiencing a large stress on its water resources due to a combination of effects ranging from climate change to anthropogenic pressures due to an increasing water demand for domestic and industrial use, expansion of irrigated areas, and tourism activities. More than half of the water-poor population of the world is concentrated in the Mediterranean basin, which holds only 3% of the world's fresh water resources. These resources are unevenly distributed over space. Half are located in Italy and Greece and 25% in catchments in France and Turkey. Catchments on the southern and eastern rims provide, respectively, only 4% and 2% of Mediterranean water resources (Milano et al., 2013).

Water resource availability in the Mediterranean has already been affected by environmental change, and is seriously jeopardized in future environmental, economic, and demographic scenarios (Garcia-Ruiz et al., 2011). Most global hydrological models are based on expected trends in precipitation and temperature. However, a number of studies have demonstrated the influence of land cover on river discharge and water resources. Climate and land cover change (artificial and natural reforestation, deforestation, expansion of farming areas) are likely to amplify water stress in the Mediterranean region, caused by a combination of decreased water resource availability (lower precipitation and increased evapotranspiration) and increased water use pressure resulting from economic growth and urban expansion. Special attention to mountain areas is required, as they are the most important sites for water resource generation worldwide, and particularly in temperate and semi-arid areas including the Mediterranean basin. However, mountain areas are facing increasing hydrological stress caused by a combination of i) increasing temperature and decreasing precipitation, exceeding that in the lowlands; ii) land use change, including natural and deliberate reforestation of abandoned farmland, thus increasing evapotranspiration and water consumption; and, (iii) increasing pressures on surface and groundwater resources, thus reducing river discharge and lowering the depth of the water table in groundwater-dependent areas.



River discharge of freshwater into the Mediterranean

Sources: Struglia, M.V., Mariotti, A. and Filograsso, A. (2004). River discharge into the Mediterranean Sea: Climatology and aspects of the observed variability. Journal of Climate 17, 4740-4751; Ludwig, W., Dumont, E., Meybeck, M. and Heussner, S. (2009). River discharges of water and nutrients to the Mediterranean and Black Sea: Major drivers for ecosystem changes during past and future decades? Prog. Oceanogr. 80, 199-217.

Figure 1.2. River discharge into the Mediterranean (UNEP/MAP, 2012)

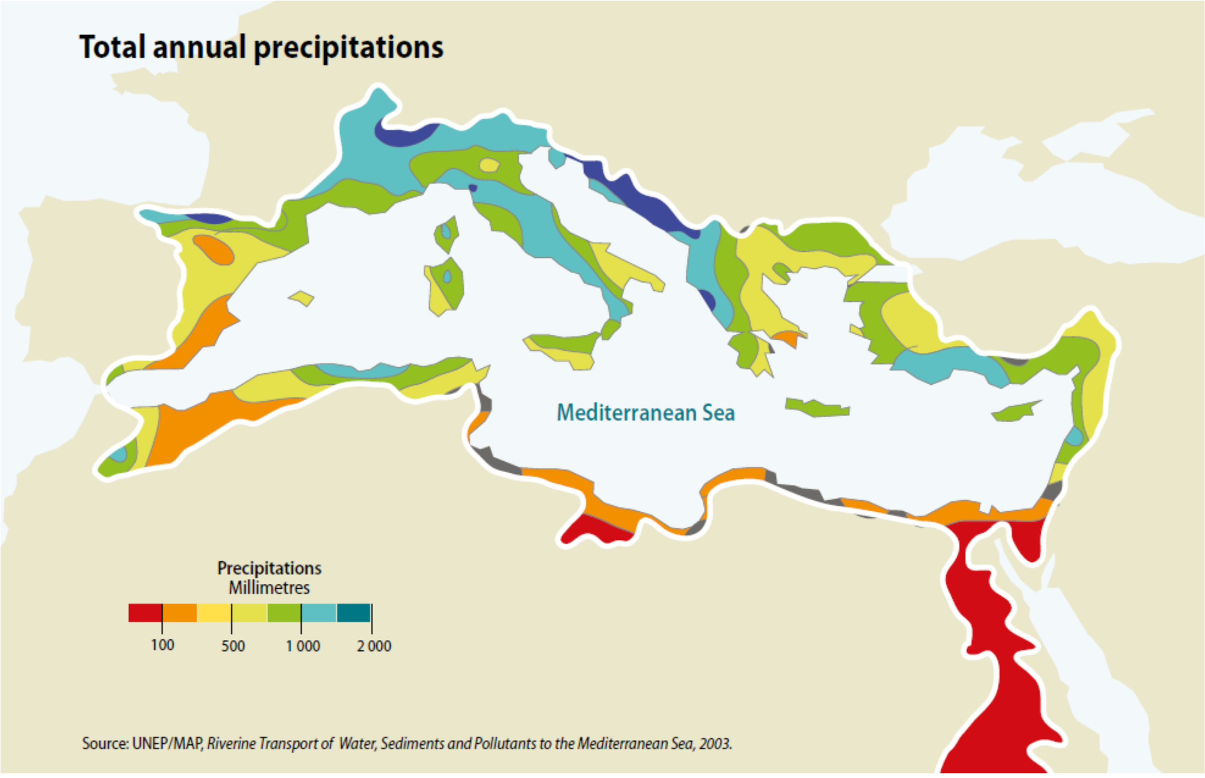


Figure 1.3. Total Annual Precipitation (UNEP/MAP, 2012)

The amount and distribution of rainfall in Mediterranean localities is variable and unpredictable. Along the North African coast from Gabès in Tunisia to Egypt, more than 10 inches (250 mm) of rainfall per year is rare, whereas on the Dalmatian coast of Croatia there are places that receive 100 inches (2,500 mm). Maximum precipitation is found in mountainous coastal areas (Figure 1.3). The climate in the region is characterized by hot, dry summers and cool, humid winters. The annual mean sea surface temperature shows a high seasonality and important gradients from west to east and north to south.

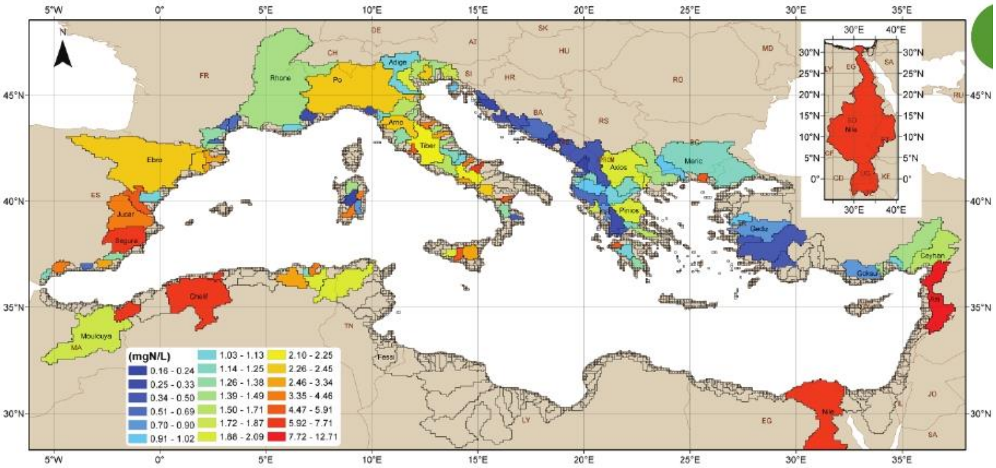
Coastal aquifers provide another source of freshwater discharge to the Mediterranean. The submarine groundwater discharge from the coastal aquifers, estimated at 2.200 m3/s, accounts for almost one-fifth of the total freshwater inflow into the Mediterranean, with more than one-third of this discharge entering from the sea's European shores. 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. 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 (UNEP/MAP, 2012, and UNEP/MAP, UNESCO, 2015).

Water and nutrient characteristics.

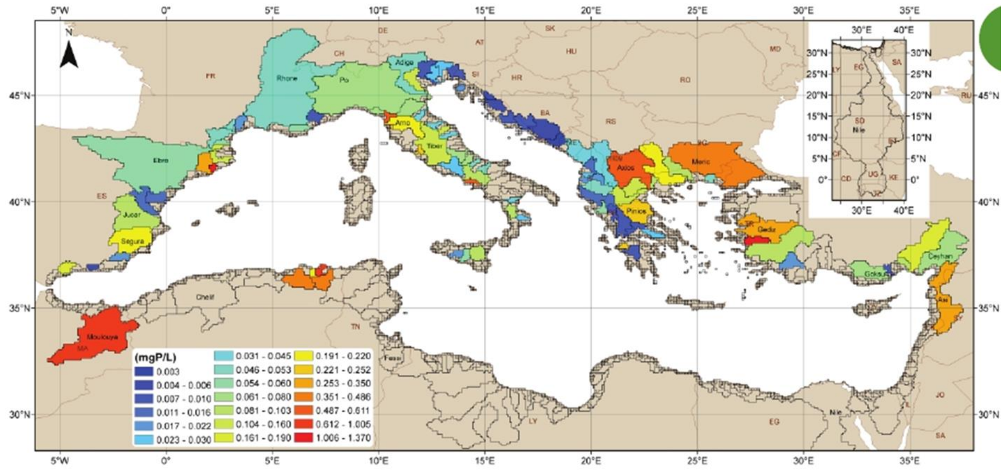
With a typical tidal range of less than 50 cm, the Mediterranean Sea is microtidal. This reduces the potential for dilution and dispersion of dissolved and particulate wastes. It is also one of the most oligotrophic (i.e. poor in nutrients) oceanic systems, and is characterised by an eastwards longitudinal gradient in this oligotrophy. The main source of nutrients in the Mediterranean lies in the inflowing Atlantic surface waters at the level of the Gibraltar Strait. These inflowing waters flow eastward along the African coasts in the western Mediterranean, then cross the Sicily Strait and continue their flow again along the northern African coasts. As the waters move eastwards from the Gibraltar Strait, they become depleted in nutrients. By the time they reach the Egyptian coasts, their nutrient signature has almost disappeared. Additionally, the Nile River nutrient signature has disappeared due to the 1960s Nile Dam construction. All this contributes towards making the Levantine Basin (at the eastern part of the Mediterranean Sea) one of the most oligotrophic areas in the world ocean (EEA-UNEP/MAP 2014).

Additional sources of nutrients exist in the Mediterranean, but these have localised and rather small impacts. One is the outflow of Black Sea surface waters into the Aegean, which have an influence limited to the north Aegean; a second source is the Po River, emptying into the Adriatic on its western coast. The most eutrophic waters in the western basin are located on the north shore, at the mouth of the large rivers Rhone and Ebro. Riverine nutrient inputs are relatively low, as most river systems discharging in the Mediterranean Sea are small. High nutrient inputs to small rivers may be important in most North African oueds, as they collect rich effluents in large quantities. In these rivers/oueds, metals, nitrates and organic carbon reach concentrations that could affect biological populations after heavy rains following dry periods (EEA-UNEP/MAP 2014).

Rivers also are a contributor of nutrients to the sea accounting about 50% for Nitrogen and 75% for Phosphorus which together with Silica are crucial elements for maintaining biological productivity in the sea (Figure 1.4). River basins accumulate the products of various natural and anthropogenic activities (agriculture, urbanisation, wastewaters, industry, etc.) emitted into surface waters which are transported downstream to the river mouths and eventually to the sea (PERSEUS-UNEP/MAP, 2015).



a)



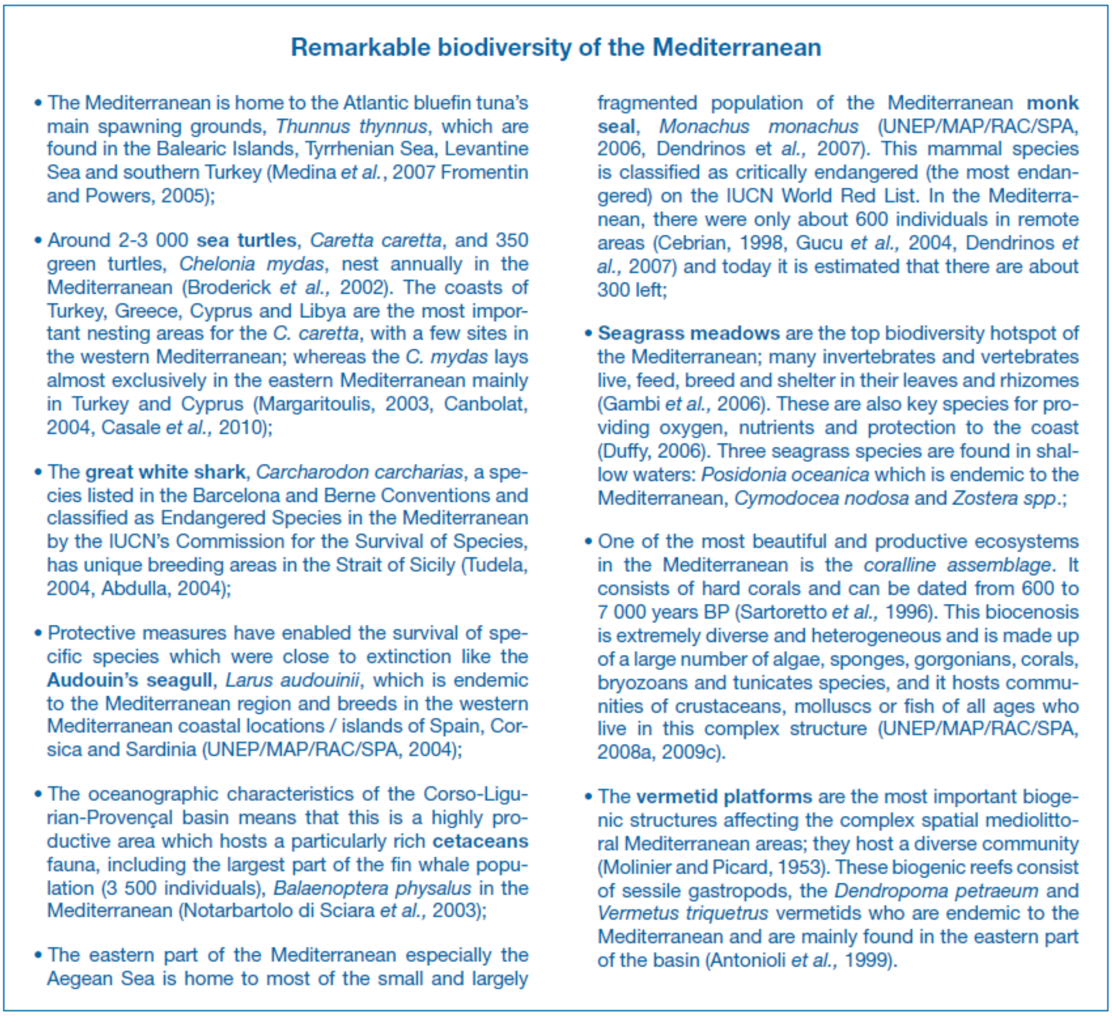
b)

Figure 1.4. a) Inter-annual average of nitrate concentrations in Mediterranean rivers calculated from available 2000-2010 data or most recent inter-annual value from scientific references; b) Average Dissolved Inorganic Phosphorus (DIP) concentrations in Mediterranean rivers calculated from available 2000-2010 data or most recent inter-annual value from scientific references. From PERSEUS-UNEP/MAP, 2015.

Biodiversity.

The Mediterranean is one of the world’s 25 hot spots for biodiversity. Its highly diverse marine ecosystem hosts around 4 to 18% of the world’s marine biodiversity (Coll et al. 2010, Gabrié C., et al. 2012). The Mediterranean provides vital areas for the reproduction of pelagic species: the Atlantic bluefin tuna’s main spawning areas, the great white shark’s unique breeding areas and sea turtles, such as the green and loggerhead turtles, nesting areas along its eastern coast. These high oceanic productivity areas host a particularly rich marine mammal fauna and the eastern part of the basin is one of the last shelters for the threatened Mediterranean monk seal. The shallow coastal waters are home to key species and sensitive ecosystems such as seagrass beds and coralligenous assemblages, whilst the deep waters host a unique and fragile fauna. Many of these species are rare and / or threatened and are globally or regionally classified by IUCN as threatened or endangered.

Biodiversity of the Mediterranean (Gabrié C., et al. 2012)



Remarkable biodiversity of the Mediterranean

- The Mediterranean is home to the Atlantic bluefin tuna's main spawning grounds, *Thunnus thynnus*, which are found in the Balearic Islands, Tyrrhenian Sea, Levantine Sea and southern Turkey (Medina *et al.*, 2007 Fromentin and Powers, 2005);
- Around 2-3 000 **sea turtles**, *Caretta caretta*, and 350 green turtles, *Chelonia mydas*, nest annually in the Mediterranean (Broderick *et al.*, 2002). The coasts of Turkey, Greece, Cyprus and Libya are the most important nesting areas for the *C. caretta*, with a few sites in the western Mediterranean; whereas the *C. mydas* lays almost exclusively in the eastern Mediterranean mainly in Turkey and Cyprus (Margaritoulis, 2003, Canbolat, 2004, Casale *et al.*, 2010);
- The **great white shark**, *Carcharodon carcharias*, a species listed in the Barcelona and Berne Conventions and classified as Endangered Species in the Mediterranean by the IUCN's Commission for the Survival of Species, has unique breeding areas in the Strait of Sicily (Tudela, 2004, Abdulla, 2004);
- Protective measures have enabled the survival of specific species which were close to extinction like the **Audouin's seagull**, *Larus audouinii*, which is endemic to the Mediterranean region and breeds in the western Mediterranean coastal locations / islands of Spain, Corsica and Sardinia (UNEP/MAP/RAC/SPA, 2004);
- The oceanographic characteristics of the Corso-Ligurian-Provençal basin means that this is a highly productive area which hosts a particularly rich **cetaceans** fauna, including the largest part of the fin whale population (3 500 individuals), *Balaenoptera physalus* in the Mediterranean (Notarbartolo di Sciara *et al.*, 2003);
- The eastern part of the Mediterranean especially the Aegean Sea is home to most of the small and largely fragmented population of the Mediterranean **monk seal**, *Monachus monachus* (UNEP/MAP/RAC/SPA, 2006, Dendrinos et *al.*, 2007). This mammal species is classified as critically endangered (the most endangered) on the IUCN World Red List. In the Mediterranean, there were only about 600 individuals in remote areas (Cebrian, 1998, Gucu *et al.*, 2004, Dendrinos *et al.*, 2007) and today it is estimated that there are about 300 left;
- **Seagrass meadows** are the top biodiversity hotspot of the Mediterranean; many invertebrates and vertebrates live, feed, breed and shelter in their leaves and rhizomes (Gambi *et al.*, 2006). These are also key species for providing oxygen, nutrients and protection to the coast (Duffy, 2006). Three seagrass species are found in shallow waters: *Posidonia oceanica* which is endemic to the Mediterranean, *Cymodocea nodosa* and *Zostera spp*.;
- One of the most beautiful and productive ecosystems in the Mediterranean is the *coralline assemblage*. It consists of hard corals and can be dated from 600 to 7 000 years BP (Sartoretto *et al.*, 1996). This biocenosis is extremely diverse and heterogeneous and is made up of a large number of algae, sponges, gorgonians, corals, bryozoans and tunicates species, and it hosts communities of crustaceans, molluscs or fish of all ages who live in this complex structure (UNEP/MAP/RAC/SPA, 2008a, 2009c).
- The **vermetid platforms** are the most important biogenic structures affecting the complex spatial mediolittoral Mediterranean areas; they host a diverse community (Molinier and Picard, 1953). These biogenic reefs consist of sessile gastropods, the *Dendropoma petraeum* and *Vermetus triquetrus* vermetids who are endemic to the Mediterranean and are mainly found in the eastern part of the basin (Antonioli *et al.*, 1999).

This natural heritage has profoundly influenced the development of populations, transforming this basin into a rich and heterogeneous mosaic of cultures. It is defined as "under siege" due to historical and current impacts of multiple stressors. Among them, fishing practices, habitat loss and degradation, eutrophication, and more recently, the introduction of alien species and climate change effects. Since the intensity of these stressors is increasing throughout most of the Mediterranean basin, temporal analyses are increasingly needed to inform effective current and future marine policies and management actions.

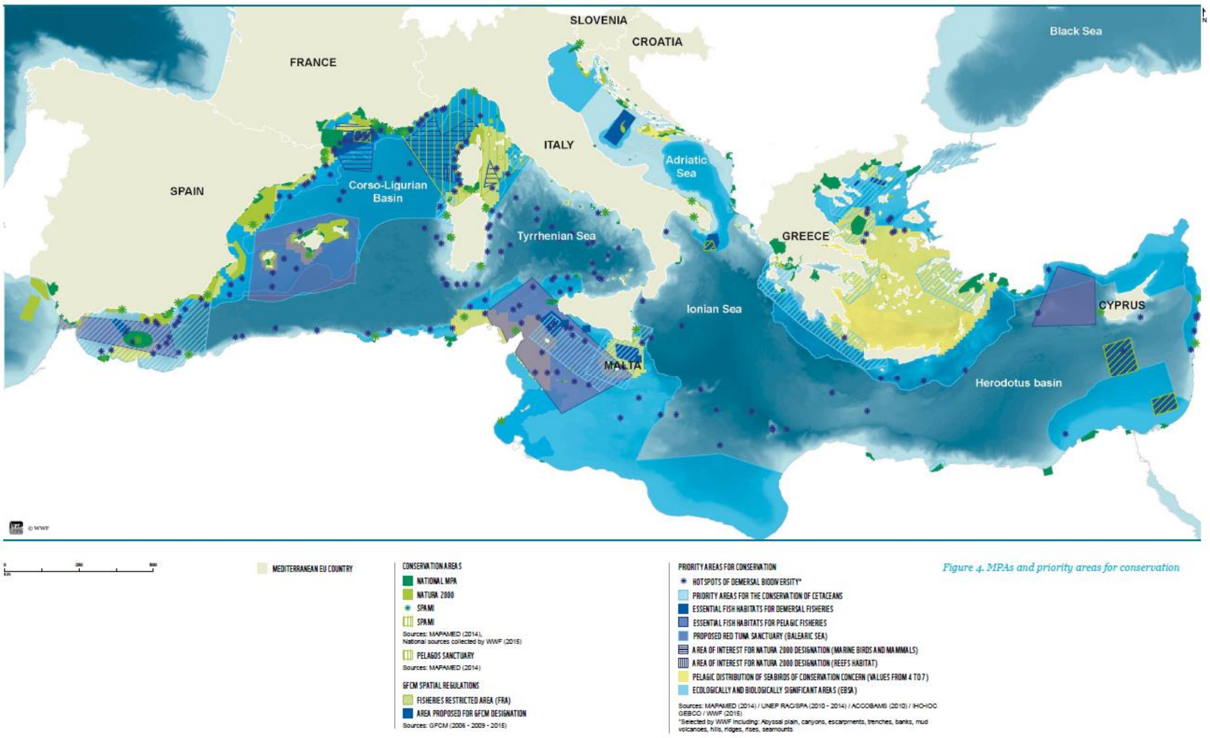


Figure 1.5. Marine protected Areas and protected areas for conservation (Piante, C., Ody, D.,2015)

Almost 86 000 km² of the Mediterranean is classified Marine Protected Areas (MPAs) or Natura 2000 site (Figure 15). In 2016, only 3 % of the Mediterranean Sea is protected. The target of 10% protection of the CBD convention is far from being achieved. New Marine Protected Areas must be created in high and deep sea, which are not represented in the current network.

1.2. Climate change

The Mediterranean region: a climate change hot-spot.

The Mediterranean region has been referenced as one of the most responsive regions to climate change and was defined as a primary “Hot-spot” by Giorgi (2006), based on the results from global climate change projection scenarios. The last report from the International Panel on Climate Change (IPPC, 2013) highlights the Mediterranean as one of the most vulnerable regions in the world to the impacts of global warming. The context of global warming stresses the necessity to assess the possible consequences of climate change on this sensitive region which would become warmer and drier (IPCC 2007, 2013).

During the 20th century, air temperature in the Mediterranean basin was observed to have risen by 1.5-4°C depending on the sub-region. Over the same period and with clear acceleration since 1970, temperatures in south-western Europe (Iberian Peninsula, south of France) rose by almost 2°C. The same warming effect can also be seen in North Africa, albeit more difficult to quantify given the more patchy nature of the observation system. A key feature for the climate of the Mediterranean region is the presence of the Mediterranean Sea itself which represents an important source of energy and moisture to the atmosphere. Sea Surface Temperature (SST) anomalies govern, at least in part, air temperature and precipitation anomalies in the surrounding land areas (UNEP/MAP, 2016).

The costs associated with mismanagement of water resources can be very substantial. Over-abstraction is causing low river flows, lowered groundwater levels, and the drying-up of wetlands. All of these trends have detrimental impacts on freshwater ecosystems (EEA, 2015). Climate change is projected to increase water shortages, particularly in the Mediterranean region (EEA, 2012).

Sea level rise (SLR).

Based on the existing models available for assessment, the central values for projections of sea level rise by 2100 range from about 30 to 40 cm, and about 60% of this increase would be due to the thermal expansion of sea water. Climate change may also be seen through the evolution and impacts of sea level rise (SLR) with trends ranging from increases of over 6mm/yr and decreases going down to more than 4mm/yr in different regions of the basin, according to the EEA climate indicator (EEA-UNEP/MAP, 2014). These variations have major impacts, especially on the southern areas of the region (IPCC, 2013). Such evolutions will be witnessed through high and low variations and very specific locations.

It is important to note that the steric contribution is only one of the components that might influence the sea level change in the Mediterranean Sea. There are other components that might determine the sea level trends in the basin, such as the melting of the continental ice sheets (Greenland and Antarctica) that, especially on the long term (centennial time scales), might become dominant. It should also be noted that in the case of SLR in the Mediterranean, scientific uncertainty is particularly high, as making multi-decadal regional projections for relatively small isolated and semi-isolated basins such as the Mediterranean is more complex than for the global ocean (EEA-UNEP/MAP, 2014 and UNEP/MAP, 2016). Nevertheless, the effect of SLR is considerable in most low-lying coasts of the Mediterranean basin where communities and infrastructure are typically located. In addition to the seawater expansion due to steric effect, coastal subsidence and global ocean level increase induced by continental glaciers melting (in Greenland and West Antartica) have to be considered as SLR components for the Mediterranean.

Climate Change related risks, vulnerabilities and impacts.

While determining tendencies and changes in the climatic system is quite delicate due to the multitude of factors that must be taken into account, the complexity of trying to identify the possible impacts of climate change is even greater, especially when considering uncertainties on regional and sub-regional trends. Indeed, these impacts are the result of confrontation between the major trends of climatic parameters and the specific conditions of the affected area, in other words the natural and manmade characteristics of the Mediterranean zone (UNEP/MAP, 2016).

Climate change is arguably one of the most critical challenges that the Mediterranean region is facing. The Mediterranean basin has been identified as one of the two most responsive regions to climate change globally. The IPCC Fifth Assessment Report considers the Region as “highly vulnerable to climate change”, also mentioning that it “will suffer multiple stresses and systemic failures due to climate changes”. The overall risks of climate change impacts can be reduced through mitigation, i.e. by limiting the rate and magnitude of climate change. However, even under the most ambitious mitigation scenarios, risks from adverse climate impacts remain, due to already locked-in climate change. Therefore, adaptation policies and measures anticipating a wide range of potential climate-related risks are essential.

Freshwater resources. The most critical impacts of climatic changes in the Mediterranean region are likely associated with the water availability. The whole region is already vulnerable to water scarcity and drought, in particular the South and East countries, while even in countries in the North, a growing percentage of water production is non-sustainable, leading to an over-exploitation of groundwater resources. A very critical situation under climate change in the region, with a reduction in precipitation and structural water shortages, is expected to affect 60 million people already from 2025 (Lionello et al. 2006). Another characteristic of water resources in the Mediterranean is their irregular geographic distribution: 71% are located in the North, 9% in the South and 20% in the Near East.

Most countries on the Southern and Eastern shores of the Mediterranean are already considered as facing chronic scarcity of water resources and the situation is expected to worsen in the future under the combined effect of increased demand for water and the projected impacts of climate change which
include declines in average rainfall and in total runoff, and depletion of groundwater resources. Coastal aquifers would become threatened by salinization due to rising sea levels and by overexploitation which declines their resilience to saline intrusion.

Moreover, despite a decrease in average precipitation, models foresee in the Mediterranean summers characterised by an increase in frequency of extreme daily precipitation. This tendency can lead to longer dry periods, interrupted by extreme intense precipitation, enhancing the risk of floods. The JRC PESETA II Project "Climate Impacts in Europe", estimates that even in the 2oC scenario direct economic damages from river flooding in Southern Europe will increase from 0,67 to 1,19 billion euros per year in the 2080s. The rapidly growing non-agricultural water needs of many countries in the area can generally not be met by further exploitation of water resources except through either the development of expensive desalination facilities or the reallocation of water resources from agriculture. This could bring major social and political change and risk exacerbating existing inequalities and regional tensions.

Coastal systems and low-lying areas. Coastal zones, arguably the most appealing assets of the Mediterranean, are already exposed to significant pressures from land-based and marine pollution, urban development, fishing, aquaculture, tourism, damming, extraction of materials, and marine biological invasions. Climate change, and especially the major driver of sea level rise, is expected to significantly increase these pressures. In particular, many coastal systems will experience increased inundations and storm flooding, accelerated coastal erosion, seawater contamination of fresh groundwater, displacement of coastal lowlands and wetlands, encroachment of tidal waters into estuaries and river systems, possible loss of nesting beaches. More frequent and severe weather and climatic events will further enhance these phenomena, while in the longer term, changes in wind and wave patterns could interfere with sediment transport leading to greater erosion or accretion.

Coastal erosion will lead over time to the inland migration of the beaches of the Mediterranean with soft sedimentary coasts being more vulnerable than harder, rocky coastlines. River deltas, due to their particular topography, are particularly vulnerable to the impacts of erosion and inundation. Damming of rivers upstream no longer allows the normal circulation of sediment, which cannot reach the delta to consolidate it. At the local scale, possible impacts from sea level rise are also determined by other non-climatic factors such as the subsidence of coastal land, subsurface resource extraction, and tectonic movements. The JRC PESETA II Project "Climate Impacts in Europe", estimates that even in the 2oC scenario the average annual costs from sea floods damage in Southern Europe will increase from 163 to 903 million in the 2080s.

Ocean systems. The Mediterranean Sea is among the richest in biodiversity of global importance, rich with endemism and autochthonous species. At the same time, it has unique marine features that make this region particularly vulnerable to climate change. The overall extent of water exchange is restricted due to the narrow connections with the Atlantic Ocean, the Red Sea and the Black Sea. In addition, due to the relatively small size of the basin, seawater in the Mediterranean can more easily heat up and evaporate, combined with hot, dry summers and low inflow from rivers. Increases in sea temperatures will alter distribution of species and foster the spread of warm water species into the Mediterranean, thus promoting the displacement of ecotypes and shifts in ecosystem functioning and ultimately lead to loss of species. The IPCC AR5 identified the Mediterranean Sea as one of the semi-enclosed seas with projected high rates of local extinction because land boundaries will make it difficult for species to move laterally to escape waters that may be too warm. Additionally, periods of extreme seawater temperature during heatwaves will contribute to mortality events that affect many invertebrate species as well as Posidonia meadows.

Another emerging climate-related threat to Mediterranean marine ecosystems, is ocean acidification, the phenomenon of shifting the chemical balance of seawater to a more acidic state (lower pH) due to increased CO2 concentrations in the sea as a result of increased CO2 concentrations in the atmosphere. Acidification is currently occurring at a geologically unprecedented rate, subjecting marine organisms to additional environmental stresses. According to the MedSEA project[2], the acidity of Northwestern Mediterranean seawater has increased by 10% since 1995 and if current CO2 emission rates continue, it will increase another 30% by 2050 and 150% by 2100. Several planktonic organisms are affected by acidification with possible negative impacts on fish populations. Moreover, acidification also threatens iconic and invaluable Mediterranean ecosystem-building species (such as sea grass meadows, Coralligene reefs and Vermetid snail reefs) which create rich key habitats and homes to thousands of species, and also protect shores from erosion as well as offer a source of food and natural products to society.

Food security and food production systems. Agriculture absorbs over 80% and 60% of total water demand in the African and European countries surrounding the Mediterranean Sea, respectively. The general decrease in soil moisture and water availability in general, and the increase in the frequency and intensity of droughts as a result of climate change in the Mediterranean will increase the existing water-related stresses and have strong negative effects on crops and agriculture in general. The increased need for irrigation will be constrained by reduced runoff, reduced recharge of aquifers, and competition from other sectors, in particular human settlements and energy.

Climate change impacts also reverberate on the agricultural and food industry, driving major consequences on food insecurity and poverty:

- In the absence of climate change, and with continuing economic progress, most regions are projected to see a decline in the number of people at risk of hunger by 2050. With climate change, however, the population living in poverty could be multiplied by 2 to 3 relative to a future without climate change, largely due to its negative impacts on incomes in the agricultural sector (FAO, 2016). Agriculture and the food sector at large have an important responsibility in climate change mitigation. Taken together, agriculture, forestry and land-use change account for about one-fifth of global GHG emissions (FAO, 2016).
- Deep transformations in agriculture and food systems, from pre-production to consumption, are needed in order to maximize the co-benefits of climate change adaptation and mitigation efforts; the agriculture sectors have potential to limit their

greenhouse gas emissions, but ensuring future food security requires a primary focus on adaptation (FAO, 2016).

Coastal Risk Index (CRI-MED) for the Mediterranean

The Regional Risk Assessment Map of coastal risk to climate and non-climate forcing, displays the result in terms of qualitative risk classes in the coastal zones investigated. The map shows the values of risk assumed by each location (cell) by applying the equation defined for the method CRIMED. Sites that assume “extremely high risk” values are indicated in red and in the context of the study these are defined as “hot-spots”.

CRI-MED is a spatial risk index, which combines variables (multiple data layers) representing different aspects of risk in such a way that coastal areas of relatively higher risk emerge from the integration of the variables. It creates an interface between theoretical concepts of risk and the decision-making process relating to disaster risk reduction. Based on a GIS application, CRI-MED provides relative hazard, exposure, vulnerability and risk maps of the Mediterranean region that allow researchers and policy-makers to identify coastal areas most at risk from coastal erosion and coastal flooding, the so-called “hot-spots”. Through the application of CRI-MED on 21 Mediterranean countries, coastal hot-spots are found to be predominantly located in the south-eastern Mediterranean region. Countries with the highest percentage of extremely high-risk values are Syria (30.5%), Lebanon (22.1%), Egypt (20.7%), and Palestine (13.7%). The CRI-MED method is intended as a scientific tool which produces easily understandable outcomes, to support international organizations and national governments to enhance and mainstream decision-making based on information that is accessible and useful. The definition of coastal hot-spots aims to support the prioritization of policies and resources for adaptation and Integrated Coastal Zone Management (ICZM). In particular, the resulting risk maps enable identification of suitable and less suitable areas for urban settlements, infrastructures and economic activities.

Beyond the north-south gradient in the Mediterranean, particularly vulnerable landscapes include deltas and coastal zones (vulnerable to sea-level rise), as well as rapidly growing cities without adequate infrastructure and institutions. In the Mediterranean regions, about 50% of the urban population lives less than 10m above sea level. Tourist destinations (concentrated along the coast) are vulnerable not only to sea-level rise but also to higher summer temperatures, which may turn tourists away toward more northern and cooler locations.

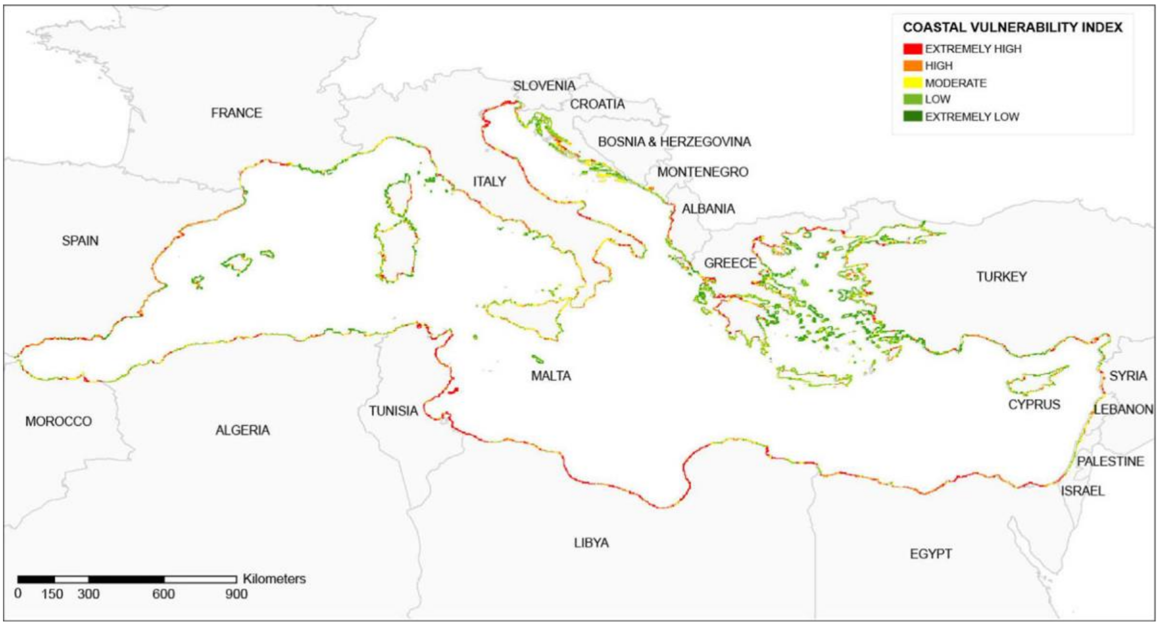


Figure 1.6. Coastal Risk Index (Satta et al., 2017)

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2. Socioeconomic characteristics of the Mediterranean

Introduction

The Mediterranean region is undergoing intensive demographic, social, cultural, economic and environmental changes. Population growth combined with the growth of coastal (peri) urban hubs generates multiple environmental pressures stemming from increased demand for water and energy resources, generation of air and water pollution in relation to wastewater discharge or sewage overflows, waste generation, land consumption and degradation of habitats, unsustainable use of living resources, landscapes and coastlines. These pressures are further amplified by tourism, often concentrated in Mediterranean coastal areas, and overall by climate change.

As mentioned in the Introduction, the Mediterranean Strategy for Sustainable Development (MSSD) 2016-2025 provides an integrative policy framework and a strategic guiding document for all stakeholders and partners to translate the 2030 Agenda for Sustainable Development at the regional, sub regional and national levels (see Figure 3.1). This is achieved through common objectives, strong involvement of all stakeholders, cooperation, solidarity, equity and participatory governance. 34 indicators have been agreed in relation to the following 6 objectives:

1. Ensuring sustainable development in marine and coastal areas
2. Promoting resource management, food production and food security through sustainable forms of rural development
3. Planning and managing sustainable Mediterranean cities
4. Addressing climate change as a priority issue for the Mediterranean
5. Transition towards a green and blue economy
6. Improving governance in support of sustainable Development

The 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development — entered into force in 2016 and in recognition of the growing importance of the role of oceans in sustainable development, Goal 14 is to Conserve and sustainably use the oceans, seas and marine resources.

Figure 2.1. The 2030 Agenda for Sustainable Development and Sustainable Development Goals

This chapter will summarize some of the key Socioeconomic characteristics and trends in the Mediterranean

Population and development.

The total population of the Mediterranean countries grew from 281 million in 1970 to 419 million in 2000 and to 472 million in 2010. The population is predicted to reach 572 million by 2030. Four countries account for about 60 % of the total population: Egypt (82 million), Turkey (72 million), France (63 million), and Italy (60 million). 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 about 100 million in 1980 to 150 million in 2005. It could reach 200 million by 2030. (Plan Bleu, based on UN World Population Prospect 2015 and on national population censuses). The concentration of population in coastal zones is the heaviest in the western Mediterranean, the western shore of the Adriatic Sea, the eastern shore of the Aegean Levantine region, and the Nile Delta (Figures 3.2 and 3.3). Overall, the population density 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/km2 in the Nile Delta to fewer than 20 people/ km2 along parts of coastal Libya (UNEP/MAP, 2012).

While population development in the north is almost stagnant, strong population growth in the southeast results in overexploitation of water, land, and other resources, driven by land clearing, cultivation of marginal land, overgrazing, and firewood harvesting. Land productivity is decreasing accordingly. In contrast, many rural areas in the northern countries experience abandonment of agricultural land, with subsequent encroachment of shrubs and trees and a greening of the land. The southern and eastern countries of the Mediterranean are rapidly urbanizing – with almost all of the future population growth projected to be in the cities – while urbanization rates in the north are more or less stable. Coastal areas are usually rich in their natural resources that provide great opportunities for economic activities, especially resource-based economic activities such as agriculture, fisheries, tourism, oil and gas extraction, and maritime transport that tend to locate in these areas.

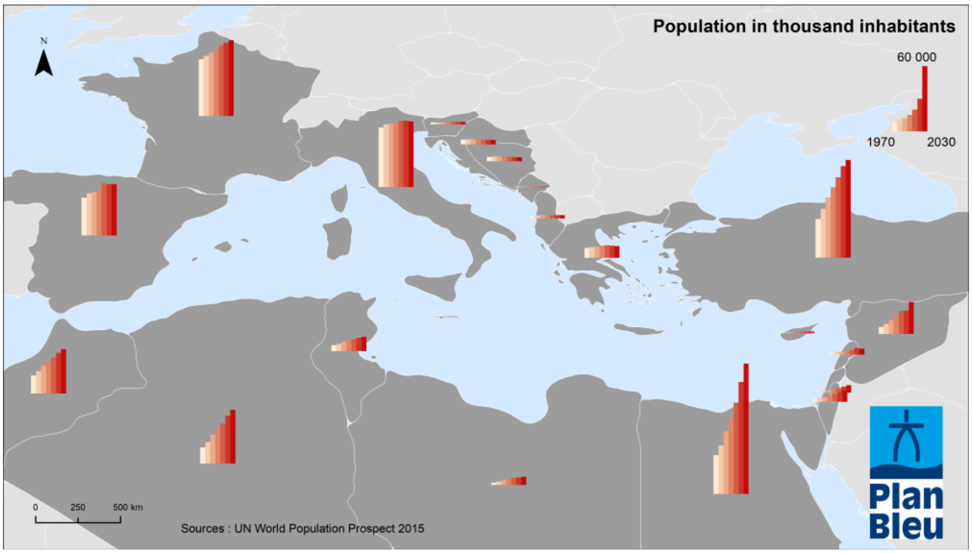

Figure 2.2. Population: trends and projections in Mediterranean countries from 1970 to 2030 (in thousands of inhabitants) (Source: UN World Population Prospect 2015)

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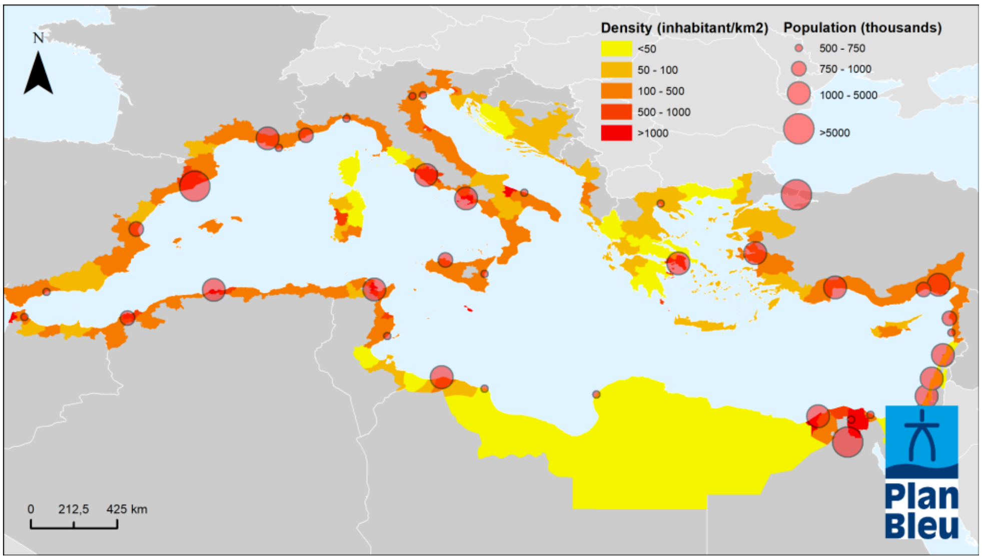


Figure 2.3. Population: Density of the coastal regions and major coastal cities (more than 500 000 inhabitants) (Source: Plan Bleu from various sources)

Approximately one third of the Mediterranean population is concentrated along its coastal regions, whereas more than half of the population resides in the coastal hydrological basins. Around 40% of the total coastal zone estimated to be under some form of artificial land cover. Close to 100% of the population in the coastal region reside in urban localities. Moreover, about 1,600 cities (more than 10,000 inhabitants) with around 100 million inhabitants are located in the Mediterranean coastal regions. Mediterranean coastal areas are threatened by coastal development that modifies the coastline through the construction of buildings and infrastructure needed to sustain residential, tourism, commercial, and transport activities. Coastal manmade infrastructures cause irreversible damage to landscapes; habitats and biodiversity; and shoreline configuration by disrupting the sediment transport. The population density is different between the countries of the north of the Mediterranean and the countries of the south and the east. The density is more homogeneous in the European Mediterranean countries.

In 2015, the average income per capita in the South and East Mediterranean countries is 2.5 times lower than the average income in the EU Mediterranean countries. The GDP growth rate in the south and east Mediterranean countries are much higher than those of the EU Mediterranean countries. However, they are considered low when compared to the population growth rates, as the demographic growth is still high in the southern Mediterranean countries. The share of the Mediterranean GDP in the world GDP is decreasing: from more than 13.5% in 1990 to 11.5% in 2010 and 9.7% in 2015. Meanwhile, the share of the Mediterranean population remains constant in the world population (about 7%).

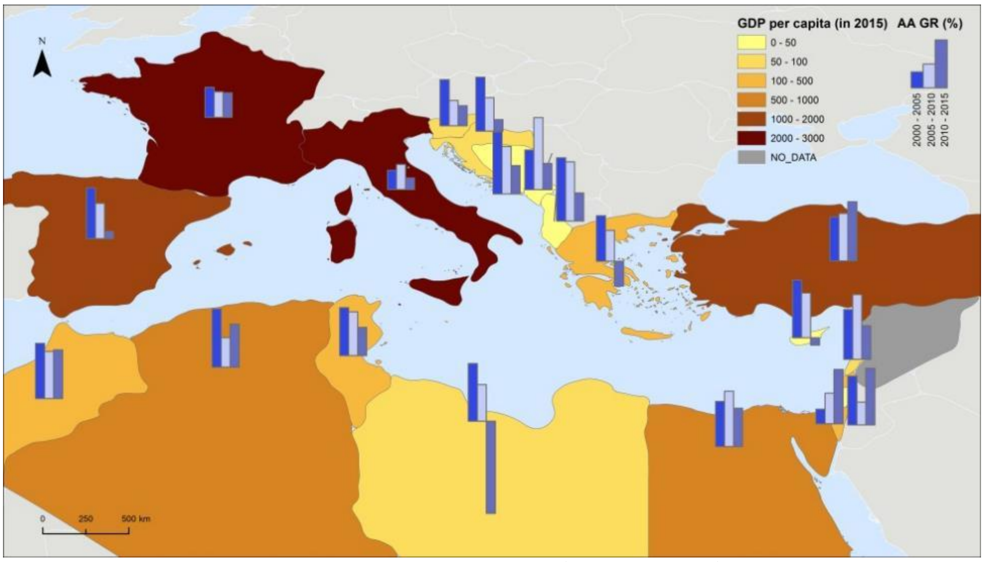


Figure 2.4. Gross Domestic Product, 2015 (World Bank)

Tourism.

The Mediterranean is the world's leading tourism destination in terms of both international and domestic tourism with more than 300 million international tourist arrivals representing 30% of total world tourists for 2014. International tourist arrivals have grown from 58 million in 1970 to nearly 314 million in 2014, with a forecast of 500 million by 2030. About 50% of these arrivals are in coastal areas (Figure 3.5).

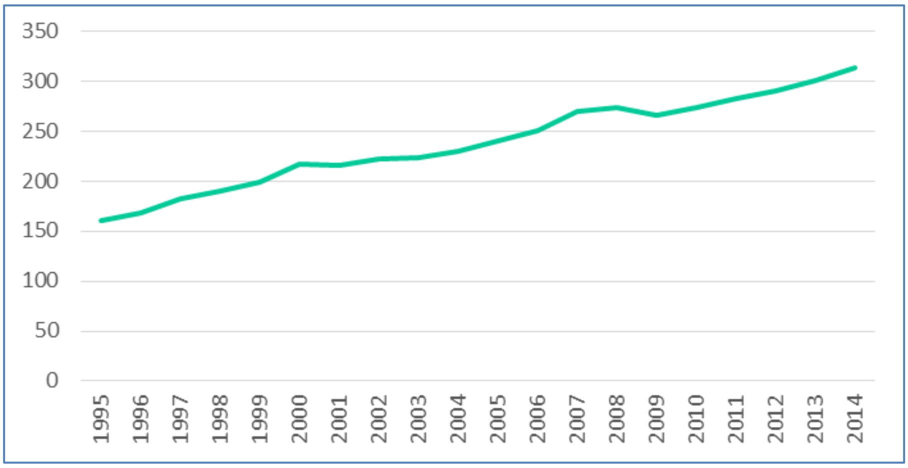


Figure 2.5. International Tourism Arrivals trends from 1995 to 2014 (Source UN-WTO)

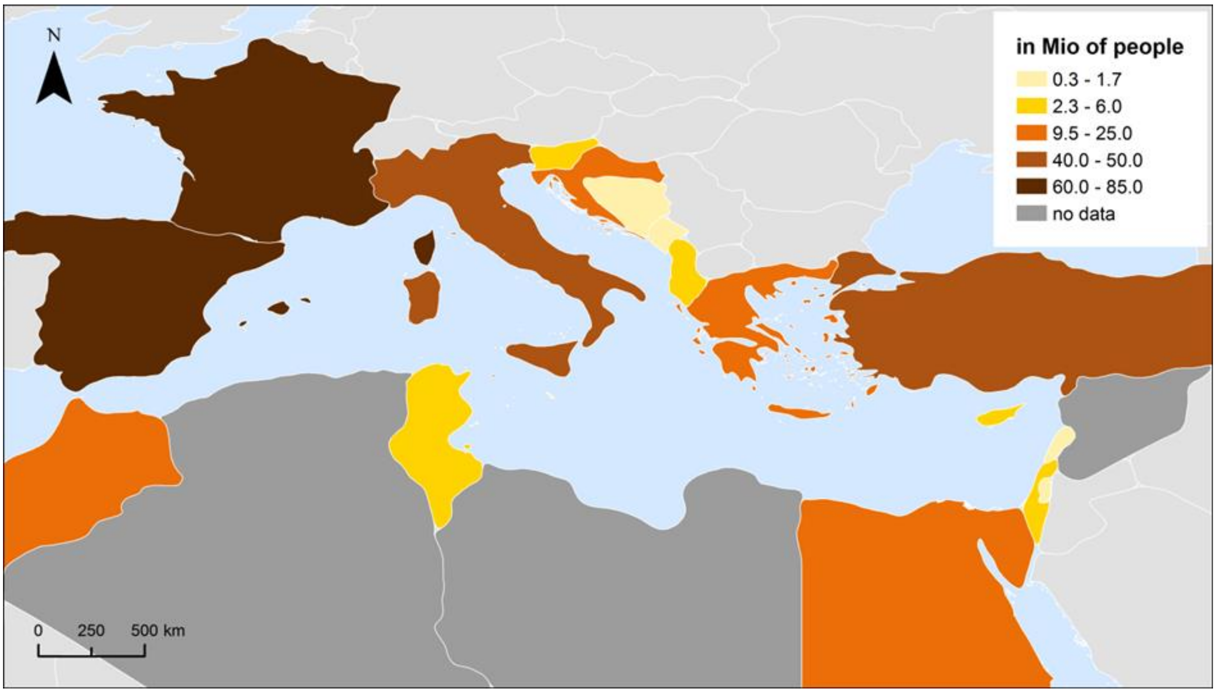


Figure 2.6. International Tourism Arrivals in the Mediterranean countries in 2014 (Source UN-WTO)

In 2016, Tourism contributed to create 333.2 billion US$ in the Mediterranean countries. During the last 20 years, the direct contribution of tourism to GDP in the Mediterranean region has increased by 53%. Tourism is a major pillar of Mediterranean economies, offering consistent employment (11.5% of total employment in 2014) and economic growth (11.3% of regional GDP). In the Mediterranean basin, tourism is vital for many countries: considering exclusively coastal areas economy, tourism represents over 70% in terms of Production Value and Gross Value Added (Figure 3.17).

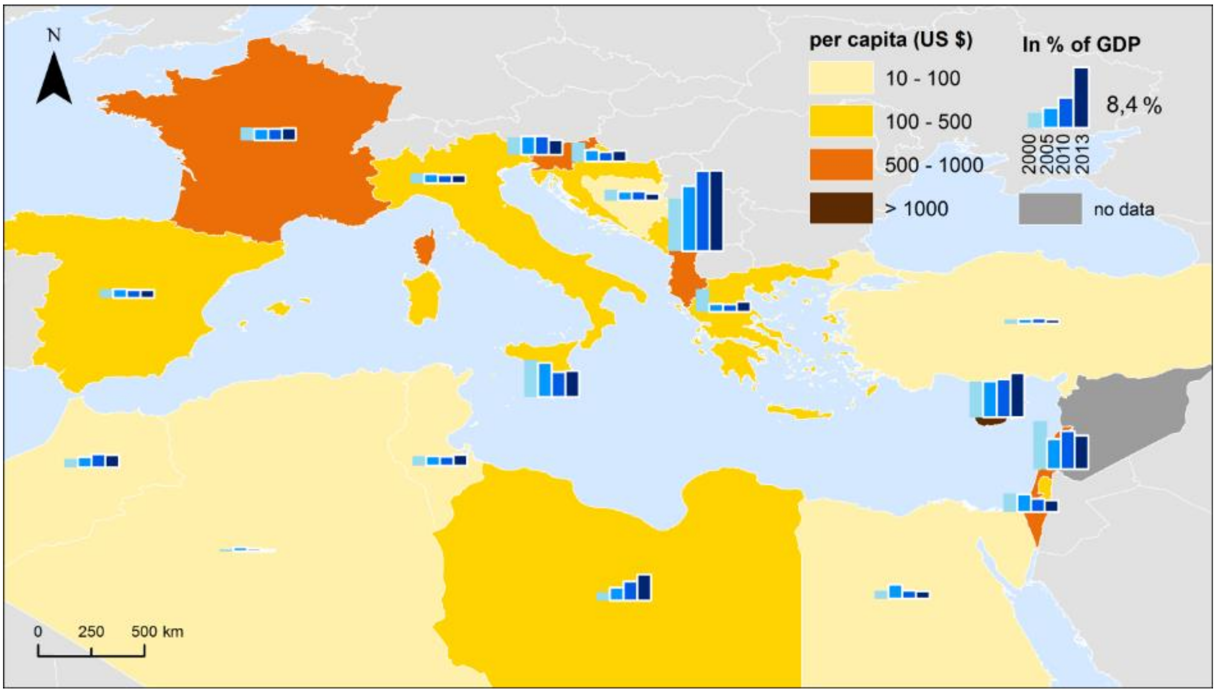


Figure 2.7. International Tourism Receipts, 2013 (Source UN-WTO)

Mediterranean coastal tourism has benefited and contributed to the democratization of the holiday dream, offering easy-to-reach and affordable leisure breaks through the so-called 3S (Sea, Sand and Sun) model. (Plan Bleu, 2017)

All-in-one packages including low-cost airlines, comfortable accommodation and cheap food, have massively increased tourist flows towards the Mediterranean coasts. Over the years, the 3S model has been extended to include different facilities, including golf courses, swimming pools, leisure parks, etc. Visitor travel patterns have also evolved: whereas at the beginning they used to spend their holiday at the same place for a longer period, nowadays they prefer to get away more often during the year for shorter stays away from home. In general, the relationship between the economic benefits, usually captured by large international operators, and the induced social and environmental transformation at destination level remains problematic. Local communities are increasingly concerned to preserve their natural, economic and social assets from negative impacts, which may arise from the development of facilities for tourism purposes.

Coastal tourism represents many of the problems associated with uncontrolled human activities and the following issues have been identified:

- Linear and coastal urbanization, consuming the precious but very limited resource of coastal areas;
- Water pollution, waste generation and marine littering;
- Overconsumption of scarce natural resources (water, etc.), in particular during seasonal periods (summer);
- Land degradation, biodiversity losses and decrease of the aesthetic value of landscapes;
- Greenhouse gas emissions due to energy mismanagement and inefficiencies;
- Obsolescence of 3S model, low level of competitiveness, resilience and innovation;
- Poor quality of employment generated (seasonal, low salaries, unqualified, often part-time, etc.);
- Economic leakage, i.e. unbalanced distribution of tourism generated revenues;
- Lack of integration of sustainable tourism needs in planning for other sectors.

In addition, the Mediterranean Sea is among the most important cruise areas in the world: it reached 27 million passengers in 2013, with a sustained increase of around 5% per year. Cruise infrastructures remains located on northern shore: 75% of Mediterranean ports are in Italy, Spain, France, Greece, Croatia and Slovenia, while 9% of ports are in Turkey and Cyprus; and 7% in Northern Africa. (Plan Bleu 2017)

Maritime transport.

The Mediterranean Sea is one of the busiest seas in the world, harvesting 20% of seaborne trade, 10% of world container throughput and over 200 million passengers. Furthermore, as maritime traffic is steadily increasing it adds environmental pressure, such as rising CO2 emissions, pollution, marine litter and collisions with large cetaceans, underwater noise and introduction of non-indigenous species. Container port traffic development shows a clear trend of rapid growth of the sector, which undoubtedly increases the environmental pressure and strengthens the need for a transition to a sustainable maritime.

Figure 3.8, presents the density of AIS (Automatic Identification System) signals of all vessels (including EU fishing vessels over 15m) in 2014 (Piante, C., Ody, D., 2015). Major traffic routes are dominated by crude oil shipments (that originate from the eastern Black Sea, Northern Egypt, or from the Persian Gulf via the Suez Canal) and by container ship traffic. From the mid-1990s to the mid-2000s, the Mediterranean Sea recorded a rise of 58%

of transit capacity, combined with an increased size of vessels by 30% since 1997, and it is expected that shipping in the Mediterranean basin will increase in the coming years, both in number of routes and traffic intensity. Maritime traffic towards and from EU Mediterranean ports will be influenced by the doubling of the Suez canal that will allow a proportional increase of the traffic, but also by key drivers such as weak oil refining capacity outlook for Europe, a changing energy mix, the global demand for Liquified Natural Gas (LNG) as a fuel for maritime shipping, the implementation of Trans-European Networks, the potential designation of the Mediterranean as a Sulphur Emission Control Area (SECA) and a limited renewal rate of the world fleet.

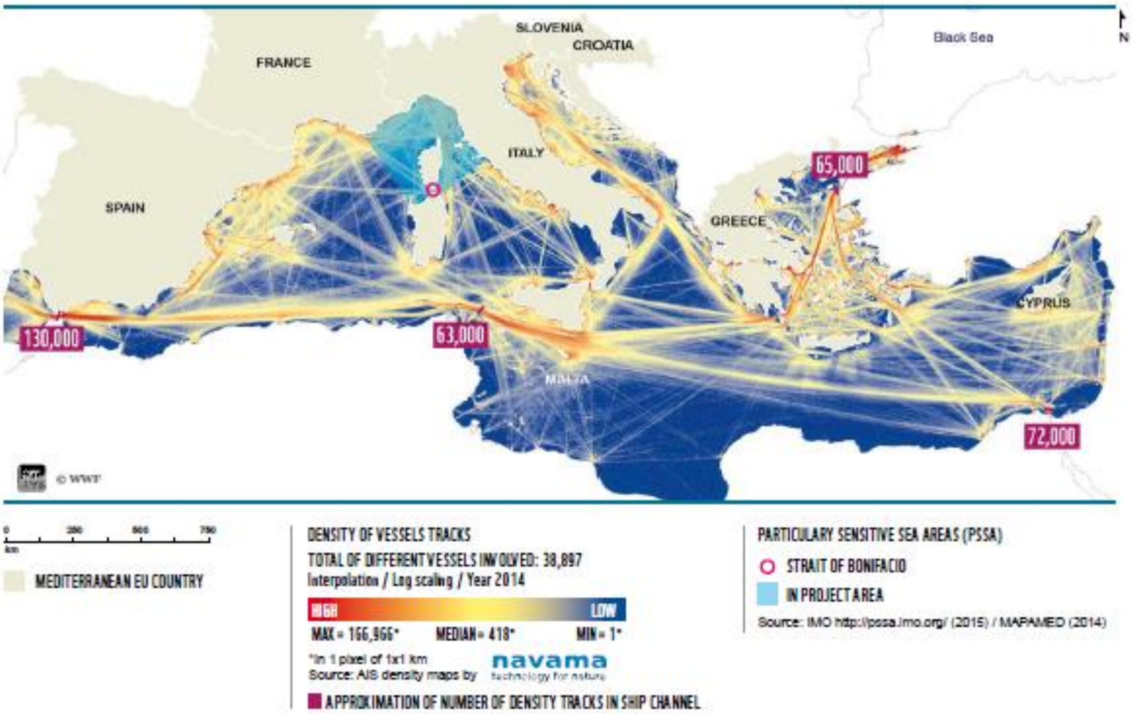


Figure 2.8. Density of AIS signals of all vessels in 2014 (Piante, C., Ody, D., 2015).

Energy, Gas and Oil exploration and exploitation, 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).

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.

In the Mediterranean there are almost no tides and steady waves to deploy ocean energy technologies. Ocean Thermal Energy Conversion may be feasible but is still in an early development stage. Onshore wind and PV installations close to the coast may be considered as part of the Blue Economy but are seen in this report as Green Economy. Today the only commercially available sustainable, i.e. renewable, energy technology that can potentially be deployed in the Mediterranean Sea is offshore wind.

Due to deep waters, mainly floating wind turbines would be feasible but while experience with this technology is growing, it is not widely available yet. Overall the offshore renewable energy sector in the Mediterranean is still almost not existent as there are no commercial offshore wind projects yet. Deployment can be expected once costs further decrease; the latest tenders for offshore wind the North Sea are quite promising in this regard.

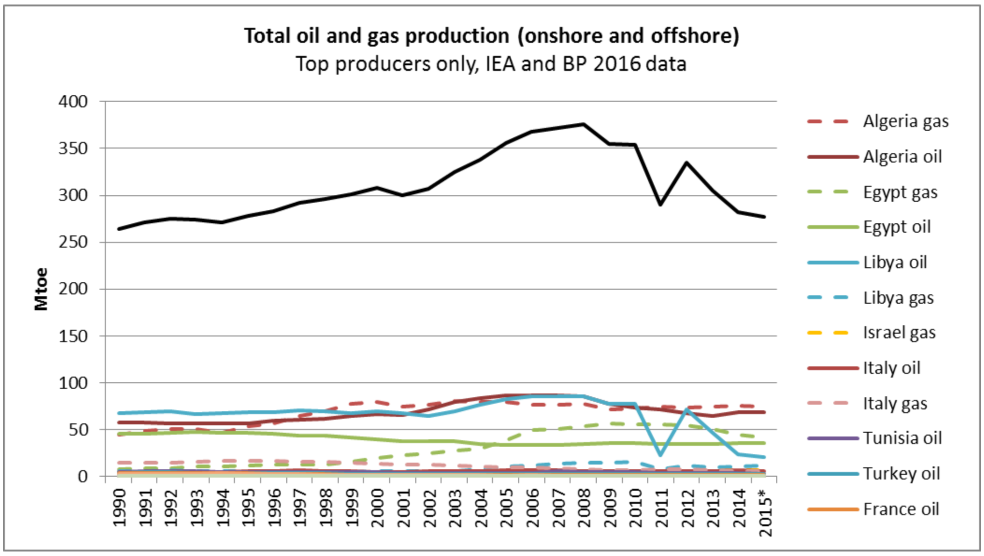


Figure 2.9. Total oil and gas production (1990-2015) by country. Black line: total of all countries.

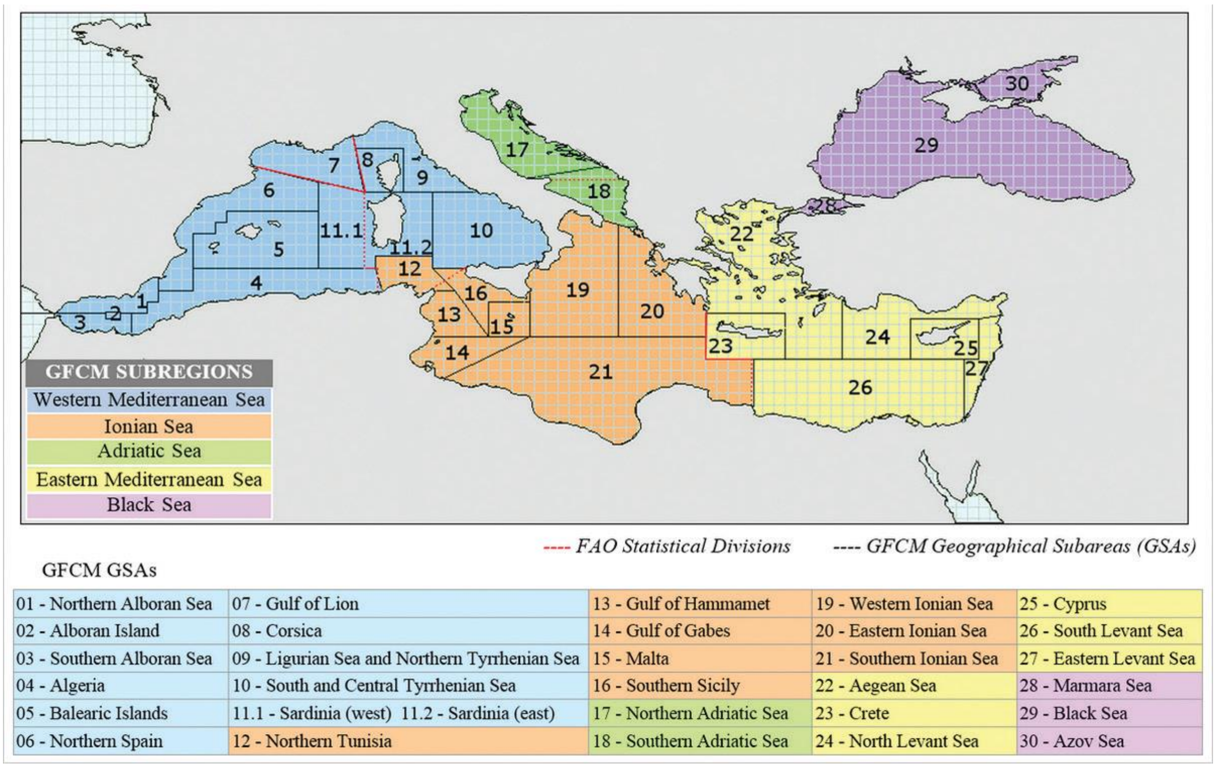
44% of the Med area are either contracted or designated for oil & gas exploration (WWF 2015 Medtrends) – this poses a risk that those zones, especially the ones in the Eastern Mediterranean, may be explored at one point, potentially leading to increased pollution. In addition to the emission of greenhouse gases, offshore oil and gas operations in a sea with considerable seismic activity come with a risk of accidents and oil spills posing a real threat to the fragile Mediterranean ecosystem.

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.

Fisheries and aquaculture

About 85 percent of Mediterranean and Black Sea stocks assessed are fished at biologically unsustainable levels. Demersal stocks experience higher fishing mortality rates, while small pelagic stocks show average fishing mortality rates close to the target (FAO, 2016b). Hake stocks in the Mediterranean Sea show the highest fishing pressure, with a fishing mortality rate that is an average of 5 times higher than the target, and for some specific stocks, up to 12 times higher than the target. Conversely, small pelagic stocks show average fishing mortality rates that are close to the target, while for some specific stocks, the fishing mortality rate is estimated to be below the target. The volume of fishery discards in the Mediterranean is in the order of 230 000 tonnes per year, or about 18 percent of total catches. Bottom trawls are responsible for the bulk of discards (more than 40 percent)

The percentage of landings assessed has nearly doubled in recent years, rising from about 20 percent in 2013 to around 45 percent in 2014 and 2015. Moreover, there are regional differences in the knowledge of stock status, with fewer stock units assessed in the Ionian Sea and eastern Mediterranean, compared with the western Mediterranean, the Adriatic Sea.



GFCM GSAs

01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant Sea
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Sea
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - Southern Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 2.10. GFCM sub-regions (FAO, 2016b)

The officially reported fishing fleet operating in the Mediterranean and the Black Sea comprises some 92 700 vessels. The fishing fleet is unevenly distributed in the GFCM area of application, with the eastern Mediterranean accounting for the largest share of vessels (28 percent), followed by the Ionian Sea (27 percent), the western Mediterranean (19 percent), the Adriatic Sea (14 percent) and the Black Sea (12 percent). Turkey, Greece, Italy and Tunisia are, in decreasing order of importance, the countries with the largest fleets, accounting for more than 60 percent of the total number of vessel. Artisanal or small-scale fisheries constitute more than 80 percent of the fishing fleet.

In the Mediterranean, landings increased until 1994, reaching 1 087 000 tonnes, and subsequently declined irregularly to 787 000 in 2013.Algeria, Greece, Italy, Spain, Tunisia, Turkey and are together responsible for slightly more than 80 percent of total landings in the Mediterranean.

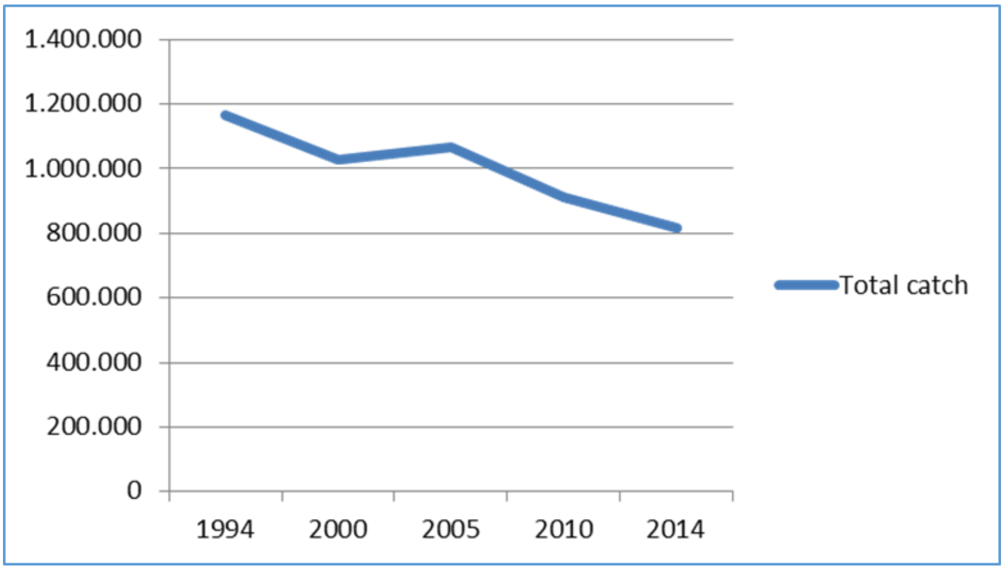


Figure 2.11. Total fish catch 1994 – 2014 in 1000 tonnes (Source Fishstat)

A group of 13 main species accounts for some 65 percent of landings, with anchovy (393 500 tonnes) and sardine (186 100 tonnes) being by far the dominant species. In contrast with other regions, clams (56 000 tonnes), mussels (21 000 tonnes) and the species group of squid, cuttlefish and octopus (58 000 tonnes) account for substantial landings.

The total value of fish landings across the Mediterranean is estimated to US$5 billion. The sub region with the highest landing value is the western Mediterranean (US$1.57 billion), followed by the Ionian Sea (US$1.41 billion), the eastern Mediterranean (US$1.07 billion), the Adriatic Sea (US$979 million). Five countries account for approximately 80 percent of the total landing value: Italy with the highest landing value close to US$900 million followed by Turkey, Greece, Spain, and Algeria.

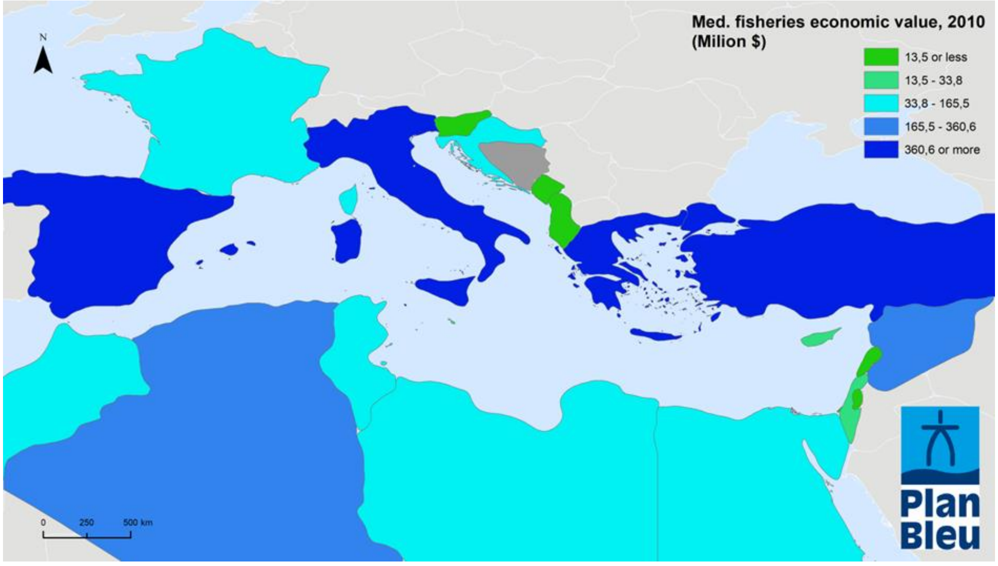


Figure 2.12. From 1990 to 2010 the total value of Mediterranean fisheries have risen 160 %

The average landing prices observed in the western Mediterranean, the Ionian Sea and the Adriatic Sea is about US$3 900 per tonne. In the eastern Mediterranean the average price is about US$1 900 per tonne. At Least 250 000 people are employed on fishing vessels in the Mediterranean and the Black Sea. Artisanal or small-scale fisheries in the Mediterranean and the Black Sea play a significant social and economic role: they employ at least 60 percent of those workers directly engaged in fishing activity and account for approximately 20 percent of the total landing value from capture fisheries in the region. (FAO, 2016b). In the Mediterranean, **aquaculture production** is increasing 239,556 tonnes in 1995 to 452,719 tonnes in 2015. The production of Turkey, Italy and Greece represents about 78% of the Mediterranean production. The **total value of aquaculture** in the Mediterranean is about to US$2 billion. Four countries account for approximately 82 percent of the total aquaculture value: Turkey with the highest value about US$670 million followed by, Greece, Italy and Spain. (Plan Bleu, based on FISHSTAT data).

Land-based pollution sources.

Approximately Eighty percent of marine pollution originates from land-based human activities. Different types of pollutants (e.g. nutrients, heavy metals, Persistent Organic Pollutants, marine litter) affect marine and coastal ecosystems and related economic activities such as fishing or tourism.

Waste management has become a major concern for Mediterranean countries where waste represents an enormous loss of resources in the form of both materials and energy. Due to the large share of the population and human activities located in coastal regions bordering the Mediterranean Sea, waste is a significant pressure on coastal and marine environments, causing visual pollution and contributing to beach and marine litter. Such threats to the coast and sea are especially significant in areas where coastal dumpsites are still used or are used without rehabilitation.

The Strategic Action Plan (SAP-MED) is a long-term policy framework to combat pollution from land-based sources in the Mediterranean. SAP-MED foresees for urban solid waste management the reduction at source, separate collection, recycling, composting and environmentally sound disposal by 2025. The Regional plan on Marine litter Management (2013) boosts the application of the waste hierarchy as a priority order in waste prevention and management legislation and policy, i.e.: prevention, preparing for re-use, recycling, other recovery, e.g. energy recovery and environmentally sound disposal (UNEP/MAP, 2015).

With regard to Municipal Solid Waste (MSW) generation, Figure 3.12 shows generation of MSW for 2003, 2007 and-2011 for the Mediterranean region and per country, while Figure 3.13 shows the generation of MSW per capita for 2003, 2007 and 2011 per country.

Overall it is noted that:

- An overall reduction trend on MSW generation has been identified in the Mediterranean region for the period 2003-2011; however, this regional trend needs to be further confirmed with data missing from some countries for certain years.
- As for MSW generation per capita per year, the highest rates are close to 600 kg/capita/year. The lowest rates in the region are between 200-300 kg/capita/year.
- Most EU countries show collection rates near 100% while the other countries vary between 40-85%.
- Open air dumping is a common disposal method in several Mediterranean countries.
- Recycling and composting are not common in most Mediterranean countries.

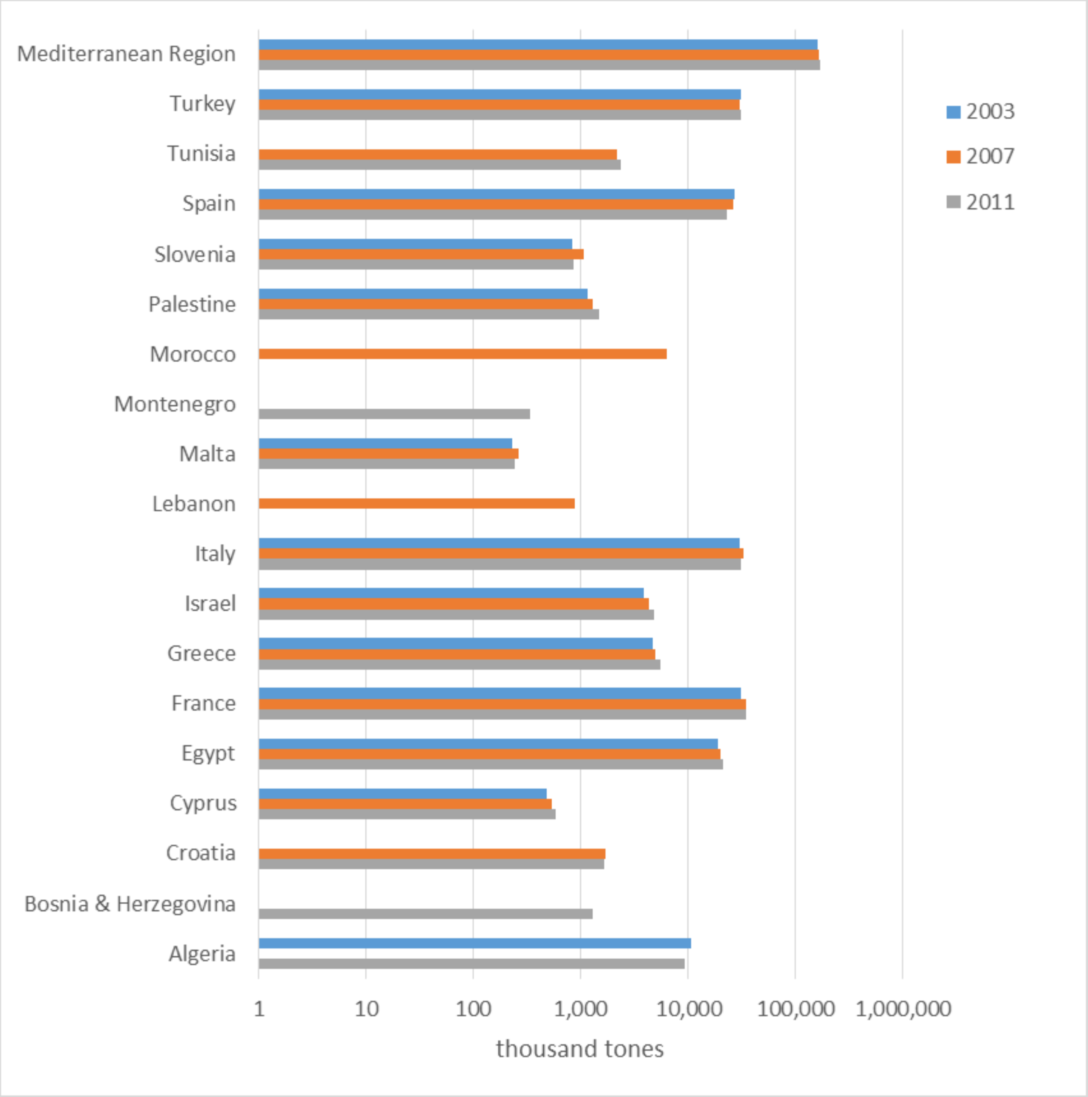


Figure 2.13. MSW generation in Mediterranean countries. Source: Eurostat and SEIS report (Algeria and Tunisia in 2011), UNSD (Algeria in 2003) and Medstat compendium 2006 (Egypt in
2000, Lebanon in 2007, Morocco in 2000 and Tunisia in 2004)

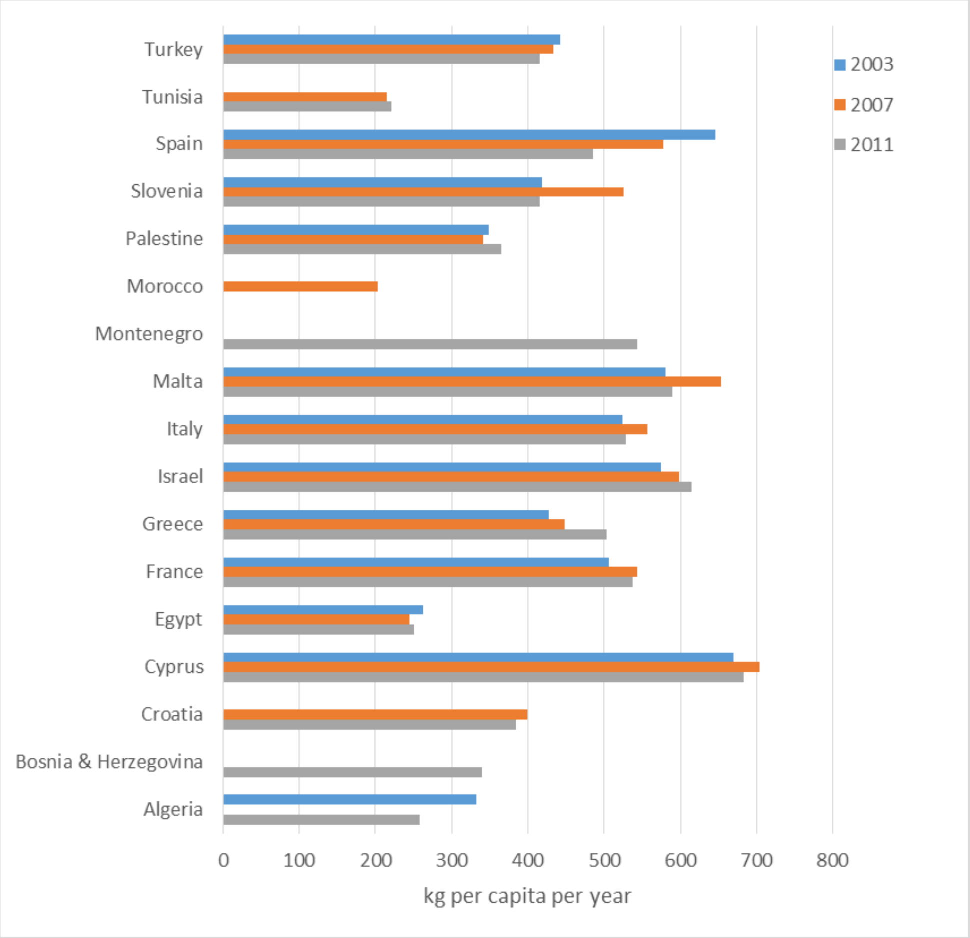


Figure 2.14. MSW generation per capita per year in Mediterranean countries
Source: Eurostat and SEIS report (Algeria and Tunisia in 2011), UNSD (Algeria in 2003) and Medstat compendium 2006 (Egypt in 2000, Lebanon in 2007, Morocco in 2000 and Tunisia in 2004)

Industrial pollution is generated on a wide scale along the Mediterranean coastline. Industrial pollution is one of the major environmental pressures addressed by the Land-Based Protocol (LBS) of the Barcelona Convention and its related policy and regulatory framework, at both regional and national levels, e.g. the Strategic Action Programme SAP MED and the National Action Plans (NAPs) to combat pollution from land-based sources and activities. Most of the countries are making significant efforts to control pollution from this source by developing specific strategies for dealing with wastewater treatment, solid waste management and abatement of air pollution, and are issuing, inter alia, legislation on Effluent Limit Values (ELVs) for specific industrial sectors and/or specific pollutants, as well as Environmental Quality Standards (EQSs) for the receiving waterbodies (EEA-UNEP/MAP, 2014).

Regarding the releases of pollutants to the marine environment from industrial development, **a**ccording to the National Baseline Budget (NBB) data for 2003, 2008 and 2013 (UNEP/MAP, 2015) pollutants most emitted/ discharged in 2003 are hydrocarbons (minerals), BOD5 and sulphur oxides (SOx/SO2). In 2008, pollutants most emitted/ discharged are oils and greases (organic), carbon monoxide (CO) and nitrogen oxides (NOx/NO2). In 2013, atmospheric pollutants such as Nitrous Oxide (N2O), Carbon Monoxide (CO), Nitrogen Oxides (NOx/NO2) and Sulphur Oxides (SOx), and BOD5 are the most emitted pollutants in the region (Figure 3.14). Regarding the key industrial sectors, waste and wastewater management, mineral industry, energy sector and chemical industry show general increasing trends from 2003 to 2013, while production of metals, paper and wood processing and food and beverage sector present particular decreasing trends from 2008 to 2013 (Figure 3.15).

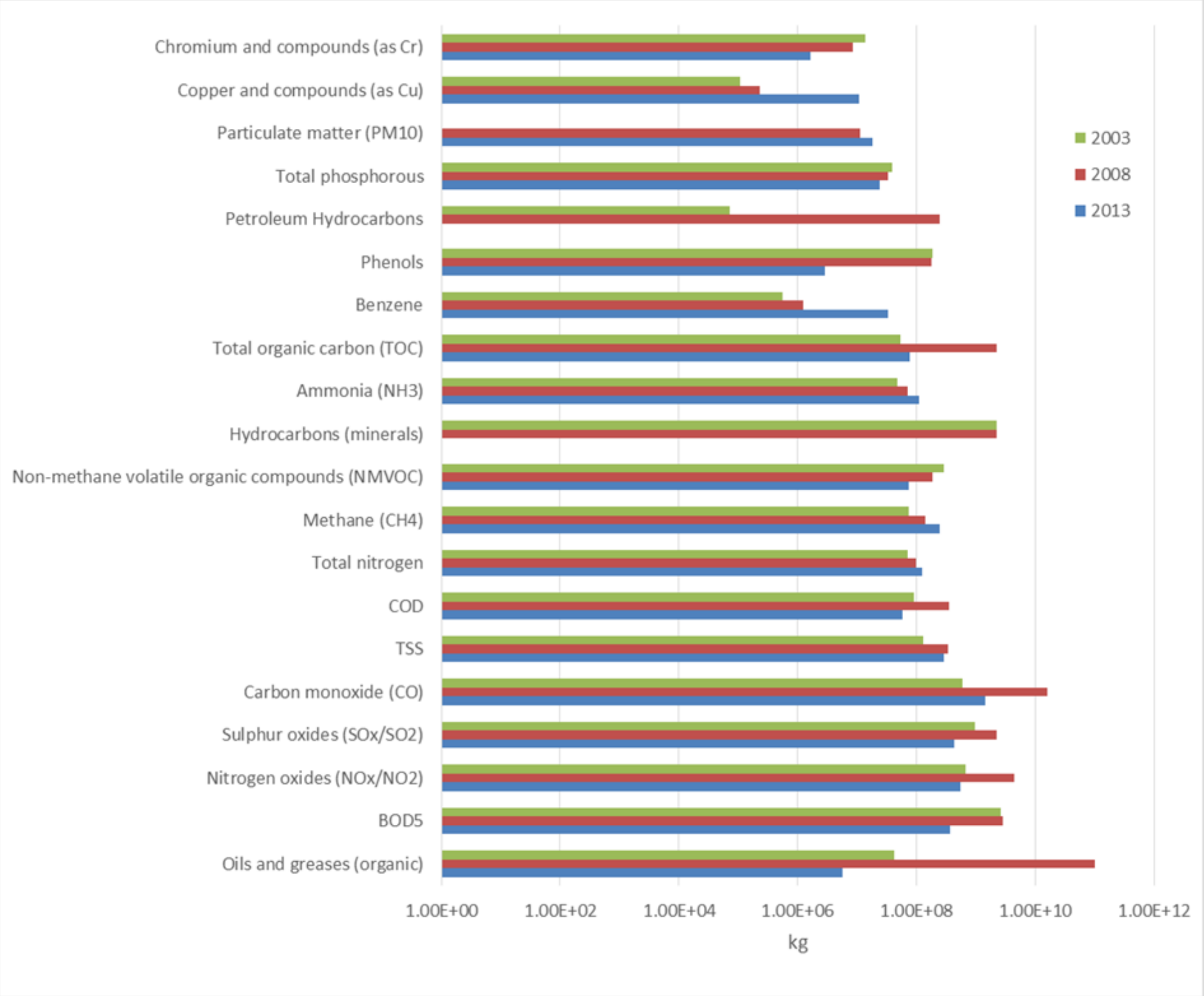


Figure 2.15. Top pollutants by emission values (NBB 2003, 2008, 2013 and E-PRTR, 2013)[23].

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[23] NBB 2013 for Egypt, Lebanon, Israel, Montenegro and Turkey.
E-PRTR 2013 for Cyprus, France, Italy, Greece, Malta, Slovenia and Spain.

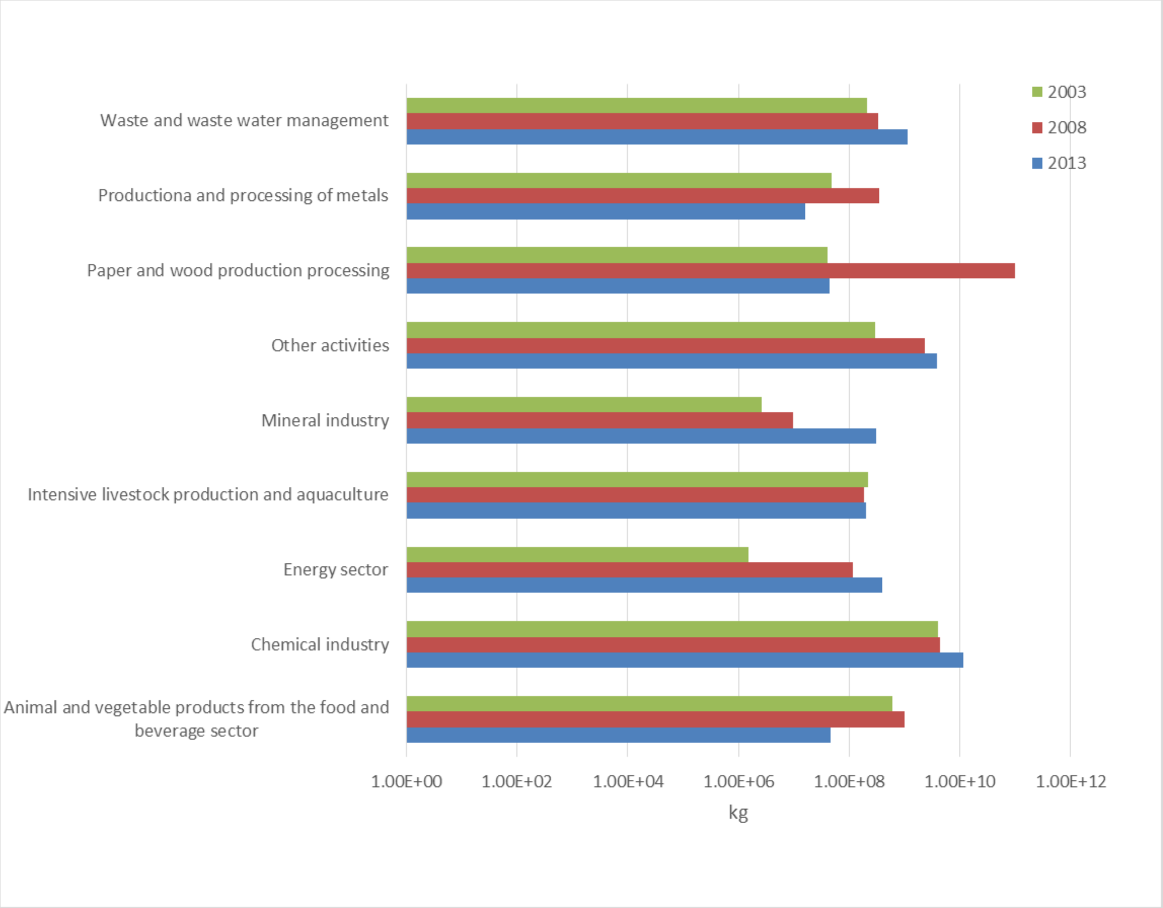

Figure 2.16. Total aqueous effluent values per sector (NBB 2003, 2008 and 2013 and E-PRTR 2013)[24]

SAP MED sets specific pollution reduction targets for 33 different substances emitted from land based sources to be achieved by 2010 and 2025. In this regard, Table 3.1 shows the level of achievement, based on NBB 2003, 2008 and NBB, E-PRTR 2013 data, of such SAP MED targets for the whole Mediterranean region.

Table 3.1. Level of achievement of SAP MED targets based on 2003, 2008 and 2013 NBB data and E-PRTR 2013 data

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[24] NBB 2013 for Egypt, Lebanon, Israel, Montenegro and Turkey.
E-PRTR 2013 for Cyprus, France, Italy, Greece, Malta, Slovenia and Spain.

SAP MED Category	Substance	SAP MED target	2003	2008	2013[25]	Current status 2013 vs 2003[26]
Nutrients and suspended solids	BOD5	Reduce 50% inputs of BOD by 2010	2,577,842,346	2,857,684,084	3,601,714,55.4	-86%
POPs	Aldrin	Phase out inputs of 9 pesticides and PCBs and reduce to the fullest possible extent hexachloro benzene, dioxins and furans by 2010	-	133.1	127.1	-5%[27]
	Dieldrin		-	69.59	124.23	79%[27]
	Endrin		-	0.06	37.97	>100%[27]
	Heptachlor		-	0.07	92.00	>100%[27]
	Hexachlorobenzene		0.36	29.57	25.17	>100%
	PCB/PCT		5.2	14.93	7,289.15	>100%
	PCDD/PCDF		5.18	1,037.62	147,195.57	>100%
PAHs	PAH	Phase out to the fullest possible extent inputs of PAHs by 2010	512,331	421,053	12,434	-98%
Heavy metals (Hg, Cd, Pb) and organometallic compounds	Mercury	Phase out to the fullest possible extent discharges and emissions and losses of heavy metals by 2025	1,029,131	612,618	58,671	-94%
	Cadmium		21,057	11,347	38,506	83%
	Lead		1,760,068	1,245,723	342,117	-81%
Other heavy metals	Zinc	Reduce discharges, emissions and losses of zinc, copper and chrome by 2010	7,753,795	3,110,815	851,796	-89%
	Copper		107,641	226,923	10,520,102	>100%
	Chrome		13,843,036	8,516,046	1,602,495	-88%
Organohalogenated pesticides	Lindane	Reduce discharges, emissions and losses into the Mediterranean Sea by 2010	0.03	267.71	105.90	>100%

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[25] 2013 values include NBB 2013 for Egypt, Lebanon, Israel, Montenegro and Turkey. E-PRTR 2013 for Cyprus, France, Italy, Greece, Malta, Slovenia and Spain

[26] Current status (in %) has been calculated following the formula: (kg substance reported 2013-kg substance reported 2003)/kg substance reported 2003. Numbers in red mean a net increase from 2003 to 2008 while numbers in green mean a net reduction from 2003 to 2008.

[27] Current status calculated following: (kg substance reported 2013-kg substance reported 2008)/kg substance reported 2008.

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Annexes

Annex I

List of Case Studies for the Ecological Objectives 5 (Eutrophication), 9 (Contaminants) and 10 (Marine Litter)

The Annex I provides the list of Case Studies that have been submitted by Contracting Parties and Partners for the Ecological Objectives 5 (Eutrophication), 9 (Contaminants) and 10 (Marine Litter).

EO5	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Long-term variability along a trophic gradient in the North Adriatic Sea	Croatia Italy	M. Chaves Montero, M. Lipizer, A. Giorgetti, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS (Italy) Robert Precali, Tamara Djakovac, Cener for Marine Research, Rudjer Boskovic Institut (Croatia)
2	Overview of the assessment of pollution related indicators – EO5 Common Indicators with link to the EO9, based on results of CAMP Montenegro assessments and EcAp/MSP Boka Kotorska Bay pilot project	Montenegro	Jelena Knežević, MAP FP, Ministry of Sustainable Development and Tourism Ivana Stojanović, assistant to MAP FP, Ministry of Sustainable Development and Tourism Ivana Bulatović, MEDPOL FP, Environmental Protection Agency
3	Eutrophication Status of the Turkish Mediterranean Coastal Waters and Trend Analysis of the Eutrophication-Related Parameters in the Mersin Bay	Turkey	Süleyman Tuğrul, Koray Özhan, İsmail Akçay, Middle East Technical University-Institute of Marine Sciences Çolpan Polat Beken, TUBITAK Marmara Research Center Hacer SELAMOĞLU ÇAĞLAYAN, Ministry of Environment and Urbanization of Turkey, Middle East Technical University,
EO9	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Levels and trends of Cadmium (Cd) and Zinc (Zn) bioaccumulation in Israeli Mediterranean coastal marine mollusks (*Patella sp.*)	Israel	Prof. Barak Herut, Israel Oceanographic and Limnological Research Institute (IOLR) Jack Silverman, Israel Oceanographic and Limnological Research Institute (IOLR) Shefer Edna, Israel Oceanographic and Limnological Research Institute (IOLR) Dror Zurel, PhD, Marine Monitoring and research Coordinator, Israel Ministry of Environmental Protection, Marine Environment Protection Division
2	Levels and trends of TriButyltin (TBT) in Israeli ports and marinas	Israel	Barak Herut, Israel Oceanographic and Limnological Research Institute (IOLR) Dror Zurel, Marine Monitoring and research Coordinator, Israel Ministry of Environmental Protection, Marine Environment Protection Division
3	Concentration of key harmful contaminants in sediments and *Posidonia*, Malta	Malta	Environment & Resources Authority
4	Overview of the assessment of pollution related indicators – EO5 Common Indicators with link to the EO9, based on results of CAMP Montenegro assessments and EcAp/MSP Boka	Montenegro	Jelena Knežević, MAP FP, Ministry of Sustainable Development and Tourism Ivana Stojanović, assistant to MAP FP, Ministry of Sustainable Development and Tourism Ivana Bulatović, MEDPOL FP, Environmental Protection Agency

	Kotorska Bay pilot project (as presented under EO5)		
5	Surveillance de la qualité des eaux de baignade des plages du Marco	Morocco	Laboratoire National des Etudes et de Surveillance de la Pollution relevant du Secrétariat d'Etat chargé du Développement Durable en collaboration avec la Direction des Ports et du Domaine Publics Maritime relevant du Ministère de l'Equipement, du Transport, de la Logistique et de l'Eau ; avec l'appui de la Fondation Mohammed VI pour la Protection de l'Environnement
EO 10	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	DeFishGear coordinated and harmonized pilot surveys to assess marine litter on the surface and the sea floor of the Adriatic and Ionian coasts	Albania Bosnia and Herzegovina Croatia Greece Italy Montenegro Slovenia MIO-ECSDE	Thomais Vlachogianni, Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE) Aikaterini Anastasopoulou, Hellenic Centre for Marine Research (HCMR) Tomaso Fortibuoni, Italian National Institute for Environmental Protection and Research (ISPRA) Francesca Ronchi, Italian National Institute for Environmental Protection and Research (ISPRA) Christina Zeri, Hellenic Centre for Marine Research (HCMR)
2	Marine litter found on the *sea floor of the Mediterranean Sea: abundance at regional scale and time trends in the north-western basin*	France Italy	Gerigny, O., Institut Français de Recherche pour l'Exploitation de la Mer, France Spedicato, M., COISPA Tecnologia & Ricerca, Bari, Italy, MEDITS coordinator Jadaud, A., Institut Français de Recherche pour l'Exploitation de la Mer, France Ioakeimidis, C., UN Environment/Mediterranean Action Plan MED POL, Athens Galgani, F., Institut Français de Recherche pour l'Exploitation de la Mer, France
3	Marine Litter Fluctuations at the Metu Beach, Mersin Bay (Turkey), the Northeastern Mediterranean during 2013-2017	Turkey	Güven, O., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey Kideys, A.M., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey Gökdağ, K., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey
4	Microplastic Pollution on the Sea Surface, Water Column and Sediment of Mersin Bay (Turkey), in the Northeastern Mediterranean	Turkey	Kideys, A.E., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey Güven, O., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey Gökdağ, K., Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey Polat Beken, Ç., TUBITAK Marmara Research Center

			Olgun Eker, E.,Ministry of Environment and Urbanization of Turkey

Common Indicator: CI13. Concentration of key nutrients in water column (EO5); CI14. Chlorophyll-a concentration in water column (EO5)

Case Study title: Long-term variability along a trophic gradient in the North Adriatic Sea

Author(s): M. Chaves Montero, M. Lipizer, A. Giorgetti, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS (Italy); Robert Precali, Tamara Djakovac, Cener for Marine Research, Rudjer Boskovic Institut (Croatia)

1. Brief introduction

Data used in this Case Study were made available thanks to the long-term initiative of the European Marine Observation and Data Network (EMODnet, http://www.emodnet-chemistry.eu/) Chemistry, promoted and financed by the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE). All data collected since the 1980s by research institutions in the framework of several national and European projects, were merged together with those collected by environmental agencies for national monitoring, to assess eutrophication (Ecological Objective 5) in the North Adriatic. In the Case Study area, the North Adriatic, eutrophication has been recognized as an environmental problem along the western Italian coast, particularly during the 1970s, 1980s and early 1990s, responsible for algal blooms, red tides and bottom oxygen depletion (Justic, 1987; Marchetti et al., 1988; Fonda Umani, 1996). Conversely, recent studies report an overall decrease of eutrophication pressure, with a consequent decrease in phytoplankton biomass, starting from the beginning of the XXI century (Mozetic et al., 2010; Cabrini et al., 2012; Djakovac et al., 2012). This modification in trophic conditions was ascribed to reduction in phosphorus loads consequent to policy interventions (banning of phosphate in detergents, improvement in municipal discharge), as well as to climatic modifications resulting in reduced precipitations and river runoff (Giani et al., 2012). The whole area is, however, subject to intense temporal and spatial variability due to contribution of different drivers (continental discharges, meteo-climatic forcing, marine circulation, anthropogenic pressure) which may lead to modification in trophic conditions as well in ecosystem status and food web integrity. This study focuses on long-term variability of nutrient and chlorophyll-a concentration in the upper part of the water column, which are common indicators of eutrophication pressure.

2. Methodologies used for the collection and analysis of the data

Data on nutrient and chlorophyll-*a* concentrations are made available by EMODnet Chemistry, which manages data provided by a consortium of institutions from several countries, involved in scientific research and in environmental monitoring. As the quality of the data is a fundamental and critical aspect when merging heterogeneous data coming from different laboratories, periods, and geographic areas, EMODnet Chemistry dedicated great effort to guarantee that all data used in this study are harmonized and archived according to commonly agreed protocols, adopting the same vocabularies and the same measurement units. Data Quality Control has been performed using standard procedures implemented in the framework of EMODnet Chemistry, according to a shared approach tuned with all European Regional Sea Conventions (UNEP/MAP, BSC, OSPAR, HELCOM) in order to guarantee consistency among data from different providers and covering long time periods (Vinci et al., 2017). Data used in this Case Study where collected in the North Adriatic Sea (Figure 1), between January 1980 and December 2009, in the framework of several national and European research projects and of national monitoring programs, and derive from *in situ* sampling. Institutions providing data are listed in the Annex.

In order to assess the long-term variability of the Common Indicators 13 (Concentration of key nutrients in water column) and 14 (Chlorophyll-*a* concentration in water column), and to compare it with limits of Good Environmental Status indicated by UNEP/MAP (UNEP/MAP, 2017), horizontal distribution of surface salinity has been mapped, using spatial interpolation tools available in Ocean Data View (Schlitzer, ODV, 2016). Different water masses were identified, in terms of freshwater influence on surface salinity, following the limits indicated in UNEP/MAP (2017) (Table I). Geometric mean (G-mean) and 90% quartiles of chlorophyll-*a* have been computed for the different water masses identified in the area for the 1980s, 1990s and 2000s, and compared with coastal water types reference conditions and boundaries in the Mediterranean (Table II). Lastly, for the whole area north of 44.5°N, median and ranges of nutrient (phosphate, dissolved inorganic nitrogen – DIN and silicate) and chlorophyll-*a* concentrations have been computed using data from the upper 5 meters of the water column.

3. **Results of the Indicator Assessment**

The outcomes of this Case Study derive from a very heterogeneous dataset, consisting in data collected on a regular temporal basis during national monitoring programs, mainly along the coast, as well as in data gathered in the framework of scientific projects, which are mostly limited in time and centered on a specific area of interest (Figure 1 and2). Data spatial and temporal distribution is, therefore, not homogeneous over 30 years and results obtained may depend on these constraints. However, as EMODnet Chemistry has gathered most data collected in the area by the institutions listed in the Annex, the analysis is based on the largest possible availability of data. Some EMODnet data were not used in the analysis as representative of extremely limited conditions (e.g. very coastal data close to Po River mouth available only after 2000, and data collected inside river mouth or in internal waters in Slovenia) as they may introduce biases in detection of long term trends.

The results obtained from this Case Study allow to recognize the different distribution and surface extension of water masses over 3 decades, indicating long-term variability in the North Adriatic, with an increased ingression of saltier Water Type III from the Eastern Basin observed in the recent decade (Figure 3). Trophic status according to Common Indicator 14 is always within the Good/Moderate (G/M) boundaries in Water types II and II and has improved in Water type III since the 1980s, with an almost 30% decrease in surface chlorophyll-*a* concentration (Table II). In the last decade, an increase in chlorophyll-*a* is observed in Water types I and II, particularly remarkable in areas interested by freshwater inputs, however, values still lie within the G/M boundaries (Figure 4). Concerning median values for the whole area, concentrations of key nutrients and of chlorophyll–*a* in the upper part of the water column, which is mostly influenced by continental inputs, are characterized by pronounced long term variability, with highest values of DIN, phosphate and chlorophyll-*a* during the 1980s and lowest in the 1990s, except phosphate which remained stable. In comparison with the first decade (1980 – 1989), the last decade (2000 – 2009) displays a consistent decrease in phosphate (-30%) and in chlorophyll-*a* (-30%), a moderate decrease in DIN (-8%) and, conversely, a moderate increase in silicate (+2%) (Table IV, Figure 5). Long-term decrease of phosphate concentration has already been documented in scientific literature (Solidoro et al., 2009; Giani et al., 2012), and is mainly consequent to regulations to control eutrophication, leading to improvement of wastewater treatment and banning of phosphate in detergents. In the long-term, phosphate reduction seems to be the main cause of the observed decrease in chlorophyll-*a* concentrations. Beside legislative interventions, observed modifications in key nutrients are also due to temporal dynamics of river inputs, precipitation regime and sea currents, which all contribute to shape the trophic conditions of the North Adriatic (Lipizer et al., 2011). The recent increase in DIN, silicate and chlorophyll-*a* median concentrations is also accompanied by a rise in concentration maxima (Table IV), which indicates an increased variability in biogeochemical properties. Possible drivers of increased variability may be related to exceptional meteo-climatic forcing which are predicted to become more frequent due to climate change. In fact, extreme meteorological forcing such as heavy rainfalls and windstorms may cause abrupt disturbances on biogeochemical properties and the planktonic ecosystem in shallow areas such as the North Adriatic (Lipizer et al., 2012). The long-term variability in trophic status may, thus, be ascribed both to direct anthropogenic pressure and to large scale meteo-climatic drivers.

4. Lessons learnt and/or recommendations

Efforts of large scale European marine data infrastructures such as EMODnet provide a useful contribution to access data which are fragmented in several institutions, with different formats and difficult to obtain. In fact, long term environmental data are crucial to assess and, in the long-term, to achieve Good Environmental Status of marine waters as required by European directives (e.g. Water Framework Directive, Marine Strategy Framework Directive). Improved dialogue among several EU and non-EU initiatives involved in marine data acquisition and management and administrators, in charge of environmental assessment and management, is highly required in order to address common threats to the marine environment, to develop policies to protect vulnerable areas of our coasts and oceans, to understand trends and to forecast future changes.

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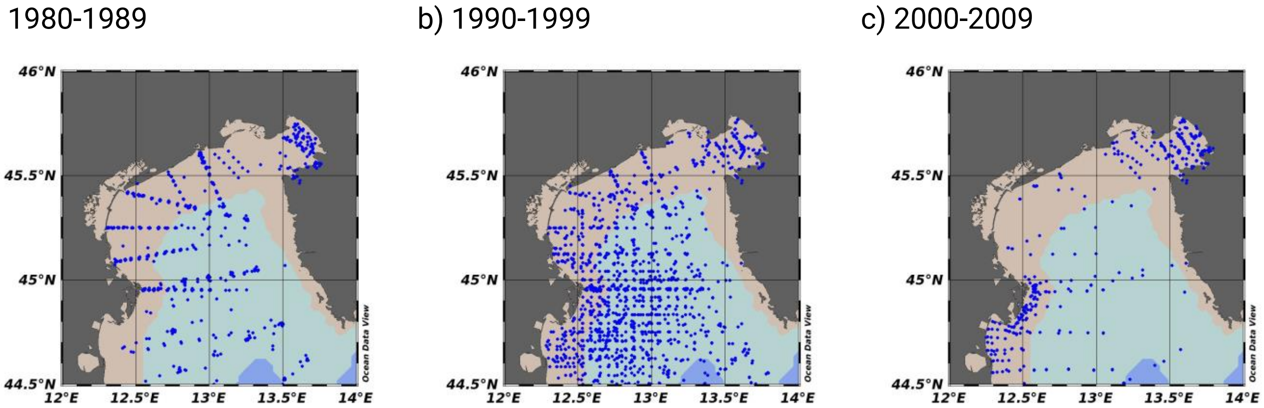
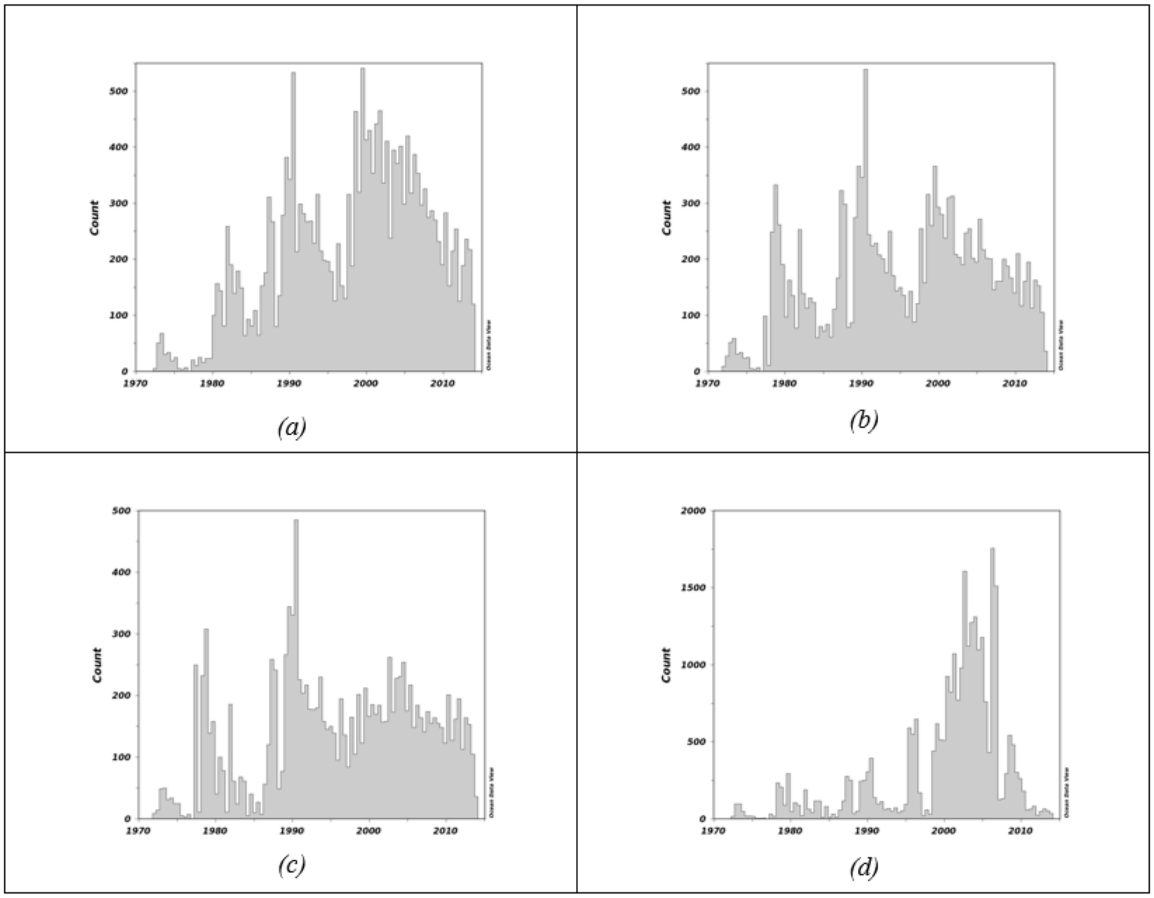
6. *Graphs, pictures and tables*


a) 1980-1989

b) 1990-1999

c) 2000-2009

Figure 1. Distribution of stations with nutrient and chlorophyll data for the three decades considered in the Case Study. Only data within 0-5 m depth are considered



(a)

(b)

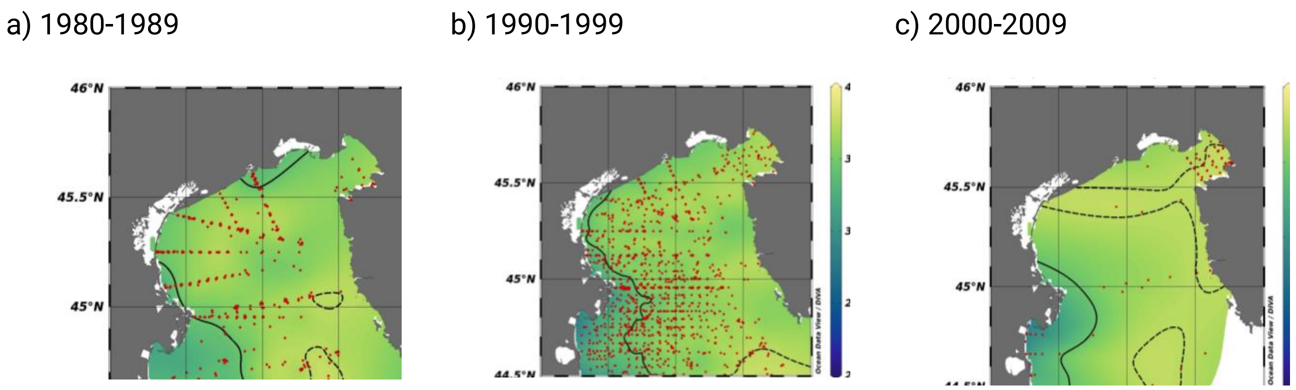
(c)

(d)

Figure 2. Histograms showing temporal availability of data of DIN (a), phosphate (b), silicate (c) and chlorophyll-a (d)

Table 1. Salinity baselines from Appendix 2 in UNEP/MAP (2017)

	Type I **coastal sites highly influenced by freshwater inputs**	***Type IIA*** **coastal sites moderately influenced not directly affected by freshwater inputs**	**Type IIIE** **not influenced by freshwater input (Eastern Basin)**
Salinity	< 34.5	34.5-37.5	> 37.5



a) 1980-1989 b) 1990-1999 c) 2000-2009

Figure 3. Surface salinity for each decade considered in the Case Study. The contour lines are drawn at 34.5 (solid) and 37.5 (dashed), indicating the limits of the water types according to Table I

Table 2. *G-mean (bold) and 90 percentile values for Chlorophyll-a in the three water types identified during the decades studied. Values are in the first 0-5 m depth. Boundaries for Good/Moderate (G/M) status from Appendix 2 in UNEP/MAP (2017)*

	Water type I	**Water type II**	**Water type III**
1980-1989	**1.86** 6.40	**0.93** 3.40	**0.92** 2.45
1990-1999	**1.04** 3.90	**0.6** 1.86	**0.58** 1.26
2000-2009	**3.65** 12.27	**0.94** 5.20	**0.66** 1.40
Boundaries G/M status	6.3 90% per. 10.2 – 17.73	1.5 90% per. 4.0	0.64 90% per. 1.7

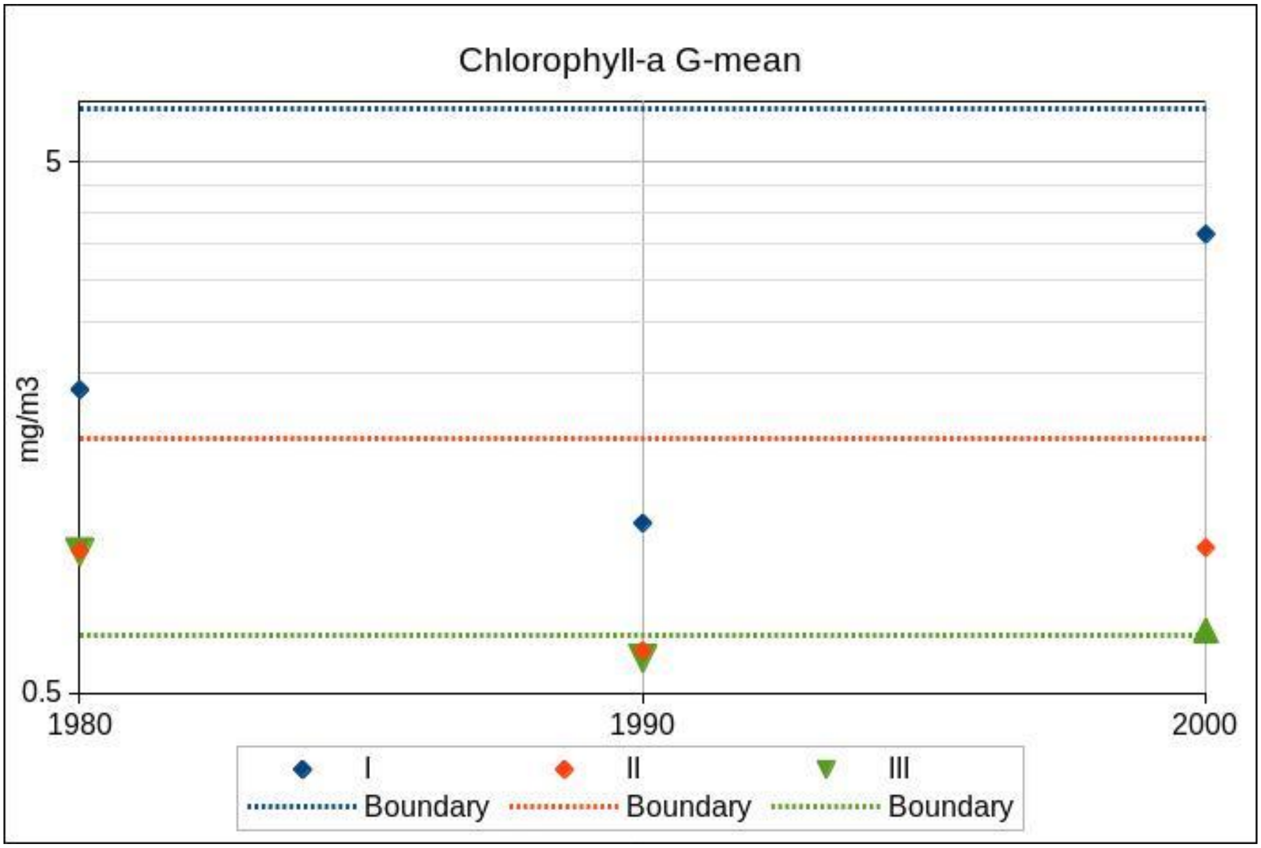
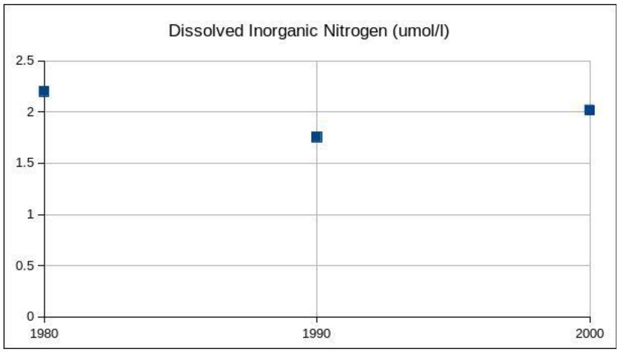


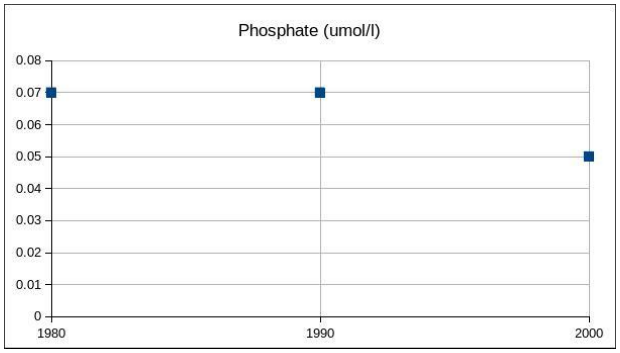
Figure 4. Evolution of Chlorophyll-a G-mean for the three water types identified (different colors). Dashed lines indicate the boundaries of G/M status waters for each type of water according to UNEP/MAP (2017). The scale is logarithmic

Table 3. Statistics for nutrients and chlorophyll for the data within the 0-5 m depth in the periods studied. Concentrations larger than 100 µmol/l of DIN and 6 µmol/l of phosphate have been considered as outliers and have been removed from the analysis

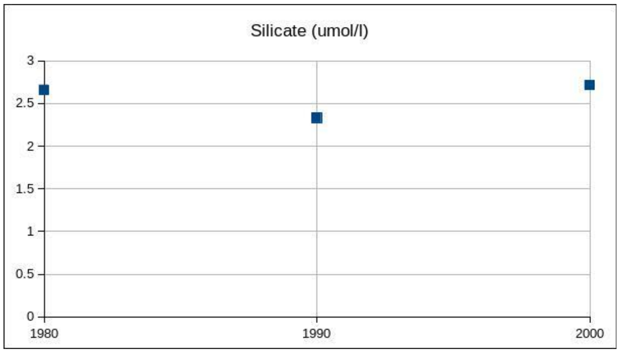
		PERIOD		
		1980	**1990**	**2000**
DIN	Median	2.20	1.76	2.02
	Min	0.01	0.01	0.01
	Max*	49.47	73.60	74.14
Phosphate	Median	0.07	0.07	0.05
	Min	0.004	0.005	0.0001
	Max*	5.420	2.520	3.910
Silicate	Median	2.66	2.33	2.72
	Min	0.01	0.01	0.001
	Max	59.50	61.40	66.82
Chlorophyll-a	Median	1.15	0.76	0.77
	Min	0.07	0.02	0.02
	Max	28.18	24.14	40.20



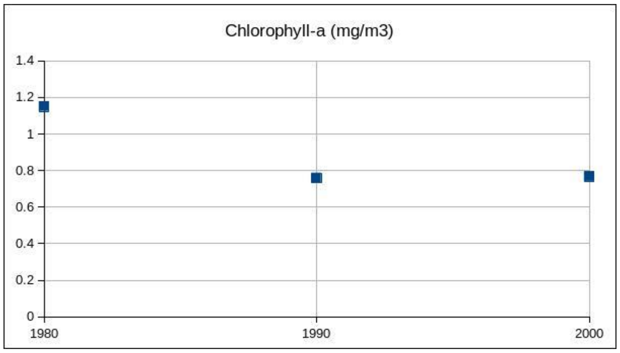
(a)



(b)



(c)



(d)

Figure 5. Temporal evolution of median values of DIN (a), phosphate (b), silicate (c) and chlorophyll (d)

Annex: List of data providers

ARPA Emilia-Romagna - Struttura Oceanografica Daphne
ARPA Friuli-Venezia Giulia - Alto Adriatico Observatory
Center for marine research - Rudjer Boskovic Institute
CNR (Consiglio Nazionale delle Ricerche)
ICRAM (Istituto per la Ricerca Scientifica e tecnologica Applicata al Mare)
Institute of Biology of the Southern Seas
Institute of Marine Science (ISMAR) - Ancona
Institute of Marine Science (ISMAR) - Bologna
Marine Biology Laboratory of Trieste
National Institute of Biology - NIBMarine Biology Station
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)

Common Indicator:
Common Indicator 13. Concentration of key nutrients in water column (EO5);
Common Indicator 14. Chlorophyll-a concentration in water column (EO5);
Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater);
Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9);
Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9).

Case Study title: Overview of the assessment of pollution related indicators – EO5 Common Indicators with link to the EO9, based on results of CAMP Montenegro assessments and EcAp/MSP Boka Kotorska Bay pilot project

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Ivana Bulatović, MEDPOL FP, Environmental Protection Agency.

1. Brief introduction

In the context of implementation of the Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol) and analyses conducted for the purpose of spatial planning and environmental protection in Montenegro, an assessment of general vulnerability of the coastal zone has been carried out within Coastal Area Management Programme (CAMP) Montenegro (2011-2014) on the basis of vulnerability of individual environmental segments. The main goal of the analysis was to assess sensitivity and the extent to which the coastal environment has been endangered and/or polluted in order to implement sustainable spatial planning and management and thus provide for healthy and preserved environment. Results of the assessment served as one of the baselines for identifying remediation measures. The objective of the vulnerability assessment was to contribute to protection, preservation and improvement of the sea quality, marine biodiversity and other characteristics in line with Montenegrin legislation, constitutional provisions on the development of Montenegro as an ecological state, as well as in line with commitments accepted with the ratification of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its protocols.

For the purposes of CAMP, all available historical data until 2013 were collected in one GIS data base which served as the basis for evaluation of the pollution of marine and coastal ecosystem. Marine pollution was analysed based on bathing water quality, eco-toxicology of the sea, marine pollution at *hot spot* locations and pollution with wastewater – all according to criteria of the magnitude of impact/pollution. In the period 2016-2017, the Ministry of Sustainable Development and Tourism initiated a small pilot project in Boka Kotorska Bay with the aim to test the Ecosystem Approach (EcAp) indicators (including assessment of the gaps in present data availability) to identify the status and impacts to the marine environment, as well as to make the vulnerability assessment for the purpose of applying Marine Spatial Planning (MSP) in regulation of the activities and uses of marine environment.

The aim of this Case study is to give a brief overview of the results of the above specified project activities that can be used for the purpose of making relevant assessments for:

- EO9 EcAp Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (related to biota, sediment, seawater),
- Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood,
- Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards, presenting also identified gaps and possible improvements,
- Common Indicator 13. Concentration of key nutrients in water column (EO5),
  Common Indicator 14. Chlorophyll-a concentration in water column (EO5).

2. Methodologies used for the collection and analysis of the data

The coastal and marine area of Montenegro encompasses a territory of six coastal municipalities – Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj – with the total surface of 1.591 km2 as well as inland waters and territorial sea of Montenegro with the surface of 2.500 km2 and 300 km long shoreline. As a very unique part of the Montenegrin coastal area from the point of view of its cultural, landscape and natural value, Boka Kotorska Bay covers 3 of the 6 mentioned coastal municipalities.

The basis for the assessment of vulnerability and pollution of Montenegrin coastal sea waters includes data on its quality collected through the annual national Monitoring programme of the state of coastal ecosystem in Montenegro which has been continuously conducted since 2008 (with significant reduction of monitoring stations and monitored parameters in 2012 and absence of the monitoring programme in 2013). The programme of monitoring of marine waters was supported by MEDPOL Programme from 2008 to 2011 and was aligned with the relevant national regulations. According to the monitoring programme of the *hot spot* locations, data are collected twice a year.

Furthermore, as a good example of importance of availability of more detailed data, in the Pilot project "EcAp/MSP testing in Boka Kotorska Bay" the present status was assessed by applying relevant EcAp status indicators and later on it was expressed through the value index. The pressures were also assessed by applying relevant EcAp pressure indicators and were subsequently expressed through the exposure index. Having the values of exposure and value index the appropriate sanitation and protection measures were proposed as to improve the present status of marine environment.

In next phase, the vulnerability of the marine ecosystem for different activities that may be placed in marine environment were assessed by combining the value and exposure indexes with the expert assessment of the adaptive capacity of the marine environment to accept new pressures once the future sea uses and related activities take place. Following the vulnerability assessment results, the more and less suitable zones for certain activities were identified by applying MSP. The conflict uses of the marine space were also identified guiding spatial planers to assess and recognize the most suitable zones for the activities that may be acceptable but also to recognize those zones and activities that may not take place in marine environment or only within limited capacities.

Common Indicator 17: Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)

Pollution/ the extent to which the sea is endangered at *hot spot* locations has been determined based on the data from the Monitoring programme on the state of coastal ecosystem in Montenegro. The parameters for the sea water quality have been measured twice a year at determined *hot spot* locations are: physical-chemical characteristics, heavy metals (Fe, Mn, Cd, Hg, Cu, Ni, Pb, Zn, Cr, As), organotin compounds (TBT and MBT, DBT), organochlorine pesticides, chlororganic compounds, PAHs, PCBs, TPH and VOC.

As there are no regulations in Montenegro which define standards for the quality of sediment, it is necessary to apply the international regulations which define the impact of sediment pollution on the human and ecosystem's health and sediment, such as CEFAS: Centre for Environment, Fisheries and Aquaculture Science and MPC-Maximum Permissible Concentration-Sediment quality objective in the Netherlands (Dutch standards). The parameters monitored in sediments at *hot spot* are: HM (Cd, Hg,Cu, Ni, Pb, Zn, Cr, As, Sn - TBT i TMT), POPs, organochlorine pesticides, chlororganic compounds, PAHs, PCBs, VOC, mineral oils of petroleum origin, together with granulometry analysis of sediments.

The levels of contaminants in biota is measured in organisms which are used as bioindicators - mussels (*mityllus galoprovincialis*) and fish (*Mullus barbatus*) for the parameters which are regulated by the Rulebook on laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs ("*Official Gazette of Montenegro*", 81/2009 and 55/2015), as well as by the relevant EU regulation: heavy metals (Mn, Cd, Hg, Cu, Ni, Pb, Zn, Cr, Sn, As), organotin compounds (TBT and MMT), PAHs, PCBs, dioxins and furnas.

Common Indicator 20: Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)

The levels of the contaminants in the seafood have been monitored from 2014 on the farming sites for the parameters which are regulated by the Rulebook on laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs ("*Official Gazette of Montenegro*", 81/2009 and 55/2015), as well as by the relevant EU regulation.

Parameters that have been measured once a month, from April to October, are: ecotoxicological test on heavy metals in fish (Hg, Pb, Sn, Cd, Cu, Zn), ecotoxicological test of pesticides in fish (DDD, DDE, DDT, Lindan (gamma-HCH) and Aroclor), POPs, organochlorine pesticides, chlororganic compounds, PAHs, PCBs, VOC.

Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)

Data on the quality of bathing water are collected and analysed from May to October, twice a month, by applying standard reference methods which are regulated by the national Decree on classification and categorization of surface and ground water (*Official Gazette of Montenegro*", no. 02/07: Annex I and Annex IV). Methodology used for the measurement of microbiological parameters is in line with standards ISO 7899-2. This programme of monitoring intestinal *enterococci* started in 2010 and was anticipated from 2005 by the program of monitoring other microbiological parameters: Total coliform bacteria*/100ml-TC*, faecal *colif.* bacteria*/ 100ml-FC* and *E.Coli/100ml.-EC*.

Common Indicator 13 and 14. Concentration of key nutrients and Chlorophyll-a concentration in water column (EO5)

Monitoring of the sea water quality from the point of view of eutrophication is measured once a month during the year on 3 depths, on 12 locations determined in the Programme of monitoring of the coastal ecosystem of Montenegro. Parameters measured are: water temperature, pH, transparency, salinity, orthophosphates (P-PO4), total phosphorus (TP), total nitrogen (TN), silicate (Si), soluble oxygen, oxygen saturation, nitrates (NO3-N), nitrites (NO2-N), ammonia (NH4), chlorophyll-a, , total coliforms bacteria, total faecal bacteria, enterococci and *E. coli*, qualitative and quantitative analysis of phytoplankton and zooplankton groups and species. Eutrophication was calculated using the TRIX index

3. Results of the Indicator Assessment

According to the results of the vulnerability assessment (Figure 1), high sea vulnerability has been identified in the Bay of Boka and at the open sea. Sea in the Bay of Boka is highly vulnerable, especially in the the section of Bay's narrow part between Bijela Shipyard and Porto Montenegro harbour, as well as in Igalo bay. Given the attractiveness of the space intended for development of high quality tourism and having in mind potential impacts of pollution which in a transboundary context reaches the sea through Bojana river and by sea currents from Drač inlet in Albania, the most vulnerable part of the open sea in the coastal zone is limited shallow belt from Valdanos to Bojana river mouth. It should be also pointed out that the entire narrow coastal belt of the open sea and the Bay of Boka is highly vulnerable in case of accidental pollution (such as oil spills due to maritime accidents).

From the point of view of general contamination, map of the total pollution/the extent to which the sea is endangered (Figure 2) shows that Kotor and Tivat Bays, ports in Budva and Bar, as well as section from Ulcinj to Port Milena are highly endangered. When pollution of the open sea is compared to the conditions in the Bay of Boka, situation is much more favourable; for the Bay of Boka it is evident that urgent remediation measures have to be undertaken for *hot spot* locations, as well as for regulating sewage systems in Kotor and Tivat Bays. Level of pollution at the open sea is lower due to relatively big depth and good mixing of waters.

Assessment of water quality based on the values of TRIX index shows that on locations outside the Bay of Boka water has good – intermediate quality, except in Ulcinj at Mala beach and Port Milena where poor water quality prevails. Water quality in the Bay of Boka is intermediate – poor, especially at the Institute for Marine Biology (IBM) location in Kotor Bay. The reason is high content of nutrients and chlorophyll. Obtained results indicate that problem of communal wastewater discharges needs to be resolved urgently which means that wastewater has to be treated before discharging into the natural recipient. The biggest problem of the sea water quality is marine eutrophication or high content of nutrients (NO2, NO3, NH4, PO4) that fluctuates during a year.

Based on the assessment of pollution/ the extent to which marine ecosystem is endangered at *hot spot* locations from eco-toxicology aspect describes the extent to which marine ecosystem is currently endangered at observed locations taking the data on the level of pollution gathered through the MEDPOL program in Montenegro as a starting point.

Pollution of the sea on the *hot-spot* locations associated primarily with the contaminated sediment pollution in these locations, the pollution of soil pollution sites, as well as by pollution from sewage discharges. Trend of the pollution of water, sediment and bio-indicators on hot-spot locations monitored in the ports of Herceg Novi, Tivat, Marina Porto Montenegro, Kotor, Risan, Zelenika and Dobrota - IBM, occasionally at the locations of sensitive areas: Orahovac, Solila and Sv. Neđelja, and locations from the middle of the bay: Tivat, Risan, H. Novi and Kotor Bay with a reference point at the entrance to the Bay - the island of Mamula.The highest level of contamination of the sea out of the category A3 (according to the Decree on classification and categorization of surface and ground waters ("*Official Gazette of Montenegro*", 02/07) has been identified at the following locations: Kotor Bay, Tivat Bay, Port of Tivat and Porto Montenegro, Shipyard Bijela, and IBM location in Dobrota. In addition to the increased content of TM and PAHs increased concentration of NO2, NH4 and PO4 have been determined as well as of the mineral oils, which indicate a combined effect of pollution from industrial and municipal sources, vessels and other marine activities. The waters of the Bay of Tivat are occasionally outside of the category by the content of toxicants: Hg, PAH, mineral oil, As, Cd, TBT. Water quality in the aquatorium of Tivat and Kotor are mainly determined as very polluted.

A particularly high-water pollution in the immediate vicinity of the Shipyard Bijela and the location of the former Overhaul Institute “Arsenal” in Tivat contaminated with heavy metals and organic pollution (TPH, VOCs, PAHs). The cause of such a high pollution of the sea is the content of large quantities of waste material from the grit dredging at the mentioned locations in the sea.

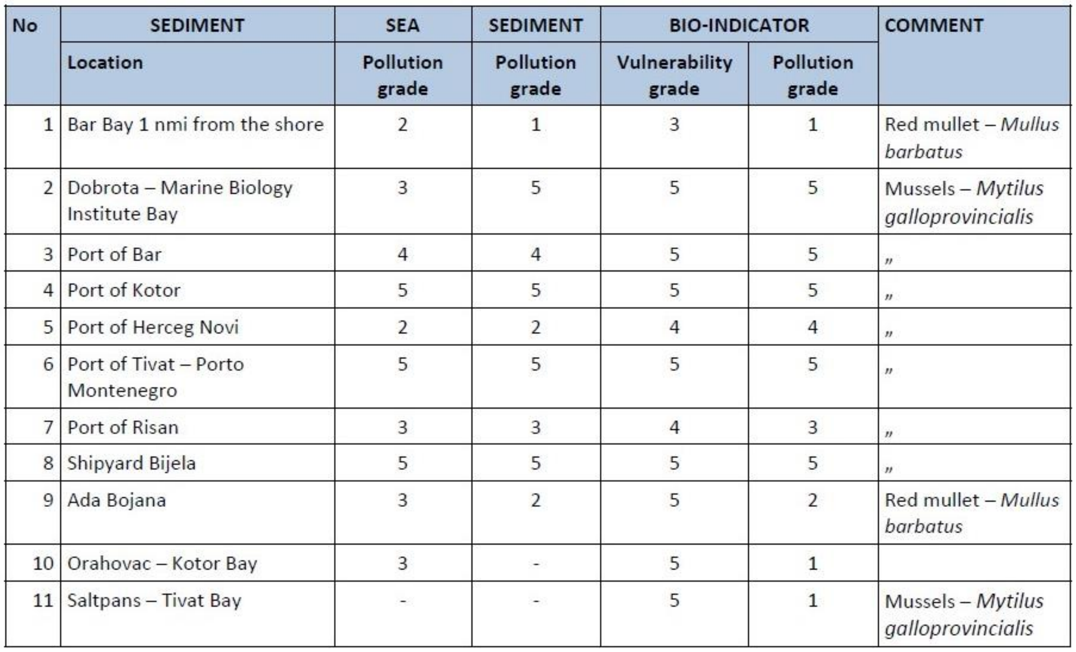
Assessment carried out in this way represents a guideline for planning the remediation measures needed to achieve desired state of marine ecosystems. Pollution/the extent to which the sea is endangered at *hot spot* locations from ecotoxicology aspect is shown in the Figure 3. The vulnerability and pollution assessment of the coastal waters on the 1 mile distance from the coastal line gives a projection of the absorption capacities of marine ecosystem in relation to impacts which can bring a further degradation of the ecological status of marine ecosystem.

Pollution/the extent to which the sea is endangered at *hot spot* locations from the aspect of sediment’s quality analysis provides information on the absorption capacity of marine ecosystem at observed locations in relation to impacts that can lead to further pollution accumulation in sediments at observed sites (Figure 4).

Sediment quality affects to a large extent the quality of sea water as well as bio-accumulation of dangerous substances from sediment into shells and other biological organisms. Furthermore, sediment migrate due to sea waves and currents (around 3.5 m/s), and traffic at the sea, therefore the pollution is spread in a relatively easy way. Of special importance is bio-accumulation in shells at shell fish farming sites near *hot spot* locations: Shipyard Bijela, location of the former Overhaul Institute “Arsenal” in Tivat Bay and Kotor Bay, where pollution impacts have been assessed as unacceptable.

For the evaluation of marine environment from the aspect of the analysis of toxicological pollution for bio-indicators EU regulations setting the standards for maximum allowed concentrations of toxic substances have been applied. Table 1 provides summary information on pollution at locations (in order to enable easy overview of the impacts that sea and sediments quality have on the quality of bioindicators) at which samples for all three matrixes (water, sediment, biota were taken at the same places.

Table 1: Comparative overview of marine ecosystem pollution at *hot spot* locations (where the grade 1 represents a very low level of pollution, 2 - Low level of pollution, 3 - Medium level of pollution, 4 - High level of pollution, 5 – Very high level of pollution).



No	SEDIMENT	SEA	SEDIMENT	BIO-INDICATOR		COMMENT
	Location	Pollution grade	Pollution grade	Vulnerability grade	Pollution grade	
1	Bar Bay 1 nmi from the shore	2	1	3	1	Red mullet – *Mullus barbatus*
2	Dobrota – Marine Biology Institute Bay	3	5	5	5	Mussels – *Mytilus galloprovincialis*
3	Port of Bar	4	4	5	5	„
4	Port of Kotor	5	5	5	5	„
5	Port of Herceg Novi	2	2	4	4	„
6	Port of Tivat – Porto Montenegro	5	5	5	5	„
7	Port of Risan	3	3	4	3	„
8	Shipyard Bijela	5	5	5	5	„
9	Ada Bojana	3	2	5	2	Red mullet – *Mullus barbatus*
10	Orahovac – Kotor Bay	3	-	5	1	
11	Saltpans – Tivat Bay	-	-	5	1	Mussels – *Mytilus galloprovincialis*

Through the EcAp/MSP project the assessment of the status of and pressures on the marine pollution was carried out by elaboration of the data which were available for assessment of EO9 and EO5 related indicators. In addition to the findings of the assessed EcAp indicators described above through CAMP assessment results, data on heavy metals and pollutants in samples from the following farming sites: Kotor-IBM, Tivat, Risan, Orahovac, Shipyard “Bijela” and Solila Tivat shown that in these samples increased levels of toxic contaminants have not been found.

Bioaccumulation of the contaminants in the shellfish is a consequence of the pollution of sediment and sea water, therefore the farming sites require and should be planned in those areas with a high quality of water and sediment.

Water (sanitary) quality should be kept in mind as a factor that affects bathers’ health; the area considered is a narrow zone of the coastal sea used for swimming (up to 50 m from the shore). Discharges of communal wastewater as well as streams with constant flows used for the same purpose (that is as wastewater recipients) have the most significant impact in this zone. For the assessment of the quality of bathing waters, according to the Regulation on the classification and categorization of waters (which defines categories define categories K1 – excellent and K2 – sufficient). The program of monitoring the sanitary quality of sea water included the 85 locations on public beaches where the seawater sampling was conducted twice a month during the summer bathing season from May to October. On the basis of data analysed from 2006 to 2016 it can be concluded that the sanitary quality of sea water at Montenegrin coast is very good, and that the percentage of samples with satisfactory water quality (K1 and K2 categories) ranged from 90.6% to 100%. In addition, a trend towards improvement of sanitary water quality over the years can be noticed as a result of significant investment in the construction of sewage systems along the coast and adequate wastewater treatment. The reason for the occasional occurrence of samples with an increased number of bacteria (out of category), i.e. samples with poor quality, is the illegal discharge of waste water of sewage sources directly into the sea or into streams which content is casted into the sea (Figure 5).

4. **Lessons learnt and/or recommendations**

Obtained results point out that available data in Montenegro for the pollution of the marine ecosystem can be used to assess the EcAp indicators relevant for the data that have been collected in Montenegro by now. Nevertheless, there is a significant gap in available data with regard to all EcAp indicators, including data on pollution of the marine ecosystem in Montenegro. It is therefore necessary to enable significant efforts as to provide reliable data for all EcAp indicators.

The results highlight also the necessity to identify in the future national spatial plan those coastal zones which are particularly sensitive to the pollution in the context of the current quality state, as well as in the plan for the protection and remediation of the quality of ecosystems. Special attention should be attached to the existing industrial pollution and cumulative impacts that toxic polluters have on biota. It is also of particular importance the quality of water in terms of impacts on the health of humans – sanitary quality for the narrow coastal zone which is used for bathing (up to 50 m).

Measures must be foreseen for the remediation of the Shipyard in Bijela, i.e. dredging of sediment and waste grit in the sea and providing adequate locations for its temporary and safe disposal, as well as for its long-term disposal. The same should be applied on the remediation of the pollution of sediment in Port of Tivat-Porto Montenegro (former Overhaul Institute “Arsenal) which negative impact on the marine water, sediment and bioindicators quality is evident.

The area of the Boka Kotorska Bay is foreseen for mariculture activities which require certain standards on the quality of water. Zones favourable for the mariculture should be defined in the context of the existing water quality, and locations at the open sea should be identified. Measures of sanitation should be implemented at the level of the seabed close to the former Overhaul Institute “Arsenal” in Tivat, and solving problems related to sanitation of Port Milena is a priority in the area of Ulcinj municipality.

In the EcAp/MSP pilot project, the assessment of the status of and pressures was carried out by elaboration of the data which were available for calculation of EO5 and EO9 related indicators. Beside the significant lack of data, it is also important to mention that even historical data used for this purpose require data quality assurance, in particular with regard to the fact that revision of the methodology for data collection and evaluation have to be undertaken once when IMAP is introduced into national monitoring of the marine environment.

As the final important remark, improvement of the national programme of monitoring of the marine environment is of crucial importance, by harmonization with the UNEP/MAP Integrated Monitoring and Assessment Programme for the Mediterranean (IMAP) following the recommendations given in relevant Indicator Guidance Fact Sheets developed in 2017, as well as with Marine Strategy Framework Directive requirements. Although this requires significant financial resources, it would allow for a better data availability and data trends, redefinition of monitoring stations and frequency of sampling, use of adequate survey methods and elaboration of data, as well as the possibility to monitor and report on all the segments of marine ecosystem.

5. References and web links

General Vulnerability Assessment, Coastal Area Management Programme - CAMP Montenegro (2013), Ministry of Sustainable development and tourism, www.camp.mrt.gov.me;
“EcAp/MSP testing in Boka Kotorska (Kotor) Bay”, Ministry of Sustainable development and tourism in cooperation with PAP RAC, Podgorica 2016-2017 (in its final phase).

6. ***Graphs, pictures and tables***

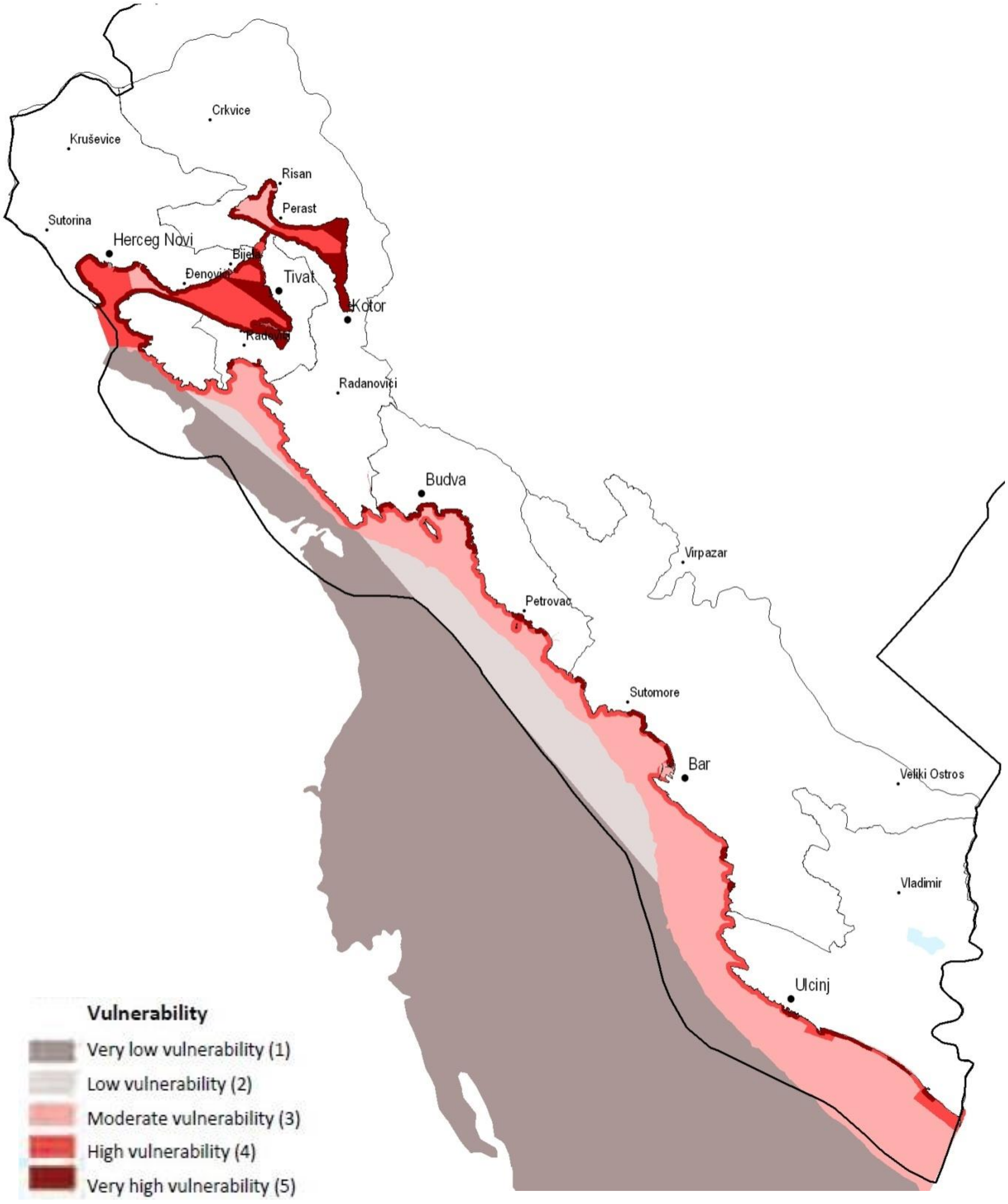


Figure 1: Sea vulnerability - joint model: regulated average value

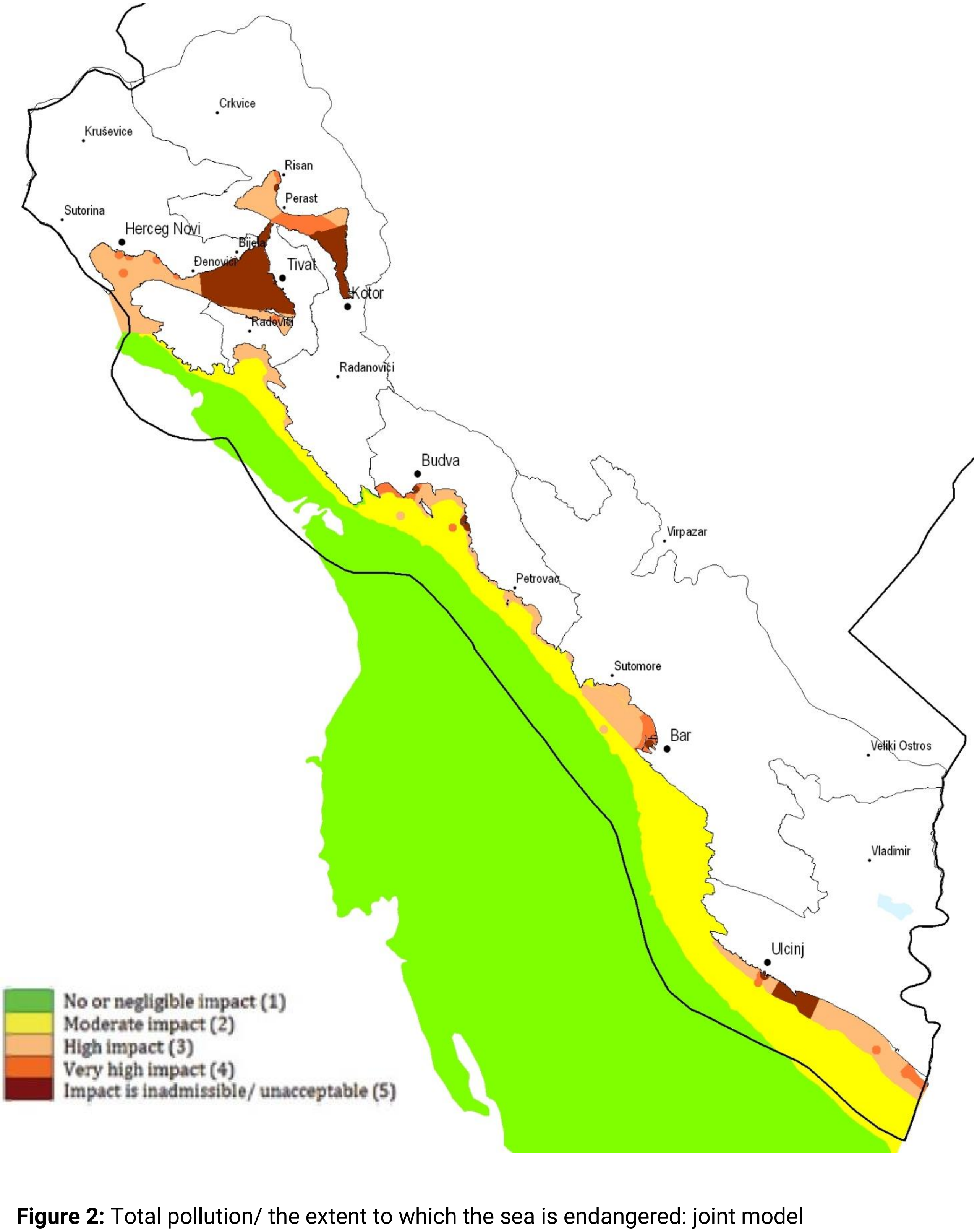


Figure 2: Total pollution/ the extent to which the sea is endangered: joint model

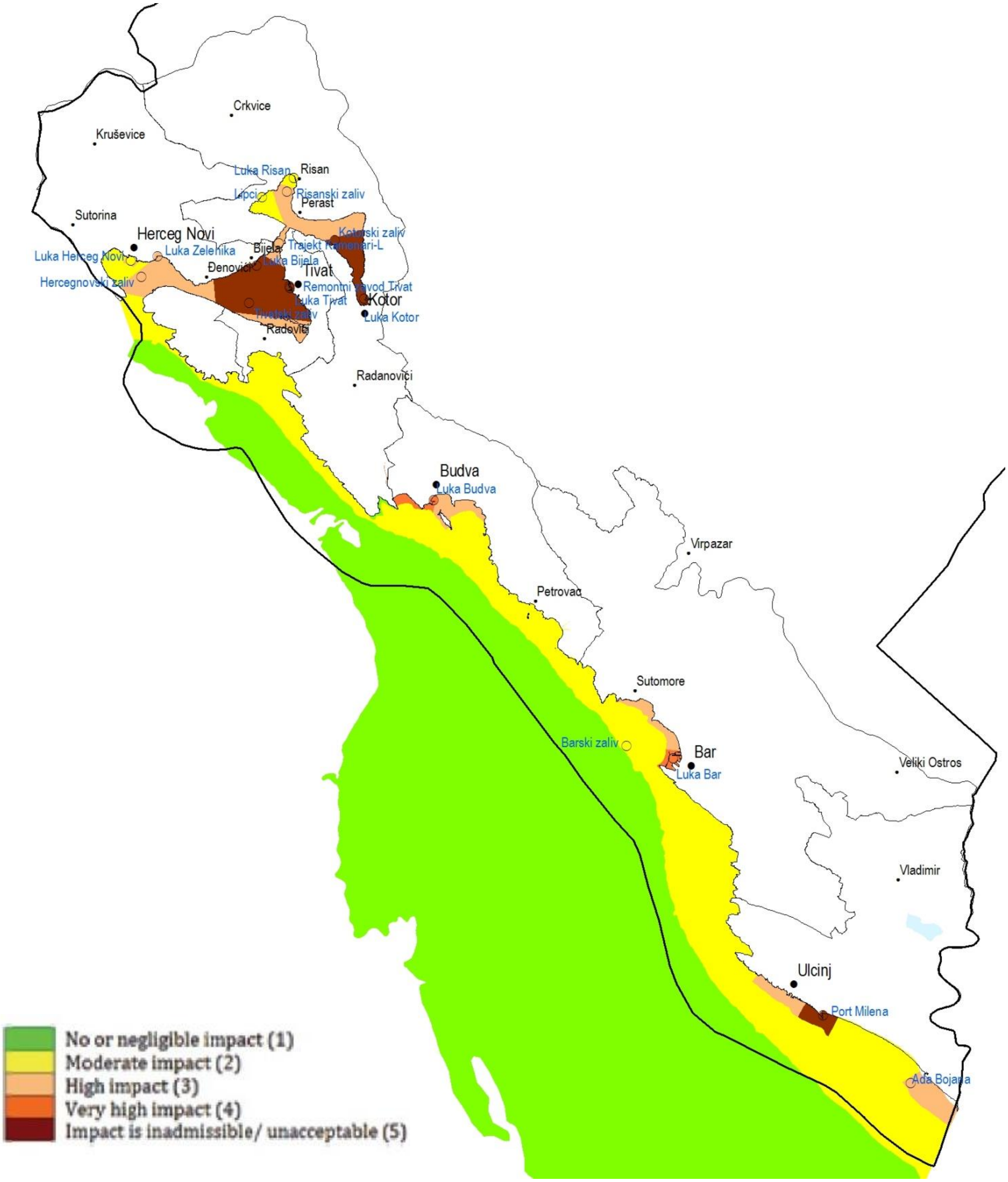


Figure 3: Pollution/ the extent to which the sea is endangered at *hot spot* locations from the aspect of marine eco-toxicology

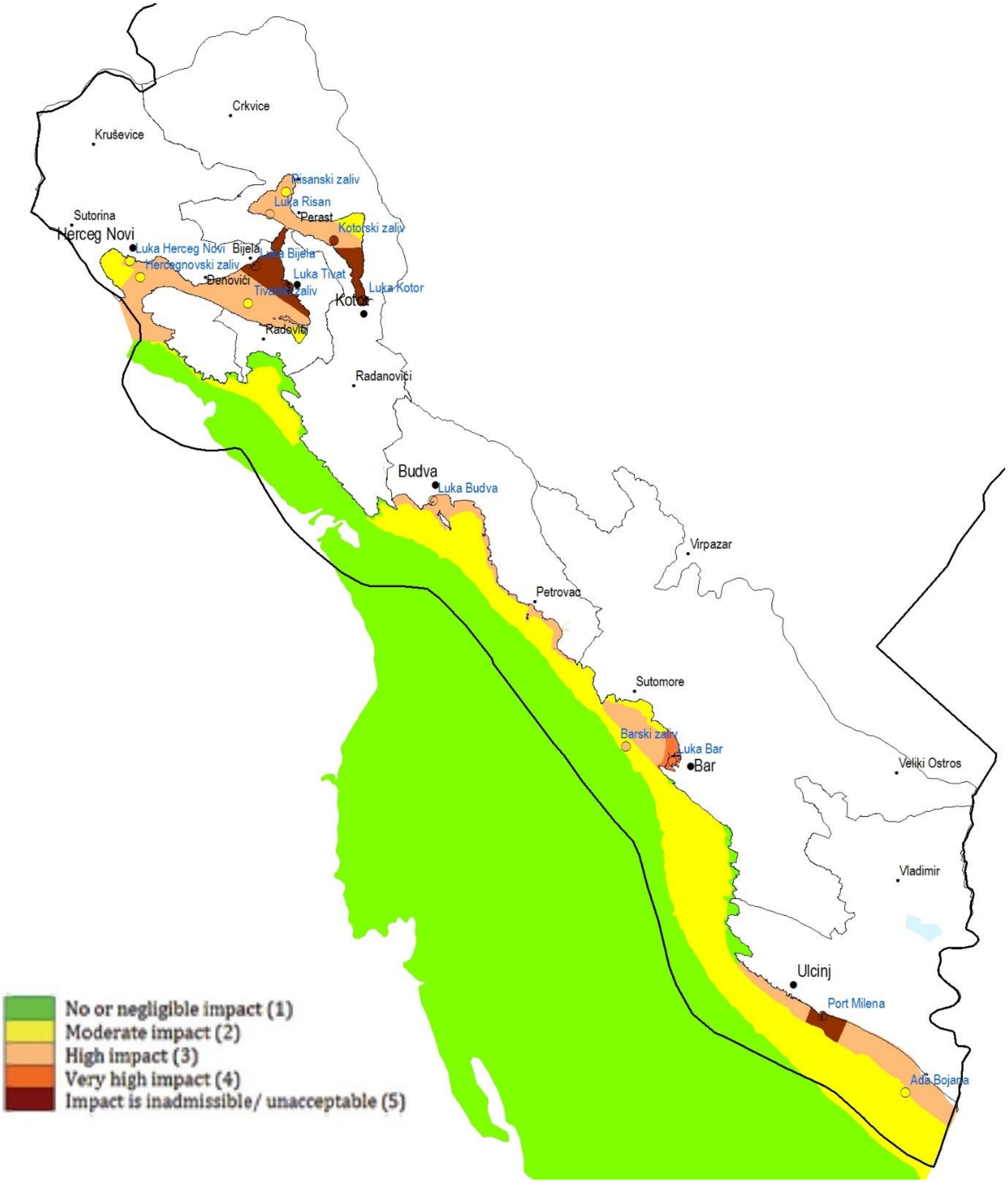


Figure 4: Pollution/ the extent to which sea water is endangered at *hot spot* locations from the aspect of sediment analysis

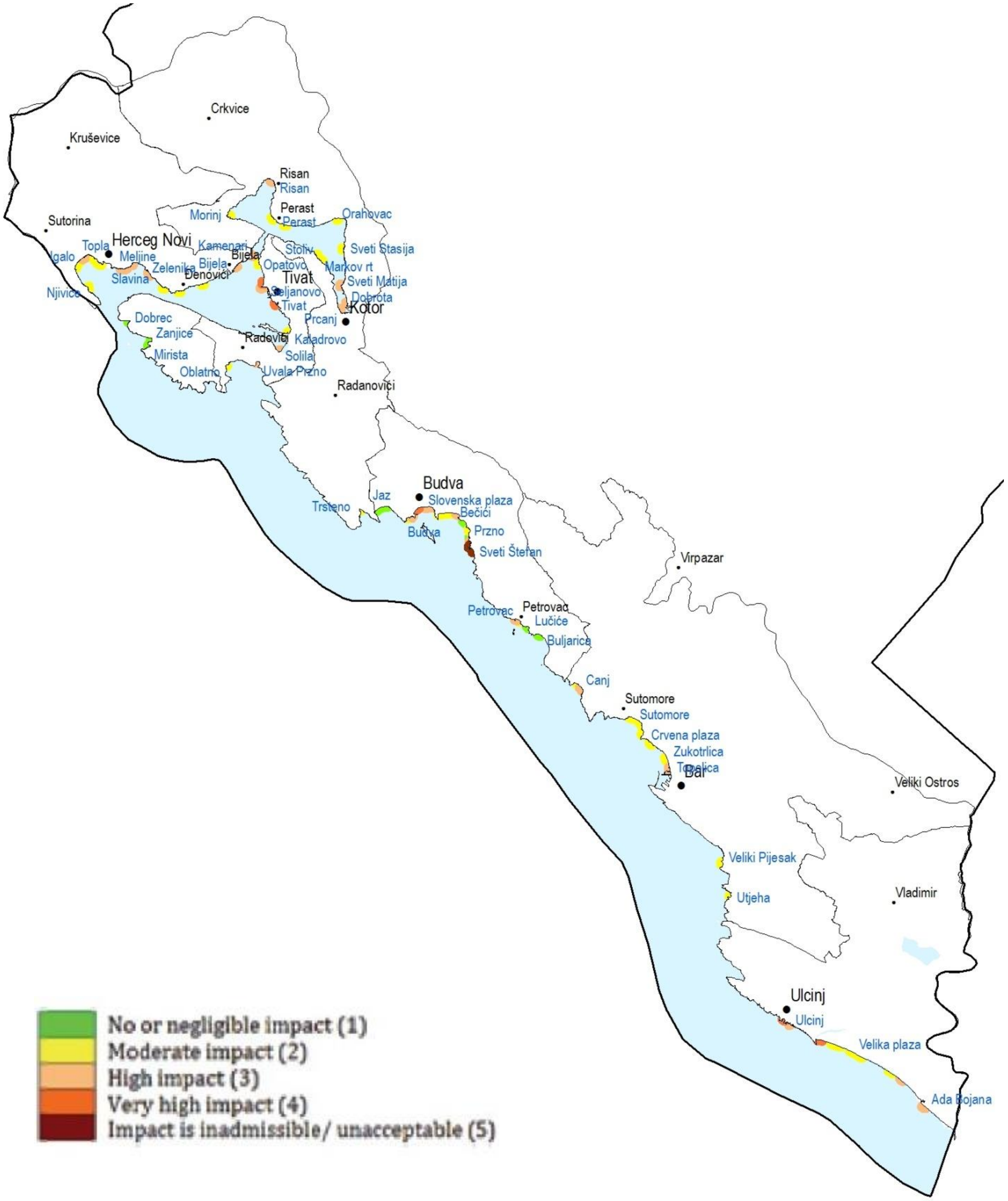


Figure 5: Pollution/ the extent to which bathing water is endangered

Common Indicator: Common indicator 13 Concentration of key nutrients in water column (EO5 eutrophication); Common indicator 14 Chlorophyll-*a* concentration in water column (EO5 eutrophication);

Case Study title: Eutrophication Status of the Turkish Mediterranean Coastal Waters and Trend Analysis of the Eutrophication-Related Parameters in the Mersin Bay

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1. Brief introduction

The national monitoring program implemented by the Ministry of Environment and Urbanization (MoEU) is coordinated by MoEU with TUBITAK Marmara Research Center (TUBITAK MRC) with the involvement of several Marine Sciences Institutes and Water Resources Department of the national Universities (Table 1). The 2014-2016 “Integrated Marine Pollution Monitoring Programme” covers three summer and two winter cruises in the North Eastern Mediterranean, with about 65 stations visited during each field survey. The 3-year monitoring programme, covers the principal concepts, protocols and recommendations of Regional Conventions (Barcelona and Bucharest Conventions) and National Legislation, and the basic eutrophication parameters of the Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD).

The main purpose of the eutrophication monitoring program implemented by MoEU is to provide high-quality data of the eutrophication indicators (parameters) to assess ecological eutrophication status of the different bodies defined along the north-east (NE) Mediterranean coastal region. Approximately a total of 62-68 stations were determined along the NE Mediterranean coastal areas (including the bays) to measure the levels of the eutrophication (inorganic nutrients, total-P, Chl-a and dissolved oxygen, phytoplankton composition and Sechhi depth) in winter and late summer seasons (Table 1). These data sets were examined to assess anthropogenic pressures on the development of human-induced eutrophication using basic classification tools of TRIX and HEAT at different bodies of the studied areas. For the achievement of the ultimate objective of the project, principal physical (temperature, salinity, density, secchi disc depth, in situ fluorescence, turbidity) and biochemical variables (nutrients, total phosphorus, chlorophyll-a, dissolved oxygen) were measured at about 65 stations in September 2014, in the winter and summer periods of 2015-2016. Then the current trophic status of the 22 water bodies along the NE Mediterranean coastal areas have been assessed by applying the ecological water quality assessment tools of TRIX and HEAT, using the 3-year data.

2. Methodologies used for the collection and analysis of the data.

Field surveys were conducted using the research vessel R/V BILIM-2 of METU-IMS. During the field surveys, *in situ* physical measurements, temperature, salinity, density, *in situ* fluorescence and turbidity, were carried out by a SEABIRD model CTD probe coupled to a 12-PVC Niskin bottles (volume: 8 L) Rosette System by which seawater samples were obtained from selected depths of each station by remote-control. Dissolved oxygen measurements were performed by

Winkler titration method (Grasshoff et al., 1983; UNEP, 2005). Dissolved inorganic nutrients (nitrate, nitrite, ammonium, phosphate, silicate) were measured using a Bran+Luebbe Model four-channel Autoanalyzer by standardized methods (Grasshoff et al., 1983). Total phosphorus measurements were carried out by the conventional colorimetric method at 880 nm wavelength (Strickland and Parsons, 1972; Grasshoff et al., 1983; Koroleff, 1983) after persulfate digestion procedure was applied for the samples (Menzel and Corwin, 1965). Chlorophyll-*a* (Chl-a) measurements were performed by the conventional spectrofluorometric method after digestion of filter samples by 90% acetone solution (vol/vol) (Strickland and Parsons, 1972; UNEP/MAP, 2005; Wasmund et al., 2006) using a HITACHI model F-2500 Fluorescence Spectrophotometer (Table 3). The chemistry laboratory of the METU-IMS has successfully participated in the international QUASIMEME-Laboratory Performance Studies between 2014 and 2016. Table 3 summarizes analysis methods followed in the national monitoring studies.

The TRIX Index (developed by Vollenweider et al.,1998) was first applied for the eutrophication classification in the eastern part of Mersin Bay using the date sets obtained seasonally at 15 stations between 2005-2010 periods and then to the NE Mediterranean coastal water using the last 3-year data sets.

$TRIX = [\log_{10} ([TP]*[DIN]*[Chl\text{-}a]*A\%DO) + 1.5]/1.2$

Nutrient and Chl-a concentrations in μg/L,

A%DO represents absolute deviation of the dissolved oxygen (DO) measured from the saturation conditions in %.

In addition to TRIX Index classification, HEAT scaling tool (Table 2) was also used to assess ecological water quality (human-induced eutrophication level) of the visited water bodies. The HEAT tool, a multi-metric technique (HELCOM, 2009) is principally based on eutrophication-related indicators (Andersen et al., 2011) that are used in the TRIX method. In the HEAT tool, ecological quality ratios (EQR; Scale: 0-1) are calculated for each eutrophication-related parameter after the assessment of "reference concentrations" (RefCon) for each sub-region. The EQR values are determined according to equation in Andersen et al. (2011) as follow:

EQR = RefCon/AcStat, for parameters showing positive response to nutrient inputs such as Chl-*a*

EQR = AcStat/RefCon, for parameters showing negative response to nutrient inputs such as SDD

RefCon: Reference Concentration;

AcStat: Observed Concentration at a given location.

3. Results of the Indicator Assessment

TRIX Index Classification: The calculated TRIX values in the surface mixed layer waters (0-10 m) of the Turkish Mediterranean coastal region varied spatio-temporally between 0.30 and 4.80; the index values are consistently much higher in the inner bay surface waters of Mersin and Iskenderun regions highly affected by direct discharges of partially treated domestic wastewaters and contaminated river inflows (Figure 3; Figure 4; Figure 13). Moreover, the winter TRIX values are higher than in summer due to effect of winter mixing introducing nutrients from bottom layer to the surface in addition to terrestrial inputs enhancing in winter-early spring period.

In summer of 2014-2016, the shallow coastal waters of the eastern part of Mersin Bay, Ceyhan and Asi River Deltas and Iskenderun inner bay surface waters possesses relatively high concentrations of nutrients and Chl-*a* due to domestic wastewater discharges and riverine nutrient inputs. The calculated TRIX Index values, however, varied from 2.5-4 in the inner bays and shallow coastal waters in summer, representing oligotrophic or tendency to mesotrophic properties due to small increases in the oxygen saturation level (deviation from %100 saturation level) of the inner bay. It appears that the inner bay surface mixed layer waters, having limited ventilation rate by the open sea in summer, were relatively enriched in nutrients and biomass, but oxygen saturation remained at limited levels. TRIX Index values were less than 2.5 in the coastal areas and bays, where the direct effect of urban and riverine inputs is very limited. Specifically, in the coastal regions between Anamur-Alanya, Finike-Kaş, and Marmaris shelf regions, receiving limited inputs of river inflow and domestic discharges, displayed apparently oligotrophic status (TRIX<2.0) as the reference points of NE Mediterranean shelf (Figure 3; Figure 4; Figure 13).

Spatial distributions of TRIX index values in the Mersin Bay were produced regarding the color codes of Water Framework Directive (WFD). In Mersin Bay human induced eutrophication has enhanced in the last 30 years due to high nutrient inputs carried by the contaminated major rivers and direct waste water discharges of the Mersin City. According to the conventional TRIX Index, open waters of the Mersin Bay displayed oligotrophic property (TRIX<3.0) within the study period. In wet winter-early spring period, TRIX values increased to 4-5 range in the shallower locations receiving high levels of nutrient loads, leading to both markedly high concentrations of algal biomass (Chl-*a*) and nutrients with low secchi disc depth (SDD) in the near shore shallow waters (depth<20 m) displaying from mesotrophic to tendency to eutrophic status in winter months (Figure 5-12).

Application of HEAT Scaling Tool

Based on the biochemical concentrations of the “reference condition” (Table 2) defined from the long-term data in the Mersin Bay, the HEAT classification method was applied to determine trophic status of the Turkish coastal waters of NE Mediterranean from the Iskenderun Bay to the Marmaris Bay. For this goal, data obtained in the winter and summer periods of 2016 were evaluated and the classification results were illustrated using the WFD color codes of water quality (Table 5-6). In summer 2016, for example, the Iskenderun Bay surface waters displayed bad quality with respect to NO_3+NO_2 and NH_4 contents of the reference water. The inner part of Mersin and Antalya Bay displayed moderate level water quality (Table 5). In winter 2016, the bays of Iskenderun Bay, Mersin Bay and Antalya were occupied with bad quality waters due to large inputs of NO_3+NO_2 by the regional rivers spreading locally over the visited sites (Table 6).

Evaluations of Physicochemical Parameters for the 2014-2016 period

In the NE Mediterranean shelf zone, surface nutrient concentrations were consistently higher in the river-fed zones and the inner bay waters having limiting exchange rates where high biomass (in terms of Chl-*a*) and low SDD values were recorded. However, the summer concentrations were generally less than wet winter values in the sensitive coastal zones and the offshore waters.

Basic physico-chemical parameters measured at about 65 stations (including reference points) during the monitoring program were evaluated for better understanding of major indicators dominating the eutrophication development in the NE Mediterranean coastal regions divided into 22 coastal water bodies by the expert group. In the 2014-2016 monitoring program, bio-optical and chemical properties of the upper layer waters exhibited remarkable seasonality at the 62-68 stations within the 22 water bodies from winter to summer, with the higher variations in the coastal and inner bay waters where the development of eutrophication (bad quality status) or tendency to eutrophic conditions (moderate/bad status) were observed (Figure 5-12). Expectedly, the highest surface nutrient and biomass concentrations were markedly high in the river-influenced coastal waters in winter. Moreover, high levels of NH_4 concentrations measured in the surface waters is a good indicator of land-based pollution by direct wastewater discharges and/or polluted river inflows as previously experienced in the near shore waters of the Mersin and Iskenderun Bays and in the past and present study period (water body no: AKD-2 and AKD-5) (Figure 10). It should be noted that in winter period, the surface dissolved inorganic nitrogen (DIN: NO_x +NH_4) concentrations reached maximum levels at the hot points fed by DIN-laden river discharges with greater volume fluxes (Figure 11). However, in the summer of 2015, surface waters of the Iskenderun inner bay and Ceyhan delta region were relatively enriched in DIN due to partially treated domestic wastewater discharges and riverine inputs (Figure 11).

Spatial distributions of Chl-*a* concentrations in the surface waters displayed an apparent decreasing trend from the eastern part of the Turkish Mediterranean to Marmaris Region (Figure 5). Winter Chl-*a* concentrations were higher than summer values, indicating the apparent effect of land-based inputs on algal biomass enhancement in the coastal waters fed by the nitrate and silicate laden Asi, Seyhan and Ceyhan Rivers inflows (water body No: AKD-1, AKD-4 and AKD-5). Lowest Chl-*a* values were recorded in the surface waters of Marmaris Region displaying oligotrophic properties (TRIX <2) (Figure 5).

Surface DO concentrations slightly exceeded the saturation level of seawater at the measured temperature; the oxygen saturation values mostly ranged between 105-110% in the high productive sites. In winter seasons, though the O_2 concentration increased by 1-1.5 mg/L to 7,5 mg/L (Figure 6) in the cool surface waters (15-16 ˚C), the summer oxygen saturation level is greater than the winter rates due to effective vertical mixing in winter. In the summer periods of 2014 and 2016, no apparent oxygen deficiency (saturation >70-75%) were recorded in the near bottom waters of the visited locations along NE Mediterranean coastal regions and bays.

Measurements of Secchi disc depth (SDD), an indicator of the euphotic zone thickness, exhibited remarkable spatial and seasonal variability in the coastal waters affected directly by land-based inputs of nutrients. The largest spatio-temporal variations were recorded in the eastern coastal regions of the NE Mediterranean fed by major river discharges and wastewater discharges. Specifically, the lowest SDD were measured between 2-5 m in the water bodies of AKD-4, AKD-5 and AKD-8 at a level 2-5 m. High SDD values, ranging merely between 15-30 m seasonally, were measured at the reference points having very low levels of nutrient and biomass (Chl-*a)* concentrations in summer (Figure 7).

Trend Analysis in Mersin Bay: The trend analyses of nutrient and Chl-*a* data obtained in the Mersin display a weak decreasing trend from 1991 to 2016 with higher variability in winter due to the enhanced inputs of organic and inorganic nutrients to the coastal zone of the Northeastern Mediterranean (Figure 14). During the study period (2014-2016), monitoring programme in the bay was performed in summer and winter; nutrient and Chl-*a* concentrations did not show significant variability in summer period as compared the higher concentrations determined between 2005-2010 period. The winter nitrate (NO_3+NO_2) concentrations were markedly high in 2015 due to visits of coastal stations after heavy rains and excess fresh water discharges with high NO_x concentrations. In the following winter, 2016, the surface nitrate concentration values decreased apparently to its natural levels measured previous years.

4. Lessons learnt and/or recommendations

Close correlations observed between TRIX estimates and the eutrophication-related indicators strongly suggest the development of human-induced eutrophic conditions in surface waters of the river-fed Mersin and Iskenderun inner bay regions polluted by wastewater discharges as reported in the other studies conducted recently in these areas (Doğan-Sağlamtimur and Tuğrul, 2004; Tuğrul et al., 2011).

The results of the current monitoring programme reveal that the classical TRIX classification method cannot provide adequate resolution of eutrophication development in the NE Mediterranean coastal waters having different trophic status. Since oligotrophic shelf waters of NE Mediterranean have very low concentrations of nutrients and Chl-*a*, high SDD (high light penetration depth), the development of mesotrophic and tendency to eutrophic conditions cannot be resolved by the present TRIX classification. The present TRIX index, just allows us to assess regional variations of TRIX Index over the entire coastal basin water quality and determine major hot points highly influenced by human-induced pressures. Therefore, a scale calibration should be needed for the conventional TRIX Index (Kaptan, 2013; e.g., Table 4) to assess local and temporal changes in trophic status of the NE Mediterranean coastal waters displaying oligotrophic properties as the reference points of the human-induced coastal and bay waters.

On the other hand, the HEAT tool that is used in ecology-based water quality classification (EQR estimates) first needs regionally-defined “reference” and “threshold” values of the eutrophication indicators (Table 2), representing their natural peak levels in winter and/or highly productive seasons. In eutrophic coastal or closed seas, the estimation of “threshold values” are rather difficult and needs modeling studies to assess reference conditions representing reachable and sustainable “good environmental targets” as already experienced in some regions of the Baltic Sea.

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6. Tables and Figures

Table 1. Mediterranean Sea 2014-2016 Monitoring programme

Mediterranean Sea 2014-2016 Monitoring programme					
Years/Station numbers	2014	2015		2016	
Cruise season	Summer (September)	Winter (February)	Summer (August)	Winter (February)	Summer (August)
Water column	66	62	64	66	68
Phytoplankton	24	26	25	25	25
Macrozoobenhtos	15	0	15	0	15
Macroflora (Algae)	10	0	11	0	11
Fish and litter (bottom)	0	0	0	0	8
Microplastic	3	0	3	0	3
Pollutants-SEDIMENT	10	0	11	0	32
Pollutants-BIOTA	5	0	5	0	5
Radioactivity	1	0	5	0	5

Table 2. Eutrophication limit values for Mediterranean Sea and color codes (Salinity>38.5)

PARAMETER	**Poor-Bad (EQR < 0.52)**	**Moderate (EQR 0.52-0.66)**	**Good (EQR 0.67-0.80)**	**High (EQR > 0.80)**	**Reference Value**
Phosphate (PO_4) µM	>0.08	0.08-0.06	0.06-0.05	<0.05	0.04
Total Phosphorus (TP) µM	>0.40	0.40-0.30	0.30-0.25	<0.25	0.2
Nitrate (NO_3 +NO_2) µM	>0.40	0.40-0.30	0.30-0.25	<0.25	0.2
Ammonium (NH_4) µM	>0.40	0.40-0.30	0.30-0.25	<0.25	0.2
Silicate (Si) µM	<0.40	0.40-0.55	0.55-0.65	>0.65	0.8
Si/NO_3	<1.0	1.0-1.3	1.3-1.6	>1.6	2
Chl-*a* (µg/L)	>0.60	0.60-0.45	0.45-0.38	<0.38	0.3
SDD (m)	<3.5	3.5-5.0	5.0-7.0	>7.0	10
O_2-sat. (%) in deep water	<75	75-80	80-85	>85	95
TRIX	>5.0	5.0-4.0	4.0-3.0	<3	3
Color Code	**Red**	**Yellow**	**Green**	**Blue**	

Table 3. Analysis Methods followed in the National Monitoring Studies.

Parameter	**Methodology**
Secchi disc	Diameter 30 cm.
Dissolved oxygen	CTD probe, Winkler method (UNEP, 2005; Grasshoff et al., 1983).
Chl-a	Aseton ekstrat Spectrofotometre (Wasmund et al., 2006).

PO_4	Colorimetric method (10 cm cell); Ortophosphate method (Grasshoff et al., 1983; Koroleff, 1983).
TP	Colorimetric (10 cm cell) Persulfate Method (APHA, 2005; Grasshoff et al., 1983).
SiO_2	Colorimetric Molibdosilicat (2 cm cell)
NO_3+NO_2-N	Cadmium reduction; Colorimetric
NH_4-N	Colorimetric Fenat Method (10 cm cell) Flow injection method

Table 4. Ranges of the TRIX Index determined by the previous studies

Region	**Adriatic Sea**	**Ionian Sea and Aegean Sea**	**Mersin Bay (NE Mediterranean)**
Eutrophication Status	**Eutrophication Range**[a]	**Eutrophication Range**[b]	**Eutrophication Range**[c]
High	2-4	<1.6	< 2
Good	4-5	1.6-2.8	2-3
Moderate	5-6	2.8-4.0	3-4
Poor	6-8	4.0-5.3	4-5
Bad		> 5.3	5-6
[a]Pettine et al., 2007; [b]Primpas and Karydis, 2011; [c]Kaptan, 2013			

Table 5. August 2016 Marine Assessment Units evaluations according to HEAT

Summer 2016	**ISKENDERUN BAY**	**MERSIN BAY**	**ANTALYA BAY**	**FINIKE**
PO_4 (μM)	0,03	0,03	0,03	0,03
TP (μM)	0,18	0,18	0,17	0,17
NO_3+NO_2 (μM)	0,63	0,17	0,29	0,15
NH_4 (μM)	0,37	0,37	0,21	0,21
Si (μM)	1,55	1,96	0,81	1,57
Si/NO_3	2,46	11,29	2,83	10,72
Chl-*a* (μg/L)	0,23	0,29	0,17	0,06
SDD (m)	13,40	13,28	21,50	23,03
DO (%)	99,53	100,39	104,91	101,23
TRIX	1,93	1,65	1,97	1,34
WFD Assessment	**Poor-Bad**	**Moderate**	**Good**	**High**

Table 6. February 2016 Marine Assessment Units evaluations according to HEAT

Winter 2016	**ISKENDERUN BAY**	**MERSIN BAY**	**ANTALYA BAY**	**FINIKE**
PO_4 (μM)	0.05	0.03	0.03	0.02
TP (μM)	0.15	0.15	0.13	0.11
NO_3+NO_2 (μM)	0.65	0.47	0.47	0.31
NH_4 (μM)	0.57	0.38	0.23	0.19
Si (μM)	1.68	1.58	1.44	1.91
Si/NO_3	2.6	3.35	3.05	6.26
Chl-*a* (μg/L)	0.28	0.38	0.15	0.18
SDD (m)	13.59	14.7	12.29	17.43
DO (%)	102.15	101.18	100.37	100.32
TRIX	2.25	2.07	1.44	1.26
WFD Assessment	**Poor-Bad**	**Moderate**	**Good**	**High**

Figure 1. Marine assessment units and the sampling stations in 2016

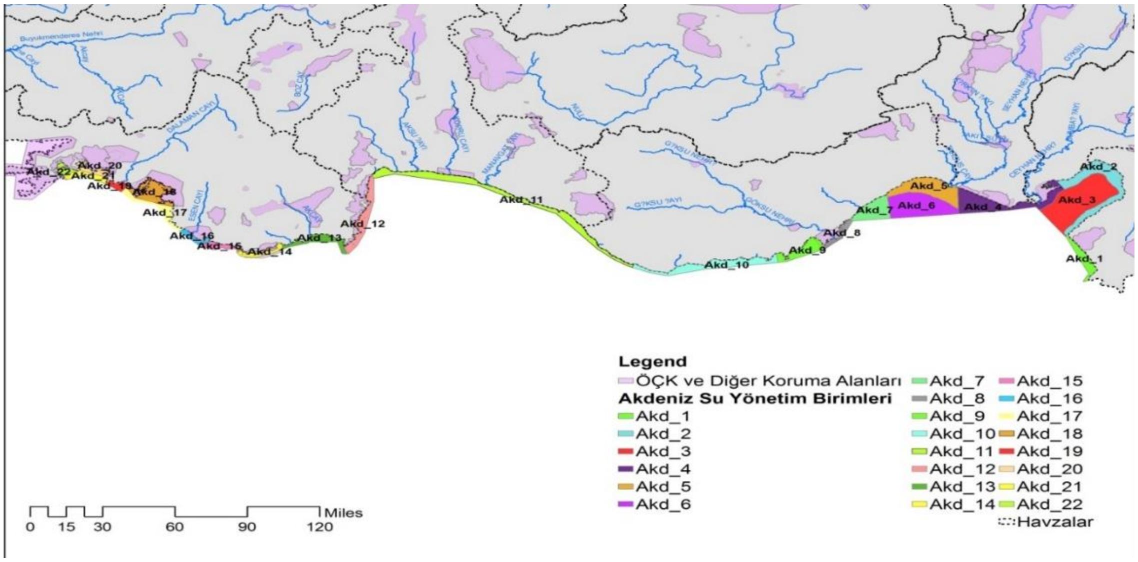

Figure 2. Coastal water bodies

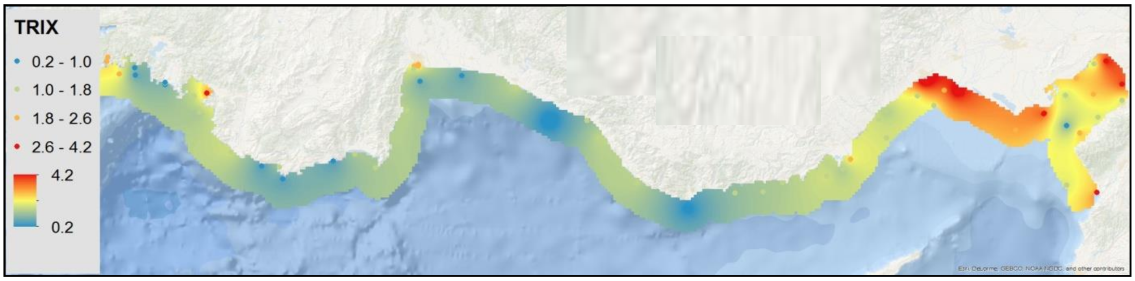

Figure 3. Surface TRIX distribution at 22 coastal water bodies, February 2016

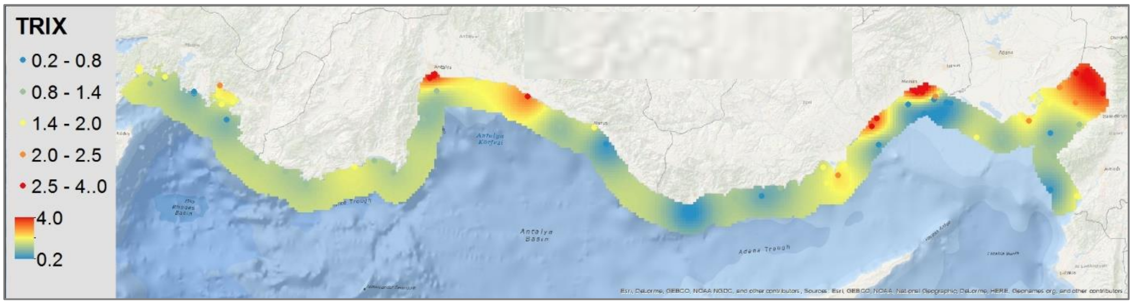

Figure 4. TRIX distribution at 22 coastal water bodies, August 2016

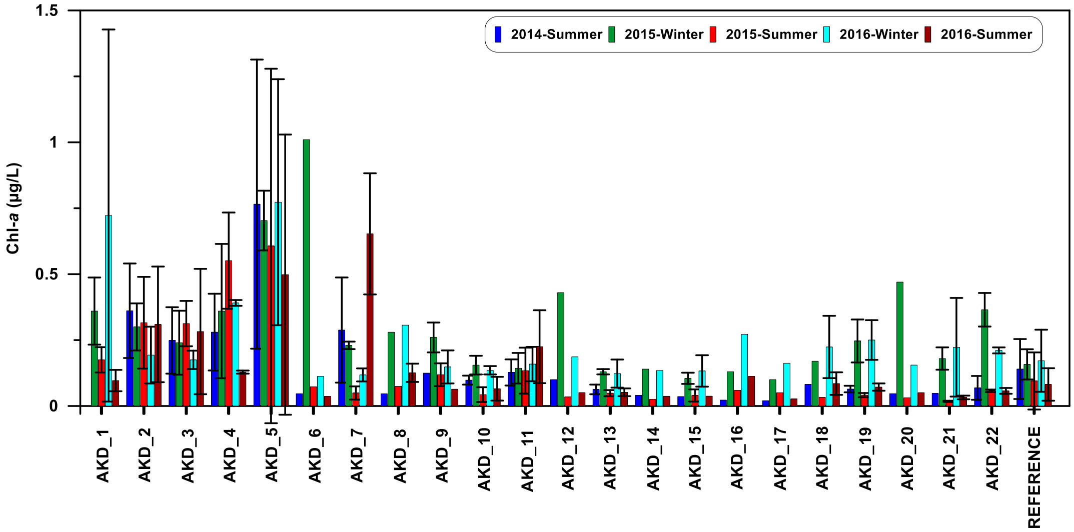

Figure 5. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer Chlorophyll-a average and standard deviations for 22 coastal water bodies.

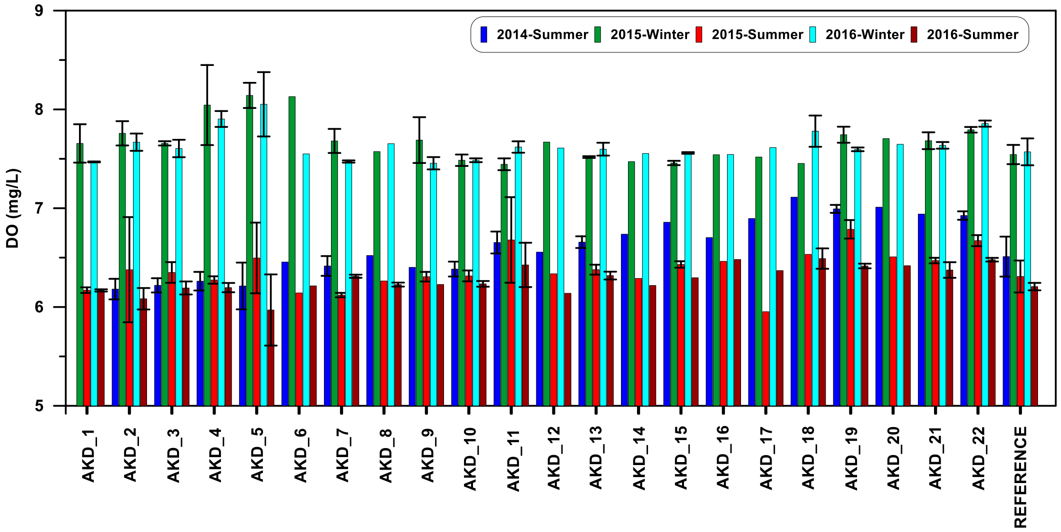

Figure 6. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer dissolved oxygen (DO) average and standard deviations for 22 coastal water bodies

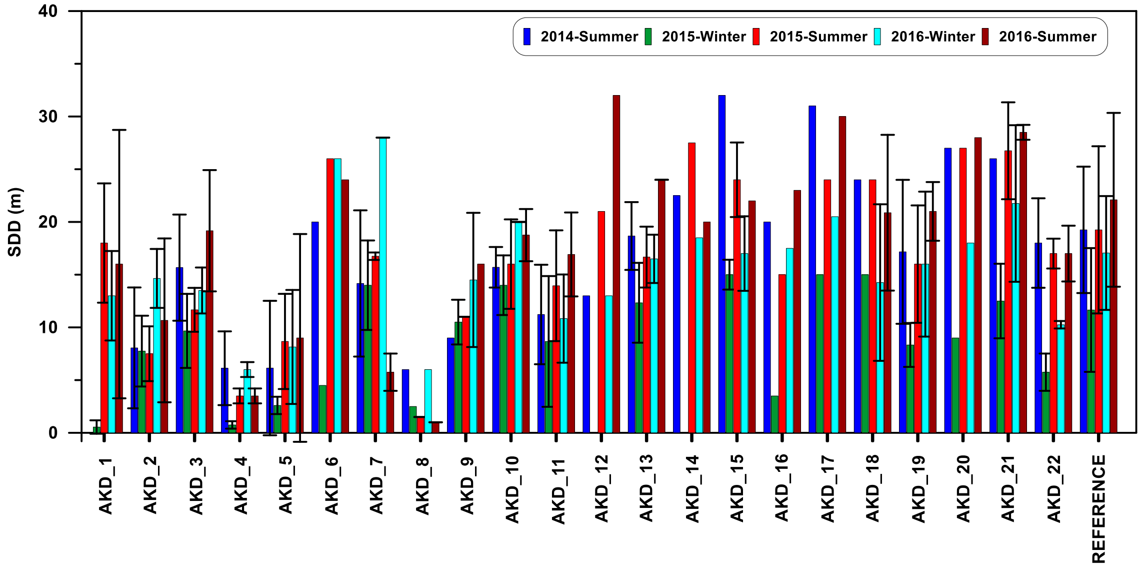

Figure 7. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer secchi disc depth average and standard deviations for 22 coastal water bodies

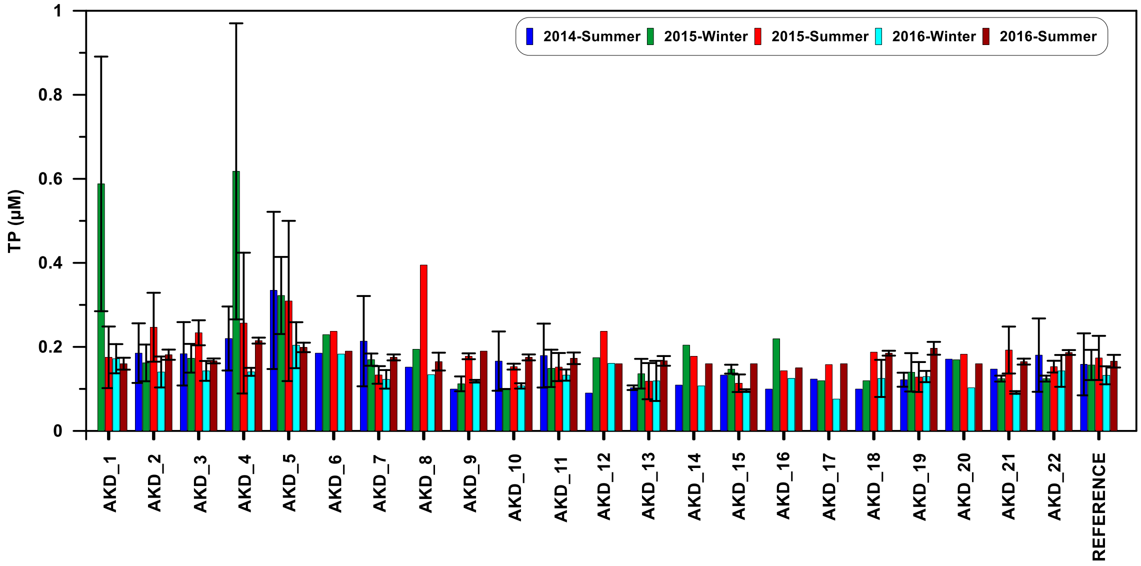

Figure 8. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer total phosphorus (TP) average and standard deviations for 22 coastal water bodies

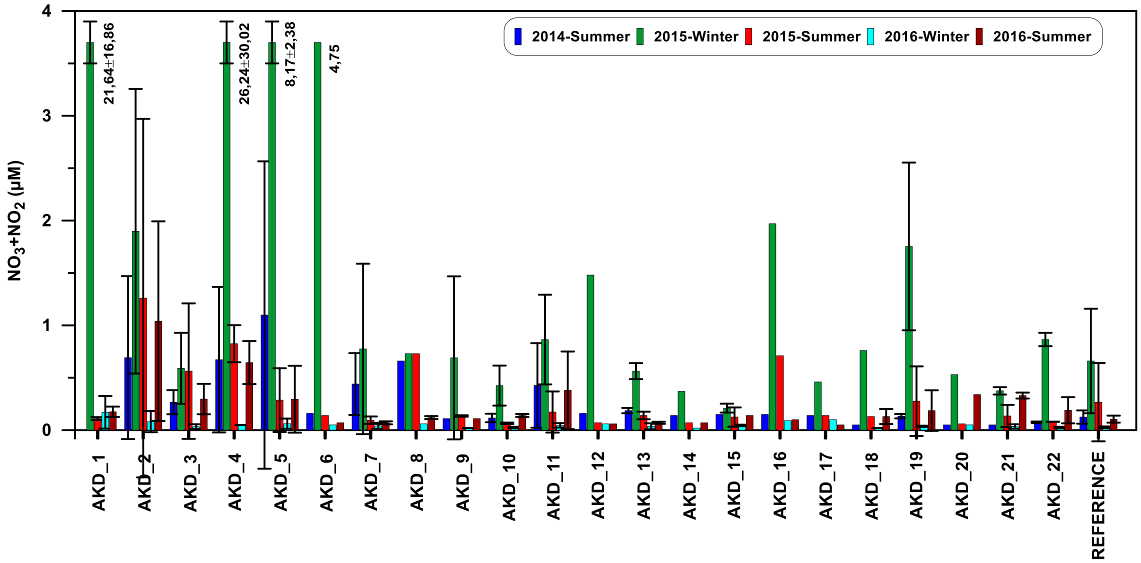

Figure 9. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer NO_3+NO_2 average and standard deviations for 22 coastal water bodies

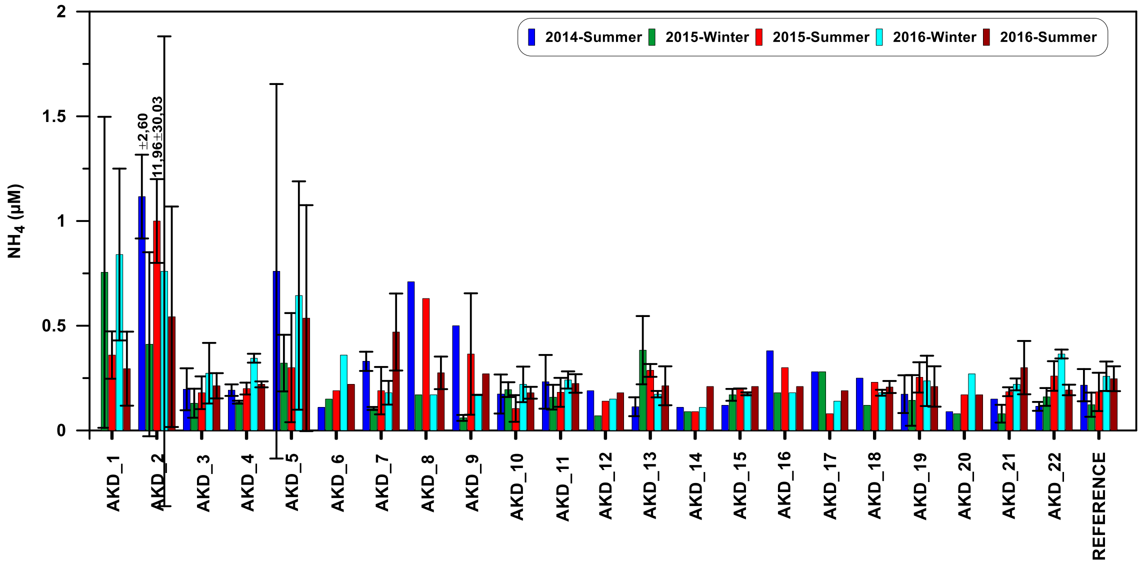

Figure 10. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer NH_4 average and standard deviations for 22 coastal water bodies

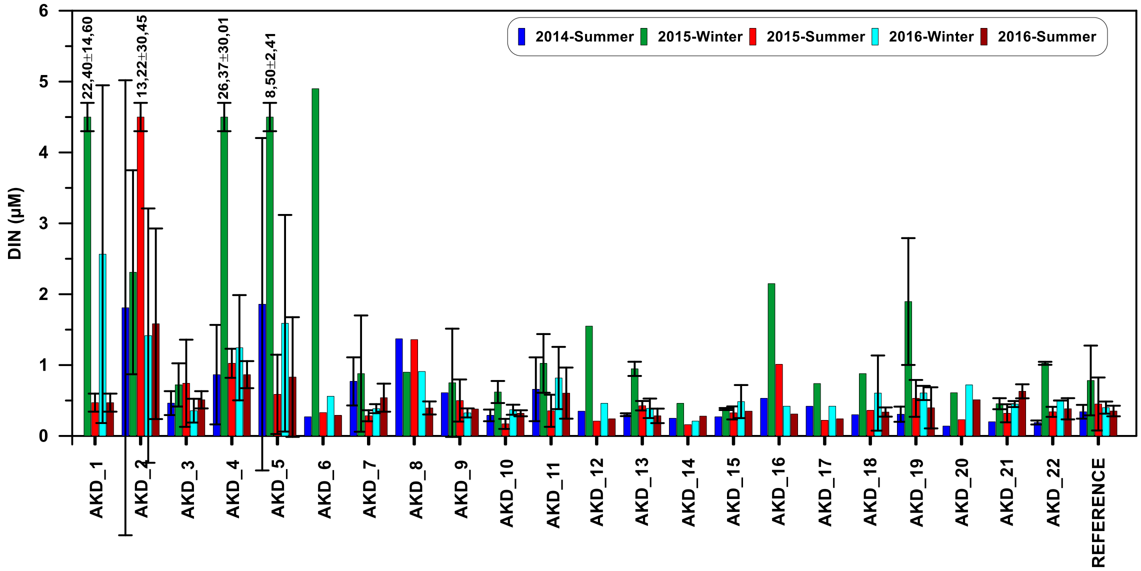

Figure 11. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer dissolved inorganic nitrogen (DIN) average and standard deviations for 22 coastal water bodies

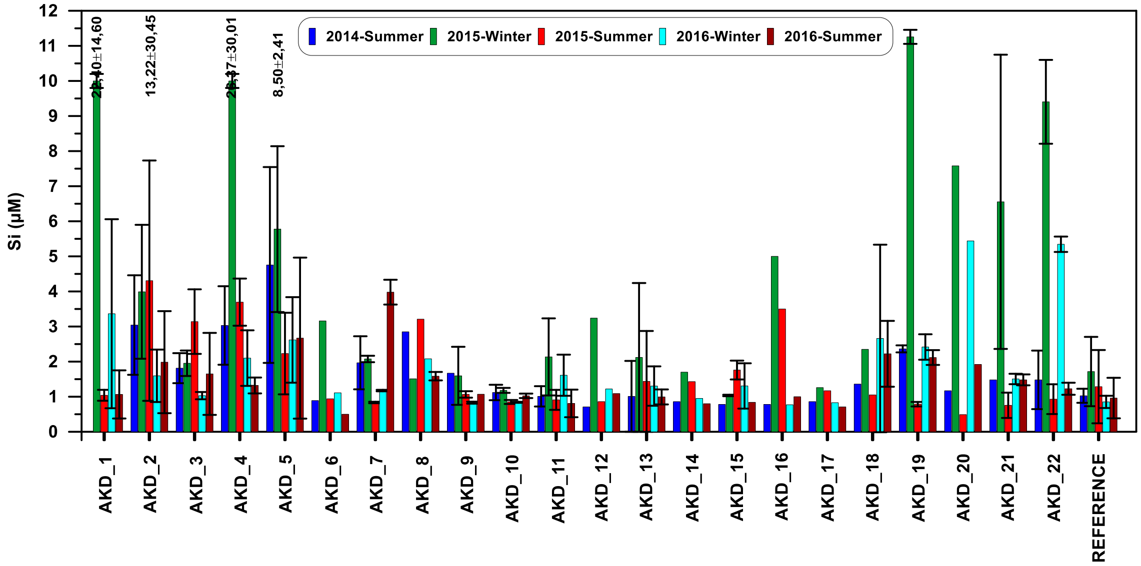

Figure 12. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer silicate (Si) average and standard deviations for 22 coastal water bodies

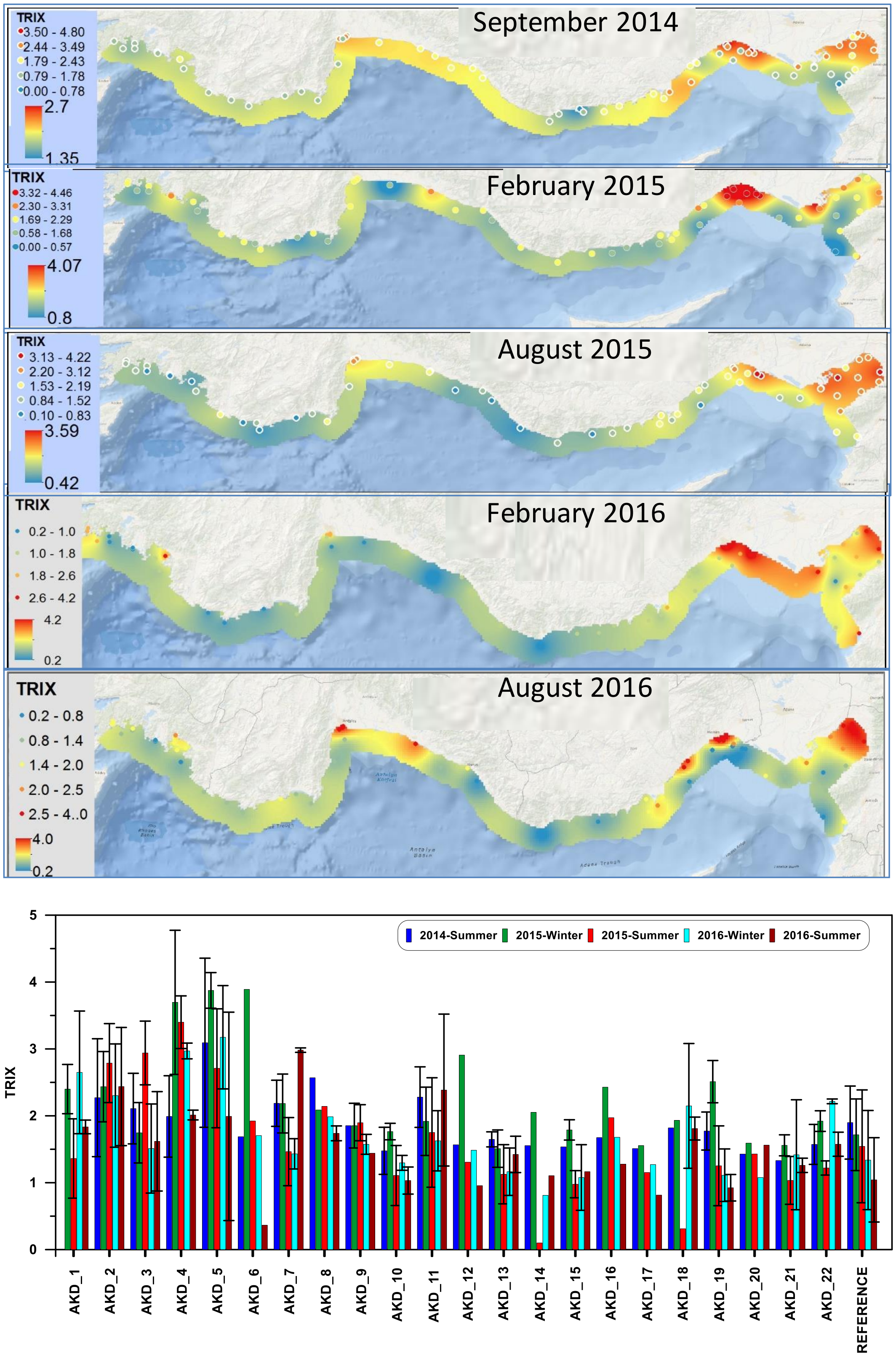

Figure 13. Mediterranean Sea surface water 2014 summer, 2015 winter and summer, 2016 winter and summer TRIX distribution and average and standard deviations for 22 coastal water bodies

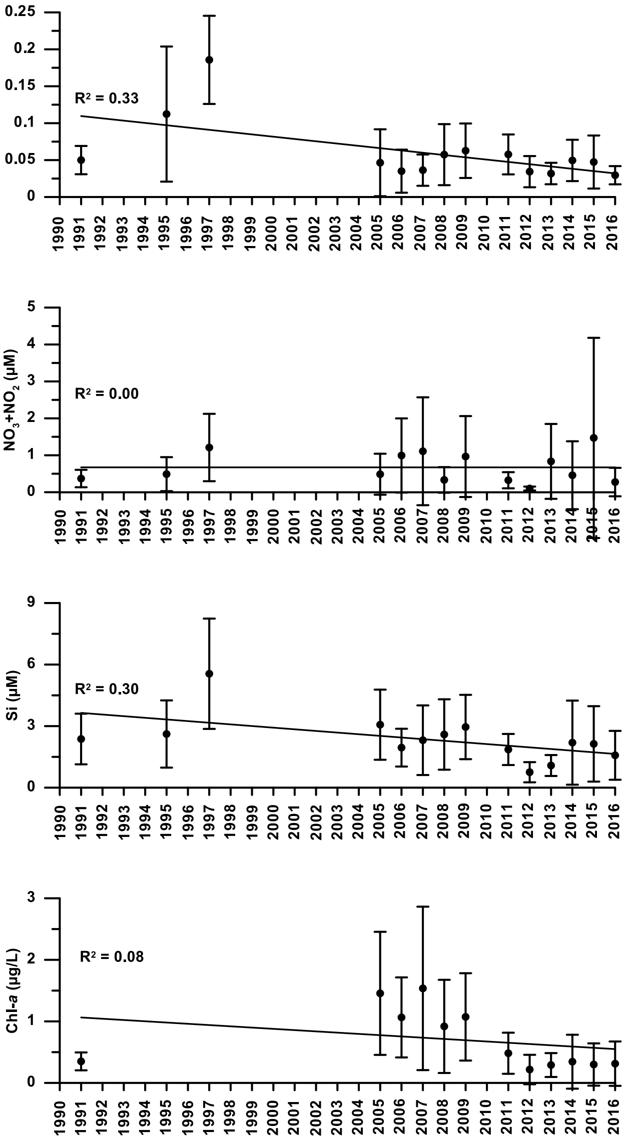

Figure 14. Mersin Bay trend analysis for the surface water nutrient and Chl-a concentrations

Common Indicator: Ecological Objective 9: Contaminants cause no significant impact on coastal and marine ecosystems and human health; Common Indicator 17: Concentration of key harmful contaminants in biota, sediment or water

Case Study title: Levels and trends of Cadmium (Cd) and Zinc (Zn) bioaccumulation in Israeli Mediterranean coastal marine mollusks (*Patella sp.*)

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1. Brief introduction

Trace metal accumulation in marine organisms has been shown to be a useful bio-indicator for the quality of seawater and sediments. Therefore, many monitoring programs have adopted this tool in order to follow long-term trends in water and sediment quality including the National Monitoring Program of the Israeli Mediterranean coast (Herut et al. 2016). The main objectives of this monitoring approach are to follow long-term trends, to identify pollution hotspots and then to assess the effectiveness of regulatory measures taken to improve water and sediment quality. During the period 1995-2012, trace metal levels were monitored on an annual basis in marine mollusks (*Donax trunculus, Mactra stultorum*, *Patella sp.* and *Cellana rota*) along the Mediterranean coast of Israel in polluted and unpolluted areas. Currently, trace metal loads into southern Haifa Bay are significantly lower compared to the early 2000s. In 1999, the fertilizer producing plant situated above the Qishon River started using phosphate rock imported from the Kola Peninsula instead of the local Negev rock, which has a significantly lower content of cadmium (Cd) and Zinc (Zn) by a mean factor of 15 (Figures 1-2). Together with implementation of effluent purification measures, Cd and Zn (and other heavy metals) loads to the Qishon River decreased by 95-98% during the period 1999-2002.

2. Methodologies used for the collection and analysis of the data

Specimens of the gastropods *Pattela sp* and *Cellana rota* were collected at sites in the southern part of Haifa bay, located at the northern part of the Israeli Mediterranean coast at Shemen Beach. All specimens were kept frozen at -200C until analysis. Prior to analysis, the specimens were thawed, rinsed in distilled water, and the long diameter of their shells was measured. After this, the soft tissue of each specimen was removed completely from the shell and weighed (wet weight) after taking care to remove particles adhering to the soft tissue. The whole soft tissue of the mollusks were used for analysis. The samples were then lyophilized/dry-frozen (about 10-20% dry matter depending on the species) and digested with concentrated nitric acid in Uniseal, Teflon-lined, high pressure decomposition vessels. From 2012 onwards samples were digested in a Microwave oven (MarsX CEM). Until 1998 the solutions were analyzed for Cd and Zn using a Perkin –Elmer 1100B flame atomic absorption spectrophotometer and since with a Varian AA220 flame atomic absorption spectrophotometer. After 2012 samples were analyzed with Agilent flame spectrophotometer (280FS AA). Until 1998 the method detection limit (MDL), for Cd and Zn was 0.03 and 0.07 µg/g wet weight (wt.), respectively, and since 0.05 µg/g wet wt. Cd and Zn water and sediment samples were also taken at the Haifa Port entrance, about 1.5 km from Shemen Beach.

3. Results of the Indicator Assessment

The time series of Cd and Zn in Patella in southern Haifa Bay very likely reflect the effects of short and long duration of anthropogenic loading and sediment re-suspension events (Figures. 1-2), demonstrating the sensitivity of these measurements. The time series' for the period 1999-2012 of mean Cd levels (Figure 1) display a variety of short and long term behaviors. From 1999-2001 Cd decreased by 80% from ~1 µg/g wet wt. in Shemen Beach (near Haifa Port entrance) samples. In Shemen Beach, Cd began to increase in 2003 to a maximum of ~0.6 µg/g wet wt. in 2007 after which it varied with an average value of ~0.4 µg/g wet wt. Zn levels at Shemen Beach (Figure 2) decreased by about 50-60% relative to the levels measured in 2000 and then stayed relatively constant from 2004 onwards. During the period 2005-2010 a coherent increasing and decreasing pattern of trace metal levels in Patella collected at Shemen Beach were observed, that peaked in 2008 and decreased to 2005 levels by 2010 (Figs. 1-2). Relative to 2005, the peak trace metal levels were higher by a factor of 3-6. These patterns of increase and decline coincided with the dredging works and construction of the Carmel B container terminal in Haifa Port that commenced in July 2005 and were completed in May 2009. It is possible that continuous re-suspension of polluted sediments in Haifa Port throughout the period were the cause of this behavior. Clearly, these results demonstrate the sensitivity of these measurements and the importance of mitigation efforts during dredging operations.

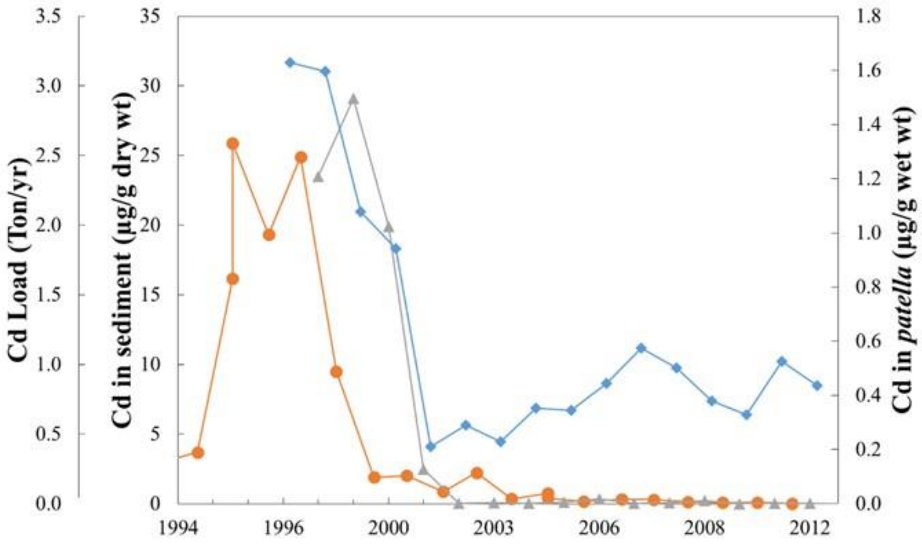

Figure 1. Time series of Cd load from: i) Qishon River industrial sources (grey triangles); ii) in sediments sampled at the Haifa Port entrance near Shemen Beach (orange circles); and iii) mean levels in Patella specimens (blue diamonds) sampled at the nearby Shemen Beach station during the period 1994-2012. Data for Patella were extended backwards in time using data from Herut et al. (1999).

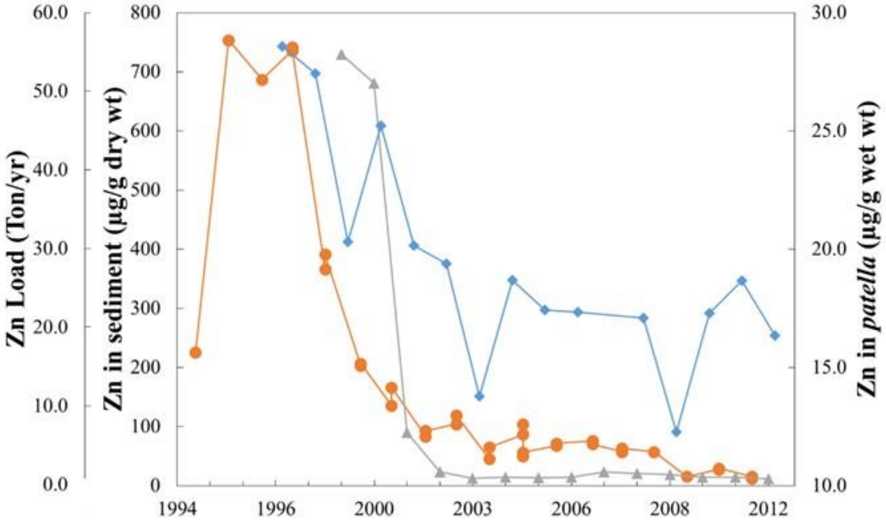

Figure 2. Time series of Zn load from: i) Qishon River industrial sources (grey triangles); ii) Zn levels in sediments sampled at the Haifa Port entrance (orange circles); and iii) mean Zn levels in Patella specimens (blue diamonds) sampled at the nearby Shemen Beach station during the period 1994-2012. Data for Patella were extended backwards in time using data from Herut et al. (1999).

4. Lessons learnt and/or recommendations

Our observations support the basic assumption that bio-accumulation of trace metals in marine organisms is sensitive to the state of water and sediment quality. Furthermore, it appears that bio-accumulation is more sensitive to the effects of sediment re-suspension, which wasn't correlated with high sedimentary trace metal levels. Thus, highlighting the importance of implementing mitigation measures during dredging operations as well as promoting the importance of contaminated sediments rehabilitation in ports and estuaries even after the cessation of external trace metal loading. This issue is of crucial importance considering the pending large scale dredging operations that usually take place as part of ports expansion project.

5. References and web links

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www.ocean.irg.il

Common Indicator: EO 9: Contaminants cause no significant impact on coastal and marine ecosystems and human health; Indicator 17- Concentration of key harmful contaminants in biota, sediment or water.

Case Study title: Levels and trends of TriButyltin (TBT) in Israeli ports and marinas

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1. Brief introduction

Organotin-based TriButyltin (TBT) antifouling paints were introduced in the mid-1960s and their use increased unchecked for some decades. The harmful impacts of TBT contamination were first noticed in the late 1970s when reproductive failure and shell deformations affected shellfish farms. Since then, TBT and its degradation products, mono- (MBT) and dibutyltin (DBT), and triphenyltin (TPT), were recognized as most toxic materials intentionally introduced into the sea, and confirmed as harming a wide range of organisms. Due to its highly toxic effects on the marine environment, the use of TBT-containing paints has been banned worldwide. Due to its slow degradation, TBT and its derivatives (DBT, MBT) are very persistent in the marine environment. In frame of Israel's National Marine Monitoring Program in the Mediterranean Sea carried out by IOLR, TBT and its derivatives concentrations were measured in water and sediments at ports and marinas long the Mediterranean coast of Israel since the year 2001 (in sediments) and 2002 (in water). Based on the monitoring program first year's results, in 2003 the Ministries of Environmental Protection and Transportation prohibited the use TBT antifouling paints within Israel and on Israeli vessels. Afterwards, in 2010, TBT containing antifouling paints were banned in Israel.

2. Methodologies used for the collection and analysis of the data.

Annual cruises were conducted with the R.V. Etziona at all ports and marinas along the Mediterranean coast of Israel (Fig. 1). Surface sediment samples (top 2 cm) were collected during 2001-2015 and surface water samples during 2002-2015. Sediments were sampled by a Van-veen grab (0.08 m^2), stored in glass containers, frozen and lyophilized prior to analysis. Water was sampled with a peristaltic pump and transferred for butyltin analysis using Gas Chromatography – Flame Photometric Detector (GC/FPD) Krones method. The detection limit is 12 ng L^{-1} for TBT.

3. Results of the Indicator Assessment

In all ports and marinas the TBT concentrations in seawater show a decreasing trend between 2002 and 2011 (Fig. 2) and were below the detection limit during the last 5 years (2011-2015). Similar trends were observed for DBT (Fig. 2) TBT concentrations dropped from >300 ng/L in 2004 at Haifa port to less than 12 ng/L after 2011. While a distinct phase-out trend was observed in the seawater, the organotins in the sediments are still relatively high with no clear trend (Fig. 3). Nevertheless, in some cases lower concentrations were recorded in the last years. However, the TBT/DBT ratio in several ports and marinas imply the presence of a "fresh" TBT source.

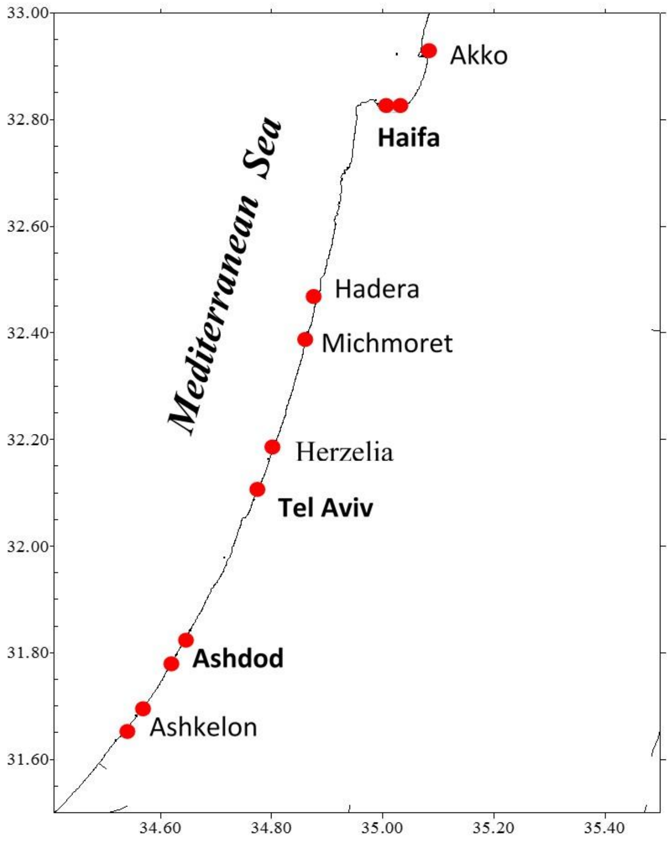

Figure 1. Location map of ports and marinas along the Mediterranean coast of Israel, in which sediment and seawater were sampled for organotin compounds.

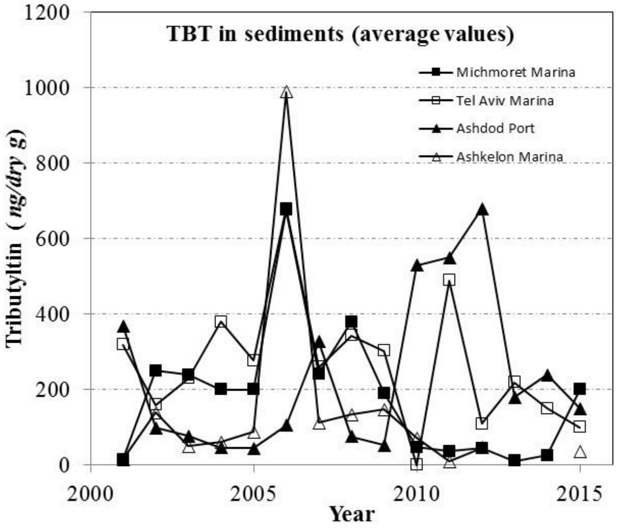

Figure 2. Long term trend (2002-2015) of TriButyltin (TBT) and dibutyltin (DBT) concentrations in surface seawater in ports and marinas along the Mediterranean coast of Israel.

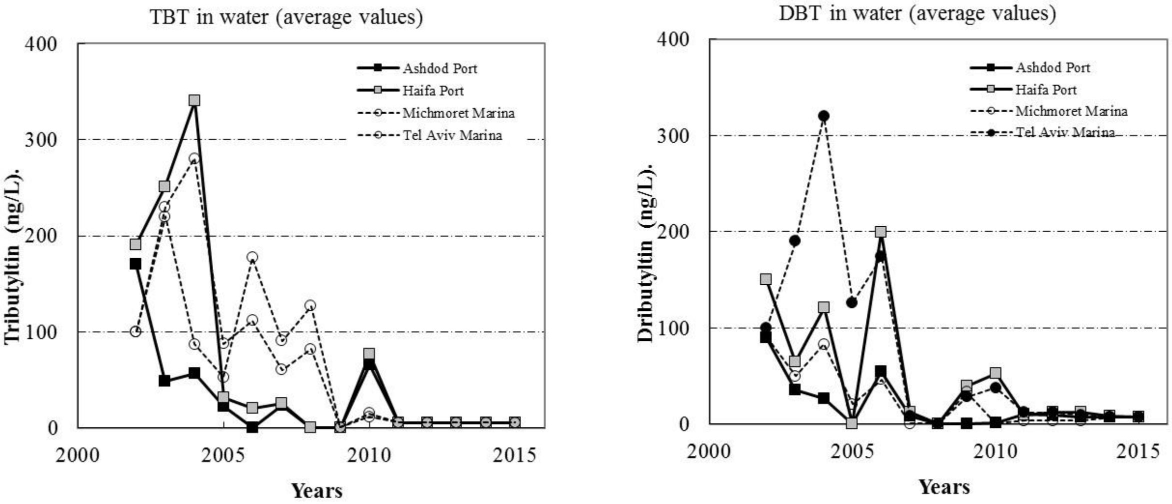

Figure 3. Long term trend (2001-2015) of TriButyltin (TBT) concentrations in surface sediments in ports and marinas along the Mediterranean coast of Israel.

4. Lessons learnt and/or recommendations

Relatively high levels of TBT in seawater and sediments at ports and marinas were detected in the past by the National Monitoring Program. The results successfully triggered a strict enforcement of the prohibition to use TBT antifouling paints within Israel and on Israeli vessels and later banning the use of TBT by law. This governmental environmental policy was successfully monitored and detected in the water phase while the sediments in some ports and marinas still contain relatively high levels of TBT. TBT is a persistent pollutant that degrades very slowly, and can be found in the sediment a long time after its use in the marine industry has been restricted. Degradation time of chemicals should be taken into account when considering use of the chemical in the marine environment.

5. References and web links

Herut B. and all scientific group of IOLR, National Institute of Oceanography (201**6**). The National Monitoring Program of Israel's Mediterranean waters – Scientific Report for 201**5**, IOLR Report H42/2016.

Cohen Y. and Herut B. (2003). Pollution of TBT in ports and marinas. IOLR Report H28/2003.

www.ocean.org.il

Common Indicator: Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)

Case Study title: Concentration of key harmful contaminants in sediments and *Posidonia*, Malta

Author(s):
Environment & Resources Authority

1. Brief introduction

In the context of implementation of the EU Water Framework Directive and the Barcelona Convention, a one-year monitoring programme for coastal waters was implemented as part of an ERDF[28] funded project entitled 'Development of Envrionmental Monitoring Strategy and Environmental Monitoring Baseline Surveys' (2012 – 2013). This project generated a baseline dataset with the intention of providing a benchmark for long-term monitoring programmes and assessments. The monitoring processes covered hydromorphological, physicochemical and biological quality elements in coastal waters.

The aim of this Case study is to give a brief overview of the results of the above specified project activities that can be used for assessment processesin relation to EO9 EcAp Common Indicator 17: Concentration of key harmful contaminants measured in the relevant matrix (related to biota, sediment, seawater).

All monitoring stations are shown in Figure 1 below whilst sediment sample points and biota sampling points are shown in Figure 2 and 3 respectively.

2. Methodologies used for the collection and analysis of the data

Contaminants in sediments.

As part of the requirements of the EU Water Framework Directive, Malta has monitored substances included in the EU Environmental Quality Standards (EQS) Directive 2008/105/EC in relevant environmental matrices, including water column, sediments and biota. A number of priority substances established by EU Directive 2008/105/EC which tend to accumulate in sediments, as well as substances of potential national concern to the water environment were monitored in superficial sediments collected from 17 selected sampling stations. These stations were sampled once in 2012 and two replicate samples were collected in order to execute and compare two different chemical analyses.

Sediment samples were initially collected through a pilot survey carried out from 29th May to 6th June 2012. Such pilot sampling was undertaken by divers who were able to undertake a detailed analysis of the morphology of the seabed. Following this pilot survey, the sediment sampling activities were conducted from 1st August to 22nd August 2012 by means of a Van Veen grab sampler. Such equipment has been used with the support of a research vessel of about 12m and equipped with a crane and winch to allow the lowering of the grab into the sea.

The Van Veen grab allows to sample up to approximately 60Kg of sediment; the sediment was then placed in a container of adequate size and sub-samples were immediately stored for

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[28] ERDF 156: Developing National Environmental Monitoring and Infrastructure Capability

analysis. A data sheet was prepared for each sampling point showing the coordinates of sampling, the lithology of the extracted material and the photographic documentation.

The analytical methods used for mercury, cadmium and lead were: EPA 3051A 2007 + EPA 6020A 2007

Contaminants in biota (*Posidonia oceanica*).

The EU EQS Directive 2008/105/EC (prior to the amendments through Directive 2013/39/EC) requires that hexachlorobenzene, hexachlorobutadiene and mercury are monitored in biota tissue by choosing the most appropriate indicator among fish, molluscs, crustaceans and other biota. The marine seagrass *Posidonia oceanica* was selected as a bio-indicator for the Maltese baseline. The use of *Posidonia oceanica* as a bioindicator for contaminants in biota was mainly due to the natural featuresof the seagrass (benthic, long-living) and also due to its distribution within coastal areas, which are generally exposed to anthropogenic impacts. These characteristics make *Posidonia oceanica* both prone to bioaccumulation and easy to collect, as required for the design of representative and cost-effective biomonitoring programs.

Contaminants in *Posidonia oceanica* were monitored at 18 stations (see Figure 3). Within such stations, the seagrass was sampled once during the 12-month monitoring period. A pilot survey was undertaken in May/early June 2012. This pilot survey was followed by a baseline survey undertaken at the end of July/early August 2012.

During the surveys, a fixed number of orthotropic shoots of *Posidonia oceanica* were sampled at each of the stations. To ensure the robustness of the analysis, 12 shoots were collected from the central part of the seagrass bed at 14-17m depth for each station. The sampling was carried out in such a way to minimise any stress and further damage to the plant.

After the sampling, the shoots were preserved at -20°C and shipped to an accredited laboratory where samples were kept frozen prior to the analysis. Seagrass shoots were then dissected in order to separate rhizomes from leaves and foliar basal parts. Approximately 300mg obtained from the part of interest (rhizome) were then singularly picked up and processed for the analysis according to the following standard procedures: UNI EN 15763:2010 (for Mercury); UNI EN 15662:2009 (for Hexachlorobenzene); EPA 5021A 2003 + EPA 8260C 2006 (for Hexachlorobutadiene).

3. Results of the Indicator Assessment

Concentration of chemicals in sediment.

Malta has not yet established Environmental Quality Standards (EQS) for contaminants in sediments. Furthermore, no long-term data on contaminants in sediment is available to enable assessment of trends. Assessment of status was thus based on a comparison analysis between the measured values and the EQS's established in Italy (Decreto n.56/2009). The Italian quality standards were derived on the basis of field and laboratory ecotoxicology data. References to EQSs hereafter are referring to the EQSs established by Italy.

It has to be noted that while EQSs are expressed as annual averages, the results from one field sampling as in this case can give a good indication of pollutant concentrations. One survey a year is usually considered sufficient to determine the environmental quality of the sediments.

The results for metals in sediment show EQS exceedances for mercury and lead at three monitoring points (CP04-1, CP06-1 and CP06-2). Lead, in particular, presents very high concentrations (more than 6 times the EQS) in the sediment taken from CP06-1 and CP06-2 whilst mercury is remarkably high (30 times the EQS) at the CP04-1 monitoring station. The concentrations of cadmium are generally below the EQS (0.3 mg/kg), although at monitoring points CP04-1, CP06-1 and CP06-2 measured concentrations are very close to EQS for this metal. It should be noted that CP06-1 and CP06-2 are located within coastal water body MTC 106 which, prior to the operation of the Urban Waste Water Treatment Plant in the South of Malta, was subject to discharge of raw sewage.

With respect to organic contaminants, high values of PAHs significantly above the EQS were measured in the Grand Harbour and Marsamxett harbour (monitoring points CN05-1, CN05-2 and CP05). The monitoring points CN05-2 and CP05 within this harbour area measured the highest PAHs concentrations.

The concentrations of contaminants in sediments (see Table 1 and Figure 4) were compared to the IMAP Assessment Criteria. In accordance with the assessment undertaken the concentrations of most contaminants are below the IMAP Assessment Criteria Values (COP18 Decision) except for 3 out of 17 monitoring stations for lead, mercury and cadmium. It should be noted that while cadmium levels at the three monitoring stations were below EQSs established by Italy, such levels exceeded the IMAP assessment criteria.

Table 1. Concentrations of contaminants in sediments compared to the IMAP Assessment Criteria

Heavy metal	IMAP Sediments BAC level (µg/kg d.w.)	Number of sampling stations where exceedences occur (out of 17 stations)
Cadmium	150	3 sampling stations
Mercury	45	6 sampling stations
Lead	30 000	3 sampling stations

These results indicate that there are four substances which may be of concern in Maltese sediments: mercury, lead, cadmium and PAHs. Such contaminants are restricted to coastal waters which were either subject to discharge of raw sewage prior to the operation of urban waste water treatment plants, or constitute harbour areas. Such pressures on coastal waters have been or are being addressed through targeted management measures.

Contaminants in biota (*Posidonia* oceanica).

The Environmental Quality Standards for the contaminants analysed in *Posidonia oceanica* cannot be directly applied, since the EQSs refer to higher trophic levels. For this reason, the reference values for the Maltese scenario were determined after comparison between the analytical results obtained from the impacted areas during the whole survey and other zones where pollution is judged to be scarce (pristine areas). The identification of pristine areas along the Maltese coast was based on specific literature data together with the analytical judgment of expert personnel. Further to this, analytical data obtained from Maltese areas were compared to “blank” measurements from marine zones belonging to other European countries, that are generally considered as pristine areas, such as Haute-Corse (Northern Corsica) (see e.g. Biasi et al., 2009; Pergent-Martini, 1994; Pergent-Martini, 1998), as well as mean values collected along the Italian coast (Costantini et al., 1991).

The results seem to indicate a substantial homogeneity among the different stations with respect to the organic xenobiotic compounds hexachlorobenzene (<0.0001mg/Kg) and hexachlorobutadiene (<0.01 mg/Kg), which are either absent or lower than the detection concentration.

Measured concentrations of mercury in *Posidonia* were compared to two different types of reference values, namely, mean values collected along Mediterranean coast from mild to high impacted areas, and measurements from marine zones that are generally considered to be relatively 'pristine' areas (reference sites). The levels of mercury in *Posidonia oceanica* in Malta are comparable with those from the reference sites and lower with respect to both mild and heavily impacted sites. Therefore, mercury levels in biota are of lower concern than in the other environmental matrices.

Mercury levels in biota could not be compared with IMAP Assessment Criteria Values (COP18 Decision) since Malta did not use fish or mussels as bioindicators. The marine seagrass *Posidonia oceanica* was confirmed as a suitable bioindicator for Maltese coastal waters up to 40m depth. However, for biota sampling at greater depths, it is necessary to rely on alternative biological species. Monitoring programmes have been amended to include a wider spectrum of biota species that needs to be monitored.

4. Lessons learnt and/or recommendations

The 2012-2013 data identifies mercury, lead, cadmium and polyaromatic hydrocarbons as pollutants of concern in Maltese coastal sediments. Exceedances of the concentrations of heavy metals to Assessment Criteria were restricted to three sampling stations within coastal areas. One of these coastal stretches was subject to discharge of untreated urban waste water in the past, hence contamination can be related to such activity. Exceedances in PAHs on the other hand can be attributed to harbour activity.

Although this data was generated by a one-off survey and further long-term monitoring data is required to assess trends, it points towards the need for managing the input of specific contaminants in the marine environment. Management processes in relation to urban waste water treatment and harbour activity are already in progress as part of related EU and regional policy, including the Barcelona Convention, however the need for better understanding between levels of contaminants in the marine environment and sources is key to effective management processes. The link between contamination in water and sediment could also shed light in this regard.

For example, mercury concentrations were not only high in the sediment matrix but also in the water column. Mercury contamination in the surface waters occurs not only where there is a high mercury contamination in sediments (sites CP04-1, CN05-1, CP06-1 and CP06-2) but also where the mercury concentrations in the sediments were low. After analysing the specific location of the points which show a high concentration of mercury, it could be seen that CP04-1 is close to an important urban area and that CP06-1 and CP06-2 are close to a waste water treatment plant; hence the high concentrations could be attributed to urban emissions from combustion activities in CP04-1 and discharge of domestic sewage in CP06-1 and CP06-2. However transboundary sources (such as atmospheric deposition and Mediterranean hydrographical transportation from Mediterranean states) could also have a part to play in contributing to the presence of mercury all around Maltese coastal waters. There is therefore a need to investigate potential mercury sources at a regional scale and look further into the potential contribution of transboundary sources. Any identified potential contributor would have to be attested by long-term monitoring data.

The Programme of Measures in Malta's Second Water Catchment Management Plan put forward by Malta pursuant to the EU WFD processes and as part of Malta's National Action Plan under the Barcelona Convention Pollution from Land-Based Sources and Activities (LBS) Protocol, includes measures to address significant management issues as identified for Maltese coastal waters, including chemical quality of coastal waters. Such actions address:

- the regularization of industrial discharges,
- the knowledge gaps pertaining to the role of hydrological catchments as a pathway and contributor to contaminants,
- the need to enhance knowledge on the sources of contaminants of concern and the hydrographic characteristics of the marine environment beyond Malta's waters
- the need to control and investigate cumulative impacts in particular stretches of coastal water bodies (including cumulative impacts of discharges)

In conclusion, links between levels of contaminants with sources/activities are considered key to elaborate effective management processes in the marine environment. In this regard, the importance of having an inventory/baseline budget of emissions, discharges and losses in the marine environment becomes even more pertinent Regional cooperation is also important noting the possibility of transboundary sources of pollution. Monitoring needs to be sustained to achieve long-term data that would enable the establishment of EQSs or assessment criteria as well as assessment of trends. In addition, monitoring programmes should constitute living documents which are updated to reflect emerging needs on the basis of improved knowledge.

5. References and web links

1. Water Catchment Management *http://era.org.mt/en/Pages/Water-Catchment-Management-Plan.aspx*
2. Reports on Water Quality Monitoring: *http://era.org.mt/en/Pages/Reports-on-Water-Quality-Monitoring.aspx*

6. Graphs, pictures and tables

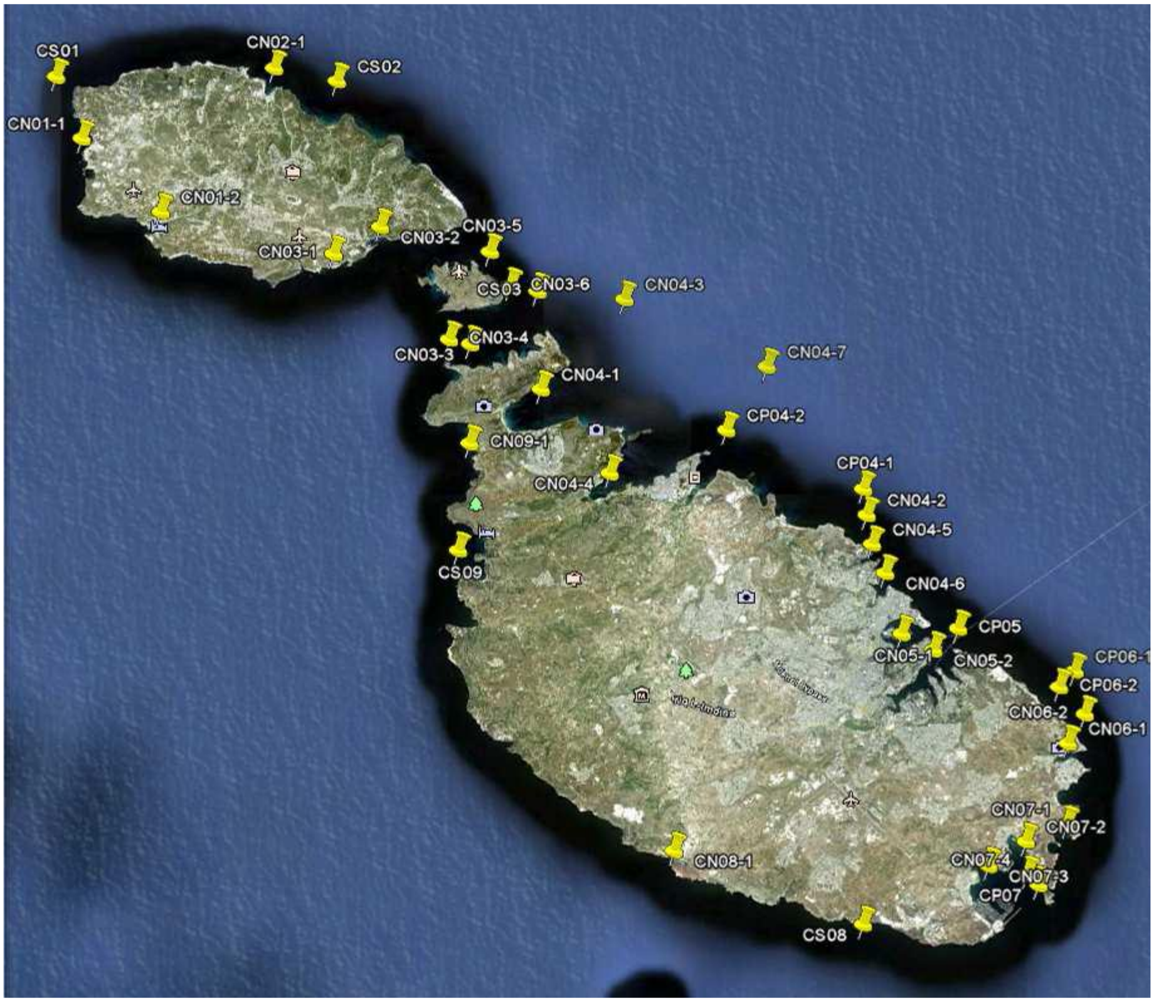


Figure 1. Representation of all of the sampling points

Figure 2. Representation of the sediment sampling points

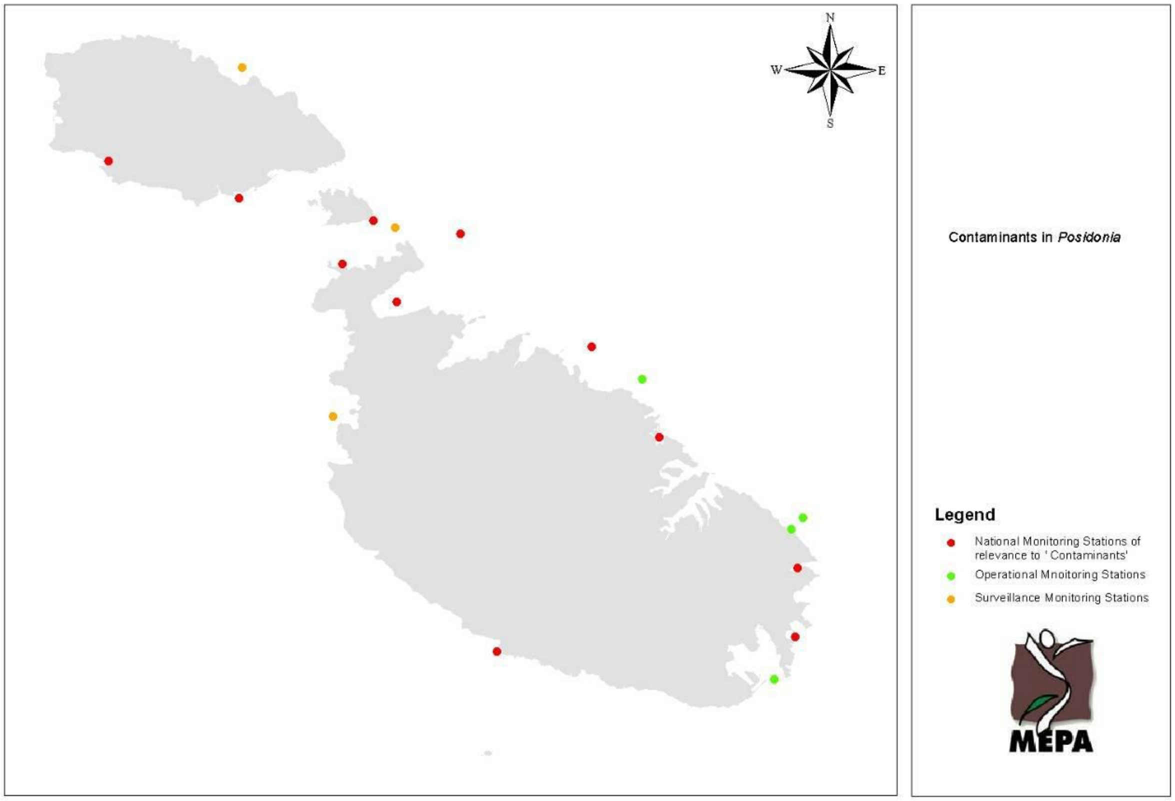


Figure 3. Monitoring stations for contaminants in *Posidonia oceanica*

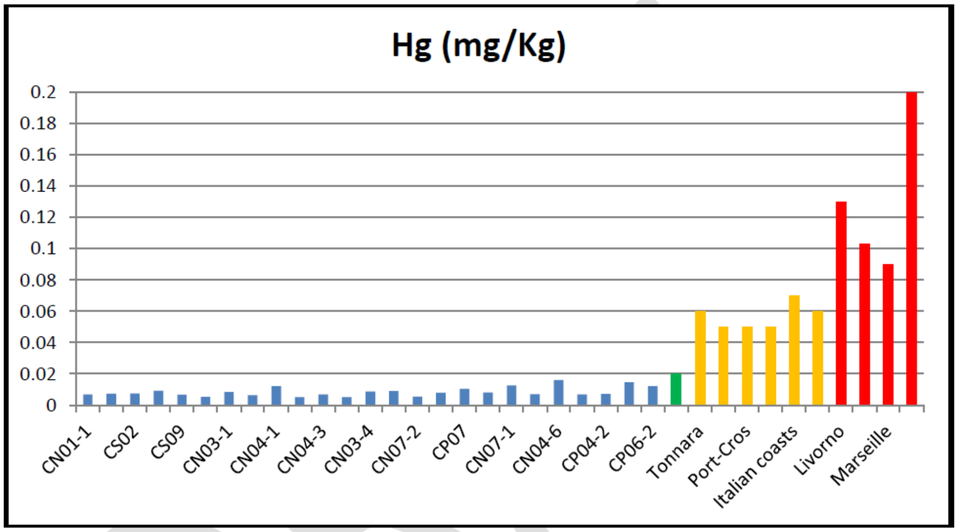


Figure 4. Comparison of Mercury concentrations in biota among Maltese coastal waters (marked in blue) and Mediterranean reference sites (green, yellow and red).

Indicateur commun 21 (OE9): Pourcentage de relevés de la concentration d'entérocoques intestinaux se situant dans les normes instaurées

Titre de l'étude de cas: Surveillance de la qualité des eaux des baignade des plages du Maroc

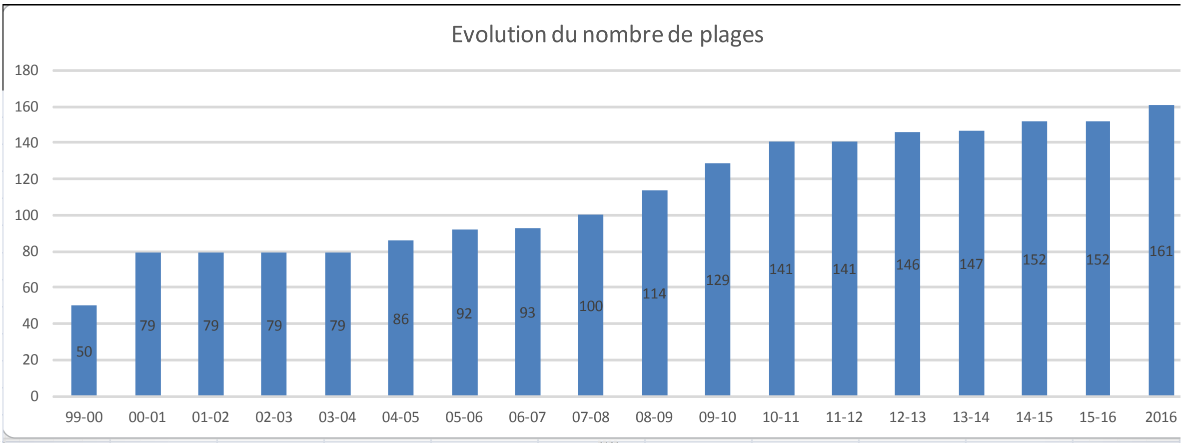
Auteur (s) : Laboratoire National des Etudes et de Surveillance de la Pollution relevant du Secrétariat d'Etat chargé du Développement Durable en collaboration avec la Direction des Ports et du Domaine Publics Maritime relevant du Ministère de l'Equipement, du Transport, de la Logistique et de l'Eau ; avec l'appui de la Fondation Mohammed VI pour la Protection de l'Environnement.

1. Introduction

Le Maroc a le privilège de disposer de deux façades maritimes méditerranéenne et atlantique qui s'étalent sur 3500 Km; c'est ainsi que la politique nationale concernant les eaux de baignade revêt une importance confirmée au fil des saisons balnéaires, puisqu'elle permet de protéger le grand public des pollutions qui surviennent de façon accidentelle ou chronique à l'intérieur des abords des zones de baignade.
Convaincu que la qualité des eaux de baignade constitue un atout important pour le développement du tourisme balnéaire, les pouvoirs publics ont adopté un programme national pour assurer la surveillance de la qualité des eaux des baignade des plages du Maroc. Ce programme national est mené conjointement depuis 2002 suivant un protocole d'accord conclu entre les 2 départements ministériels.

2. Méthodologies

Le nombre de plages objet du Programme National de Surveillance évolue depuis plusieurs années il est passé de 18 en 1993 à 161 plages en fin 2016. Cette évolution du nombre des plages marocaines surveillées sont illustrées dans le graphique ci-dessous.



Ainsi, le tableau ci-dessous donne la répartition régionale des plages du Royaume avec les stations de prélèvements et de surveillance:

Régions	Nombre de plages	Nombre de stations	Nombre de Prélèvements
Orientale	11	26	252
Tanger Tétouan El Hoceima	58	150	1484
Rabat-Salé-Kenitra	18	46	459
Casablanca - Settat	36	111	1110
Marrakech - Safi	10	30	300
Souss-Massa	12	41	410
Guelmim-Oued Noun	7	15	150
Laâyoune- Saguia Al Hamra	5	8	78
Dakhla-Oued Ed Dahab	4	4	40
Total à l'échelle nationale	**161**	**431**	**4283**

N.B: La zone Méditerranéenne comprend 48 plages

La liste des points de surveillance ainsi que les sites de surveillance sont choisis en fonction de l'importance de la fréquentation, de la nature des lieux (relief, forme du rivage) et des risques particuliers de pollution pouvant exister (rejet d'eaux usées, embouchures de rivières, ports, etc.).

L'évaluation de la qualité des eaux de baignade du littoral marocain se fait chaque année du mois de mai jusqu'au Septembre avec une fréquence de prélèvement bimensuelle et porte sur l'analyse des paramètres microbiologiques applicables et mentionnés par la directive **76/160/CEE** et transcrite par la norme marocaine de la qualité des eaux de baignade.

La présence de ces germes dans l'eau témoigne de la contamination fécale des zones de baignade. Ils constituent ainsi un indicateur du niveau de pollution par des eaux usées et laissent suspecter par leur présence, celles de germes pathogènes. Plus ils sont présents en quantité importante, plus le risque sanitaire augmente.

Durant la saison balnéaire, chaque résultat est interprété par rapport à la norme marocaine NM 03.7.200. Les informations relatives à la qualité des eaux de baignade des sites surveillés, sont portées à la connaissance du public par l'affichage régulier (périodique), au niveau de chaque plage, d'un bulletin d'information.

Paramètres microbiologiques	Valeurs guides(VG) UFC/100ml	Valeurs impératives (VI) UFC/ 100ml

Coliformes fécaux (CF)	100	2000
Streptocoques fécaux(SF)	100	400

- **VG : valeurs recommandées pour la détermination de la qualité des eaux**
- **VI : valeurs maximales admissibles pour juger la qualité des eaux de baignade**

Les eaux de baignade sont classées selon les catégorisés suivants :

Eaux de classe A	**Eaux de classe B**
• Au moins 80% CF ≤ aux VG (100/100ml) ; • Au moins 95% des résultats CF ≤ VI (2000/100ml) • Au moins 90%des résultats en SFVG (100/100ml).	L'eau est de qualité moyenne lorsque le nombre impératif fixé par la directive CF est respecté dans au moins 95% des prélèvements.
Les eaux classées en catégorie A ou B sont conformes à la baignade	
Eaux de classe C	**Eaux de classe D**
L'eau des points de surveillance pour laquelle la fréquence de dépassement du 5% ≤ VI (CF) ≤ 33,3%.	Les conditions relatives au VI pour les CF sont dépassées au moins une fois sur trois.
Les eaux classées en catégorie C ou D ne sont pas conformes à la baignade	

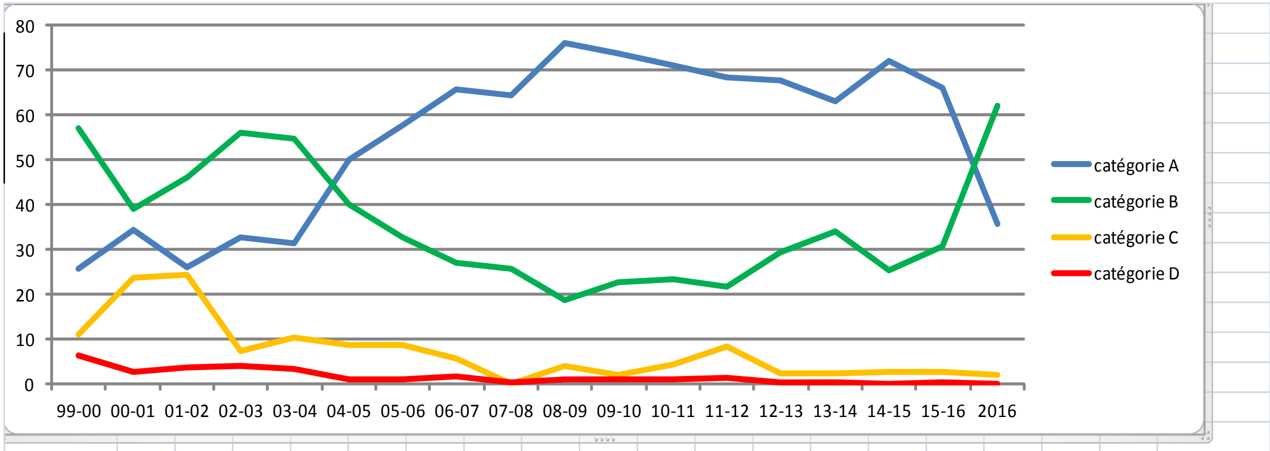
Aussi, depuis l'adoption de la nouvelle norme NM ; 03.7.199, transposée de la Directive Européenne 2006/7/CE ; les eaux de baignade sont classées également conformément aux valeurs prescrites suivantes:

		Entérocoques intestinaux			
		P95<100	P95>100 P95<200	P95>200 P90<185	P90>185
Escherichia coli	P95<250	**Excellente**	**Bonne**	**Suffisante**	**Insuffisante**
	P95<500 P95>250	**Bonne**	**Bonne**	**Suffisante**	**Insuffisante**
	P95>500 P90<500	**Suffisante**	**Suffisante**	**Suffisante**	**Insuffisante**
	P90>500	**Insuffisante**	**Insuffisante**	**Insuffisante**	**Insuffisante**

3. Résultats de l'évaluation

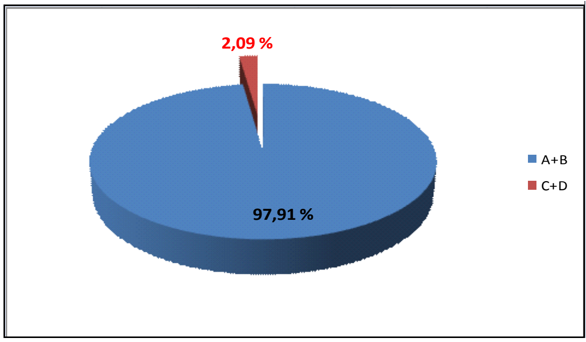
Evolution du nombre des plages

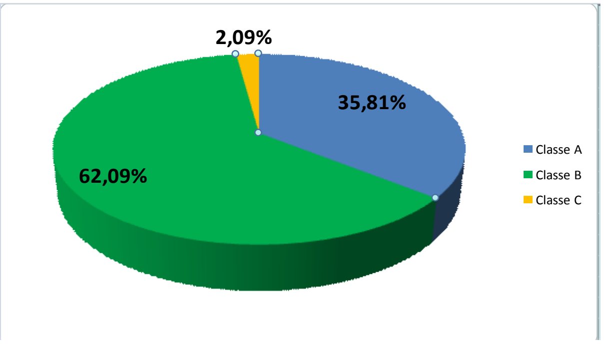
Le nombre de plages surveillées est passé de **18** en 1993, puis à **79** en 2002, et à **161** plages en 2017: 48 plages sur la façade méditerranéenne et 113 plages sur la façade atlantique. Le nombre de stations surveillées par les deux Ministères est **431 stations,** qui ne cessent d’augmenter au fil des années.



Au titre 2016, Sur les 430 stations de prélèvements, qui ont fait l’objet d’un nombre suffisant de prélèvements pour le classement, 421 stations (soit 97,91%) ont été déclarées de qualité microbiologique conforme aux exigences de la norme des eaux e baignade NM. 03.7.200 transposée de la Directive Européenne (76/160/CEE.

La quasi-totalité des 9 stations (soit 2.09%), déclarées non conformes pour la baignade lors de cette saison, subissent l’influence des rejets d’eaux usées et connaissent une forte concentration de baigneurs, conjuguées à l’insuffisance des infrastructures d’hygiène.





Parmi les 430 stations, 283 stations ont fait l’objet d’une analyse simultanée selon les normes NM 03.7.200 et NM 03.7.199 (transposée de la Directive Européenne 2006/7/CE). Les taux de conformité respectifs sont donnés ci-après:

- **Classification selon NM 03.7.200 96,82% conformes 3,18% non conformes;**
- **Classification selon NM 03.7.199 80,21% conformes et 19,79% non conformes.**

Avec 16,61% de stations ayant subi une dégradation en passant de la NM 03.7.200 à la NM 03.7.199.

4. Recommandations:

Malgré les efforts déployés pour l'amélioration de la qualité des eaux de baignade, notamment par les actions d'assainissement, de sensibilisation, de gestion des plages; il faut noter que pour les plages, qui connaissent encore des problèmes de non-conformité, les recommandations suivantes sont proposées pour améliorer davantage la qualité des eaux des plages marocaines:

- ➢ Opter pour le traitement les eaux pluviales avant rejet en mer;
- ➢ Mettre en place les mesures de résilience pour faire face aux impacts des changements climatiques;
- ➢ Dépolluer les cours d'eau et encourager la réutilisation des eaux usées.
- ➢ Renforcer les plages en infrastructures d'hygiènes et procéder au nettoyage du sable même en dehors de la période estivale.
- ➢ Les activités pratiquées sur la plage doivent être encadrées en matière de gestion des eaux polluées et des déchets solides (sports nautiques, restaurations, activités équestres et camelines).
- ➢ Accélérer l'élaboration des normes de rejets industriels en mer.
- ➢ Aucun rejet industriel ne doit être déversé en mer sans traitement préalable.
- ➢ Le phénomène de réchauffement climatique contribue à l'apparition dans les côtes marocaines de méduses et même de physalies. A cet effet, il y a lieu de renforcer les programmes de surveillance de cette espèce en coordination avec les communes littorales pour la protection des baigneurs.

5. Références

- Rapport National de surveillance de la Qualité des eaux de baignade des Plages du Royaume : Edition 2017
- Rapports nationaux de surveillance de la qualité des eaux de baignade de 2002 à 2016
- www.environnement.gov.ma

Common Indicator:

Common Indicator 23 Trends in the amount of litter in the water column, including micro-plastics and the sea floor (EO10)

Case Study title:

The DeFishGear coordinated and harmonized pilot surveys to assess marine litter on the sea surface and the seafloor of the Adriatic and Ionian Seas

Author(s):
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1. **Brief introduction**

The IPA-Adriatic funded DeFishGear project performed one-year-long surveys to assess the amounts, composition and sources of marine macro-litter on the sea surface and the seafloor of the Adriatic and Ionian Seas. This is the first effort to-date aiming to assess in a coordinated, consistent, comprehensive and harmonized way marine litter on in the water column and obtain comparable field data within the same timeframe and through the application of common monitoring protocols. The sea surface and seafloor marine litter surveys were carried out in the six out of the seven countries of the Adriatic-Ionian macroregion, namely Bosnia and Herzegovina, Croatia, Italy, Greece, Montenegro and Slovenia. More specifically: (i) 66 floating litter transects were conducted with small-scale vessels covering a distance of 415 km, while a total of 9,062 km were surveyed by observers on ferries; (ii) for the seafloor litter 11 locations were investigated with bottom trawl surveys and 121 hauls were performed, while 38 transects were performed in 10 locations with underwater visual surveys with scuba/snorkeling, thus covering a total area of 5.83 km^2 of seafloor.

The partners involved were: (i) in floating litter monitoring: Institute of Marine Biology (Montenegro), Institute for Oceanography and Fisheries (Croatia), Institute for Water of the Republic of Slovenia (Slovenia), Italian National Institute for Environmental Protection and Research & Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy). Adriatic and Ionian waters were surveyed using the ferries connecting Greece to Italy by 'Accademia del Leviatano' (Italy) in collaboration with MIO-ECSDE.; (ii) in seafloor litter monitoring with trawls: Institute of Marine Biology (Montenegro), Institute for Oceanography and Fisheries (Croatia), Italian National Institute for Environmental Protection and Research & Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy), Institute for Water of the Republic of Slovenia (Slovenia); (iii) in seafloor litter monitoring with scuba/snorkeling: Hydro-Engineering Institute of the Faculty of Civil Engineering (Bosnia and Herzegovina), Institute of Marine Biology (Montenegro), Institute for Water of the Republic of Slovenia (Slovenia).

2. Methodologies used for the collection and analysis of the data

For floating litter, all surveys performed followed the “Methodology for Monitoring Marine Litter on the Sea Surface-Visual observation (> 2.5 cm)” that was developed within the framework of the DeFishGear project (IPA-Adriatic DeFishGear project, 2014b). The methodology on monitoring floating macro-litter through visual observation by a dedicated surveyor on a vessel was prepared based on the EU Marine Strategy Framework Directive (MSFD) TG10 “Guidance on Monitoring of Marine Litter in European Seas”(Galgani et al., 2013) and the NOAA “Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment”(Lippiat et al., 2013), taking into consideration the draft “UNEP/MAP MEDPOL Monitoring Guidance Document on Ecological Objective 10: Marine Litter (2014)”. Litter items were identified according to litter type and size. Six size classes were recorded (2.5-5 cm; 5-10 cm; 10-20 cm; 20-30 cm; 30-50 cm; > 50 cm) for coastal waters and three for open waters (20-30 cm; 30-50 cm; > 50 cm).

For seafloor litter, surveys were performed following the “Methodology for Monitoring Marine Litter on the Seafloor (continental shelf) – bottom trawl surveys” (IPA-Adriatic DeFishGear project, 2014c) and the “Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters 0 – 20 m) - Visual surveys with SCUBA/snorkelling” (IPA-Adriatic DeFishGear project, 2014d) that were prepared within the framework of the DeFishGear project. The methodologies were prepared based on the EU MSFD TG10 “Guidance on Monitoring of Marine Litter in European Seas” (Galgani et al., 2013), the NOOA “Marine Debris Monitoring and Assessment: Recommendations for Monitoring Debris Trends in the Marine Environment (Lippiatt et al., 2013) and the “International bottom trawl survey in the Mediterranean, Instructional Manual” (MEDITS Working Group, 2013), taking into consideration the draft UNEP/MAP MEDPOL “Monitoring Guidance Document on Ecological Objective 10: Marine Litter (UNEP/MAP MEDPOL, 2014)”.

3. Results of the Indicator Assessment

The average density of floating macro-litter (items > 2.5 cm) in coastal Adriatic waters obtained by small-scale vessels was found to be 332 ± 749 items/km^2 while the average density of items (items > 20 cm) measured by observers on ferries in the Adriatic-Ionian waters was 4 ± 3 items/km^2, (figure 1) with a higher size limit due to the height of passengers above sea-level on ferries. This considerable difference between the two datasets is attributed to the inability of the observers on the ferries to discern small sized items. The highest average abundances were recorded in the coastal waters of Hvar Aquatorium (Croatian coast) (576 ± 650 items/km^2), in the Gulf of Venice (475 ± 1203 items/km^2) and in Cesenatico (324 ± 492 items/km^2). All these areas are directly affected by the major urban-touristic centres located in their vicinity and by pathways such as the Po River. The lowest abundance of floating macro-litter items was found in two enclosed areas that were surveyed (Kotor Gulf-Montenegro and Brac Channel-Croatia). They are isolated areas and were not expected to be affected by the major transportation mechanisms of sea-surface litter, in any case.

The average seafloor litter density found at regional level by bottom trawl surveys was 510 ± 517 items/km^2 (range: 79-1099 items/km^2) and 65 ± 322 kg/km^2 (range: 3-339 kg/km^2), as seen in figure 2. In terms of the amount of litter per surface area (kg/km^2), the DeFishGear results are comparable to those reported by other studies in the Adriatic and Ionian Seas. When comparing the DeFishGear results with other seafloor litter densities reported worldwide, it is evident that the seafloor of the Adriatic and Ionian Seas is impacted by marine litter, with amounts of litter being 2-5 times higher than those reported for some other seas. These surveys showed that the most affected countries are Greece (847 items/km^2), Croatia (679 items/km^2) and Italy (400 items/km^2). The average seafloor litter density found at regional level by visual surveys with scuba/snorkelling was 2.78 ± 3.35 items/100 m^2 (figure 3). It is worth noting that the seafloor litter densities obtained within the DeFishGear project through visual surveys with scuba/snorkelling (27,800 items/km^2) are not comparable to the seafloor litter densities found in the bottom trawl surveys (510 items/km^2) but they are more similar to the beach densities found within this study.

When it comes to the material composition of litter found in all marine compartments of the Adriatic and Ionian seas, the majority of litter items were artificial polymer materials accounting for 91.4% of all floating litter; 89.4% of all seafloor litter (bottom trawl surveys); 36.4% of all seafloor litter (visual surveys with scuba/snorkelling). On an aggregated basis at regional level the most abundant items for floating litter were: plastic bags (26.5%), plastic pieces (20.3%), plastic sheets (13.3%), polystyrene fish boxes (11.4%), plastic cover/packaging (8.1%), other plastic items (6.0%); etc. Results obtained from the bottom trawl surveys showed that plastic sheets, plastic industrial packaging and plastic sheeting are the most abundant types of litter (27.8%), followed by bags and food containers including fast food containers, both accounting for about 11% of all items recorded (figure 4). In the visual seafloor surveys with scuba/snorkelling the most common items found were glass bottles or pieces thereof (29.2%), followed by plastic bottles and metal cans (14.3% and 12.1% respectively) as seen in figure 5. The data obtained highlighted the emerging issue of mussel nets ranking in the 7th position of the top 20 items found on beaches, while in Italy these items were the 3rd most abundant items recorded on the seafloor (8.4%).

Regarding the sources, litter from shoreline sources -including poor waste management practices, tourism and recreational activities- for the sea surface they accounted for 38.5%; and for the seafloor for 36.6% (bottom trawl surveys), values which are much lower than the Mediterranean average of 52% (UNEP/MAP MEDPOL, 2011) and the global average of 68.2% (Ocean Conservancy, 2011). When looking at the sea-based sources of litter for floating litter fisheries and aquaculture related items accounted for 8.75% of total sampled litter. The contribution of fisheries and aquaculture related items to the total number of items collected by the seafloor trawl surveys and the seafloor visual surveys with scuba/snorkelling was at regional level 17% and 6%, respectively.

4. Lessons learnt and/or recommendations

- The DeFishGear results show that for monitoring the abundance of litter floating on the sea surface it is of utmost importance to report the minimum detection size and to apply correction factors to density calculations. By utilizing fast travelling large ships, the small-sized macro-litter (2.5 cm – 5 cm) is not accurately detected and these data should be used with caution in studies aiming to assess the amount of litter present in the marine environment. Nevertheless, for monitoring the trends of floating litter and the effectiveness of mitigation measures, data obtained from large oceanographic vessels or 'ships of opportunity' can be considered adequate.
- When monitoring seafloor litter both in continental shelves (bottom trawl surveys) and shallow waters (visual surveys with scuba/snorkelling), every effort must be made to increase the number and stratification of the transects (distance from the coastline, proximity to potential sources, depth, exposure to main currents, etc.) to provide a comprehensive picture of the distribution and composition of litter items.

- Due to the crucial role of the swept area for the litter density estimation in bottom trawl surveys, it is strongly recommended to use acoustic devices mounted on the trawl net for the exact calculation of the mouth opening.
- In order to enhance monitoring of marine litter on the seafloor litter and facilitate the implementation process of the EU MSFD and the UNEP/MAP Regional Plan on Marine Litter Management with regards to setting baselines towards achieving GES, it is highly recommended to make the collection of seafloor litter data mandatory for ongoing trawl survey programs (e.g. MEDITS).

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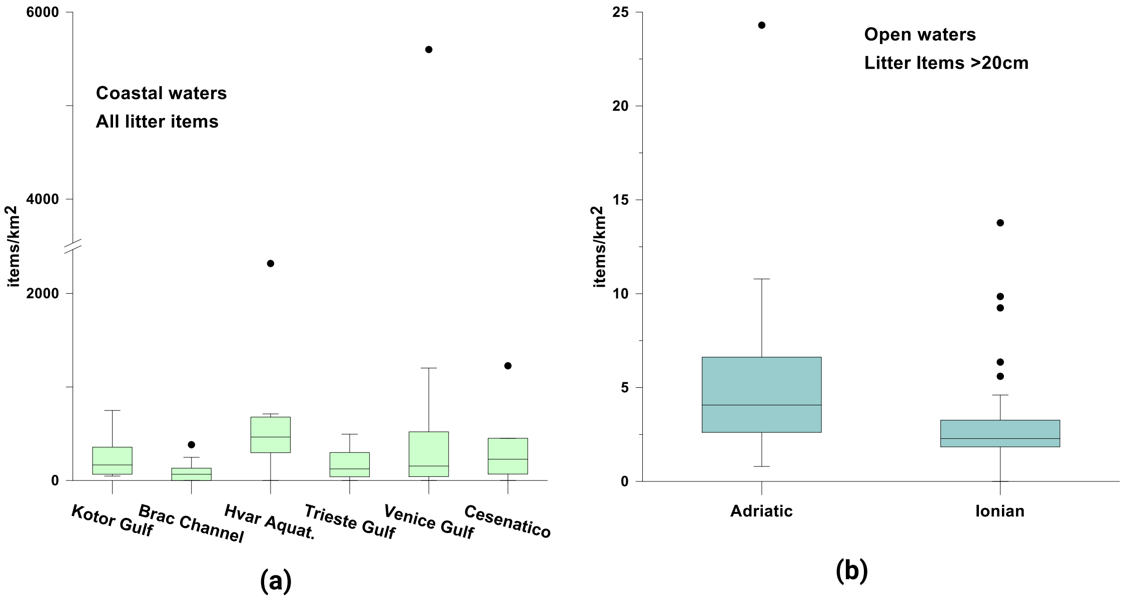

Figure 1. The range of floating litter abundances measured in: (a) coastal Adriatic waters (n = 66) using small vessels; (b) Adriatic and Ionian waters (n = 91) using ferries. The boundaries of the boxes indicate the 25th and 75th percentiles, the whiskers above and below the boxes the 95th and 5th percentiles. Outliers are indicated by black dots. The horizontal line denotes the median value

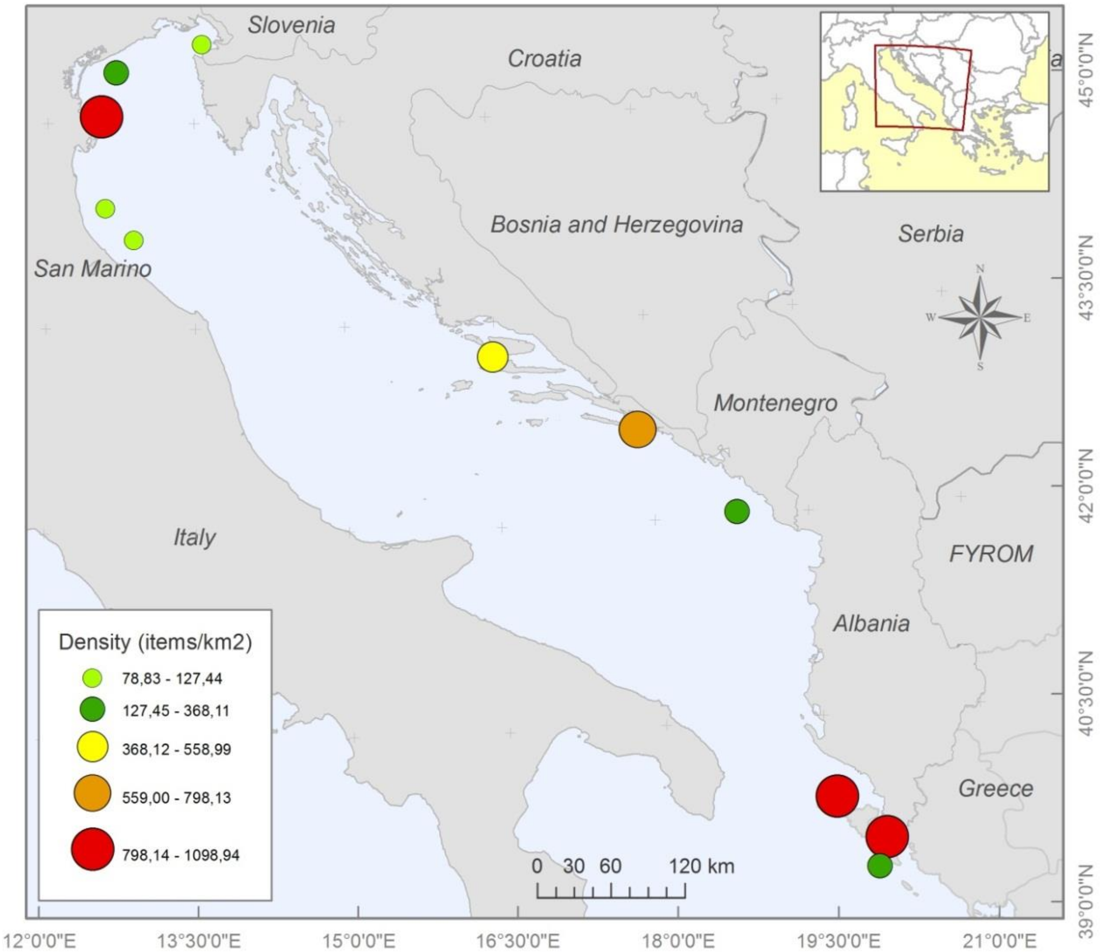

Figure 2. Spatial distribution of seafloor litter densities (obtained by bottom trawl surveys) by number in the Adriatic and Ionian Seas

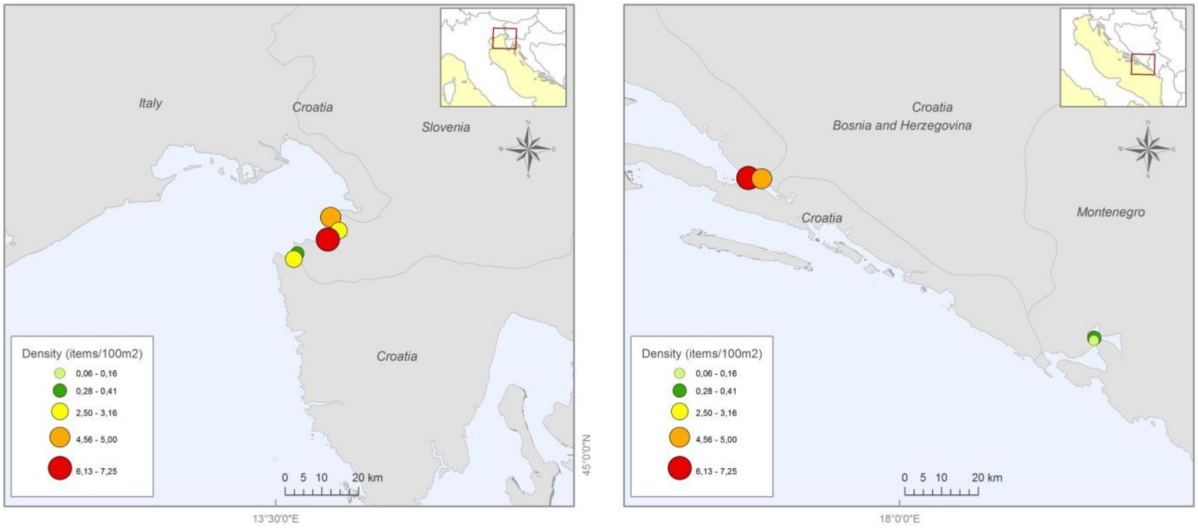

Figure 3. Seafloor litter densities (obtained by scuba/snorkeling) by number in different locations

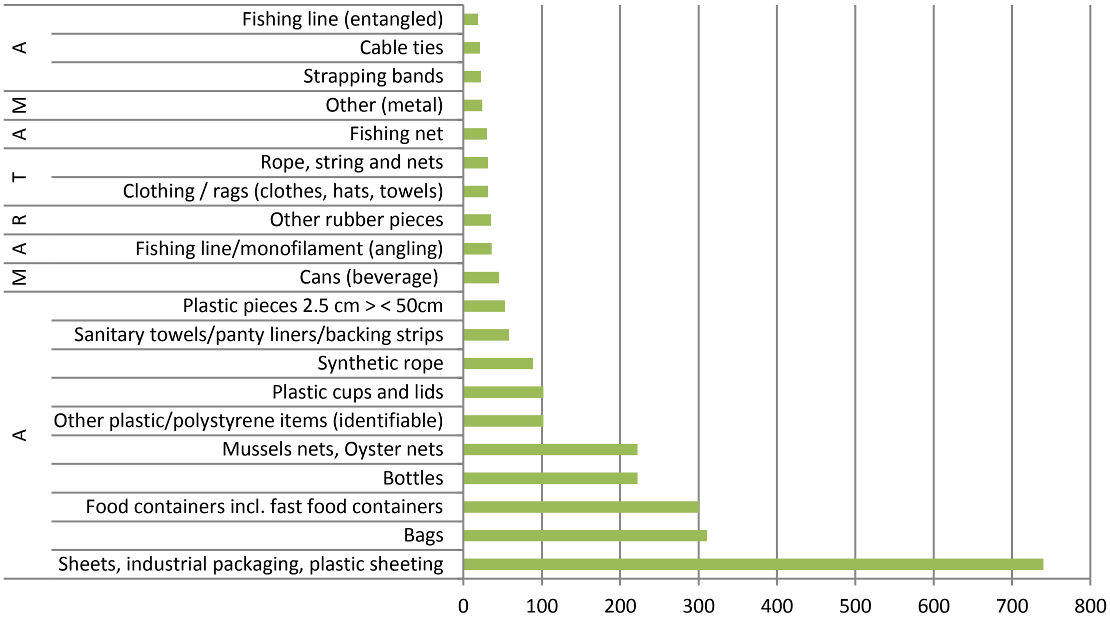

Figure 4. Top 20 items found in the seafloor of the Adriatic-Ionian Seas (as number of items)

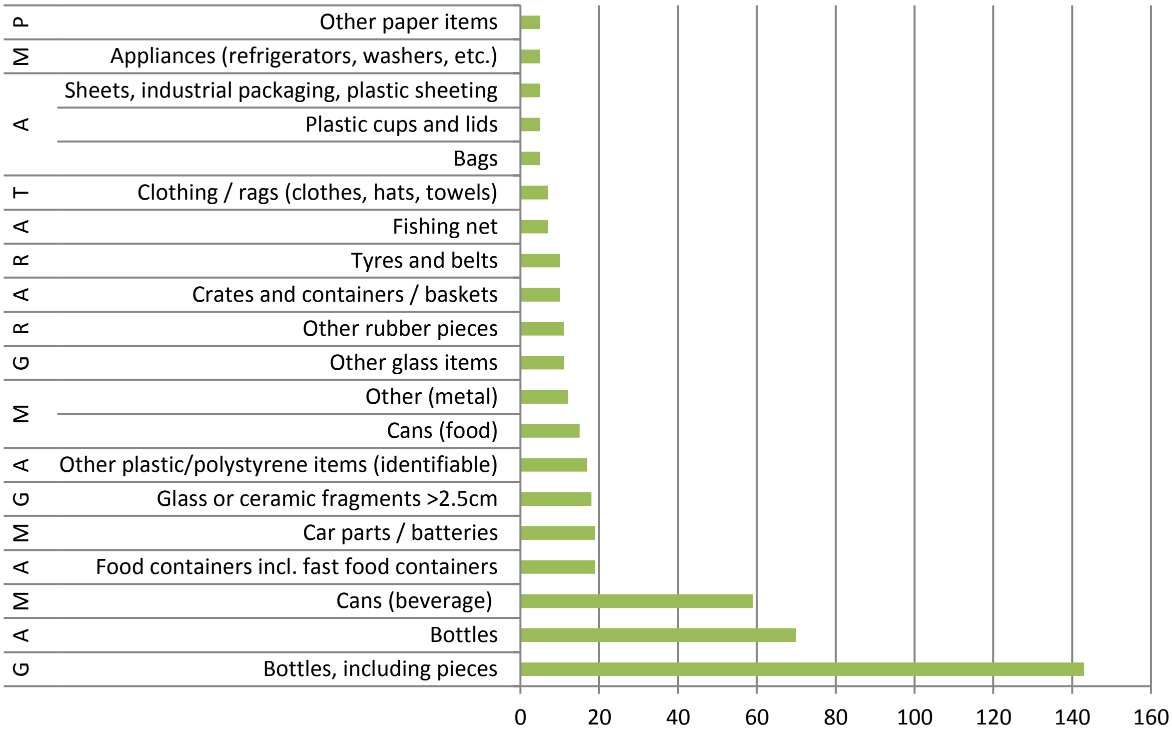

Figure 5. Top 20 seafloor litter items found in the Adriatic-Ionian Seas through visual census (number of items) (A = artificial polymer materials; G = glass/ceramics; M = metal; P = paper/cardboard; R = rubber; T = cloth/textile; W = processed/worked wood).

Common Indicator: Common Indicator 23 *Trends in the amount of litter in the water column, including micro-plastics and the sea floor (EO10)*

Case Study Title: Marine litter found on the *sea floor of the Mediterranean Sea: abundance at regional scale and time trends in the north-western basin*

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1. Brief introduction

Marine litter is found everywhere in the world ocean, with an extension to all compartments of the marine environment, from shores to the deeper areas (Thompson *et al*, 2009). As an isolated basin and a closed sea with special hydrodynamic conditions, its deep ecosystem and associated communities are considered as exceptional. All these characteristics reinforce the unique potential of the deep sea communities and the importance of preventive actions in order to limit human impacts on these fragile habitats (WWW/IUCN, 2004). In fact, accumulation of litter in on the sea floor is particularly important in the Mediterranean Sea where impacts through ingestion and entanglement of benthic organisms such as corals, sponges and gorgonians have been shown (BO *et al*, 2014).

Since the 70s, the issue of marine litter has been considered by the United Nations program and several directives and conventions (UNEP, 2015). The Mediterranean Sea, as most closed seas, has been described as one of the most affected by marine litter, and is subject to a monitoring program for seafloor litter, under development. This case study summarizes the situation of marine litter at the bottom of the Mediterranean Sea, and the results of the monitoring program for benthic litter since 1994 in the French Mediterranean Sea (Gulf of Lion).

2. Methodology (Data collection and analysis)

Data collected in the French Mediterranean Sea is mainly collected during demersal trawl surveys dedicated to the evaluation of fishery resources (Mediterranean International Trawl Surveys - MEDITS - http://www.sibm.it/SITO%20MEDITS/proprimary.htm), an international monitoring program for the assessment of fish stocks funded by the European Commission (DG Mare) and the participating countries, using a 20 mm trawl mesh with a trawl time of 20 to 150 min. The litter data are expressed in terms of density either in number per hectare or in number per square kilometer (nb / ha, nb / km²). Each item collected on board the vessel is counted and / or weighed and then classified as a litter type (by nature), in a category and sub-category as described in the MEDITS Technical Manual (2016).

3. Results of the Indicator Assessment

Data on marine benthic litter in the Mediterranean remain limited and may sometimes use different protocols (average density / weight, density / total weight, by tow, by surface area, etc.), making the results difficult to compare within each other (UNEP, 2015). These studies mainly concern the western Mediterranean, the Adriatic, the Aegean and some, rarer, from the eastern part of the basin. As summarized in Ioakeimidis et al., 2017, also considering the percentages of plastics, research enable to collect data on benthic litter by region, country and by deep ecosystem compartment,

Overall, the results indicate a high diversity of litter and accumulations in convergence zones, continental shelves, areas of high sedimentation, near coasts and urban areas and in canyons. High values were described in the western basin, in the middle of the Tyrrhenian basin and at the bottom of the eastern basin (Figure 1). A clear dominance of plastic, a common feature of the Mediterranean region, is described with several sites reaching values above 60% of plastics, and several hot-spots (> 80%) on the seabed (Ioakeimidis et al, 2017).

The first studies carried out in the area (Galgani et al., 1995, 1996, cited in Galgani et al., 2000) revealed the low density of litter on the continental shelf due to the main current and the strong flow of the Rhone River, disabling the accumulation of debris near the mouth and favoring their transport to the sea. The highest concentrations of debris were observed between 50 and 100 m depth in the northeast of the French Mediterranean (Bay of Cannes) and along the coasts around urban areas (notably Nice and Marseille).

In the Gulf of Lion, average values from 1994 to 2015 range from 0.29 to 2.9 items / ha (Figure 2). The typology indicates a great variability in the quantities of litter, with a clear dominance of the plastic items, which always exceed 80% per cruise. After plastics, textiles, glass and metals are the most encountered types in the Golf du Lion. While plastic, from undefined origin, was the most important part fishing was a major source of litter (Figure 3). Long-term data are scarce, but they show no clear or significant trend in changes in waste quantities, particularly plastics, over time in the Gulf of Lion.

4. Lessons learnt and/or recommendations

Access to the deep sea environment is considered as difficult, requiring expensive research and observations. Monitoring of benthic litter is therefore constrained by sampling difficulties and costs. Despite these obstacles, these studies appear imperative in order to better protect the deep Mediterranean ecosystem and to initiate targeted and effective actions for its preservation. It is therefore recommended that the work on marine litter should be opportunistic, as much as possible, in order to reduce monitoring costs. Monitoring programs for fish stocks are particularly suited for monitoring seabed litter.

The annual MEDITS fisheries cruises on fish stocks provide an opportunity for regular monitoring at limited costs, and the evaluation of the efficiency of measures. A common protocol facilitates the harmonization of methods and data management between countries. The information needed to calculate the number of debris per unit area (type of gear, sample area, trawl speed, etc.) can benefit from existing infrastructures for data collection and storage. The protocol enables to assess the quantities, typology, sources, location and trends. This protocol also contributes to the collection of seabed debris.

Despite this, monitoring needs to be further strengthened, particularly focusing on accumulation areas, in particular near the coasts, urban areas and canyons. This will then support reduction measures, in particular for plastics and debris from fisheries, the most represented litter on the Mediterranean Sea floor.

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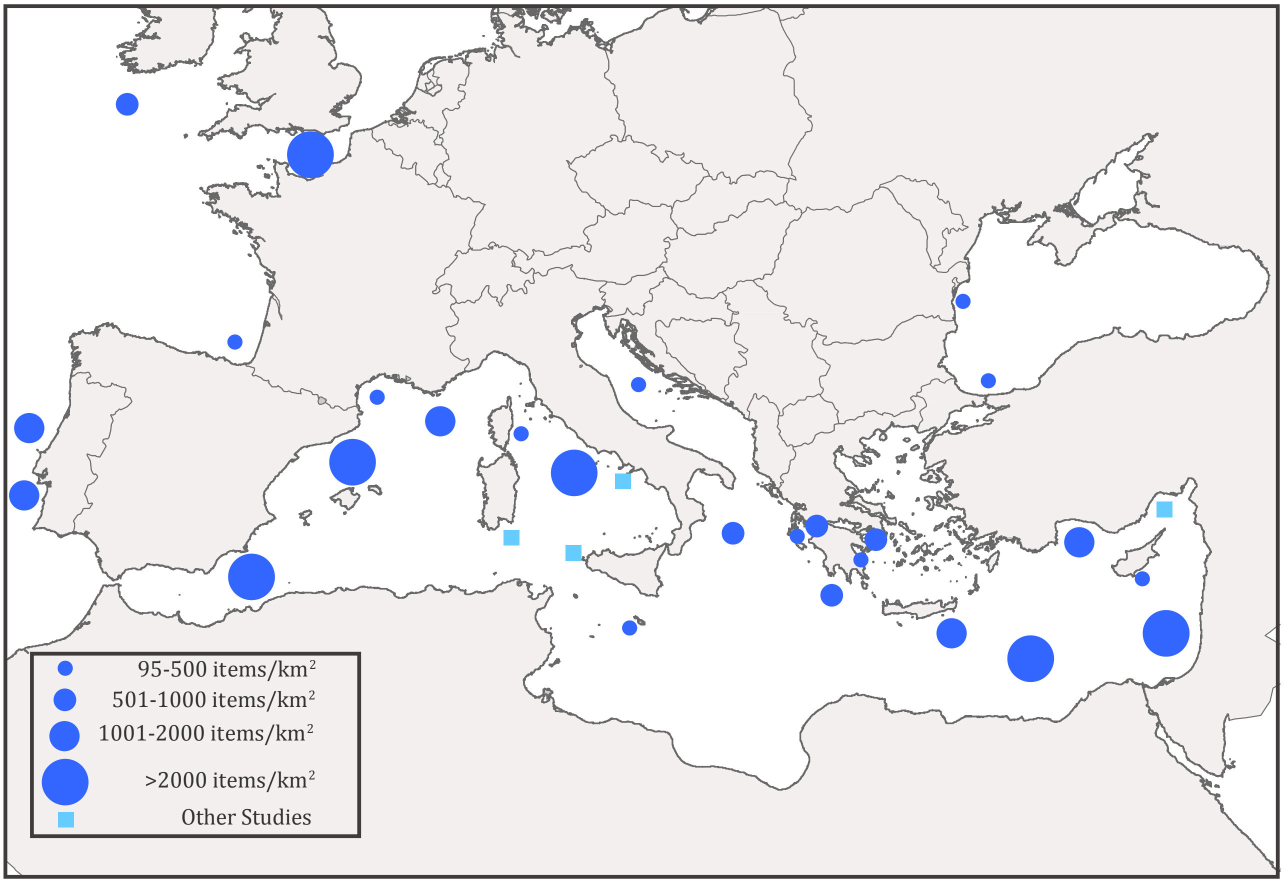

Figure 1: Seafloor marine litter distribution in the Mediterranean (Source: Ioakeimidis et al, 2017)

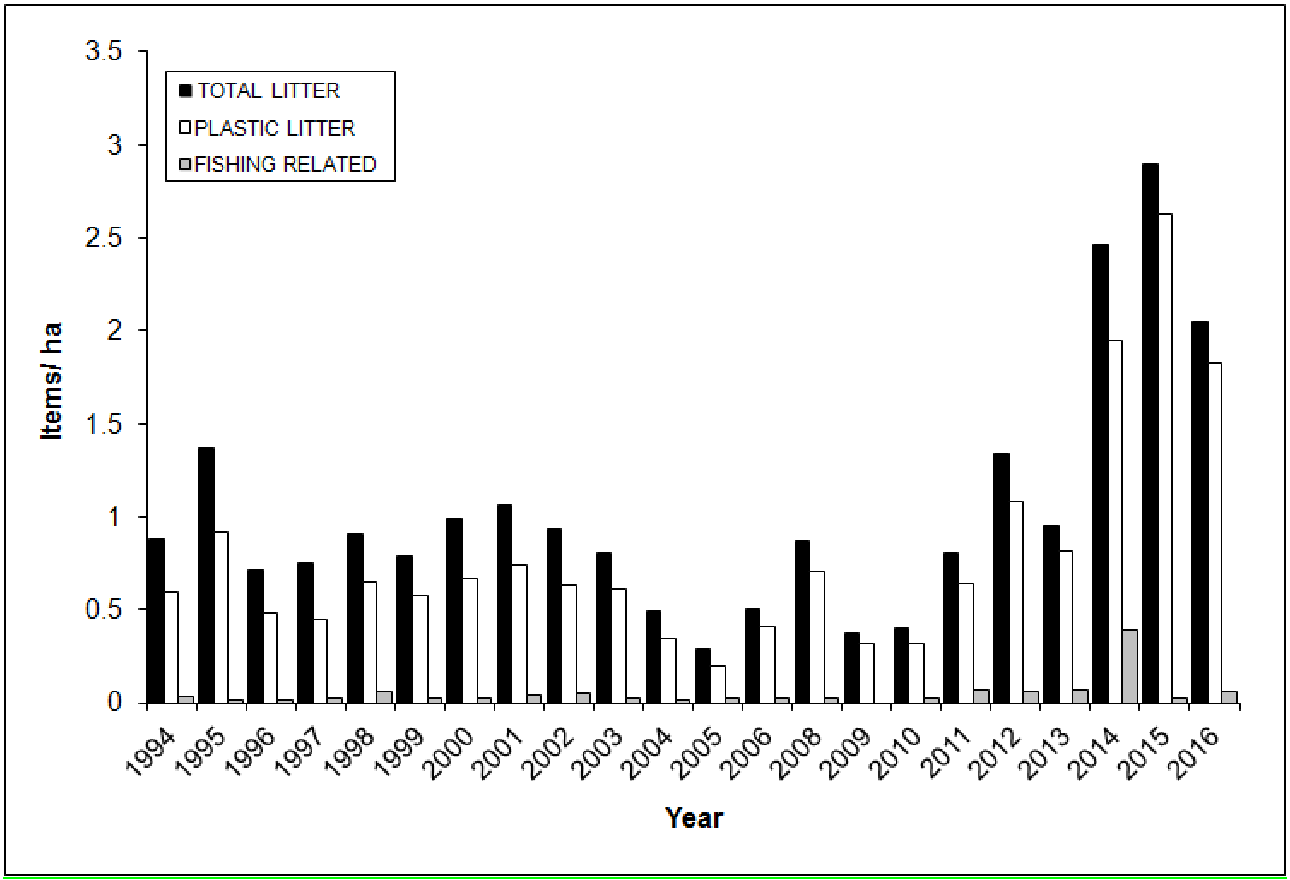

Figure 2: Sea floor Litter densities between 1994 and 2016 in the Gulf of Lion, French Mediterranean Sea, as collected during the MEDITS cruises (mean values)

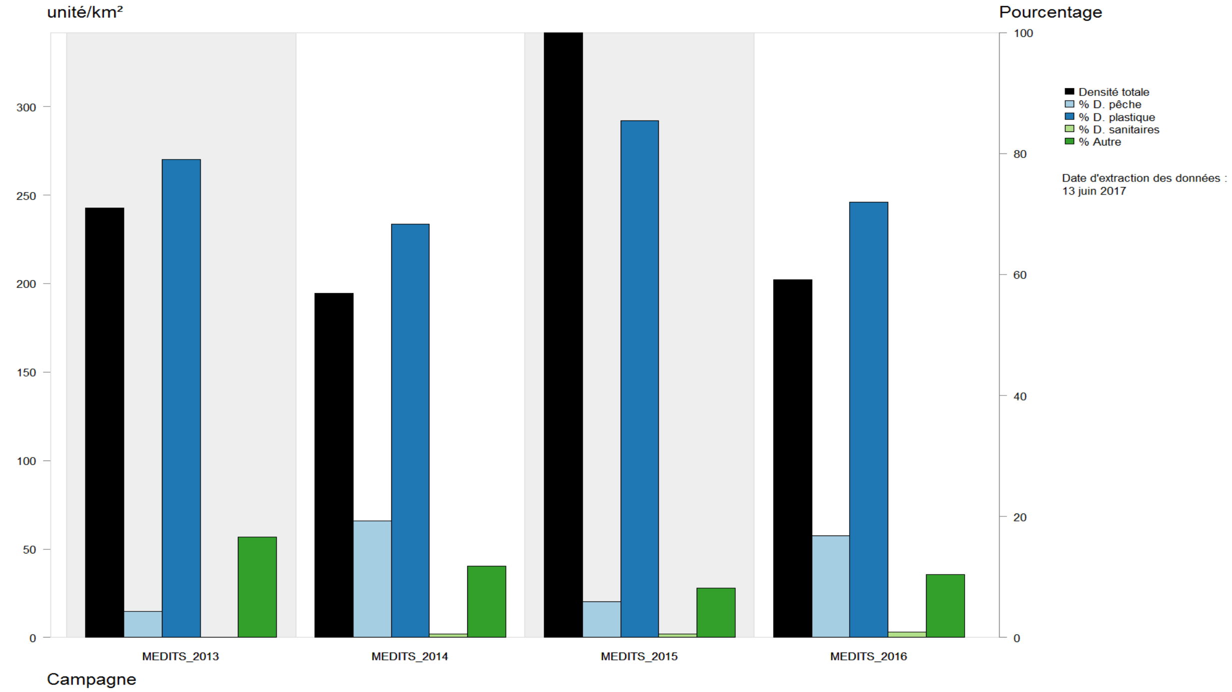

Figure 3: Total densities and percentages of types/sources of marine litter, Gulf of Lion, French Mediterranean Sea, MEDITS cruises

Common Indicator: Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source)

Case Study title: Marine Litter Fluctuations at the Metu Beach, Mersin Bay (Turkey), the Northeastern Mediterranean during 2013-2017

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1. Brief introduction

Beach marine litter were assessed along the Turkish coast in the North-Eastern Mediterranean Sea by Institute of Marine Sciences, Middle East Technical University (IMS-METU). This includes a pilot study, with 13 different beach locations, at Metu beach in 2014, and a monthly monitoring program (for a total duration of41 months) along the Cilician coastline during 2013 and 2017.

The Cilician coastline is a densely populated area of multiple uses, situated on the Turkish coast in the North-Eastern Mediterranean Sea, which hosts agricultural, tourism, fisheries and industrial activities. A total of 13 beaches, each one featuring a minimum transect of 100 m, of different substrate types (sand n=12; small gravel n=1) were selected for the surveys. During the study, environmental predictors characterizing beach use and potential land-based marine litter point sources located close to the beaches, were linked to litter densities in order to identify marine litter sources. Marine litter sources were assessed both in terms of function and origin by also taking into account transboundary marine litter items, and also secondary uses of items (see Aydin et al., 2016).

The beach at IMS-METU was used to survey marine litter between September 2013 and June 2017, as a model beach, which is restricted to public use and access and is, located in the Turkish coast of North-Eastern Mediterranean Sea. Results of the survey were analyzed until February 2017. The study was initiated in the framework of the MERMAID[29] project, in collaboration with two European partners. The selected beach is restricted to public use and access, with the exception of personnel and/or their families working or living at IMS-METU, who being environmentally aware of the marine litter problems, and hence their marine litter footprint on the beach was very limited. A pre-cleaning activity was carried out in the study area in order to be able to monitor marine litter deposition after the first sampling. The sampling area is also an important nesting area for the loggerhead turtle *Caretta caretta* and the green turtle *Chelonia mydas*, for which the nesting season starts in May (Cihan 2015). In the present case study, the preliminary results of the marine litter data collected over the period of 41 months from IMS-METU beach are presented.

2. Methodologies used for the collection and analysis of the data

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[29] (SEAS-ERA-EU FP7 ERA-NET / TUBITAK: 112Y394) – Marine Environmental targets linked to Regional MAnagement schemes based on Indicators Developed for the Mediterranean” (MERMAID)

For both the Cilician coastline and the IMS-METU beach the same methodology has been followed. The evaluation of the selected beaches for monitoring beach marine litter was done in accordance with the proposed beach marine litter survey site selection criteria, proposed by the Marine Strategy Framework Directive (MSFD) Good Environmental Status (GES) Technical Subgroup on Marine Litter (TSG-ML). Marine litter items with a size limit lower than 2.5 cm in their longest dimension were collected and categorized according to the "Master List of Categories of Litter Items" as provided by the TSG-ML (MSFD-TSGML, 2013). Beach marine litter abundance was expressed as number of items per square meter (items/m^2) and as weight per square meter (g/m^2). Marine litter items were collected along two different 100 m transects in sub areas along the 1800 m IMS-METU beach and were classified under 8 main material types (Plastic, Cloth, Glass and ceramic, Metal, Paper cardboard, Rubber, Wood, Unclassified).
The back of the beach was defined by a sharp change in vegetation density, the foot of a dune or a cliff or by built structures. Due to the expected high abundance of cigarette butts, these were only sampled within the 10m subunit.

3. Results of the Indicator Assessment

Cilician coastline: The average marine litter density was 0.92±0.36 items/m^2. Marine litter items resulting from convenience food consumption and smoking made up more than half of the total litter collected, while agricultural, industrial, fishing activities together contributed only 6% of the total number of items (Figure 1). Plastic items on average constituted more than 80% of the dominant material type. Percentages of the litter transported with currents from neighboring countries (transboundary litter) varied from 0 – 4.23% between the different beaches. Direct deposition on the beaches was identified as the main method for transport of items to the coastal environment. Data from this study which also provides baseline information for the area, was used to create a sound and easily applicable methodology for marine litter source determination. In the study area, evaluated beaches were exposed to high levels of litter pollution, with eight out of 13 beaches being classified as either dirty or extremely dirty according to the Clean-Coast Index (Alkalay etal. 2007).

METU beach: In total 7219 items were collected during the 41 month sampling period with a total weight of 94.4 kg (Figures 2-5). The average litter density was 0.022±0.012 items/m^2. Marine litter densities showed a similar trend and changed between 0.009 and 0.041 items/m^2, except for November 2013 (0.080 items/m^2) and February 2017 (0,195 items/m^2) (Figure 3A and B). Plastic litter was found to be the most abundant material in terms of both number and weight (Figure 4A and B). A Kruskal-Wallis H test was run to determine if there were differences in observed litter densities in the model beach between 3 years (2014 to 2015). Distributions litter densities were similar for all years, as assessed by visual inspection of a boxplot. Median litter density scores were statistically similar between years, $x^2(2) = .415$, $p = .813$ (Figure 5).

4. Lessons learnt and/or recommendations

- Monitoring beach litter especially in un-cleaned beaches (e.g. where there is restricted access to people) would have additional advantages for understanding litter transport dynamics either from the sea or from the neighbouring regions.
- Long term monitoring of the standing stocks of coastal macro-litter in the model closed beach indicates that the average litter densities showed a no significant difference through the 2014 – 2016 period.

- Beach use has been shown to remarkably contribute to the litter abundance on the beaches of the Cilician Coast, explaining among others the densities of the most prevalent litter functions (Rapid Consumption and Smoking).
- In order to achieve any reduction on coastal marine litter, the littering behaviour of beach goers and users and also that of the coastal inhabitants must be addressed through management plans. The high number of domestic tourists in the study region, many being present all year-round, makes easy the establishment of a target-group specific education programs and awareness campaigns.

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6. Graphs, pictures and tables

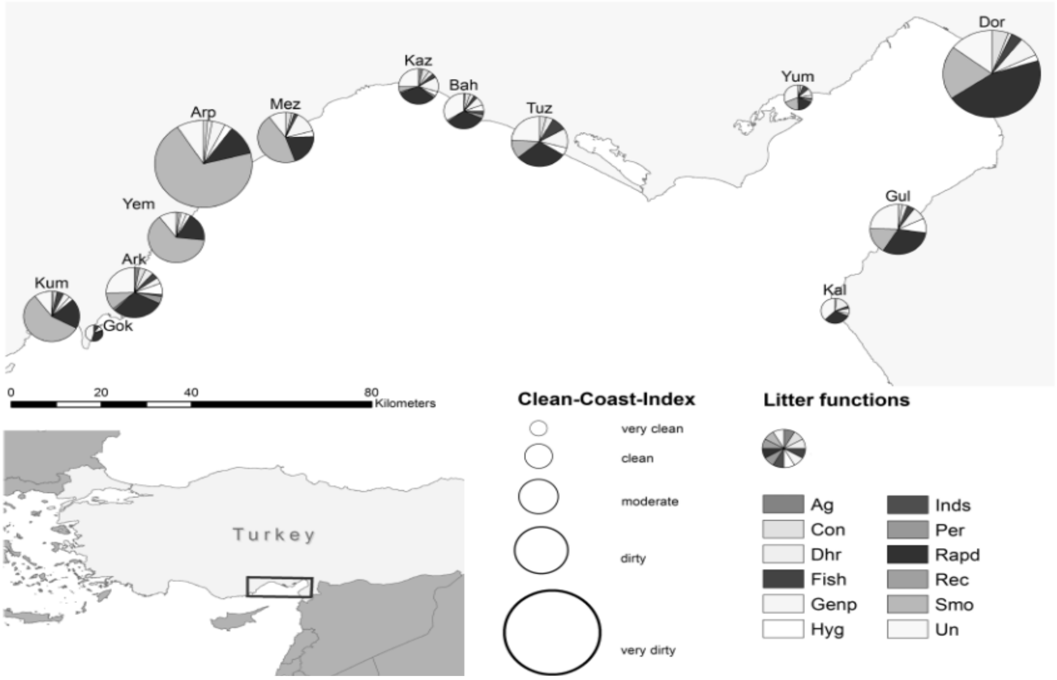

Figure 1: Composition of coastal litter in the Cilician Basin according to functions. The sizes of the charts vary according to the pollution status of the beach, expressed using the Clean Coast Index (Alkalay et al. 2007), with bigger charts referring to higher litter densities. (Ag: Agriculture, Con: Construction, Dhr: Domestic and Household, Fish: Fishing, Genp: General Packaging, Hyg: Medical and Personal Hygiene, Inds: Industrial, Per: Personal Use, Rapd: Rapid Consumption, Rec: Recreation, Smo: Smoking, Un: Unclassified) (Aydin et al., 2016)

Figure 2: Two sub sampling areas (L and O3) were sampled monthly for the evaluation of litter washed ashore and/or deposited on the coastline at a model beach between September 2013 and February 2017

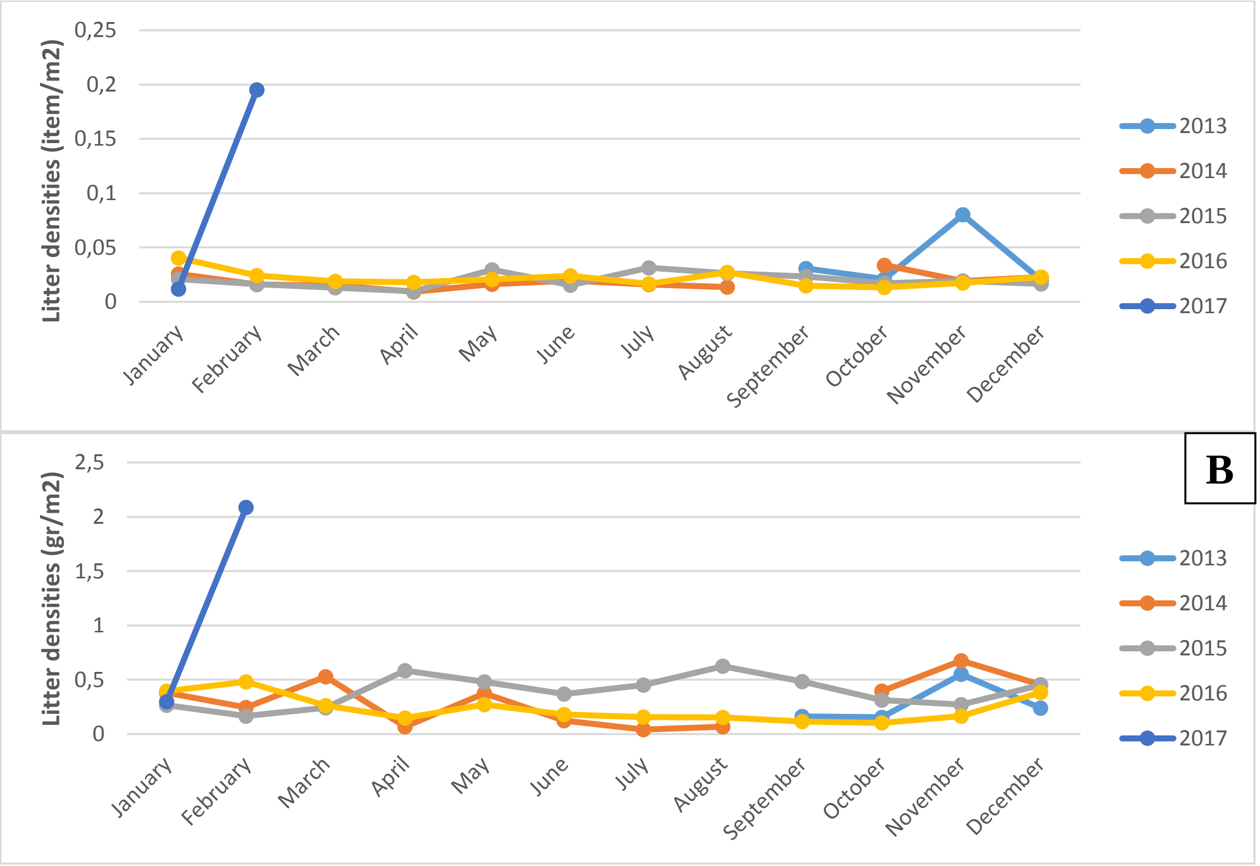

Figure. 3: Temporal changes in METU beach (Erdemli, Mersin, Turkey) litter densities (A: item/m^2, B: gram/m^2)

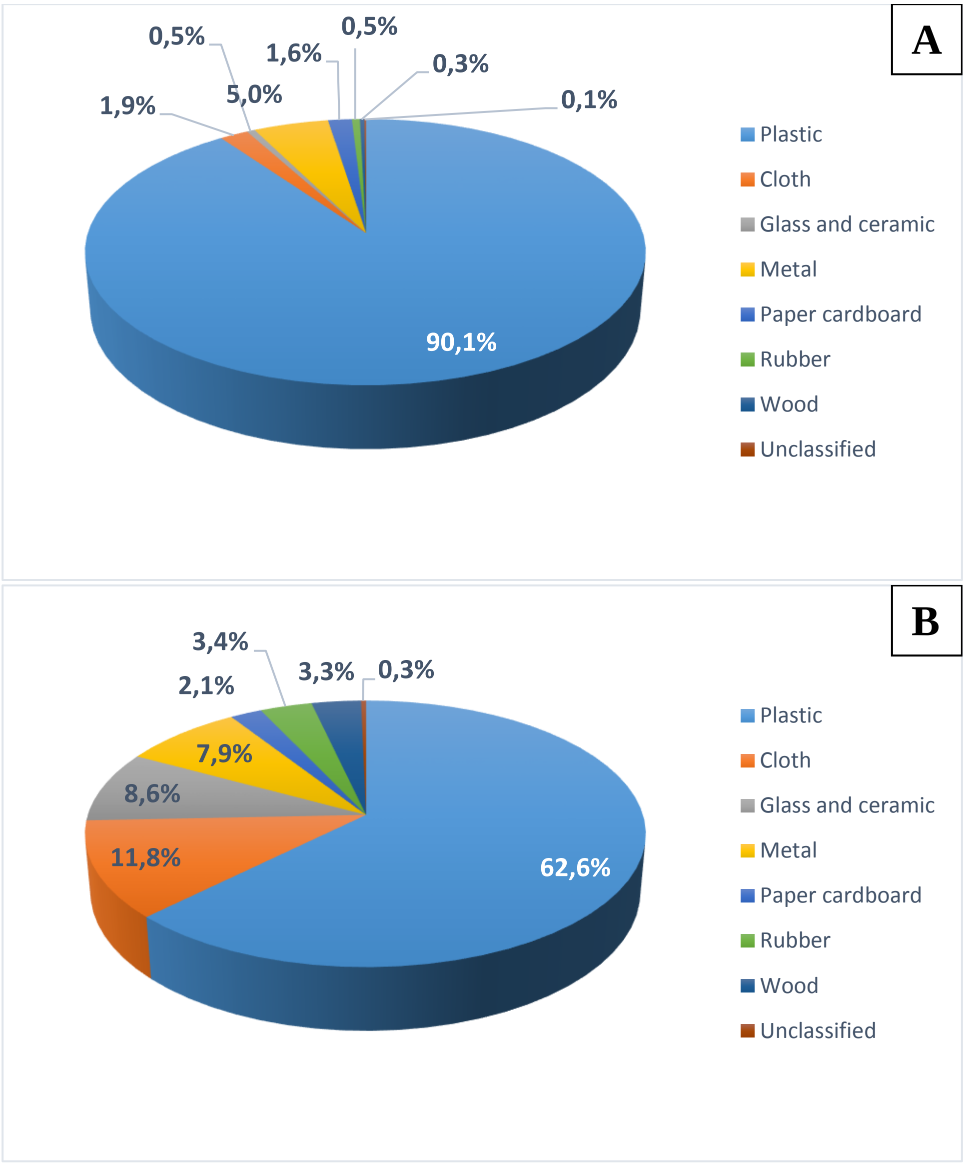

Figure 4: Composition of beach litter in the METU model beach according to material (A: number of litter, weight of litter)

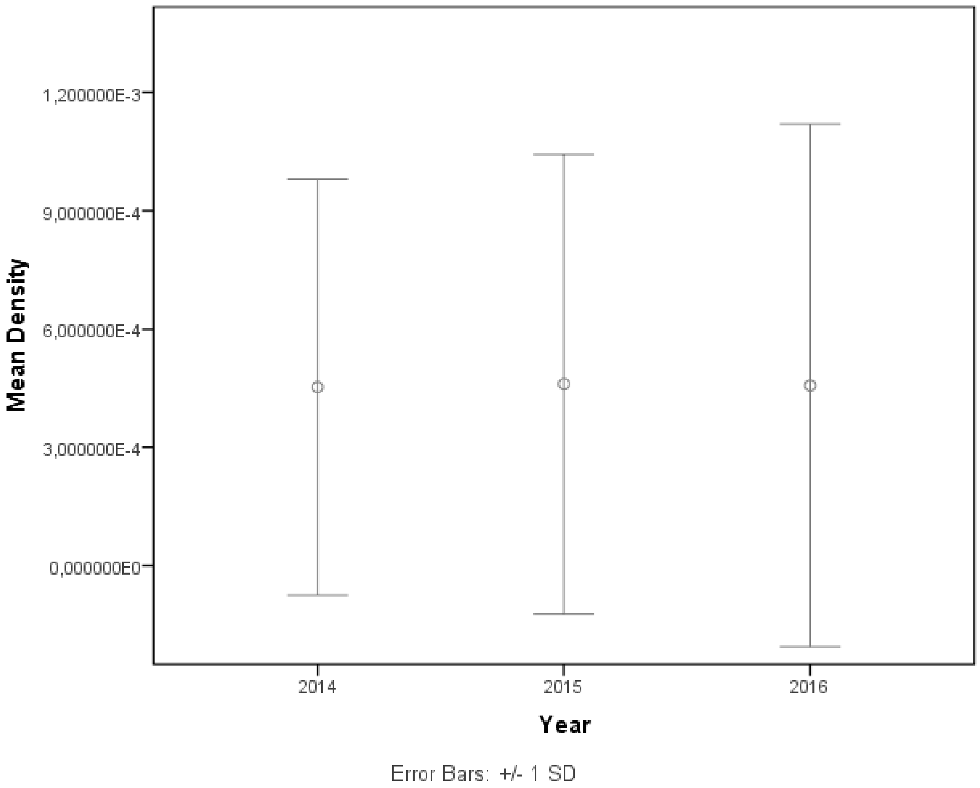

Figure 5: Average litter densities between 2014 to 2016 in the METU model beach

Common Indicator: Common Indicator 23 *Trends in the amount of litter in the water column, including micro-plastics and the sea floor (EO10)*
Case Study title: Microplastic Pollution on the Sea Surface, Water Column and Sediment of Mersin Bay (Turkey), in the Northeastern Mediterranean

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1. Brief introduction

It is well documented that marine litter is found almost in every component of the oceans, from densely populated coastal areas to offshore waters or to the poles; from surface to the deepest regions in the sea. There are also examples of marine litter (especially plastic) ingestion or entanglement by a wide range of marine organisms.
Marine microplastics could have two different sources: (a) Primary microplastics (produced originally at microscopic size); and (b) Secondary microplastics (fragments from originally larger plastic items) (Cole et al., 2011).

Although there are increasingly more recent studies on microplastics, there are still key open questions in relation to levels of marine micro-litter in different compartments of the sea including that in the biota which are all necessary for the assessment of management actions towards reducing their levels and impacts. According to both the Marine Strategy Framework (MSFD) and UNEP/MAP, monitoring the levels of microplastics and assessing their impacts are necessary, though the methodologies for these studies are mentioned as inconclusive and require further work. We provide here the assessment of 3 years (2014-2016) of microplastics sampled from the sea surface, water column and sediment from 3 stations in Mersin Bay, in the North-Eastern Mediterranean (Figure 1; Kideys et al. 2017) as part of Turkish National Monitoring Programme[30] (MoEU-DGEIAPI & TUBITAK-MRC, 2014; 2015; 2016). Sampling was performed from the 3 stations shown in Figure 1, as single samples during the summer of 2014 and 2015 and as triplicate samples during the summer of 2016.

Evaluation of microplastic pollution in the marine environment, along the coastal zone of the Cilician Basin was also performed within the framework of a nationally funded research project. The aim of the TUBITAK-ÇAYDAG project 114Y244 (entitled as; "Estimating the quantity and composition of microplastics in the Mediterranean coast of Turkey; the potential for bioaccumulation in seafood") is the initial assessment of the extent of microplastic pollution in both water and sediment samples along the coastal zone of the Cilician Basin. A total of 18 locations were selected and evaluated in the area (Figure 2).

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[30] The large scale national monitoring program "Integrated Marine Pollution Monitoring Programme" is implemented by the Ministry of Environment and Urbanization (MoEU) and is coordinated by MoEU with TUBITAK Marmara Research Center (TUBITAK MRC) with the involvement of several Marine Sciences Institutes and Water Resources Department of the national Universities.

2. Methodologies used for the collection and analysis of the data

For both studies, the MSFD TSG-ML manual was used for the collection and processing of samples (MSFD-TSGML, 2013). A manta net (40x20 cm frame) with a mesh size of 333 µm was towed for 10 min for sea surface samplings. Standard WP2 zooplankton sampling net (60 cm in diameter with a 200 µm mesh) was used to collect water column samples. Sediment samples were collected with using Van Veen bottom sampler (having an area of 0.1 m²). 50 ml of sediment samples that were taken from the top layer of the collected sediment were stored in aluminium foils and kept frozen during survey. All samples were transported to the microplastic laboratory of the Institute for further analysis.

Sea water samples were filtered first using 1 mm sieve and then a 26 µm zooplankton mesh by vacuum device. To remove organic material retained on the mesh, sea water samples were treated with 35% hydrogen peroxide in petri dishes for one day. Concentrated saline (NACI) solution (1.2 g cm^{-3}) was used during extraction of microplastics from sediment samples by density separation technique (bulk separation). Floating material in the solution were filtered using 26 µm zooplankton mesh.

Microplastic (MP) that is stayed on sieve or mesh were picked up with tweezer under Olympus SZX16 Stereomicroscope (max magnification 30X) equipped with DP26 – Olympus 5.0 MP High Color Fidelity Microscope Digital Camera. For each station, MPs gathered to Whatman GF/F glass microfiber filters (47 mm pore size) and their photos was taken. Length of each particles was measured with Olympus cellSens platform (Image Analysis software) and kept in petri dishes for further analyses. Those particles were coded according to their physical properties (colour, material) according to the Microplastic Coding System (developed to category microplastic types by Microplastics Group of the METU-IMS). MPs were assigned inside six categories; fiber, hard plastic, polystyrene, pellet, rubber and other/miscellaneous. In addition, each category has colour codes (e.g. blue fiber (F4), black hard plastic (H12) etc.).

3. Results of the Indicator Assessment

Monitoring Program: In all three years, the main types consisting the microplastics were hard plastics, fibers, nylon (this one especially in the last year), and others (Figure 3). Whilst hard plastic and nylon prevailed in surface water and water column, fibers were the dominant microplastic type in the sediment. Considering the fact that waste treatment waters are one of the main sources of fibers (due to washing of clothes), this indicates that waste water treatment plants should be included in the research and monitoring programs for the management of marine litter.

The three-year trends in the levels of total microplastics are shown in Figure 4. Although it seems that there is a decreasing trend over the years for the all three stations studied, there is special concern for the 2014 values (which was from a single sample) because of higher probability for contamination when analyses had just begun. The last year results (i.e. 2016) were analysed with care against contamination and triplicate samples were used and hence are considered more reliable. Differences among the triplicate samples obtained in 2016 were tested, and it was found that whilst sediment samples were not different from each other, sea surface or water column samples differed statistically (Table 1). This indicates that: (a) the levels in sediment are more reliable and; and (b) the latter two marine environments should be sampled at least in triplicate. There are limited difference between the values of 2015 and 2016. It should be noted that a three-year study is not sufficient to assess the trends in the levels of microplastics in different marine environments. Monitoring at least a five-year period would be needed to see any trend of increase or decrease in their levels.

Research Project: In total 1517 microplastic particles were collected and classified. The quantity of microplastic particles in surface water samples ranged between 16.339 for SEYSW2 to 520.213 per km^2 for SEYSW3 location (Table 2). Mainly two categories were present in sediment samples - fibers and hard plastic with only an occasional occurrence of nylon (Güven et al. 2017).

4. Lessons learnt and/or recommendations

(a) Monitoring microplastic levels especially in sediment is a promising tool to be used as marine litter contamination.
(b) Triplicate sampling is important for sound assessment of microplastic levels in marine environment.
(c) At least a five-year monitoring data is needed for understanding trends in microplastic pollution.
(d) Wastewater facilities should also be monitored for their microplastic levels for the management of microplastic pollution.

5. References and web links

Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin*, *62*(12), 2588–2597. https://doi.org/10.1016/j.marpolbul.2011.09.025.

Güven, O., Gökdağ, K., Jovanović, B., Kıdeyş, A.E., (2017. Microplastic litter composition of the Turkish territorial waters of the Mediterranean Sea, and its occurrence in the gastrointestinal tract of fish. Environ. Pollut. 223, 286–294.

MSFD-TSGML (2013). Guidance on monitoring of marine litter in European Seas—a guidance document within the common implementation strategy for the marine strategy framework directive. EUR-26113 EN. JRC Scientific and Policy Reports JRC83985. 128 p. http://dx.doi.org/10.2788/99475.

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Kideys A.E., K. Gökdağ, O. Güven & Ç. Polat. İzleme projesi kapsamında mikroplastik çalışmaları –2014, 2015, 2016 ve deniz çöpleri çalışmalarına ek öneriler (Microplastics studies within the framework of monitoring project 2014, 2015, 106 and additional suggestions for the marine litter investigations). Presentation at the Meeting on the Assessment of the 2016 Integrated Monitoring Project in Turkish Seas, Ankara, 19-20 June 2017.

6. Graphs, pictures and tables

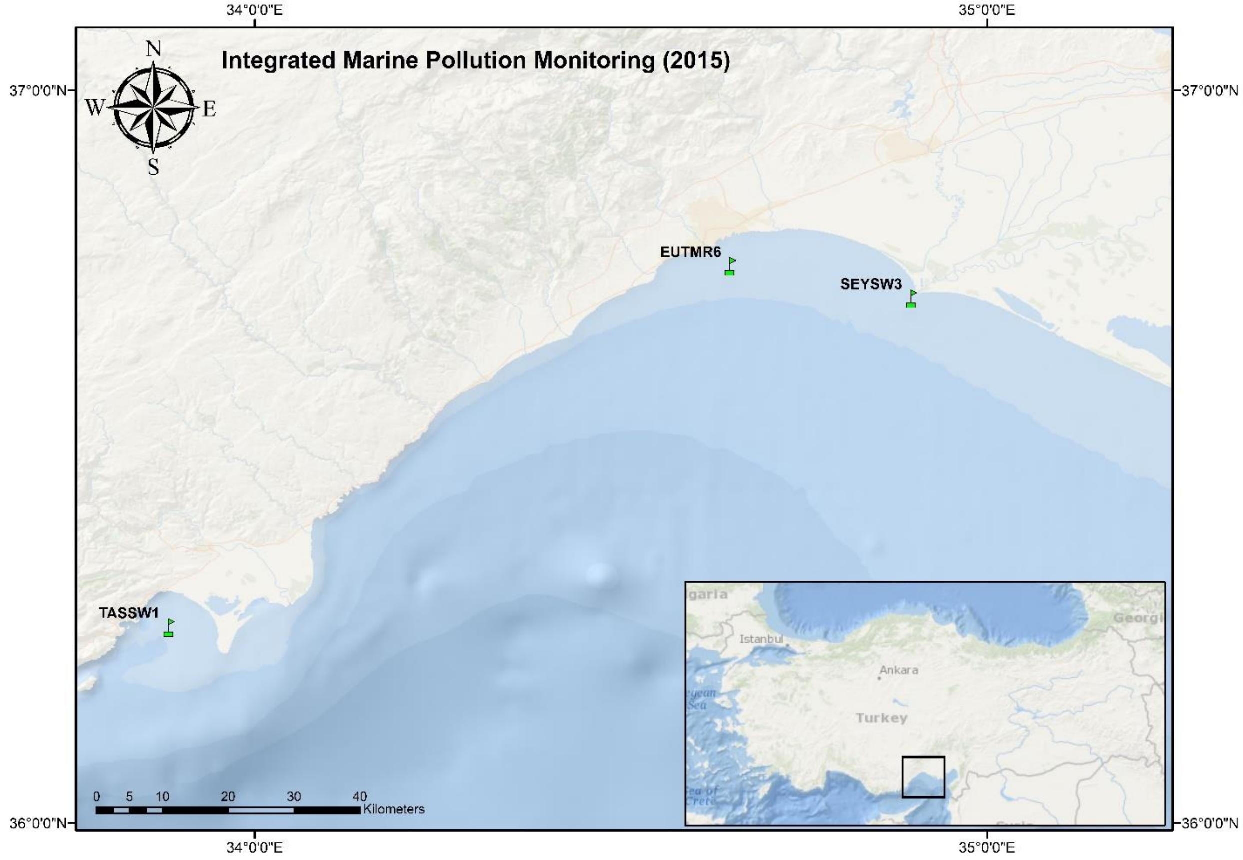

Figure 1: Microplastics sampling stations for sea surface, water column and sediment in Mersin Bay, the North-Eastern Mediterranean during summers of 2014, 2015 and 2016.

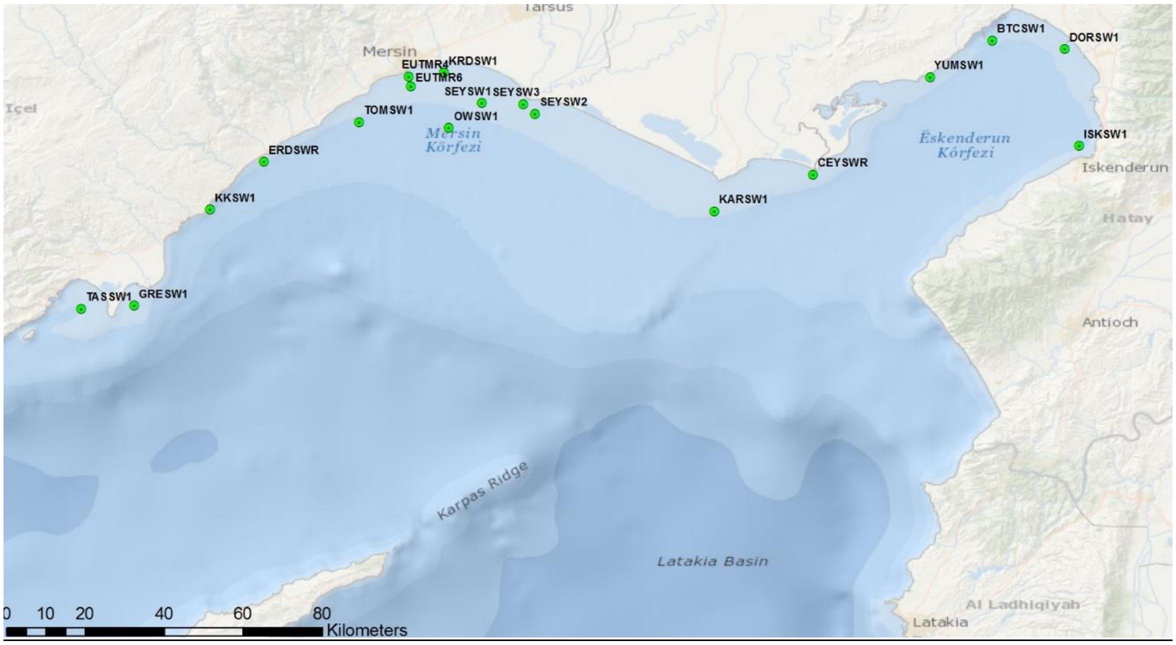

Figure 2: Map of sampling locations (114Y244)

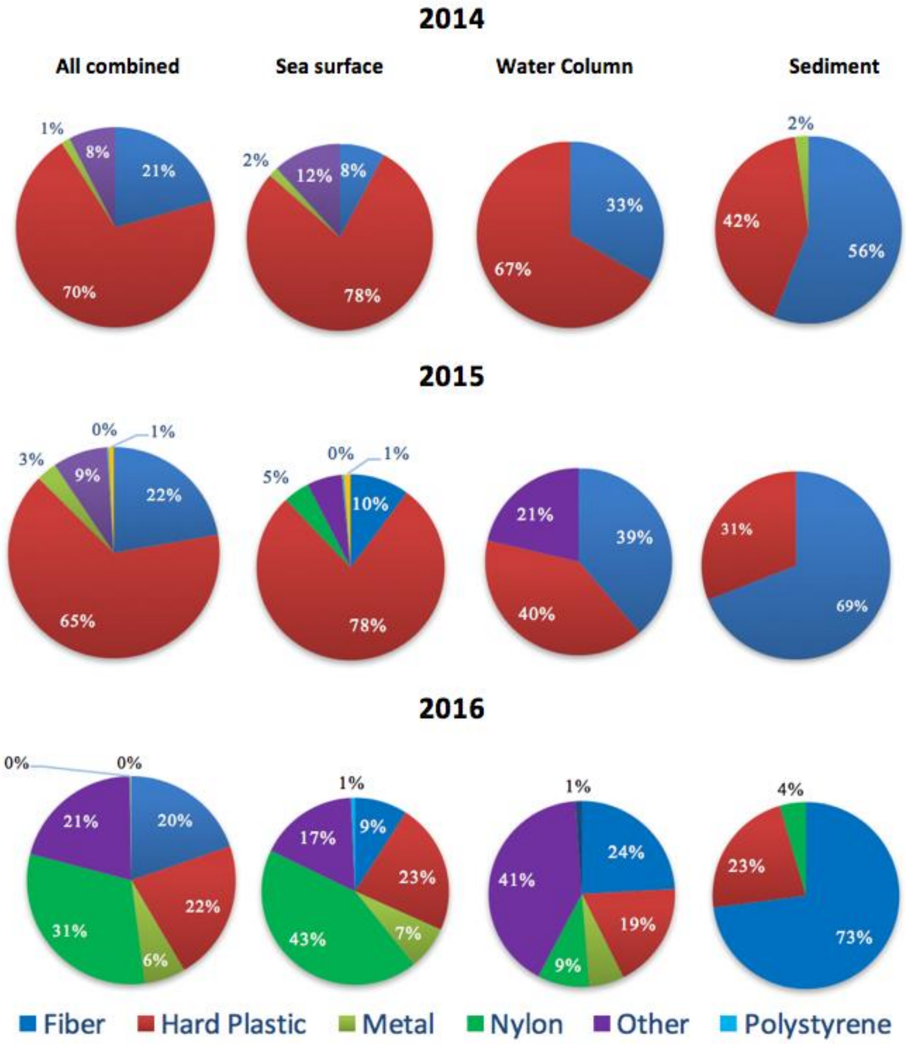

Figure 3: Trends in the microplastic types (as percentage of total number) during 2014, 2015 and 2016 based on averages of 3 stations in Mersin Bay, the North-Eastern Mediterranean. (Total particle numbers are for 2014 SW 838, WC 249, S 214, for 2015 SW 265, WC 75, S 42 and for 2016 SW 262, WC 88, S44).

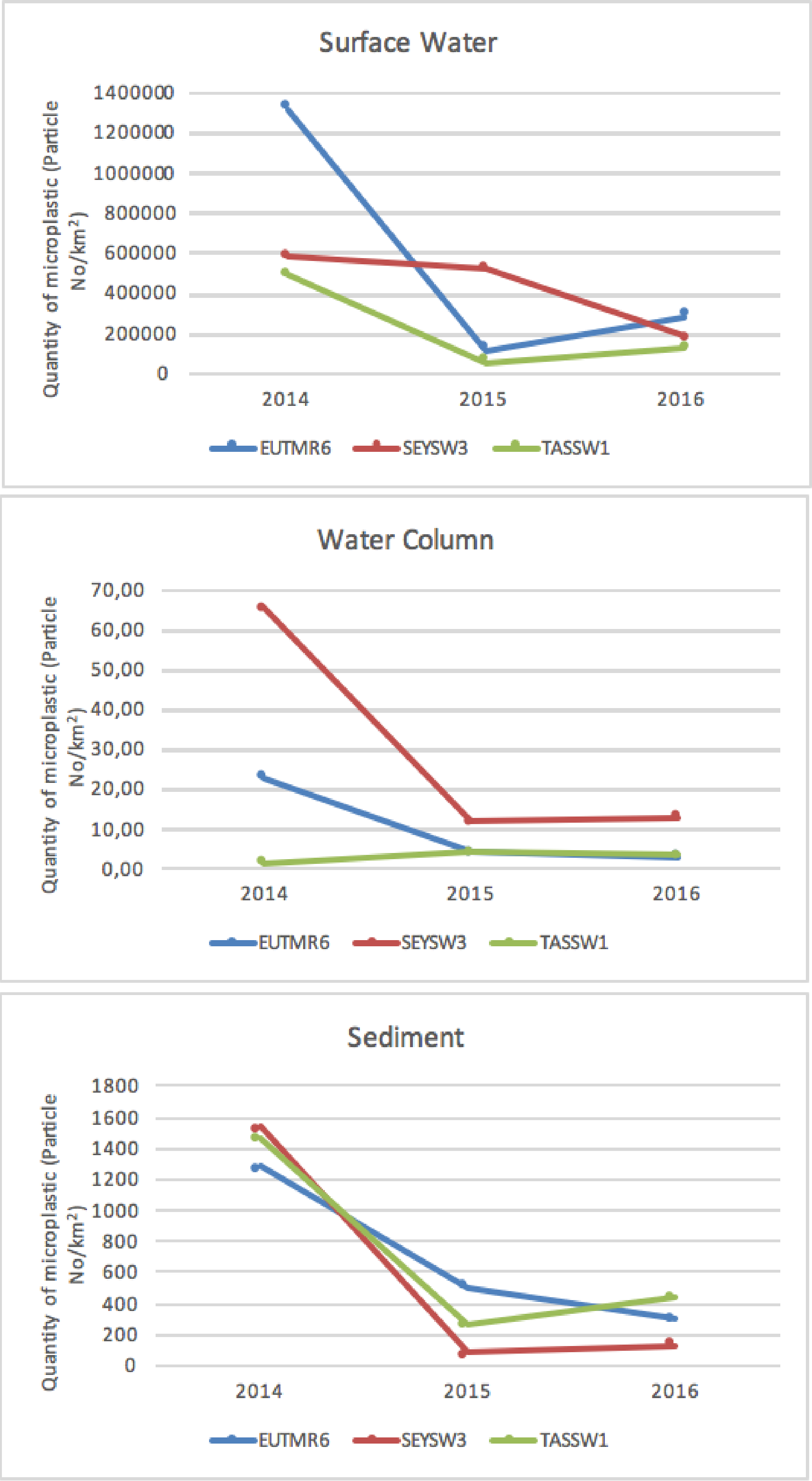

Figure 4: Trends in the microplastic levels in different components of the marine environment during 2014, 2015 and 2016 for each station in Mersin Bay, the North-Eastern Mediterranean

Table 1: Friedman Test results for analysing statistical difference (*significant at p 0.05 level) within among triplicate samples of Sea surface, water column and sediment during 2016 for each station in Mersin Bay, the North-Eastern Mediterranean

Station	***Sediment***	***Sea surface***	***Water column***
EUTMR6	*.554*	*.000**	*.256*
TASSW1	*.355*	*.004**	*.177*
SEYSW3	*.761*	*.740*	*.000**

Table 2: Quantity of microplastic particles (<5 mm) discovered in sea-surface samples (Güven et al. 2017)

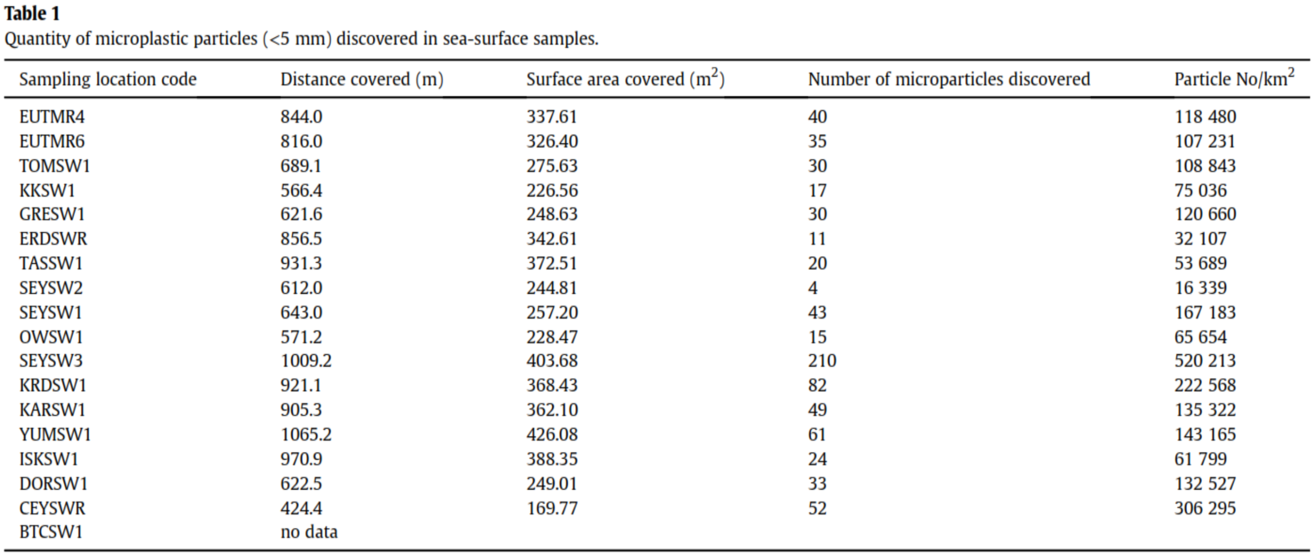

Table 1
Quantity of microplastic particles (<5 mm) discovered in sea-surface samples.

Sampling location code	Distance covered (m)	Surface area covered (m^2)	Number of microparticles discovered	Particle No/km^2
EUTMR4	844.0	337.61	40	118 480
EUTMR6	816.0	326.40	35	107 231
TOMSW1	689.1	275.63	30	108 843
KKSW1	566.4	226.56	17	75 036
GRESW1	621.6	248.63	30	120 660
ERDSWR	856.5	342.61	11	32 107
TASSW1	931.3	372.51	20	53 689
SEYSW2	612.0	244.81	4	16 339
SEYSW1	643.0	257.20	43	167 183
OWSW1	571.2	228.47	15	65 654
SEYSW3	1009.2	403.68	210	520 213
KRDSW1	921.1	368.43	82	222 568
KARSW1	905.3	362.10	49	135 322
YUMSW1	1065.2	426.08	61	143 165
ISKSW1	970.9	388.35	24	61 799
DORSW1	622.5	249.01	33	132 527
CEYSWR	424.4	169.77	52	306 295
BTCSW1	no data			

Annex II

List of Case Studies for the Ecological Objectives 1 (Biodiversity), and 2 (Non-Indigenous Species)

The Annex II provides the list of Case Studies that have been submitted by Contracting Parties and Partners for the Ecological Objectives 1 (Biodiversity) and 2 (Non-Indigenous Species).

EO1	Title	Contracting Parties, Partners	Authors and Affiliation
1	Bottlenose dolphins of the Gulf of Ambracia, Western Greece.	Greece and SPA/RAC	Joan Gonzalvo; Director Ionian Dolphin Project, Tethys Research Institute, Italy.
2	Cuvier's Beaked whale, *Ziphius cavirostris*, distribution and occurrence in the Italian waters of the Pelagos Sanctuary (NW Mediterranean sea).	Italy	Massimiliano Rosso, CIMA Research Foundation, Via Magliotto 2 - 17100 Savona, Italy. Paola Tepsich, CIMA Research Foundation, Via Magliotto 2 - 17100 Savona, Italy. Aurelie Moulins (PhD), CIMA Research Foundation, Via Magliotto 2 - 17100 Savona, Italy.
3	Overview of the assessment of the Common Indicator 1: Habitat distributional range (EO1), based on CAMP assessments results for Montenegro and EcAp/MSP Boka Kotorska Bay pilot project	Montenegro	Jelena Knezević, MAP Focal Point, Ministry of Sustanible Development and Tourism. Milena Bataković, SPA/RAC FP, Environmental Protection Agency of Montenegro. Ivana Stojanović, assistant to MAP FP, Ministry of Sustainable Development and Tourism.
4	Loggerhead sea turtle *Caretta caretta* in the Kuriat islands, Tunisia	Tunisia and SPA/RAC	Imed Jribi, Faculty of Sciences of Sfax. Mohamed Nejmeddine BRADAI, Institut National des Sciences et Technologie de la Mer (INSTM) – (National Institute of Marine Sciences and Technologies), Tunisia.

EO2	Title	Contracting Parties, Partners	Authors and Affiliation
1	Invasive versus native bottom-trawl fish species diversity and population dynamic at the soft-bottom habitats of the Southeastern Mediterranean coast of Israel.	Israel	Nir Stern, Israel Oceanographic and Limnological Research (IOLR) Hadas Lubinevsky, Israel Oceanographic and Limnological Research Dror Zurel, Marine Monitoring and research Coordinator, Israel Ministry of Environmental Protection, Marine Environment Protection Division. Prof' Barak Herut, Israel Oceanographic and Limnological Research

Common Indicator 4: Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles)

Case study title: Bottlenose dolphins of the Gulf of Ambracia, Western Greece

Author:
Joan Gonzalvo; Director Ionian Dolphin Project, Tethys Research Institute, Italy.

1. Brief introduction

The coastal waters of Greece still harbour a remarkable diversity of cetacean fauna compared to other parts of the Mediterranean. Yet, this richness is decreasing due to degradation of the marine environment. Research and conservation activities conducted, since 1991, by Tethys Research Institute (hereafter Tethys) in close cooperation with SPA/RAC, in the coastal waters of Western Greece within the frame of the Ionian Dolphin Project with the support of SPA/RAC, aim at identifying measures to slow-down, halt or reverse such trends.

In 2001 Tethys started a study in the semi-closed waters of the Gulf of Ambracia (also known by its Greek name of the “Amvrakikos” Gulf), where the common bottlenose dolphin *Tursiops truncatus* (Figure 1), hereafter referred to as bottlenose dolphin, is the only cetacean species encountered. In the Mediterranean Sea this is the most common cetacean over the continental shelf, where its distribution appears to be scattered and fragmented into small units. Identifying those population units and assessing their boundaries is crucial to implement effective conservation measures to protect small resident populations and ensure the survival of this species across its range.

Figure 1: Common bottlenose dolphins photographed in the Gulf of Ambracia showing the characteristic morphology of the species. Bottom-right image shows an adult bottlenose severely affected by a skin condition firstly reported by Gonzalvo et al. (2015). Photos by J.Gonzalvo/Tethys Research Institute.

Cetaceans living in coastal areas, and particularly in semi-closed inshore habitats, such as the Gulf of Ambracia, are exposed to risks from a variety of anthropogenic sources and are especially vulnerable because they often have restricted geographic ranges, disjoined distributions and limited movements. In this increasingly degraded Gulf, where bottlenose dolphins are found at an average density of 0.37 animals km^2, one of the highest observed densities in the Mediterranean for this species (Bearzi et al., 2008a), dolphins may be suffering significant physiological stress caused by anthropogenic activities (Gonzalvo et al., 2015). Research on dolphin abundance, population trends, site fidelity, as well as conservation activities (i.e., education and public awareness initiatives) are presented here, to document how the local dolphin community interacts with its environment and how human activities may influence its conservation status.

2. Methodologies used for the collection and analysis of the data

The Gulf of Ambracia is a shallow, semi-closed embayment of 405 km^2 whose only communication with the open Ionian Sea is through the Preveza Channel, a narrow (minimum width of 370m) and shallow (2–12 m) 3 km-long corridor (Figure 2). On average, the depth of the Gulf is approximately 30 m (maximum 60 m), and its bottom consists mostly of mud or sand. It is characterized by abundant wildlife and, in addition to providing a key habitat for bottlenose dolphins, it is an important foraging ground for loggerhead sea turtles *Caretta caretta* and a breeding site for Dalmatian pelicans *Pelecanus crispus*. Its northern side, a complex ecosystem, is composed of a double delta from the rivers Arachthos and Louros and their associated marshes and lagoons are of particular importance for bird diversity.

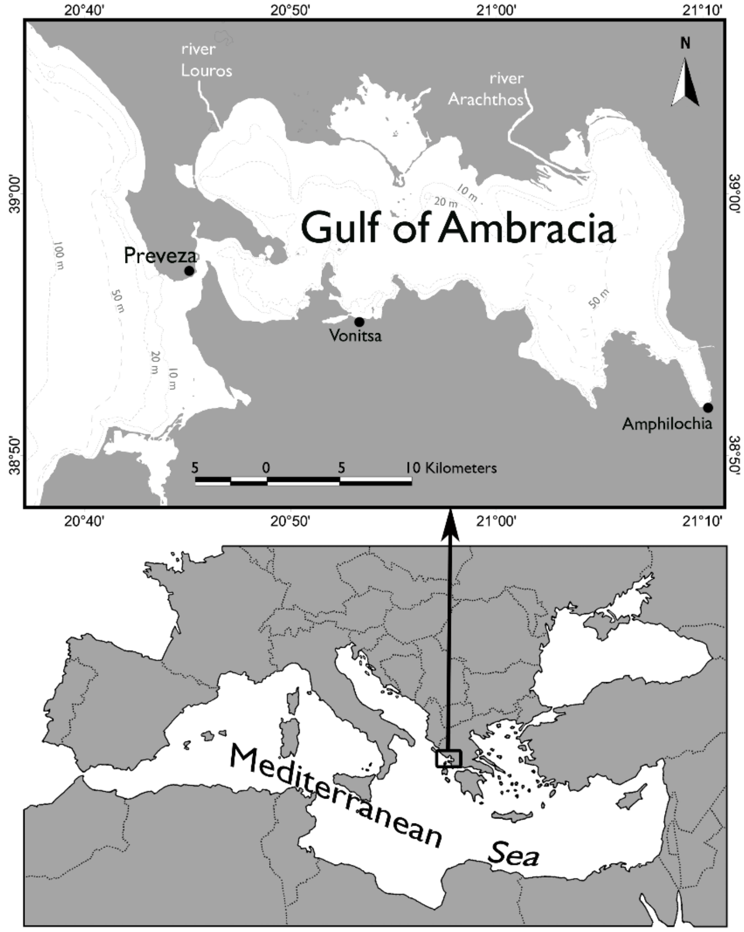

Figure 2: Map of the Gulf of Ambracia.

After the initial years of irregular research effort, since 2016, boat surveys have been conducted on predefined routes designed to guarantee monthly uniform effort coverage of the whole Gulf of Ambracia. Survey conditions were considered as “positive” under daylight and good visibility, sea state ≤3 Beaufort (large wavelets, crests beginning to break and scattered whitecaps) and with, at least, two observers scanning the sea surface looking for dolphins. When spotted, dolphin groups were approached at low speed, progressively converging with their routes and avoiding sudden changes of speed and directionality to minimize potential disturbance.

During each dolphin sighting, photo-identification effort was conducted to obtain as many good images as possible of every individual present throughout the duration of the observation, using digital SLR cameras equipped with a zoom lens, avoiding bias toward any particular individuals. Photo-identification was consistently based on long-term natural marks such as notches and nicks in the dolphins’ dorsal fins as well as on any additional marks in other body parts (Franzosini at al., 2013). Identifications were used to construct individual sighting histories. In most cases, calves were recognized in the field primarily based on their regular association with an identifiable adult dolphin (i.e. mother). This non-invasive method was used to provide information on site fidelity (i.e. how often individual animals use the Gulf) and by applying mark-recapture techniques, dolphin abundance was estimated and look at possible population trends between 2006 and 2015.

3. Results of the Indicator Assessment

Across 10 years of research in the Gulf of Ambracia, with 74 months spent in the field and a total of 770 daily surveys, more than 13,000 km of survey effort were covered under positive conditions, resulting in 631 bottlenose dolphin sightings, a total of 185 dolphins identified and almost a thousand hours spent with dolphins. Throughout 2006 and 2007 monthly surveys were also conducted in the neighbouring open waters of the Ionian Sea to look for bottlenose dolphins in the vicinities of the mouth of the Gulf, where a total of 667 km of survey effort under favourable conditions produced only one sighting in which 15 bottlenose dolphins were photo-identified; none of them were ever found inside the Gulf prior to or after that.

The rate at which new individuals were photo-identified during the 10-year study period is shown in Figure 3. This discovery curve rose sharply in 2006, coinciding with the start of the photo-identification work, and then increased more slowly followed by an asymptotic pattern from 2007 onwards. The progressive flattening of the discovery curve and the high site-fidelity shown by the dolphins (Figure 4) indicate that the population was effectively geographically closed (i.e. confined to the Gulf of Ambracia) during sampling seasons across the study period.

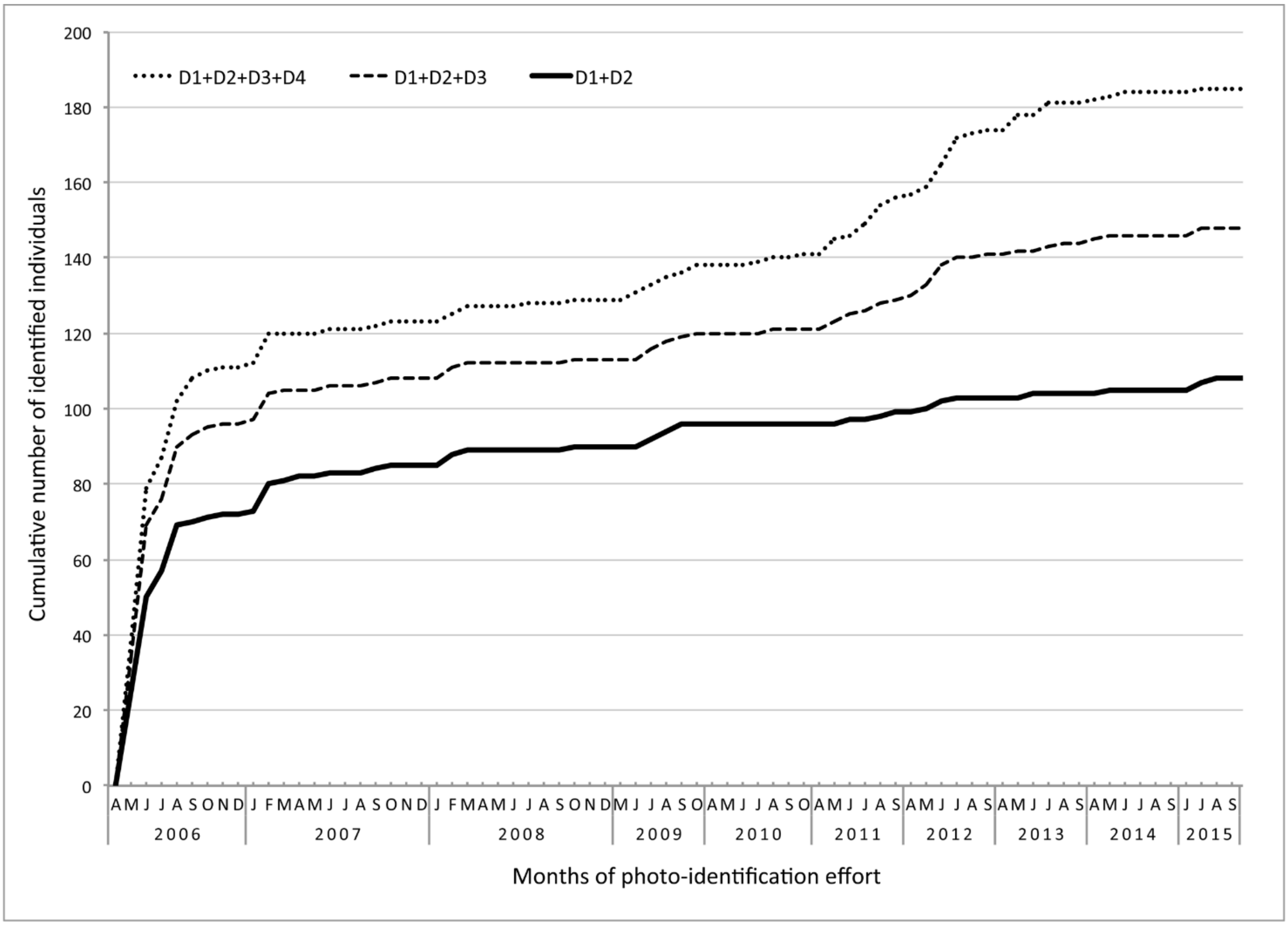

Figure 3: Discovery curves, taking into account the degree of distinctiveness (from D1-highly marked to D4-poorly marked), for individually identified bottlenose dolphins across 2006-2015 in the Gulf of Ambracia.

The population estimates over the 10-year study mostly fell between 130 and 170 with CVs (coefficients of variation) averaging about 10%. We are therefore confident that the true size of the population lies within this range. Our most recent estimate based on photographic mark-recapture resulted in 134 animals (CV = 0.11) residing in the Gulf in 2015. The estimated trend in population size over the 10 years indicated a decline of 1.6% per year; nevertheless, this was not considered to be statistically significant. These dolphin numbers are particularly relevant if we bear in mind that a population size estimated to number fewer than 250 mature individuals can be classified as Endangered under criterion D (IUCN, 2012) and our most robust estimates of the total number of bottlenose dolphins in the Gulf of Ambracia never exceeded 170 individuals.

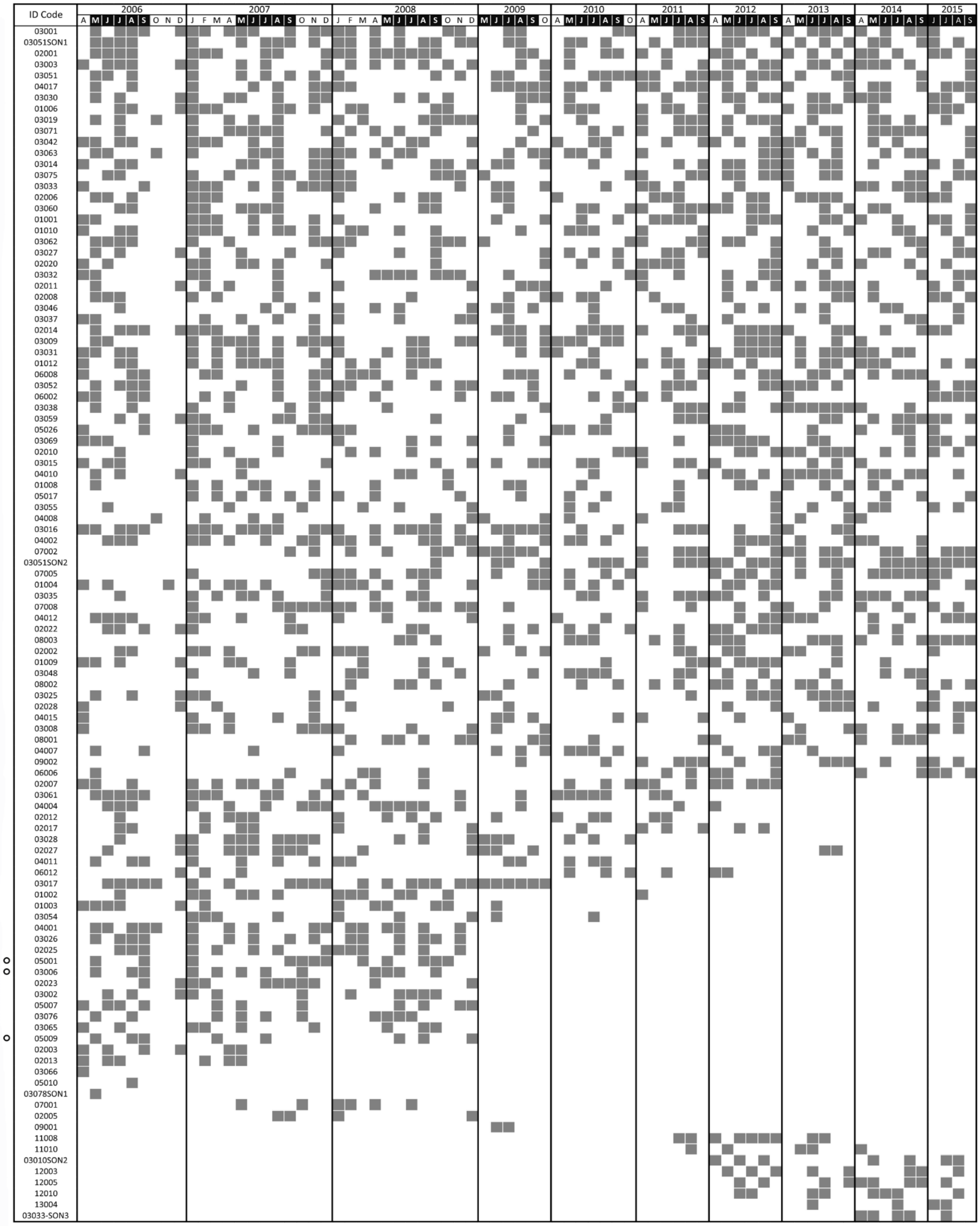

Figure 4: Residency pattern of marked (i.e., D1+D2) individuals in the Gulf of Ambracia. Grey cells indicate presence documented through digital photo-identification. Months included in the mark-recapture model are shown with white letters on black background.

Before appropriate conservation and management actions for threatened species and their habitats can be developed, it is necessary not only to obtain information on trends in abundance and status, but also to identify anthropogenic factors responsible for their decline and degradation. In this regard, fishermen's ecological knowledge, accumulated over the course of their fishing careers, can be invaluable and significantly help marine researchers and resource managers by providing information critical for improving management of fish stocks and rebuild marine ecosystems. In the Gulf of Ambracia, the local active fishing fleet totals about 360 boats and is composed exclusively of small-scale fishing boats working primarily with set nets (i.e., trammel and gill nets), targeting mainly small pelagic/epipelagic fish (i.e., sardines) and shrimp. The activities and interactions of this fishing fleet with dolphins have also been the subject of our studies. In recent years, research work was complemented by numerous local public awareness and educational initiatives, which led to the establishment of a relationship of trust between the research team and the local community and, particularly, with fishermen. This prompted, in summer 2011, to interview 50 fishermen of the Gulf of Ambracia to gain their insights into past abundance of fish and changes in ecosystem status and quality, dolphin–fisheries interactions as well as dolphin population trends and status, and to ask them about the main management measures needed in the Gulf. This initiative also helped to increase the marine conservation awareness of fishermen by inviting them to reflect on issues that traditionally have been largely ignored by their community, and to gain their collaboration and support promoting adequate ecosystem-based management measures for the conservation of this increasingly fragile coastal ecosystem.

Our interviews confirmed that local fishermen unanimously believed that fish stocks have declined significantly during the last two decades. However, they did not have a clear opinion about dolphin population trends. Despite most fishermen reporting that dolphins caused them significant economic loss through net and fish damage, they described dolphins as 'special' animals and defined them as intelligent and beautiful. This was a considerable change in the attitude of these fishermen, who in the early years, when work started in this area, were suspicious, and claimed that dolphins had to be killed. It is noteworthy that not so long ago, until the early 1970s these fishermen would be rewarded by the Greek Government for each dolphin killed; a strategy shared by other Mediterranean countries at that time. Fortunately, public opinion has changed from one of no apparent concern for dolphin suffering and death, to genuine sadness and compassion. Moreover, the intentional killing of dolphins by fishermen as a form of retaliation or culling was never reported; however, almost half of the respondents were aware of the incidental capture of dolphins, primarily in trammel and gill nets.

Fishermen of the Gulf of Ambracia advocated the introduction of measures to curtail habitat degradation as a top management priority. It is well known that due to the isolated character of the Gulf of Ambracia, its water quality is strongly influenced by man-made processes; input of organic matter and pollutants comes from various sources, with the rivers Louros and Arachthos as the main pathways bringing agricultural runoff. Fish farms, agriculture, livestock and discharges of domestic sewage from coastal towns and villages contribute to the nutrient enrichment of the Ambracian waters, which are rather murky and highly eutrophic, leading to bottom anoxia (oxygen depletion); a phenomenon especially acute in the Eastern side of the Gulf. Failure to take action in a timely manner may lead to irreversible environmental damage coupled with the need for harsher regulatory measures.

The conservation status of dolphins reflects ecosystem changes and degradation over time. In fact, the increasingly degraded conditions of the Gulf of Ambracia may be influencing the dolphin's epidermal integrity or causing them physiological stress, as suggested by the prevalence of different skin conditions in this dolphin population observed during the processing of hundreds of images derived from our extensive photo-identification efforts (Gonzalvo et al., 2015).

Since 2004, in addition to the work mentioned above with local fishermen, numerous educational and public awareness initiatives have been conducted, which have so far reached a total audience of almost 4,000 people with lectures at local schools and presentations open to the general public, to inform the local community about the work done by Tethys in the area and to raise awareness about dolphins and marine conservation.

4. Lessons learnt and/or recommendations

This long-term monitoring co-financed by SPA/RAC indicate that bottlenose dolphins density in the Gulf Ambracia is among the highest recorded anywhere in the Mediterranean Sea, even if this species is reported abundant throughout the Mediterranean coastal waters. This viability in the Gulf of Ambracia may be at risk due to their likely reproductive isolation, small population size and small extent of occurrence, as well as acute and growing anthropogenic impacts in their semi-closed shallow habitat. Management of human pressures is an obvious way of reducing such a risk, consistent with national and regional commitments to protect this coastal area and cetaceans generally. These charismatic cetaceans may be used to trigger and sustain protection of the marine environment; as flagship species they can play a crucial role in raising public awareness, to convey a clear conservation message and to gain the collaboration of stakeholders.

The natural beauty and potential for ecotourism activities in the Gulf of Ambracia, together with an already well-developed and fully operational tourism industry in the adjacent areas of the Ionian Sea, pose a favourable scenario for developing complementary activities that may help local fishermen. Both the fishing community of the Gulf and visitors have shown great interest in the possibility of developing fishing tourism (i.e. hosting people – which are not boat crew – in professional fishing boats for recreation, demonstration of fishing methods, and provision of tourism services linked to fishing). Such an activity, if properly managed, could be a significant tool for the harmonious coexistence between fishermen and the natural environment through the emergence and protection of the natural, historical, cultural and traditional values of the region.

In 2008, the Gulf of Ambracia was designated as a ‘National Park’ in accordance with Greek national legislation (11989/08 KYA). In addition, the northern side of the Gulf, characterized by its marshes and lagoons offering an important nesting area for a large diversity of birds, is included in Natura 2000 and Ramsar sites and is protected by national, European, and international legislation. These different recognitions are in progress to be translated into direct action to ensure the conservation of locally abundant marine megafauna (i.e., bottlenose dolphins and sea turtles).

In light of this long-term monitoring of the Common Indicator 4, a proposal of extension of the coverage of the existing Natura 2000 Area of the Gulf of Ambracia (to include the totality of the Gulf) was announced in June 2016 to the Greek Ministry of Environment, Energy and Climate Change.

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Common Indicator 3: Species distributional range

Case Study title: Cuvier's Beaked whale, *Ziphius cavirostris*, distribution and occurrence in the Italian waters of the Pelagos Sanctuary (NW Mediterranean Sea)

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1. Brief introduction

The Cuvier's beaked whale (*Ziphius cavirostris*) is considered among the eight cetacean species occurring in the Mediterranean sea. Its presence is confirmed for the whole Mediterranean basin, particularly in the Alborán Sea, Ligurian Sea, central Tyrrhenian Sea, South Adriatic Sea and the Hellenic Trench (Podestà et al., 2016). This typical cetacean of the pelagic deep slope habitat is particularly associated with special topographic features as submarine canyons. Sightings of this deep-diver species in the Mediterranean area was mainly inferred by using stranding data (Podestà et *al.,* 2006, 2016) since its elusive behaviour, with short surfacing and quite inconsistent blows, makes this species very difficult to study at sea (Heyning, 1989).

A high degree of genetic differentiation was observed between Atlantic Cuvier's beaked whales and the Mediterranean population (Dalebout et al., 2005). Haplotype diversity was lower in the Mediterranean Sea than in the North Atlantic, suggesting that this population may be isolated and relatively small and it should be considered as a separate Evolutionarily Significant Unit, distinct from other populations. This beaked whale Mediterranean sub-population is classified as "Data Deficient" (Canadas, 2012) by the International Union for the Conservation of Nature (IUCN) Red List and a proposal to change the current listing to "Vulnerable" or "Threatened" is currently under review. The change of classification is prompted by the multiple mass stranding of Cuvier's beaked whales which occurred in the Mediterranean basin during recent decades, causing the death of at least 100 animals, related to seismic surveys and naval exercises using mid-frequency active (MFA) sonar (Frantzis, 1998, 2015; Podestà et al., 2006, 2016).

In order to gather information about distribution, habitat preferences and population size of Cuvier's beaked whale in the Pelagos sanctuary (NW Mediterranean Sea), CIMA Research Foundation started a long-term initiative to assess the distribution of this species through the *Ziphius Project*. The monitoring began from 2004 with the aim to collect data on the species using different types platforms increasing the temporal and spatial coverage thanks to many collaborations with Italian institutions as the University of Genova (2004-2009), the whale watching company BluWest (2004-2007), WWF Liguria (2005-2006), and also ongoing cooperation with Golfo Paradiso snc (since 2011), Consorzio Liguria ViaMare (since 2011) and Corsica Ferries (since 2008).

The present case of study analyzes the Cuvier's beaked whale dataset over 10 years (2005-2014) in order to assess the status of the Common Indicator 3 "Species Distribution Range" of the "Ecological Objectives" (EO) 1 "Biodiversity" in the framework of the implementation of the ecosystem approach roadmap, particularly the IMAP.

2. Methodologies used for the collection and analysis of the data

CIMA Research Foundation committed itself to monitor and assess this deep diver species distributional range since 2004. Dedicated sea surveys were carried out in the Pelagos Sanctuary in the framework of three main projects, as the *Ziphius Project*. All along the *Ziphius Project*, survey design was conceived in order to maximize the probability of encountering the species. At this end, research effort was more concentrated in the preferred habitat for the species (Moulins 2007, Tepsich, 2014). Surveys were conducted all-year round, with more effort during spring-summer months.

Since 2005, CIMA Research Foundation colleaborated with local whale watching companies, in order to increase data collection. Every year during the whale watching season (from April to September), one researcher from CIMA Research Foundation embarked on whale watching vessels in order to collect survey data. Observers on whale watching vessels use both binoculars and the naked eye.

The monitoring Protocol for data collection differs slightly according to the vessel restrictions. The vessel position is always recorded along the survey with a tablet (equipped with a GPS) using smartphone application *Locus Map Free - GPS Outdoor* at 1 second resolution. The associated information collected along the track (as marks) is also collected using *Locus Map Free*. It includes weather conditions (recorded every half an hour), vessel traffic (together with meteorological data and every time there is a sighting), cetacean sightings (species identification, number of animals, distance sampling data, behaviour, immersion/emersion and real position when possible) and associated species sightings.

A 10x10km grid[31] was used for performing distribution analysis, a combined file from the European Environment Agency grids[32] available for Italy and France and cut in order to cover only the Pelagos sanctuary area (with an extra buffer outside of the Pelagos Sanctuary of 15km). The native projection system of the grid is Lambert Azimuthal Equal Area projection (ETRS89-LAEA), as indicated in the EU INSPIRE Directive. The 10x10km resolution is preferred to coarser ones indicated in the Indicator Factsheets considering the specificity of the species. This grid was used to plot track and sighting data in order to produce respectively effort and distribution grids. Considering the difference in sampling design, for analysis purposes dedicated/whale watching data have been grouped together (see Moulins, 2007; Tepsich, 2014) while Ferry data have been analyzed separately. Grids were produced at an annual temporal resolution as well as a global, with data from the entire considered periods. Species distribution range were investigated considering all the cells containing in at least one confirmed sighting of the target species.

As the aim of the analysis is to investigate the distributional range of the species, all the available sighting data was used, regardless of the weather condition. Considering the ecology of the species, no differences in winter/summer distributions were expected, so only annual maps have been produced. Trends were investigated by comparing annual maps, using effort grids to discuss inter-annual differences (to take into consideration effects of effort bias occurring year by year).

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[31] The grid can be visualized using www.seawetra.org with the login “Guest” and the tag “Reference grid”

[32] http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2#tab-gis-data.

3. Results of the Indicator Assessment

In 10 years (2005-2014), 203 sightings of Cuvier's beaked whale were collected (with a total number of animals of 471-498). The quantity of data obtained with this dataset is particularly high considering the difficulties to collect data on this particular species. As indicated during the Meeting of the Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries in March 2017 (UNEP/MAP, 2017) the spatial distribution of marine mammals is largely affected by the research effort thus, it is necessary to precise that the 203 sightings were collected with a research effort covering about 72000km on-effort (Table 1 in Annex).

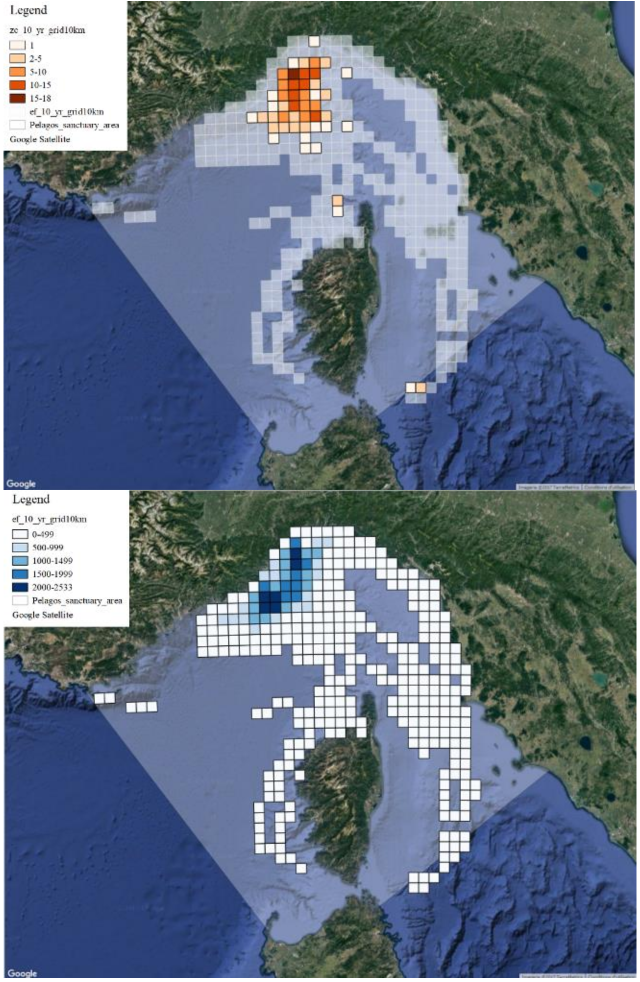

Figure 1: Sighting (right) and research effort (left) distributions in the Italian waters of the Pelagos sanctuary, over the 10-year of study, represented on the 10x10km grid. Coordinate system: ETRS89 / LAEA Europe - EPSG:3035.

The distribution map[33] of the sightings is presented in Figure 1 (left). Cuvier's beaked whale was observed in 48 cells with a range of sightings per cell of 1-18. Considering the grid resolution, the species is distributed on about 4800km^2, with a main area located in the north of the Pelagos Sanctuary and two small clusters (both of 200km^2) located off north-west of Corsica (off Saint Florent) and off the north-east of Sardinia (off Olbia). This result needs to be considered according to the spatial distribution of the research effort during the 10 years. The

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[33] The maps can be visualized using www.seawetra.org with the login "Guest" and the tag "Cetacean distribution range".

total research effort is distributed over 343 cells (cells with a minimum of 2km on-effort), covering 34300km^2 thus about 40% of the Pelagos Sanctuary area (Figure 1 right). This distribution is not even over space, with some cells more sampled than others, thus the distance per cell is ranged from 2 (the minimum to consider the cell sampled) to 2,532km.

Over the years, the number of sightings (indicated in Figure 2 and Annex-Table 1) shows a high variability (minimum of sightings: 3 in 2010; maximum of sightings: 69 in 2005), with a global average of 20.3 sightings per year. The quantity of sightings is largely affected by the variability of the research effort per year. Indeed, the maximum of sightings is reached in 2005, year with highest research effort (minimum of covered distance: 1'490km in 2008; maximum of covered distance:20107 km in 2005; see Figure 2 and Annex-Table 1). Similarly, the lowest sighting records (3 in 2010) is obtained with a relative low research effort (similarly to 2008, 2009).

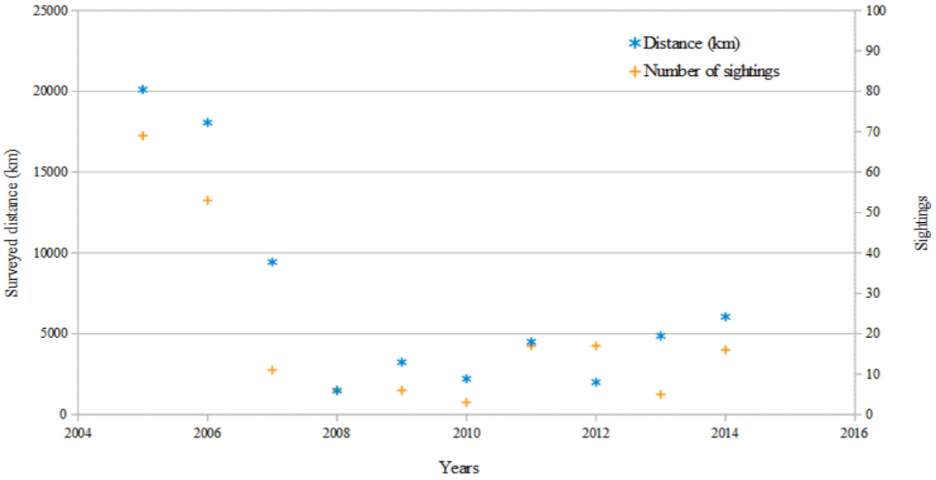

Figure 2: Surveyed distance in kilometer (km) and number of sightings per year during the 10-year study period.

Considering the strong influence of the sampling variability on the species distribution range, it is not possible to detect any trends over time. There are some variations of distribution of the species over time (Figure A1), even though observations in the north of the Pelagos sanctuary are regular over the year. The range of the species distribution is strongly influenced by the range of the research effort distribution. Indeed, Figure A1 displays the different areas prospected over time. Some areas are regularly surveyed, other are surveyed once. For instance, only in 2012, surveys were realized off the north-east of Sardinia, allowing collecting sightings in this specific area but obvious the absence of the species there, the other years, is only a consequence of the absence of effort.

The maps[34] presented in Figure 3 support the information about the high heterogeneity of research effort over space per year. They highlight the difficulties to establish a trend of species range distribution over space and time. The cells more surveyed over year are the cells more surveyed over year.

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[34] The maps can be visualized using www.seawetra.org with the login "Guest" and the tag "Cetacean distribution range".

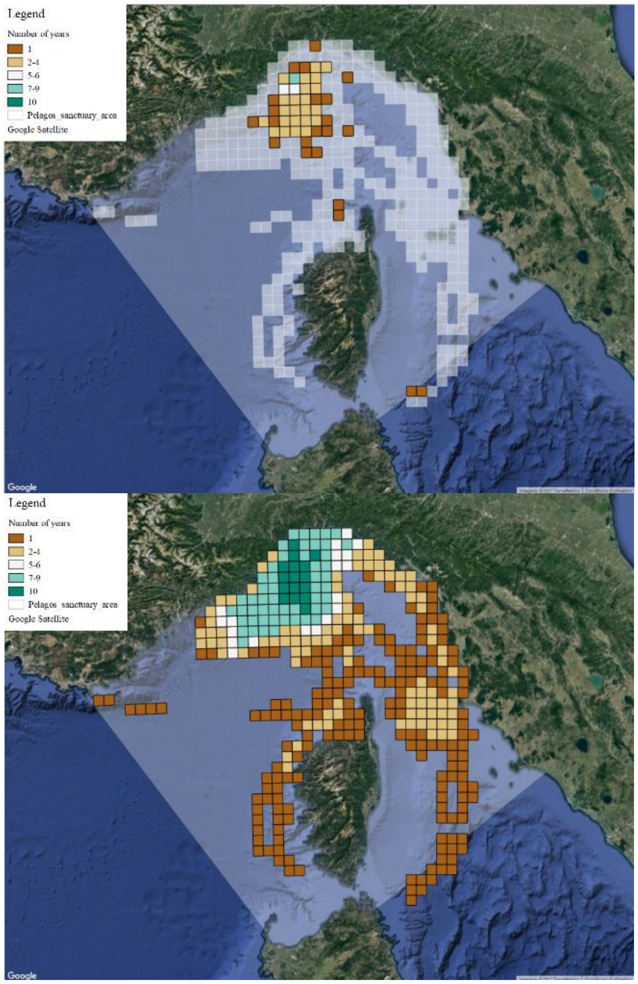

Figure 3: Number of years for which at least a sighting of Cuvier's beaked whale has been done on the cell (left) and number of years for which the research effort was higher than 2km on the cell (right). Coordinate system: ETRS89 / LAEA Europe – EPSG:3035.

4. Lessons learnt and/or recommendations

This study reports 10 years of surveys in the Italian waters of the Pelagos sanctuary, gathering a huge dataset of Cuvier's beaked whale: 203 sightings. Considering that the species is not well studied, this dataset gives strong evidence about the regular presence of the species in the north of the sanctuary. Indeed, this dataset proves that the canyon of genoa area is one of the few Mediterranean hotspots for Cuvier's beaked whale. This area should be thus taken into account for the identification of the Critical Habitat of the species.

Monitoring and assessment of the Cuvier's beaked whale distribution range is absolutely essential for the conservation of this species. Despite the recent results of surveys on cetaceans in this area, no systematic sampling by boat was executed. Aerial survey is unsuitable for determination of the distribution of deep divers such as the sperm whales, and a fortiori the *Ziphius*, due to the proportion of their time spent under the surface, and the speed of the aircraft, only a small minority of ziphiids can be detected.

This case study pointed out the spatial distribution and characteristics of the suitable habitats of the Cuvier’s beaked whale in the Mediterranean Sea, particularly the Italian waters of the Pelagos Sanctuary. Observation rate is highest for depths between 1400 and 2000 m, but they are frequent at 750 m in depth with slope range between 11 and 31m/km.

The main issue regarding the analysis of the species range distribution is the strong influence of the research effort variability over time and space. This influence is obvious looking the total dataset over the 10-years period, but also with the dataset cumulated per year or with dataset distributed over space per year. This makes it impossible to assess differences between summer range and winter range distribution. Indeed, winter months are not representatively sampled (due to adverse weather conditions). However, the species range is more likely affected by seasonal/monthly changes. Such changes could be partially related to anthropic impact such as vessel traffic. Especially in the Pelagos sanctuary, marine traffic is one of the major sources of impact on cetacean species. Changes in traffic composition and distribution (that effectively occur between seasons) could then influence changes in species range (Coomber, 2016).

Information on species presence in other areas of the Italian waters is very limited. Except for data in the northern Sardinia (Arcangeli, 2015Bittau, 2017; Gannier 2011) and stranding data from southern regions, species presence outside the Pelagos sanctuary is almost unknown. Given the complexity of the habitat inhabited by the species and its inter-species overlap, for example, with sperm whales (Tepsich, 2014), it is not advisable to perform prediction models in un-surveyed area. Applying predictive models where not enough information is available could result in an over estimation of species distribution range. For this reason, it is a priority to organize dedicated surveys on areas with low effort or no effort at all. Thus, CIMA Research Foundation plans part of its surveys in areas of the Italian waters with gaps of information as in the Tyrrhenian sea and in the Ionian Sea.

Given the species short time at the surface and its difficult-to-sight profile, further considerations about vessel speed, observer’s height above sea level, weather conditions (especially sea state) should be taken into account when analyzing data coming from different sources. Given the lack of data on species presence it is advisable to increase survey effort by applying all possible methods, differences in survey coverage and methods should be strongly included in any trends analysis.

Considering the high fidelity for the species towards specific areas (Rosso, 2010), the distribution range of Cuvier’s beaked whale might be coupled with the Common Indicator 4 ‘’population abundance‘’ and 5 ‘’ population demographic characteristics‘’for better conservation status of the species.

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Weblink

All maps of the document can be consulted using www.seawetra.org with the login "Guest" and the tag "Cetacean distribution range".

The 10x10km grid, compliant with the EC INSPIRE directive, used for the analysis, has been downloaded from: http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2#tab-gis-data.

Common Indicator 1: Habitat distributional range (EO1)

Case Study title: Overview of the assessment of the Common Indicator 1: Habitat distributional range (EO1), based on CAMP assessments results for Montenegro and EcAp/MSP Boka Kotorska Bay pilot project

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1. Brief introduction

The coastal and marine area in Montenegro encompasses a territory of six coastal municipalities – Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj – with the total surface area of 1.591 km^2 as well as the inland waters and territorial sea of Montenegro with a surface of 2.500 km^2 and shoreline of 300 km. As a result of a number of project activities conducted in cooperation of the Ministry of Sustainable Development and Tourism of Montenegro with the Italian Ministry of Environment, Land and Sea and SPA/RAC, marine habitats distribution mapping was conducted in Montenegro by applying different methodologies.

ithin the framework of CAMP Montenegro which was realized in period 2011-2014, the assessment of the general vulnerability of the coastal zone was carried out. All available historical data on distribution of habitats until 2013 were collected in the GIS data base. It serves as the basis for the vulnerability assessment of terrestrial and marine biodiversity. Results and available data from the field surveys at selected locations and the limited data archive available in the official documents (e.g. military map of sediments of sea bed in the former SFRY, reports for the Barcelona Convention and its Protocols, analysis with regard to application of requested IUCN standards and requirements of the EU directives) served as the basis for evaluation of the marine biodiversity vulnerability.

In order to improve knowledge on habitat distribution additional detailed mappings were conducted in Boka Kotorska Bay (Kotorsko–Risanski part of the Bay) along 26 transects or points during 2013. Similar surveys were conducted for Platamuni area and Ratac within the framework of MedKeyHabitat project during 2014 and 2015. In the period 2016-2017, the Ministry of Sustainable Development and Tourism initiated a small pilot project in Boka Kotorska Bay with the aim to test the EcAp indicators application (including the assessment of gaps in present data availability for EcAp indicators); to assess the status of and impacts on the marine environment; as well as to undertake thevulnerability assessment for the purpose of applying MSP in regulation of the activities and uses of marine environment.

The aim of this Case study is to give a brief overview of the results of the above specified project activities that can be used for the purpose of making relevant assessments for EcAp Common Indicator 1: Habitat distributional range (EO1), presenting also identified gaps and possible improvements, but also to make interface with all other common indicators under EO1 and EO3.

2. Methodologies used for the collection and analysis of the data

Remote sensing analysis was carried out acquiring a set of WorldView-2 scenes in April 2012 (under the project “Start-up of Katič MPA in Montenegro and Assessment of marine and coastal ecosystems along the coast” (DFS 2012). The remote sensing analysis covered the entire coastline of Montenegro, including the Bay of Kotor, encompassing the sea area of depth up to 25 m of a total surface of approximately 212 km^2. The final results of the project were as follows:

- Orthorectified satellite data: panchromatic (resolution of 50 cm) and multi-spectral (resolution of 2 m);
- Pan sharpen orthorectified satellite data obtained from the fusion of panchromatic and multispectral satellite data, with a high-resolution image (50 cm), keeping the "color" information contained in the multispectral satellite image;
- ArcGIS project of elaborated data;
- A technical report on remote sensing application with a final set of maps of seabed types and underwater vegetation coverage (depth from 0 to max 25 m) along the coast of Montenegro obtained from the elaboration of the satellite images (A3 sheet at scale 1:10.000 and A1 sheets at scale 1:25 000).

In addition, field surveys were also conducted in 4 chosen transects (2 in Katic area and 2 from Crni rt to rt Skocidjevojka – Petrovac area) in order to verify and obtain more detailed data for the chosen areas.
A rapid assessment survey of coastal habitats was carried out by SPA RAC in order to facilitate the prioritization of the new areas suitable for protection and enhance development of a network of marine and coastal protected areas in Montenegro. The methodology used consisted of the analyses of existing data available in the literature and three different survey missions of marine biodiversity conducted in 2008, 2011 and 2012.

In order to gather additional information and improve knowledge on habitat distribution in Boka Kotorska Bay, different methodologies were applied, including gathering of all existing relevant data from literature, additional data collection by side scan sonar and single beam survey (at locations Kotorsko Risanski zaliv (MEDMPAnet project), Platamuni and Ratac (MedkeyHabitat project)) as well as surveys with underwater camera along 26 transects or points and scuba diving. All available data for Boka Kotorska bay on Habitat distributional range were collected in one GIS data base by combining all available data obtained from field surveys for Kotorsko-Risanski part of the Bay with satellite data and GIS modeling, for the purpose of development of the methodological framework for marine spatial planning in the Boka Bay through application of EcAp.

3. Results of the Indicator Assessment

According to the study on the status of coastal biodiversity conducted as part of CAMP Montenegro and rapid assessment survey of coastal habitats carried out with the aim to contribute to the prioritization of the new areas suitable for protection and to develop a network of Marine and Coastal Protected Areas in Montenegro, the following 23 benthic assemblages were selected *a priori* in Montenegro:

1. Barren = encrusting coralline algae and sea urchins *Arbacia lixula* and *Paracentrotus lividus;*
2. Boulders_barren = same as above plus large boulders;
3. *Caulerpa racemosa* assemblage;
4. *Cladocora caespitosa* reefs = *Cladocora caespitosa* assemblage;
5. *Coralligenous assemblages =* Large boulders and vertical walls with dominance of Halimeda tuna, Parazoanthusaxinellae and sponges;
6. Infralittoral algal turf assemblages;
7. Infralittoral gravel assemblages;
8. Infralittoral mud assemblages;
9. Infralittoral mud and gravel assemblages;
10. Infralittoral pebble assemblages;
11. Infralittoral sand assemblages;
12. Large sponge assemblage with *Geodia, Aplysina* and *Petrosia;*
13. Mussel bed assemblage;
14. Photophilic algae assemblage with *Cystoseira spp*. and *Halopteris spp*.;
15. Photophilic algae assemblage with *Cystoseira spp*.;
16. Photophilic algae assemblage with *Padina pavonica;*
17. *Posidonia oceanica;*
18. Rubble and turf assemblage with *Codium sp*.;
19. Sciaphilic algae assemblages on hard substrata = Rocky substrates dominated by Codium bursa and Flabelliapetiolata;
20. Sciaphilic algae assemblages on hard vertical/subvertical substrata with Flabellia petiolata and Halimeda tuna;
21. Sciaphilic algae assemblages on hard substrata with Flabellia petiolata and Peyssonnelia spp.;
22. Submerged canyon;
23. Submerged caves.

According to the rapid assessment survey of coastal habitats that summarizes all available data until 2013, the benthic assemblages surveyed along the Montenegrin coast are diverse and typical infralittoral of Mediterranean hard and soft substrates, with the notable exception of those in the Bay of Kotor, which is unique. All the assemblages seem to be in a good state of health, with the exception of the upper infralittoral in the offshore sites, where fisheries has provoked a profound change in both the physical structure of the substrate and the biological composition of the benthic communities. The barren stable state characterizes the upper rocky infralittoral at all the sites of the open sea visited, except for Mamula, Seka Albaneze and Seka Kočište. Some of the areas surveyed were the object of study by algologists in past decades (Ŝ So and Antrolić, 1983), who reported a luxuriant algal canopy with several species, brown algae in particular. Sea urchin grazing hassled to the disappearance of photophilic algal assemblages from a large part of the Montenegrin coast. These assemblages have now been substituted by a coralline barren area.

Posidonia beds are recorded in the Montenegrin coast at a number of sites. The results demonstrated that the upper depth limit of meadow is about 6-7 feet deep. Only at the site near underwater caves Mikovič upper limit was found at a depth of 12 m. Among the best preserved communities of this type are those in locations in front of Petrovac and Buljarica, and in the bay Trašte. These habitats are common also in the Bay of Kotor, but are widespread at lower depths because low water transparency. In some places in Kotor and Risan Bay the underwater sea-grass meadows are in the state of regression or have completely disappeared. Probably in some places on the high seas the regression has started but there is not enough data to compare and record these changes.

Inside Boka Kotorska at Dražin Vrt Strp and Sopot,a Coralligenous assemblage was found between 12 and 30 m depth. At Dražin Vrt, impressive *Cladocora coespitosa* reefs were present and were associated with a rich assemblage of large-sized sponges and cnidarians, notably massive colonies of the false black coral, *Savalia savaglia*, the gorgonian *Leptogorgia cfr sarmentosa* and the yellow cluster anemone *Parazoanthus axinellae*.

Based on conducted remote sensing analysis within the project "Start-up of Katič Marine Protected Area in Montenegro and Assessment of Marine and Coastal Ecosystems along the coast - Analysis of Coastal Features to Assess Natural Values” map on seabed composition was produced (Figure 2). This map represents a good overall basis for modelling and indication on habitat distribution. This Map was also used with other available data for the purpose of analyses of vulnerability assessments of habitats along the coast within the CAMP project. Following the vulnerability assessment results (Figure 3), the more and less suitable zones for certain activities were identified by applying MSP. The conflict uses of the marine space were also identified what guided the spatial planers to recognize the most suitable zones for the activities that may be acceptable with regard to the present status and adaptive capacity of marine environment, but also to recognize those zones and activities that may not take place in marine environment or only within limited capacities. As a result of gathering of all available data for the purposes of the implementation of CAMP Montenegro, 7 areas (Figure 1) were identified as some possible important areas for future mapping and examination.

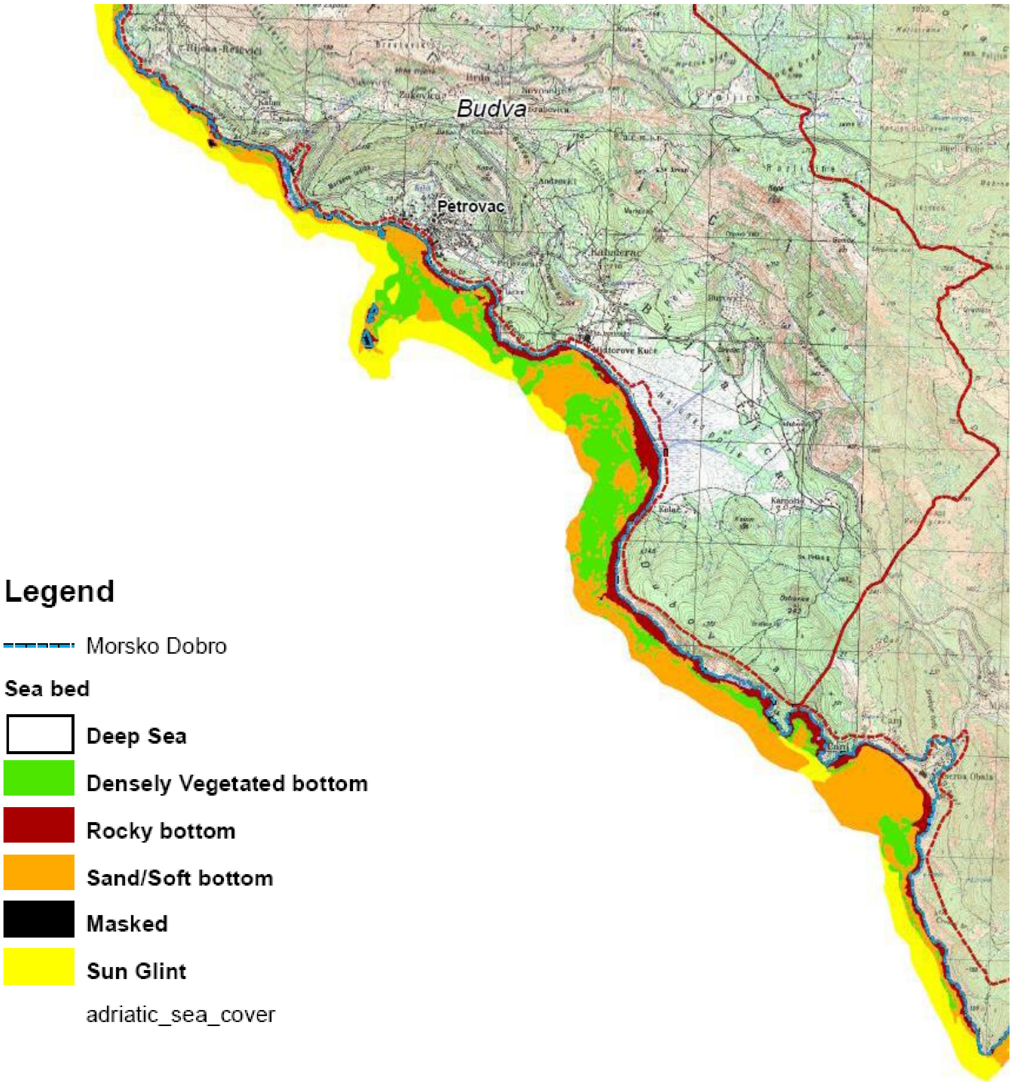

Figure 1: Sample of a seabed map obtained through remote sensing elaboration along Montenegrin coast

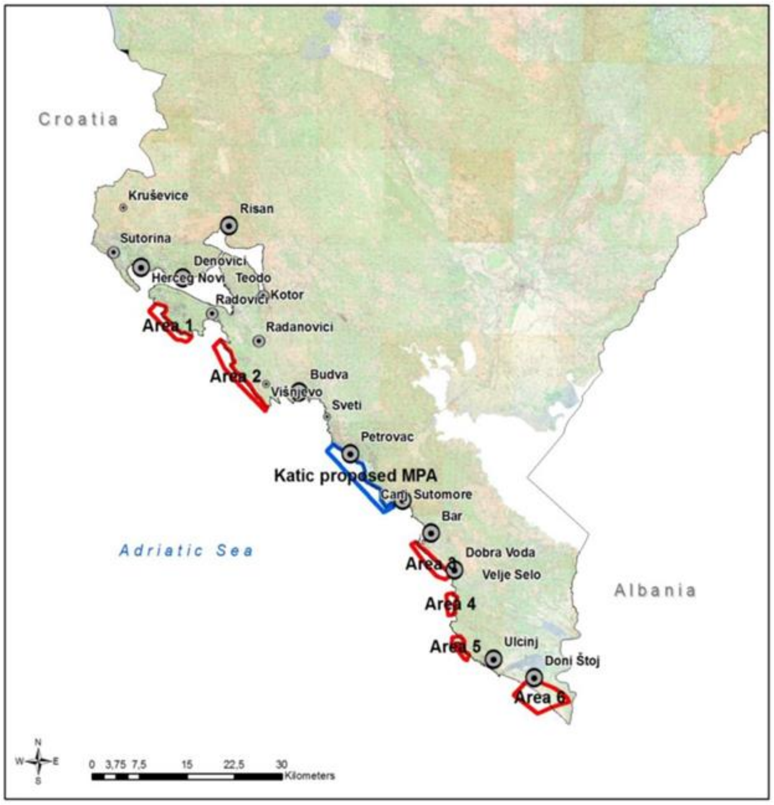

Figure 2: Map of suitable areas for establishment of future Marine Protected Areas in Montenegro

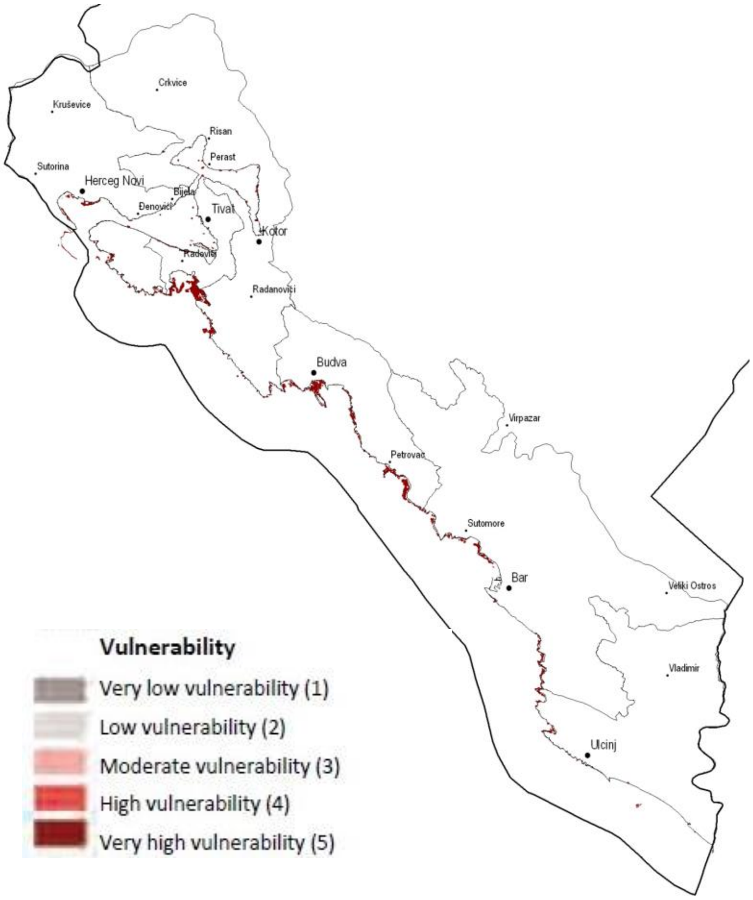

Figure 3: Vulnerability of the marine biodiversity (vulnerability assessment for two types of habitats: *Posidonia* beds and underwater caves).

Pilot project "EcAp/MSP testing in Boka Kotorska (Kotor) Bay which is aimed at development of a detailed methodological framework for marine spatial planning in the Boka Bay through application of EcAp was implemented from December 2015 to July 2017. Data sets gathered from already mentioned projects and other relevant sources were analysed by applying GIS tools. As one of the projects results, map of distribution of habitats in Boka Kotorska Bay was produced by using all available data and modelling methodology (Table 1 and Figure 4). The map gives an overview on the surface and percentage of coverage of biocenosis and assemblies in Boka Kotorska Bay.

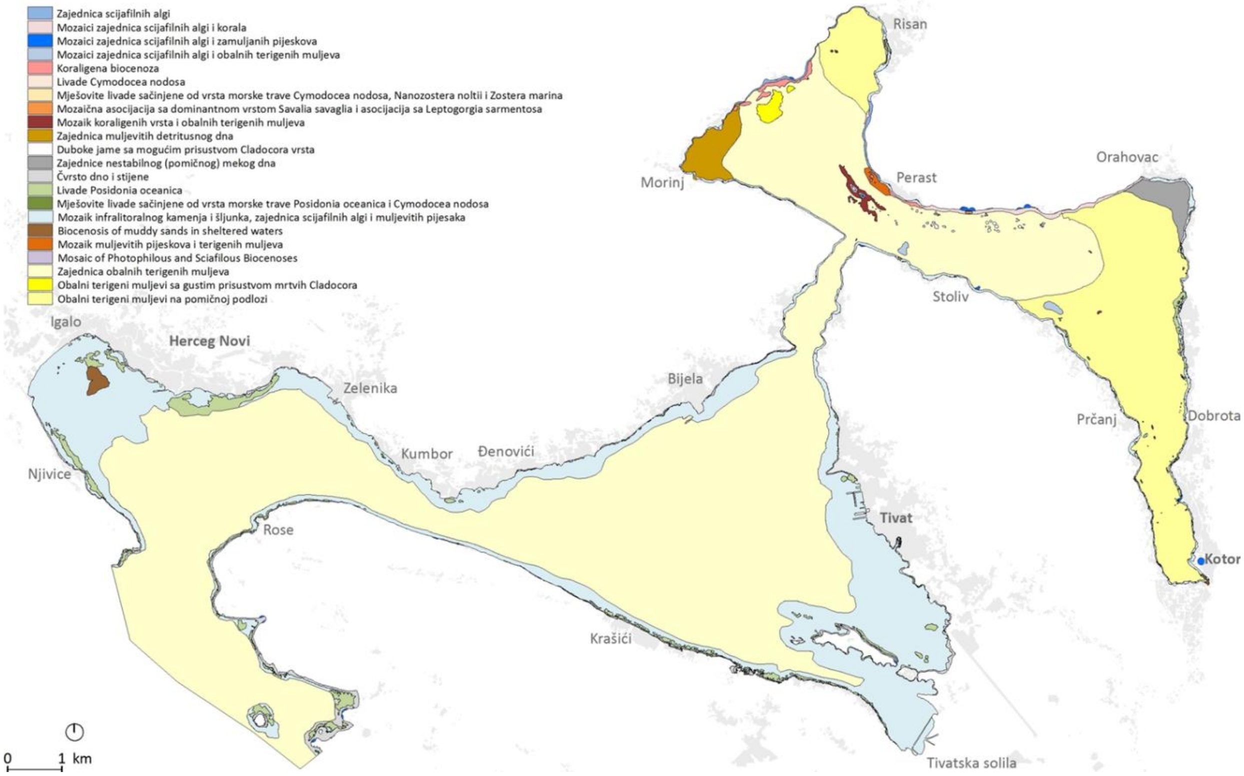

Figure 4: Habitat Distribution in Boka Kotorska Bay

he present status of habitats was then assessed by applying relevant EcAp status indicators and later on it was expressed through the value index. The pressures were also assessed by applying relevant EcAp pressure indicators and after that they were expressed through the exposure index. Having the values of exposure and value index the appropriate sanitation and protection measures were proposed as to improve the present status of marine environment. In the next phase the vulnerability of the marine ecosystem on different activities that may be placed in marine environment was assessed. It was done by combining the value and exposure indexes with the expert assessed the adaptive capacity of the marine environment for acceptance of new pressures once when future sea uses and related activities will take place. The Project was a good example of how data gaps can be overcome with modelling technique and how important is to have detailed data in order to have more reliable conclusions on vulnerability as a basis for appropriate MSP development.

Table 1: Habitat distributional range in Boka Kotorska Bay.

5 Habitat type	Surface (ha)[35]	Percentage (%)
Biocenosis of coastal terrigenous muds	5172.92	61.5
Biocenosis of Instable soft bottoms	55.46	0.66
Biocenosis of muddy detritic bottoms	77.95	0.93
Biocenosis of muddy sands in sheltered waters	14.69	0.17
Biocenosis of Sciaphilous algae	14.58	0.17
Coralligenous biocenosis	15.34	0.18
Cymodocea nodosa meadow	0.15	0.00
Deep holes with possible presence of *Cladocora species*	4.74	0.06
Hard beds and rocks	102.61	1.22
Mixed meadow composed by *Cymodocea nodosa*, *Nanozostera noltii* and *Zostera marina*	0.83	0.01
Mixed meadow composed by *Posidonia oceanica* and *Cymodocea nodosa*	0.09	0.00
Mosaic of BS and C	24.79	0.29
Mosaic of BS and MS	0.39	0.00
Mosaic of BS and VTC	8.13	0.10
Mosaic of Facies with *Savalia savaglia* (dominant) and Facies with *Leptogorgia sarmentosa*	0.51	0.01
Mosaic of Infralittoral stones and pebbles, BS and MS	1644.74	19.6
Mosaic of MS and VTC	8.45	0.10
Mosaic of *Photophilous* and *Sciafilous Biocenoses*	1.75	0.02
Mosaico of C and VTC	15.69	0.19
Posidonia oceanica meadow	145.12	1.73
VTC with abundant presence of death *Cladocora*	18.88	0.22
VTC with indication of instable conditions	1080.92	12.8

4. Lessons learnt and/or recommendations

It may be concluded that present data show significant gaps with the view to organization of the monitoring assessments based on the application of all EcAp indicators, including data of relevance for habitat distributional range in Montenegro. Significant efforts are needed as to ensure reliable data for future assessment products that will be based on application of the EcAp indicators.

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[35] Area calculated GIS based on existing data on the distribution of habitat at the Bay of Kotor.

owever all present available data can be used as the basis for overcoming data gaps by using sophisticated GIS tools and modelling techniques (combining different levels of data and methodologies). Despite that field surveys for collection of missing data remain the optimal approach. As the field surveys methodology side scan sonar may be strongly recommended for mapping the large areas, while for some smaller areas, as well as for specific habitats and more detailed investigations of the habitat's structure, diversity and condition, SCUBA diving is necessary. In cases that data are missing, available data such as satellite maps can serve as the basis and indication of possible habitat composition and can be used for the purpose of GIS modelling.

n the EcAp/MSP pilot project, the assessment of the status of and pressures on the marine biodiversity was carried out by elaboration of the data which were available for calculation of Common Indicator 1: Habitat distributional range (EO1) and Common Indicator 10: Fishing effort (EO3). Other indicators were not calculated due to significant lack of data as explained above. It has to be emphasized that even historical data usage for this purpose requires data quality assurance.

s a step towards improvement of data availability, the need to redefine the existing monitoring programme of marine environment in line with the Guidance Factsheets has to be recognized. It will require redefinition of monitoring locations, survey methods, elaboration of collected data, and implementation of risk based approach etc. After that field surveys should be organized in accordance with the improved monitoring programme for collection of new data.

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Common indicator 5: Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, marine reptiles)

Case study title: Loggerhead sea turtle *Caretta caretta* in the Kuriat islands, Tunisia

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1. Brief introduction

WThe Biodiversity and Marine Biotechnology laboratory of the *Institut National des Sciences et Technologie de la Mer* (INSTM) – (National Institute of Marine Sciences and Technologies) launched a research programme, at the beginning of the 1990s, to implement the Action Plan for the Conservation of the Mediterranean Sea turtle. In line with this objective, prospections for potential nesting beaches of the sea turtle were carried out from 1993 to 1996 with the collaboration of the Specially Protected Areas Regional Activity Centre (SPA/RAC). This prospecting showed the relative nesting importance of the loggerhead sea turtle *Caretta caretta* in the Kuriat islands where monitoring was started in 1997.

This monitoring programme is the result of close collaboration between INSTM, ANPE (Agence National pour la Protection de l'Environnement – National Agency for the Protection of the Environment) substituted then with APAL (Agence de Protection et d'Aménagement du Littoral – Agency for Coastal Protection and Management) with the guidance and support of the SPA/RAC. This collaboration is now celebrating the twentieth anniversary with success for the protection of sea turtles in Tunisia. This was crystallized by a regular and improved nesting phenomenon thanks to the seasonal presence of the monitoring team at the science camp. This plays a very important role for the following reasons:

i. Research (an important database pertaining to the biological and ecological parameters of the reproduction of *Caretta caretta* and specific studies of genetics, sex ratio and satellite monitoring);
ii. Training (including a diploma course);
iii. Awareness creation; and
iv. Conservation.

Training and awareness creation have been further strengthened through the involvement of civil society and mainly the NGO "Notre Grand Bleu" (NGB) in the monitoring activities of the Kuriat islands.

Even if the beaches of the Kuriat islands represent a minor nesting site compared with other Mediterranean beaches, its role could still be quite appreciable especially from the genetic diversity point of view. In this case study we shall focus on the collected data, its analysis and the results of the nesting monitoring indicator.

2. Methodologies used for the collection and analysis of the data

Study area: The Kuriat islands consist mainly of two small islands: the Great Kuriat island (with a surface area of almost 2,7km^2) and the small Kuriat island (nearly 0,7km2). They are located East-North-East from Cap Monastir at approximately 18km and separated from each other by approx. 2,5 km (Figure 1).

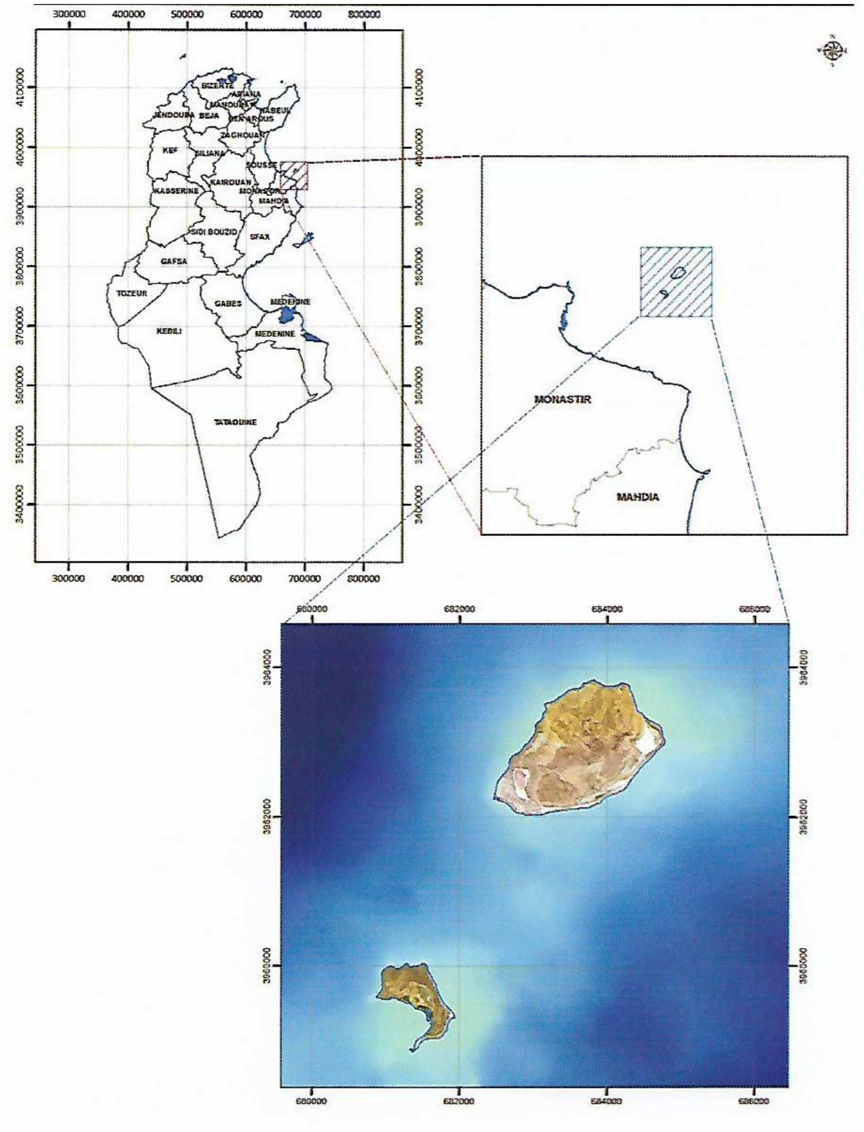

Figure 1: Map of the geographical location of Kuriat Islands

Several species of flora and fauna surveyed are extremely rare and vulnerable. As for terrestrial biodiversity, there is a great variety of vegetation which is important for some birds for whom the Kuriat islands are a nesting place and an important stage of migration. Marine biodiversity is characterized by the presence of Posidonia meadows, maërl beds, the pen shell *Pinna nobilis* and the loggerhead sea turtle *Caretta caretta* whose presence there is one of the main reasons for the protection of the Kuriat islands. Its nesting was established for the first time in 1988 on the beach of the great Kuriat island close to Monastir (Laurent et al., 1990) and that of the small Kuriat island in 1993 (Bradai, 1995).

Monitoring of nesting and data collection (plank): The scientific camp (Figure 2) is generally on the great Kuriat Island during the summer season, from June until the end of August. Daily visits are made both upstream and downstream of the camp in order to: i) locate any possible first nests; ii) monitor the emergence of the hatchlings; and iii) open the last nests.

Figure 2: Scientific camp on the Great Kuriat

During the teams stay (researchers and volunteers), nocturnal surveys were carried out to detect any new nests which had been made. In case of doubt in locating the nest, a probe was used very carefully. The nests thus detected are protected by cages in order to identify them and avoid them being trampled on by visitors. The observed nesting females were measured and tagged. Nests made in areas which are deemed to be at risk of flooding were transferred into thermos containers and taken to safer areas. Once the hatchlings are out, the nests were opened in order to count the eggs and their different stages, hatched, fertile not hatched, (early or late mortality) dead hatchlings in the nest or in the eggs and eventually any live hatchlings in the nest. This data was recorded on an Excel spreadsheet and used to determine the number of eggs and the levels of fertility, hatching and the emergence of the hatchlings. A sample of hatchlings was sometimes used to determine the metric and meristic characteristics.

To estimate the sex ratio of the hatchlings, a recording thermometer was placed with the eggs in the nests at the time of egg-laying and withdrawn after the hatching. The recorded temperatures were then analyzed and the sex ratio estimated.

To establish the migration routes of the nesting sea turtles on the Kuriat islands, a female turtle was monitored via satellite within the framework of collaboration between SPA/RAC and the Naples Zoological Station (SZN - NZS).

3. Results of the Indicator Assessment

Egg-laying period: The loggerhead sea turtle nests in the Mediterranean at the beginning of June and up to the beginning of August, but rarely in May and September (Margaritoulis et al., 2003). This parameter is to be taken into consideration in the conservation strategies especially when the egg-laying coincides with the frequentation period of the beaches (Jribi et al., 2002). The data collected over a period of 20 years of nesting monitoring on the Kuriat islands made it possible to pinpoint the egg-laying of *Caretta caretta* mainly in June, July and August of each year with a peak during the first half of July (Figure 3). It should be pointed out that from 2002 onwards, the frequency of egg-laying in August was observed only from 2002 on with an ever-increasing frequency.

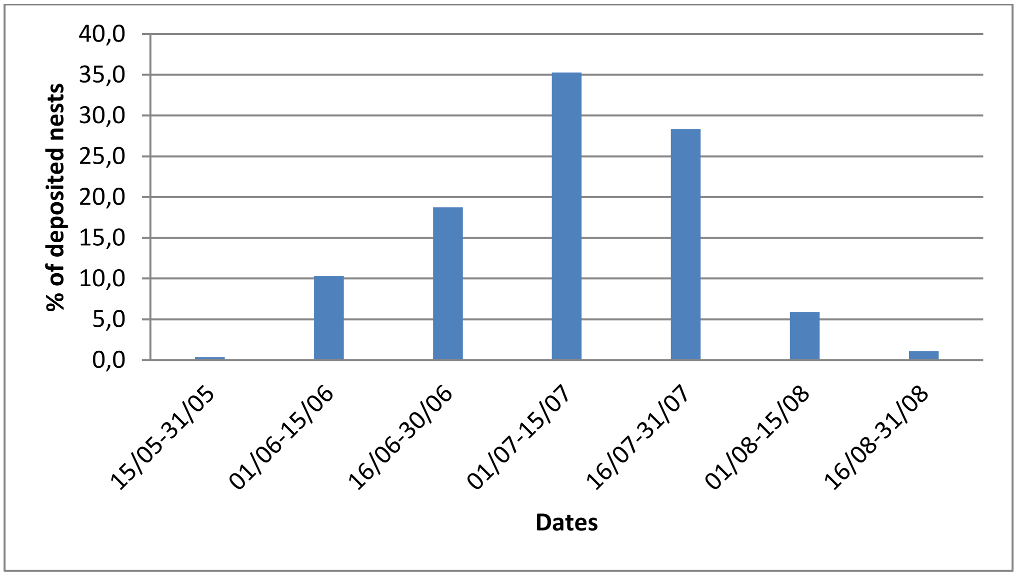

Figure 3: Importance of Laying by Period of Season (1997-2016)

Importance of nesting: Even though it is a minor site compared with other sites in the Mediterranean, the nesting phenomenon of the sea turtle *Caretta caretta* on the great Kuriat Island is a regular one. This regular and durable phenomenon is due to, amongst other things, the surveillance activities of the nests by the monitoring team. Poaching of nests had been recorded before the regular surveillance programme was established. The number of nests made annually is indicated in Figure 4. The analysis shows a clear increase in the number of nests dug by the turtles and this is thought to be connected to the protection efforts deployed since 1997. This number increased from 11 nests/year (n=10; SD= 4,8) for 1997-2006 to 24,1 nests/year (n=10; SD= 6,0) for the 2007-2016 period. On the small Kuriat island which is thought to be highly frequented by bathers, the nesting rate has declined over the years, then recovered and became regular since 2007.

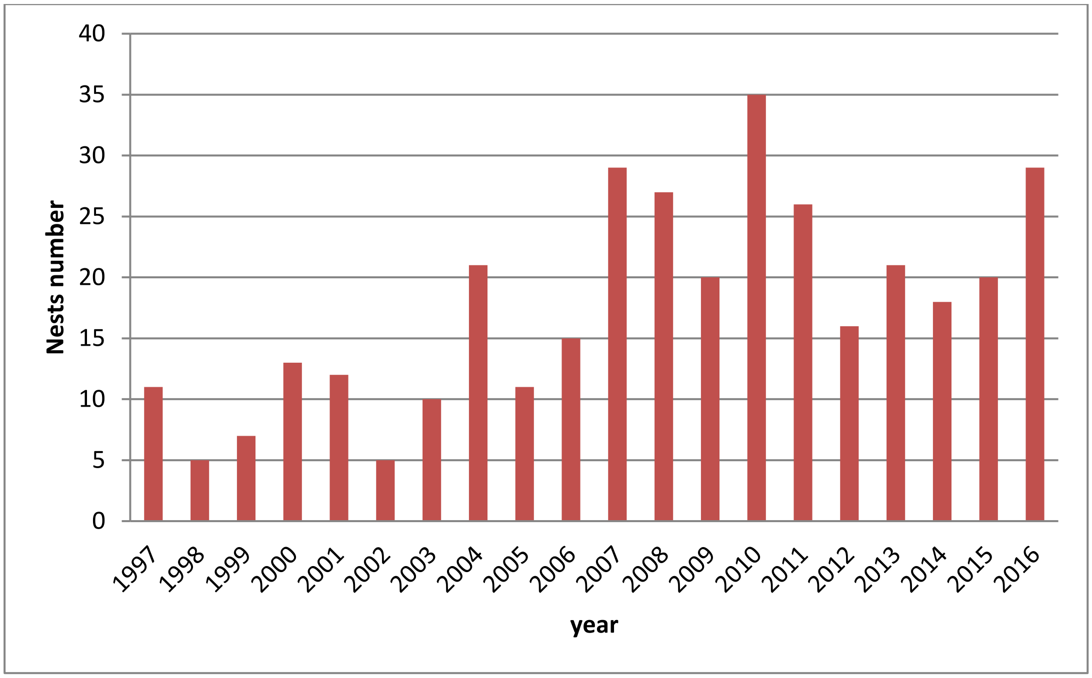

Figure 4: Number of nests deposited annually on the Kuriat Islands (1997-2016)

<u>Nesting females:</u> On the Kuriat islands, the carapace curve length of the nesting females varies between 70 and 85 cm average = 76,03cm; n= 34; SD=4,07) and the curve width varies between 60 and 74 cm (average = 66,65cm; n= 34; SD=3,61). This size is similar to that in Turkey and Libya (Margaritoulis et al., 2003) and is thought to correspond to an age of approx. 20 years according to the study of Casale et al. (2009). The presence of primiparous females, or neophytes, which were relatively small in size and were laying a small number of eggs, was also recorded (Bradai and Jribi, 2008; Jribi and Bradai, 2011 and 2013).

<u>Egg-laying cycle and inter-nesting interval:</u> Sea turtles undergo cyclical migrations between the nesting sites and the feeding areas and the females do not deposit their eggs each year. These migrations vary with cycles of 2-3-4 years with a predominance of 2 and 3-year cycles (Miller, 1997). The nesting inter-season intervals can vary even with the same female. This variation depends on several factors such as the quantity of food and energy accumulated during the year, the environmental conditions and the availability of males. urthermore, during an egg-laying season, the turtle does not lay just once. The frequency of egg-laying is the number of nests made per season per female. The determination of these parameters is based on the tagging of the nesting females. On the Kuriat islands, the egg-laying cycles is estimated at 2 years whereas the inter-egg-laying interval varies between 13 and 21 days. When the tags are lost then this becomes one of the factors which limit the successful identification of a turtle and consequently this hampers the determination of these two parameters. This situation could be obviated to a certain extent by double tagging the turtle as in our experience the metal tags are better than the plastic ones.

<u>Lutch size:</u> Lutch size is determined during the egg-laying or when the nest is dug out after the emergence of the hatchlings. On the Kuriat islands and after 20 years of monitoring the beaches, the clutch size varied from 25 to 164 eggs/per nest with annual averages varying from 58,6 to 107,32 and a general average of 88,41 (SD= 10,48; N= 20) (Table 1). The frequency of the clutch sizes out of 299 nests which had been studied is illustrated in Figure 5. Compared to other Mediterranean sites, the clutch size on the Kuriat islands seems to be similar to what has been

recorded in Cyprus and in Turkey but the clutch size is smaller than that recorded in Greece which has the largest clutch sizes (Margaritoulis, 2003).

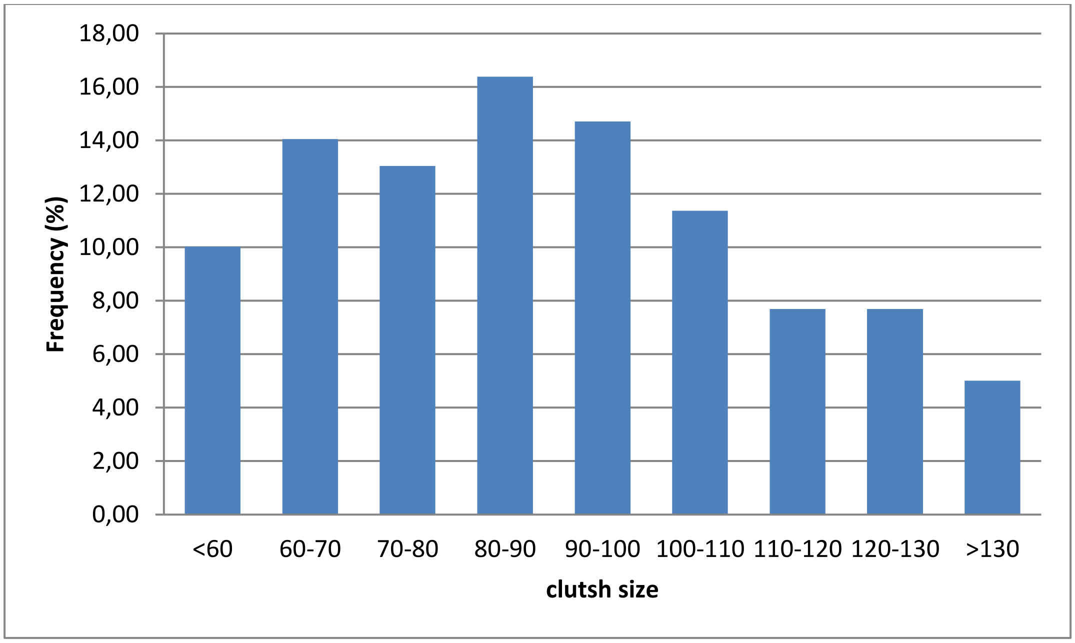

Figure 5: Frequency (%) of the different spawning sizes on the Kuriat Island

Table 1: Egg size, hatching and emergence rates on the Kuriat Islands (1997-2016)

Year	Clutsh size	range	SD (clutsh size)	Hatching rate	Emergence rate
1997	107,36	64-150	23,29	91,9	90,57
1998	81,5	70-104	15,8	75,97	46,48
1999	89,42	59-122	20,75	66,29	65,26
2000	82	49-110	18,4	62,22	62,22
2001	102,33	65-130	24,89	63,64	59,59
2002	58,6	25-82	20,73	63,48	61,77
2003	84,75	52-143	34,61	70,98	65,73
2004	94,56	61-134	21,12	63	63
2005	92,89	67-129	22,64	68,97	68,66
2006	89,93	74-112	13,95	70,64	69,37
2007	83	55-111	18,77	55,02	54,23
2008	84,08	57-114	13,5	67,43	67,43
2009	87,89	44-146	30,79	59,06	57,90
2010	84,85	48-145	22,02	46,91	44,99
2011	97,06	27-147	28,58	72,43	71,60
2012	99,33	57-164	34,88	71,57	70,87

2013	90,45	56-123	20,28	60,10	59,39
2014	74,58	60-98	10,29	62,72	62,62
2015	94,00	58-135	22,76	75,76	74,28
2016	89,68	36-161	27,74	54,77	53,99
Mean	**88,41**	**25-164**	**22,29**	**66,14**	**63,50**
SD	**10,48**		**6,61**	**9,56**	**10,08**

Duration of incubation: The egg incubation duration depends partly on the nature, the humidity and the temperature of the soil. It is very important to know how long this duration is as it can provide information on the sex ratio of the hatchlings. In fact, the incubation duration is inversely correlated with the incubation temperature. Long incubation periods imply cool temperatures producing more males and shorter periods imply warm temperatures producing more females. The incubation duration on the same site varies from one year to the next depending on the thermal conditions. The average figures recorded on some of the Mediterranean sites vary from 47,3 to 48,7 days in Cyprus (Alagadi), from 57,6 to 62,3 in Greece (Zakynthos) and from 55 to 56,9 in Turkey (Fethiye). On the Kuriat islands this duration varied between 57 and 68,33 days (6 seasons) with an average of 60,5 days.

Rate of hatching and emergence: The rate of hatching and of emergence on a beach are different as sometimes some hatchlings die just after hatching or do not manage to get out of the nest. These rates depend on several intrinsic factors such as the fertility rate of the eggs and also on extrinsic factors such as the physico-chemical conditions of the incubation linked to weather conditions, the destruction and the disturbance of the nests, flooding, erosion and predation. On the Kuriat islands and over a period of 20 years of monitoring, these rates have varied between 46,91 and 91,9% for the hatching rate and 44,99 and 90,57% for the emergence rate with respective average figures of 66,14 and 63,50% (Table 1). Even though some of the nests may be disturbed or flooded, these rates show that the site is favourable for nesting.

Sex-ratio: With sea turtles there is no sexual dimorphism in the hatchlings. The sex ration is estimated in the egg-laying sites by measuring the temperature in the nests as the sex determination depends on the incubation temperature. In general, the sex ratios are biased in favour of one of the two sexes in the TSD species (Temperature Sex Determination) like the sea turtles whose sex ratios are biased in favour of the females in most cases (Wibbels, 2003).
On the Kuriat islands and in contrast to what is generally observed, the sex ratio is biased in favour of the males. The sex ration was estimated on the basis of the temperatures recorded in the middle of the nests and varied between 2% of females (in 2013) and 84, 5% of females (in 2007).

Predation: It seems that the yellow-legged gull *Larus cachinnans which* is present in great numbers, may be a potential predator of the hatchlings especially for those that emerge during the day or early in the morning. The black rat *Rattus rattus* which has been present on the small Kuriat island for a long time and which has infested the big Kuriat island in 2013, is also thought to be a predator on the site. This rodent has been observed in attacking the hatchlings (Figure 6). To get rid of this rodent, a de-ratting action was successfully carried out in both islands in collaboration with the NGB association. Furthermore, even if human predation had been observed in the past (Laurent et al., 1990), our presence since 1997 has greatly limited this human predation. However, disturbances of nests have reported during our absence.

Figure 6: Newborns attacked by the black rat Rattus rattus on the Kuriat Islands

Other sources of nuisance: The Kuriat islands are highly suitable for the nesting of the loggerhead turtle but there are still some problems to be dealt with and the biggest problems are as follows:

- Human frequentation (Figure 7): the Kuriat islands, and especially the small Kuriat Island, are highly frequented during the summer by tourists and holidaymakers especially during the nesting period. The nests may be disturbed particularly during our absence. In order to reduce the negative effects of this frequentation, we have increased our presence on the small Kuriat island, set up awareness creation boards and even awareness creation booths with the help of civil society.
- Fishing activities (Figure 8): there is intensive fishing activity around the Kuriat islands. The fishing nets laid out close to the coast disturb the nesting females and form barriers for the hatchlings which can end up in the meshes of these fishing nets once the hatchlings emerge from their nest. To give the hatchlings a better chance of reaching the sea, sometimes they were retained and then released once the fishing nets have been withdrawn and the fishermen had left.
- Banks of dead Posidonia leaves (Figure 9): the Posidonia banks which end up on the beach sometimes constitute impenetrable barriers for nesting females. However, they may find their way out between these banks. The hatchlings manage to cross through the phanerogam deposits and reach the sea but it takes more time for them to do so and thus

they are exposed to predation by birds in case they emerge late at night and sometimes they even die through exhaustion.

Figure 7: Small Kuriat attendance by tourists and summer visitors

Figure 8: Fishing activity near the Kuriat Islands

Figure 9: Posidonia oceanica dead leaves benches

It should also be pointed out that a herd of goats (Figure 10) which had been kept for several years on the great Kuriat Island had caused considerable damage to the terrestrial ecosystems and had been taken back to the mainland after several interventions with the local authorities.

Figure 10: Herd of goats on the Great Kuriat

<u>Hatchlings:</u> A metric and meristic study of the hatchlings (Figures 11 and 12) has yielded the following results: an average length of 4,13 cm (n=627; standard deviation =0,17; range: 3,5 cm

to 5 cm) and an average width of 3,21 cm (n=627; standard deviation =0,19; range : 2,6cm to 4cm). This data is comparable to that of other Mediterranean regions (Margaritoulis et al., 2003). The average recorded mass is 14,26g. Generally, the carapace of the hatchlings of the Kuriat islands is made of 5 vertebral plates, 5 pairs of costal plates, 13 pairs of marginal plates and 3 pairs of inframarginal plates.

Figure 11and 12: Photos of hutchlings on the Kuriat Islands.

Satellite Tracking: In 2010 a nesting female was equipped on the great Kuriat Island with an Argos transmitter fixed to the carapace (Figure 13). The turtle had travelled approx. 5741 km over a period of 378 days. The emission of signals stopped when the turtle was to the South-West of the island of Lampedusa (Italy). The trajectory of this turtle is available on the following link: http://www.seaturtle.org/tracking/index.shtml?tag_id=60669a&full=1 (Figure 14).

Figure 13: Nesting female on the large Kuriat equipped with an Argos beacon on the carapace

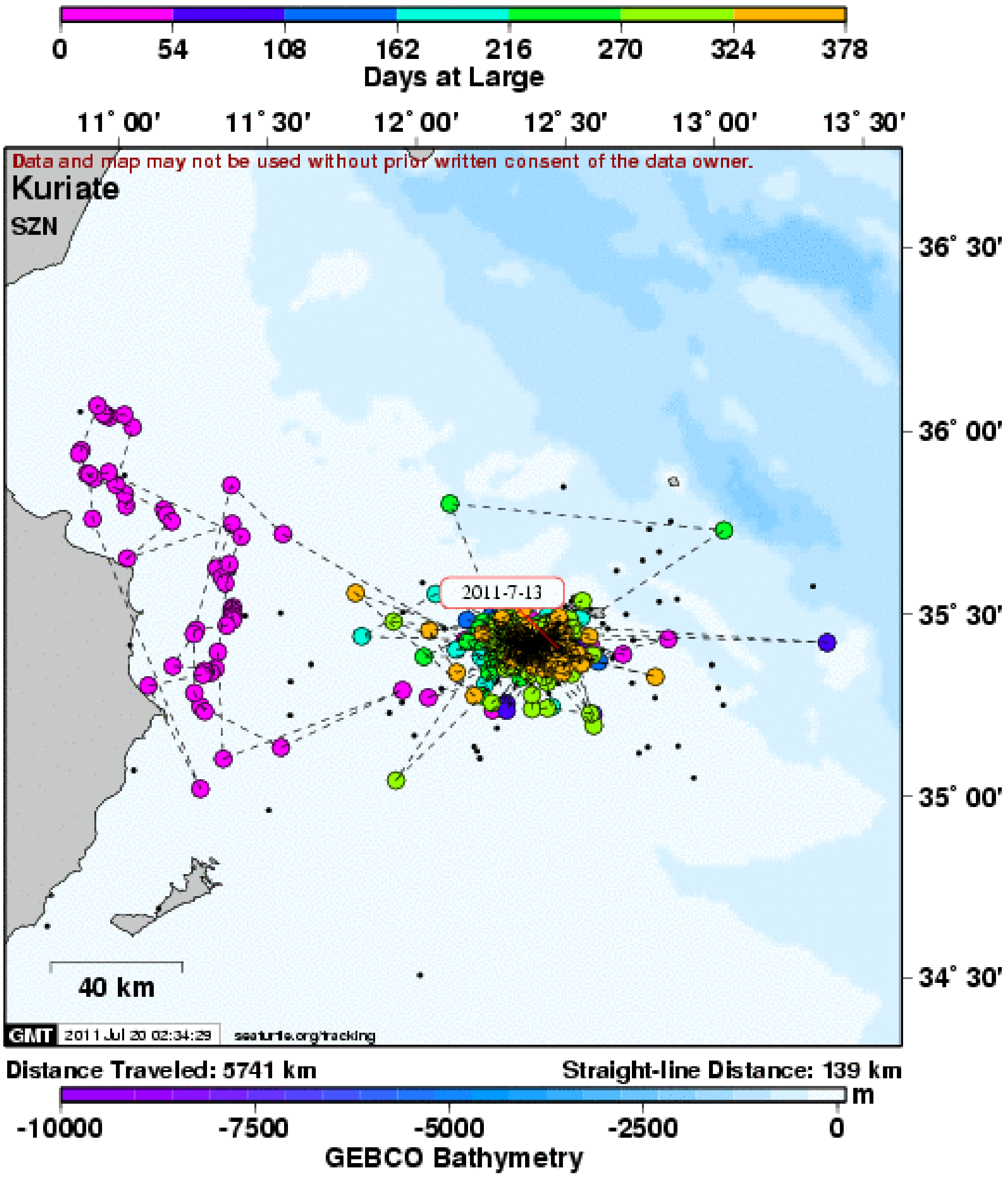

Figure 14: track of the sea turtles tagged in the framework of the monitoring programme on the Kuriat islands

4. Lessons learned and/or recommendations

The wealth of ecological characteristics of the Kuriat islands gave them the status of a sensitive coastal area (SCA) and since 1995 it is one of the areas being studied in order to be raised to the status of a Marine and Coastal Protected Area with a considerable contribution from the monitoring of the nesting beaches.

Even though there are several threats to the species and the ecosystems (i.e. too much seasonal frequentation of the beaches, anarchical fishing activity, pollution) the state of the terrestrial and especially marine ecosystems of the Kuriat islands is at present of good quality.

As there is a lack of effective protection of the Kuriat islands due to material and legal problems, the management of the Kuriat islands by the nesting turtle monitoring team could be further strengthened in order to monitor other ecological aspects until this archipelago is promoted to the status of a Marine and Coastal Protected Area (MCPA).

Since its creation in 1997, the nesting monitoring centre on the great Kuriat island welcomed over 100 Tunisian and foreign students from different higher education establishments (Figure 15). Furthermore, there were at least 2 Diplomas of Advanced Studies and 2 theses pertaining either totally or partially to the nesting activity on the site. As for research work, there were at least twenty national and international communications, 5 articles in international newspapers and two chapters in two books.

Figure 15: internship students on the Kuriat islands

Awareness creation activities (Figure 16) were carried out in collaboration with civil society associations and were highly successful. These awareness creation activities were carried out mainly within the framework of two projects financed by the Critical Ecosystem Partnership Fund (CEPF).

Figure 16: Awareness activities dedicated to visitors of the Kuriat Islands

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Common Indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)

Case study title: Invasive versus native bottom-trawl fish species diversity and population dynamic at the soft-bottom habitats of the Southeastern Mediterranean coast of Israel.

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1. Brief introduction

Non-indigenous species (NIS) are regularly reported from various coastal habitats in the Mediterranean Sea but fundamental knowledge on the assemblage structure of coastal fish communities are lacking. The vectors of introductions can be divided into two main categories, namely *accidental* and *intentional*. *Accidental* introductions include the well-known ballast water transportation which is considered the most important mode of unintentional dispersal of aquatic species worldwide. *Intentional* introductions are mainly related to human consumption and thus mainly concerns fish and mollusca species. For instance, approximately one hundred fish species have already resided in the Levant (Galil and Goren 2013; Galil et al. 2015; Kletou et al. 2016).

The data-collection capabilities of the bottom-trawl fishing industry has been long harnessed for monitoring and stock assessment around the world (Godø and Wespestad 1993; Weinberg et al. 1994). At the Israeli coasts of the Levant Basin, employing the local bottom-trawl fleet for scientific purposes have been proven crucial to evaluate shifts of fish communities and habitat distribution among native and NIS fauna (Stern 2010; Edelist et al. 2012; Levitt 2012). In addition, accurate taxonomic inspection over the survey's catch has repeatedly uncovered new NIS for the Mediterranean, some of which displayed population outbursts (Goren et al. 2009; Goren et al. 2010; Goren et al. 2011; Stern et al. 2014; Stern et al. 2015). Lastly, conducting such time-series studies eventually provides viable information to estimate local fishing pressure over time and space that may serve to form sustainable management protocols (Stern 2016).

Epifaunal long-term monitoring of the sandy-bottom at the southern fishing grounds of Israel started in the fall of 2014 within the framework of the Israel's National Marine Monitoring Program in the Mediterranean Sea carried out by IOLR (Herut et al. 2016). This programme focuses on the dynamic population structure and the temporal and spatial distribution of the Levantine epifauna. The extensive database obtained allows multiple variable and parameters analyses, and upholds a great computation power for future understanding the continuing changes in faunal biodiversity and distribution in the Levant Basin.

2. Methodologies used for the collection and analysis of the data

iannual bottom-trawl set of monitoring surveys, during spring and fall, were conducting from November 2014 off the coast of Ashdod, encompassing bottom depths of 20, 40, 60, and 80 m in both day and night net hauls. Each sampling campaign was for 24 hours and included 8 hauls in total, with a tow duration of 90 min for each haul. Tow duration is the time between the achievement of optimal net opening and the moment when speed was reduced in order to lift the net on deck. The trawler was sailing at an average speed of 2.8 Nautical miles, thus covering an estimated area of approximately 7-8 km per haul. Each haul catch was then sorted on deck into the possible lowest taxonomic level, tagged and kept in refrigerated room during the entire campaign.

At the end of each campaign, the entire catch was brought to IOLR in Haifa for further examination. At the institute, the catch was identified to specific taxonomic level, and basic measures were taken: total length, to the nearest mm, and weight to the nearest 0.1 g. Certain species were preserved and vouchered at the Steinhardt Museum of Natural History in Tel Aviv University. In addition, selected specimens were regularly sampled individually for the DNA barcoding campaign held in IOLR (Israeli barcode data center, www.ocean.org.il). Lastly, the data was added to the whole dataset for further statistical analyses.

3. Results of the Indicators Assessment

During the entire monitoring programme, different ratios of native versus non-native fish parameters were observed across the sampled isobaths. The shallow waters of 20 and 40 meters always presented higher ratios of introduced fish species, with a mean of 17.25±2.34 and 12.63±3.00 non-native fish species per haul, in comparison with 7.5±3.01 and 7.2±3.18 fish species at the 60 and 80 meters, respectively. The native Mediterranean species, however, show an opposite trend with higher average species count in the deeper waters of 60 and 80 meters (Figure 1). These differences have been previously shown by Levitt (2012) and were attributed to the water temperature and natural preferences for shallow bottoms for the Red Sea invasive species.

Adding temporal parameters to the database shows approximately stable values of the average number of invasive fish species per haul during 2014-2016 at the depths of 20-60m, with an increase in the number of non-native fish species in the 80m hauls of 2016 (Figure 2). This finding is particularly important to monitor in order to apprehend whether there is a specific trend for the non-native fish species to venture into deeper waters.

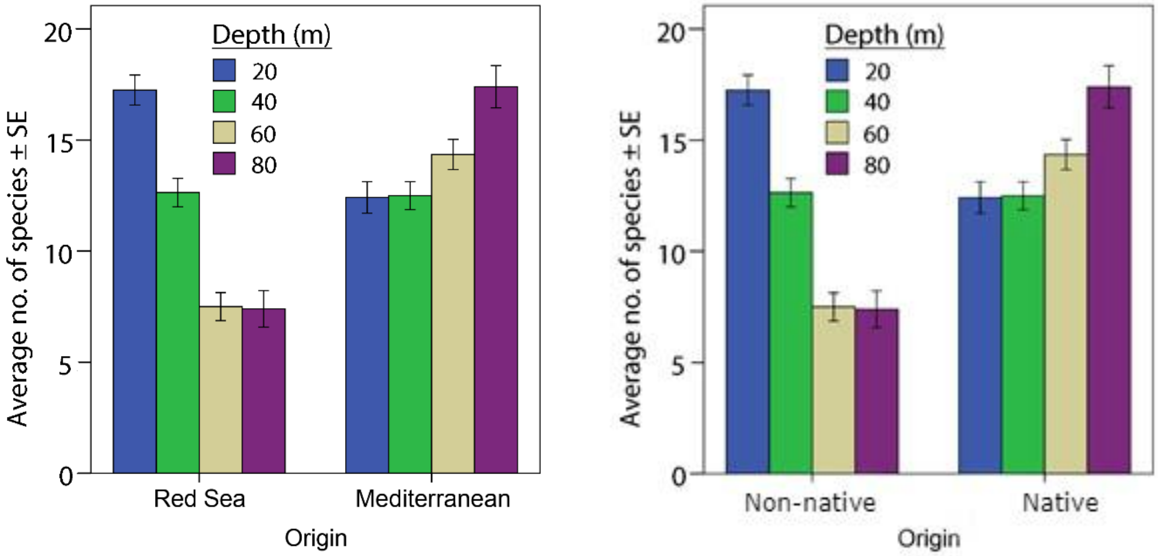

Figure 1. Average no. of fish species per bottom-trawl haul±SE, separated by the origin of the fish and sampled depths.

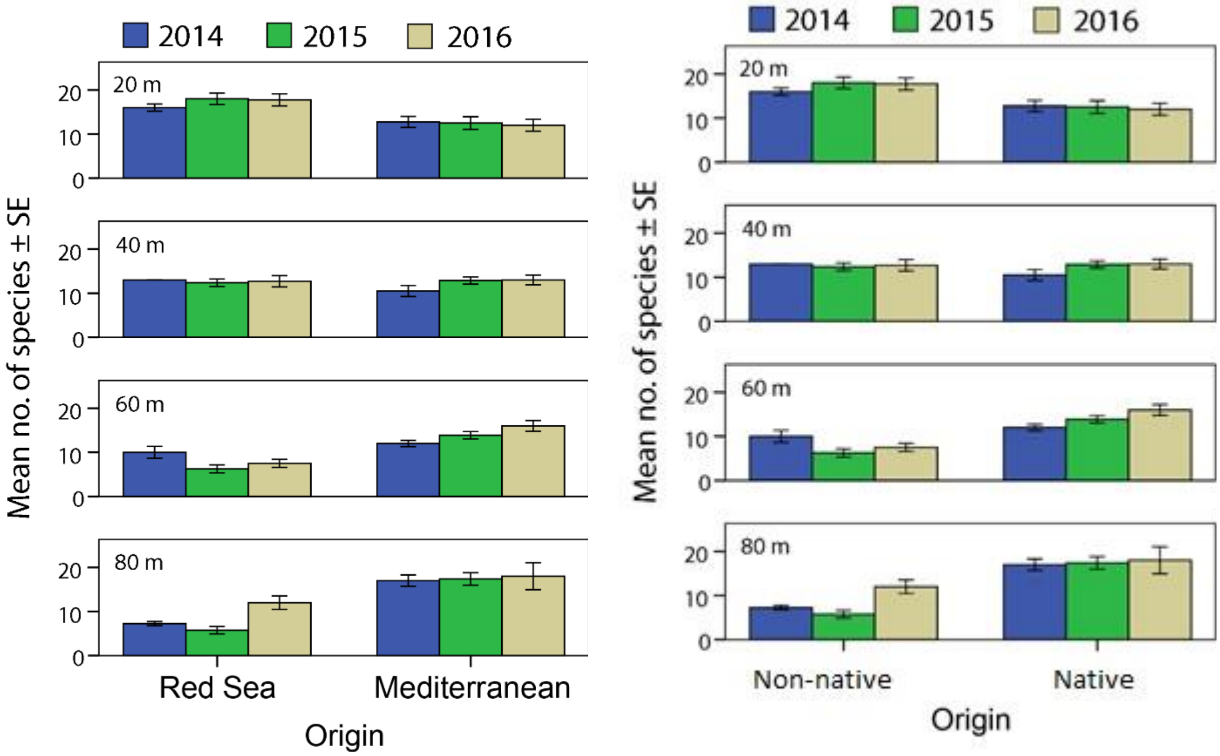

Figure 2. Average no. of fish species per bottom-trawl haul, separated by the origin of the fish, the sampled depths and years.

4. Lessons learnt and/or recommendations

Shift in non-native fish preferences: as for today, the majority of the non-native fish species are significantly more common in shallow isobaths, as shown in our data. It is vital to continue monitoring a gradient of isobaths in order to detect any change within these biological characteristics. A change within this distribution may unbalance the local trophodynamics or pose an ecological threat to the unexperienced native fauna in the newly-invaded deeper waters.

Seasonal variation: due to its non-selectivity characteristics, the bottom-trawl industry is known to be especially destructive during the recruitment season of the new generation of the catch (Stern 2016). While continuing the biannual methodology, we may witness and time the recruitment seasonality of the different commercial species (data not shown). Such long-term information is highly imperative to construct an effective sustainable fisheries management in term of optimal annual fishing moratorium.

The data gather through this monitoring programme demonstrate our ability to detect ecological trends and shifts in the Levantine soft-bottom epifauna, especially considering the fragile dynamics between the local and NIS fauna.

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Annex III

List of Case Studies for the Ecological Objectives 7 (Hydrography) and 8 (Coastal Ecosystems and Landscapes)

The Annex III provides the list of Case Studies that have been submitted by Contracting Parties and Partners for the Ecological Objectives 7 (Hydrography) and 8 (Coastal Ecosystems and Landscapes).

EO7	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Assessment of Environmental Aspects Related to a New Container Terminal (Haifa Bay Port)	Israel	CAMERI, Coastal and Marine Engineering Research Institute, Technion City, Haifa, Israel
2	Hydrological alterations and prediction on habitats impacted by the planned storage, regasification and distribution terminal of LNG in port of Monfalcone – Northern Adriatic	Italy	Giordano Giorgi, Federico Rampazzo, Daniela Berto ISPRA - Italian National Institute for Environmental Protection and Research, Via Vitaliano Brancati, 48 – 00144 – Roma, Italy.
EO8	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Implementation of indicator on length of artificialized coastline for Italy: continental part, Sardinia and Sicily	Italy	Giordano Giorgi, Tania Luti, Luca Parlagreco, Tiziana Cillari, Patrizia Perzia, Saverio Devoti ISPRA - Italian National Institute for Environmental Protection and Research, Via Vitaliano Brancati, 48 – 00144 – Roma, Italy

Common Indicator 15*:* Location and extent of habitats impacted directly by hydrographical changes (EO7)

Case Study title: Assessment of Environmental Aspects Related to a New Container Terminal (Haifa Bay
Port)

Author(s):
CAMERI, Coastal and Marine Engineering Research Institute, Technion City, Haifa, Israel

Brief introduction

The Israel Port Development and Assets Company Ltd. (IPC) prepared an Environmental Impact Assessment (EIA), for the development of a new container terminal in Haifa Port. The presented case study represents the section of the EIA that deals with hydrographical changes and addresses the following hydrographical changes: Change in Wave Climate Conditions; Location of Strong Currents; Erosion in the Vicinity of the Marine Outlets and Changes in Sediment Transport Patterns due to the Projected Haifa Bay Port construction. Please note that the report does not address the issue of habitats that are affected by these changes. Other sections of the EIA deal with ecological impacts of the project, but focus mainly on the dredging works.

1. Methodologies used for the collection and analysis of the data

The report employs the most advanced and updated models for flow and morphodynamic computations, namely MIKE 21/3, LITPACK developed by the Danish Hydraulic Institute (DHI). The bathymetry employed in the numerical modeling is based mainly on maps from a 2009 survey, and, for the projected port layout (Layout A2), on the design maps. The wave climate conditions utilized are based on wave instrumental measurements in Haifa, in which gaps were filled with data from the Ashdod dataset. The wave dataset covers 16 complete hydrographic years (01.04.94-31.03.10). The wind climate conditions are based on wind measurements at Haifa carried out by the Israel Meteorological Service (IMS) (01.04.95-31.03.10). Based on the analysis of the wave data, ten representative waves are selected so as to represent adequately sediment transport potential within the area of interest. The representative waves applied in the modeling are specified from the original 16-year wave time-series and the corresponding wind parameters are picked up from the wind time-series. The sediment parameters used for modeling are chosen according to results of sediment sampling and sediment grain size analysis conducted in the Haifa region during the last three decades.

2. Results of the Indicator Assessment

Change in Wave Climate Conditions - Some changes in wave statistics (01.04.94-31.03.10) due to the Haifa Bay Port construction are mainly obtained offshore the Haifa Port, and in the southern part of Haifa Bay (Figure 1). For the points located offshore the port marine facilities, the changes in wave height are less than 1%, for points located within the approach channel – less than 2%, for points located downstream the new container terminal – less than 5%; and in the middle of Haifa Bay – less than 1.5%. There is no change in wave climate conditions along the southern Haifa coast (Carmel Coast) and almost no changes in the northern points of Haifa Bay. Some shift in wave direction is obtained mainly in points located within the approach channel. The above findings are related to wave refraction only, and do not include reflection by the marine structures. Wave reflection may increase wave heights (theoretically can be doubled) in the vicinity of marine structures, and may cause confusion for sailing. This is the situation with any marine structure and sailing out of the affected zone is a matter of good seamanship. Extreme wave analysis shows that the expected changes in wave significant height for all return periods computed using different distribution functions (Gumbel, Weibull, exponential) are less than 1%.

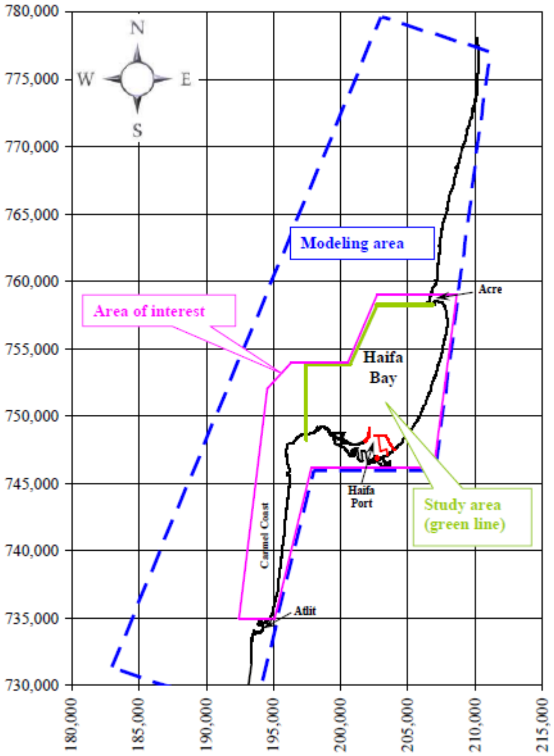

Figure 1:. Plan view of the Haifa region. The coastline is shown in black and the projected facilities of the Haifa Port are indicated in red. Study area ("green line") mentioned in EIA paragraph 1.1.3 is marked in green; the area of interest in terms of sediment transport modeling is marked in pink; and extended area required for numerical modeling is marked in blue. The coordinates are in meters on the New Israel Grid.

Location of Strong Currents - In Haifa Bay, the major impact of the port is due to the construction of the lee breakwater (BW) and the new container terminal, and hence is noticed in the sheltered area, i.e. in the southern part of the bay, limited approximately by latitudes 752,000N-753,000N (ING). For the major wave climate conditions (southern/southwest waves), the area sheltered by the new facilities with very slow flow velocities (less than 0.1 m/s) is larger for Layout A2. However, for northern/northwest waves (more rare events) some local whirlpools in the close vicinity of new terminal (just northward it) could be generated by strong wave events (significant wave height Hm0 larger than 2.5 m). For the present port, Layout A1 estimated current velocities in this place are less than 0.5 m/s. for all considered northern/northwest wave events (W06-W10). For Layout A2 and the same waves, the computed flow velocities within the 500 m width narrow, near-shore strip located just downstream the lee BW of the new container terminal, are larger than 0.5 m/s, but do not exceed 1 m/s (Figure 2).

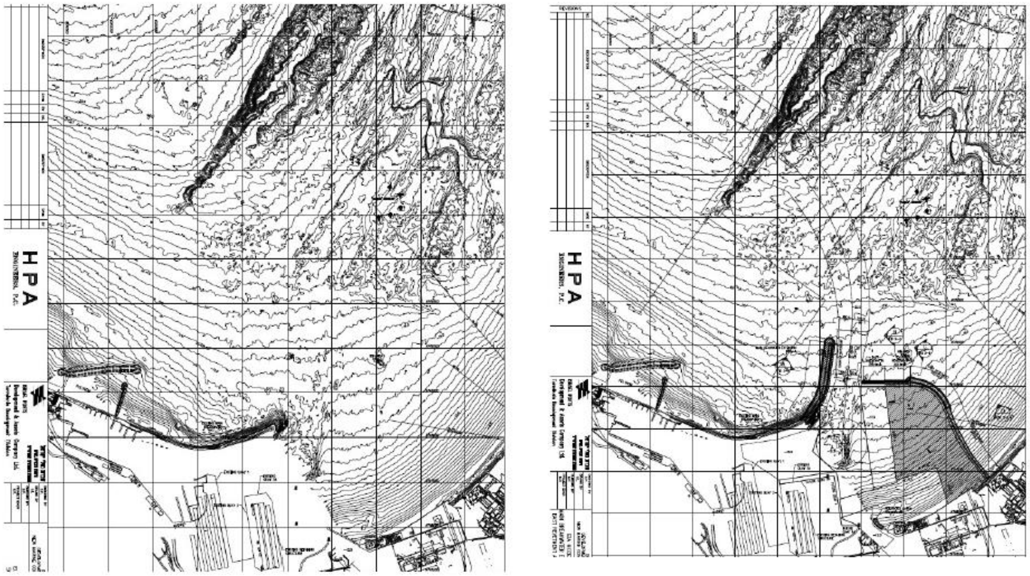

Figure 2: Present (Layout A1) and projected (Layout A2) layouts of the Haifa Port.

Erosion in the Vicinity of Marine Outlets - The results of the current investigation show that the regions affected by the Haifa Port main BW extension and the construction of the new container terminal are limited. Actually, among all the marine installations, located along the shoreline of Haifa Bay to which we were asked to refer, the 32” oil pipeline in Kiryat Haim, north of the planned terminal, is prone to the effects, which can be caused by the projected structures. The investigations performed clearly indicate that a near shore section of the pipe is exposed. The existing old pipe is not supposed to be taken away and can break due to strong erosion forecasted in this place. If no measures are taken, an expected coast retreat is about 50 m during 30-year period that corresponds to about 2 m erosion of seabed. An artificial sand nourishment to prevent this erosion can be of great importance to protect the region from adverse effects such as pipe break. Therefore, it is strongly recommended to execute this sand nourishment in order to keep the oil pipeline in appropriate conditions.

Changes in Sediment Transport Patterns - The expected morphological changes in the Haifa Bay are estimated for a three-year period, while the coastline evolution is estimated for a 30-year period. The results of numerical modeling of two real extreme storm events (20.02.01 and 21.01.07) show that the projected Haifa Bay Port construction (Layout A2) does not introduce significant bathymetric changes in Haifa Bay. The major changes are expected in the littoral zone downstream the projected container terminal. After three years of construction seabed erosion about 7.5 cm is expected in the proximity to the lee BW of the new container terminal, just northward it. Downstream the new lee BW some sand accretion is obtained along the shoreline. At water depths 5-7 m, sand is deposited close to the new facility, while seabed erosion up to 10 cm is noticed at the same water depths northward this place. For Layout A2, the extension of the main BW would lead to almost complete blocking of bypass toward Haifa Bay. The minor amount of sand bypassing the extended BW would partially spread at the large water depths of the bay and only ~600 m3/yr. could possibly reach the littoral zone of the bay.

Coastline evolution - On one hand, construction of the new container terminal leads to the local coast retreat downstream the facility. On the other hand, the projected extension of the main BW is expected to reduce the bypass rates and, consequently, to probably cause beach erosion in the southern part of the bay since in this case there will apparently be no sediment transport to compensate the north-going transport. It is obvious that any marine installation or marine structure located within the region will be subject to the effects caused by the erosion and coastline retreat. In particular, this retreat can affect essentially the oil pipeline and can even threaten the Kiryat Haim Oil Storage Terminal. The same is appropriate in respect to the Kiryat-Yam promenade which can be affected by this coastline retreat. In such conditions, some sand nourishment of about 30,000-40,000 m3/yr might be required in order to maintain the bathymetry as well as the coastline in reasonable conditions. In any case, permanent bathymetry and coastline monitoring, as well as inspection of marine structures and installations, are required in order to gain better insight to the morphological processes occurring downstream the new container terminal and, consequently, to undertake appropriate measures in the future, if necessary.

3. Lessons learnt and/or recommendations

The main outcome of the report was a detailed monitoring and coastal damages remediation plan, conducted by IPC and supervised by the Marine Environment Protection Division at the Israel Ministry of Environmental Protection. The port extension began in May 2015. During this 2-year period, significant erosion was detected in Haifa Bay coastline, more severe than the report predicted. The division worked to ensure IPC would conduct two major beach nourishments in the magnitude of 70,000 m3 in 2016 and 185,000 m3 in 2017.

4. References

CAMERI – Coastal and Marine Engineering Research Institute, (2011). Assessment of Environmental Aspects Related to a New Container Terminal (Haifa Bay Port). Final report P.N. 717/10

Common Indicator 15: Location and extent of the habitats impacted directly by hydrographic alterations (EO7)

Case Study title: Hydrological alterations and prediction on habitats impacted by the planned storage, regasification and distribution terminal of LNG in port of Monfalcone – Northern Adriatic[36]

Author(s): Giordano Giorgi[1], Federico Rampazzo[1], Daniela Berto[1]
[1]ISPRA - Italian National Institute for Environmental Protection and Research, Via Vitaliano Brancati, 48 – 00144 – Roma, Italy

1. Brief Introduction

Both Marine Strategy Framework Directive and EcAp programme for Barcelona Convention for the protection of the Mediterranean Sea (by Descriptor 7 (D7) and Ecological Objective 7 respectively), request an assessment of permanent alterations of the hydrographical conditions on marine ecosystems due to new constructions on the coast and marine installations and seafloor anchored structures starting from 2012. Changes in the tidal regime, sediment transport, current or wave action, can lead to modifications of the physical and chemicals characteristics of coastal environment which in turn implies an impact on marine ecosystem.

Environmental Impact Assessment (EIA) procedures in place take into account the overall impact of infrastructures on ecosystems, although a specific focus on a quantitative and sound linkage between alterations of the hydrographical conditions and coastal or marine environment conditions is still lacking. In this study, a 3D Hydrodynamics model (TELEMAC-3D) was implemented for the area of Port of Monfalcone in Italy, where work for deepening of the access channel and basin evolution of the port and the establishment of a small liquefied natural gas (LNG) storage, regasification and distribution terminal are planned. In order to estimate the impact on the coastal ecosystems, 3D Hydrodynamics model were coupled with D-Water Quality and D-Ecology programmes (DELWAQ) and a specific monitoring programme to collect in-situ parameters was developed to calibrate and validate the model. Boundary conditions for the hydrological modelling were provided by Copernicus Marine Environment Monitoring Services – CMEMS http://marine.copernicus.eu/.

2. Methodologies used for the collection and analysis of the data

The area of Port of Monfalcone in Italy has been identified among sites where a national EIA procedure is on-going regarding future building of strategic marine and coastal infrastructures responsible for permanent changes to hydrographical regimes and physiographic characteristics. In particular, works for the planned small LNG storage, regasification and distribution terminal, will include:

- DDredging for deepening seabed and channels;
- CCreation of an enclosed and protected damper box protected by a dam for the reception of dredged sediments;
- RConstruction of a new quay equipped with structures and plants for laying, mooring and discharge/loading of methane vessels;
- Extension of the existing flood dam;
- Laying pipelines (cryogenic conduits, lines for return steam and conduits for fire water) connecting the dock and the LNG Terminal area;
- Laying down the water supply and discharge pipelines to be used for the LNG regasification process;

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[36] Project EcAp-ICZM founded by Italian Ministry of Environment.

- Installation of the plant (storage, regasification and distribution);
- Installation of the pipeline connecting to the regional transport network SRG.

In order to assess impacts due to permanent changes to hydrological processes and physiographical characteristics, the following features are considered relevant:

- Deepening seabed and channels;
- Extension of the existing flood dam;
- Pipelines for water supply and discharge for the LNG regasification process;

Calibration and validation of the model has been done using in-situ monitoring data on n. 6 monitoring stations for particulates, dissolved and vertical profile parameters and n. 8 monitoring stations for sediments. Three monitoring campaigns were carried out on 02/03/2016, 21/04/2016 and 04/05/2017. N. 4 sea bottom and n. 2 superficial sedimentary traps were installed and recovered on three different campaigns on 04/03/2016, 18/03/2016 and 10/04/2016. Parameters on particulates phase were Particulate Organic Carbon (POC), Total Particulate Nitrogen (TPN), Chlorophyll a, Phaeopigments, Total Suspended Solids (TSS), stable isotopes of Carbon ($\delta^{13}C$) and Nitrogen ($\delta^{15}N$); on dissolved phase were Dissolved Organic Carbon (DOC), nitrite, nitrate, Dissolved Inorganic Nitrogen (DIN), Dissolved Organic Nitrogen (DON), Total Dissolved Nitrogen (TDN), orthophosphates, Total Dissolved Phosphorous, Chromophoric Dissolved Organic Matter (CDOM). Total Carbon, Total Nitrogen, Organic Carbon, stable isotopes of Carbon ($\delta^{13}C$) and Nitrogen ($\delta^{15}N$), were monitored in sediments and sedimentary traps while Total Dissolved Phosphorous only in sediments. Temperature, Salinity (Conductibility), Turbidity and Depth were measured by Idronaut probe on vertical profiles with steps separated by 20-30 cm.

Current meters were installed on n. 3 monitoring stations, of which the first station was equipped with a current meter suspended at 3.5-meter depth, the second one with both suspended at 3.5-meter depth and at sea bottom and the third station only at sea bottom.

River flows data relevant for the area have been provided by River Basin District Authority of Eastern Alps and ARPA FVG. The hydrological modelling has been forced by boundary conditions provided by the following products available on Copernicus Marine Environment Monitoring Services – CMEMS http://marine.copernicus.eu/ :

- MEDSEA_ANALYSIS_FORECAST_PHYS_006_001
- MEDSEA_ANALYSIS_FORECAST_BIO_006_006

3. Results of the Indicator Assessment

The calibrated 3D Hydrodynamics model (TELEMAC-3D) coupled with DELWAQ has produced a synoptic annual description of main hydrological process and biogeochemical parameters representative of ex-ante setting prior to the installation of LNG terminal coastal infrastructures (Figure 1). A simulation of the hydrological process with the new planned infrastructures has been carried on the area where significant and permanent changes of hydrological processes are foreseen has been identified along with its extension.

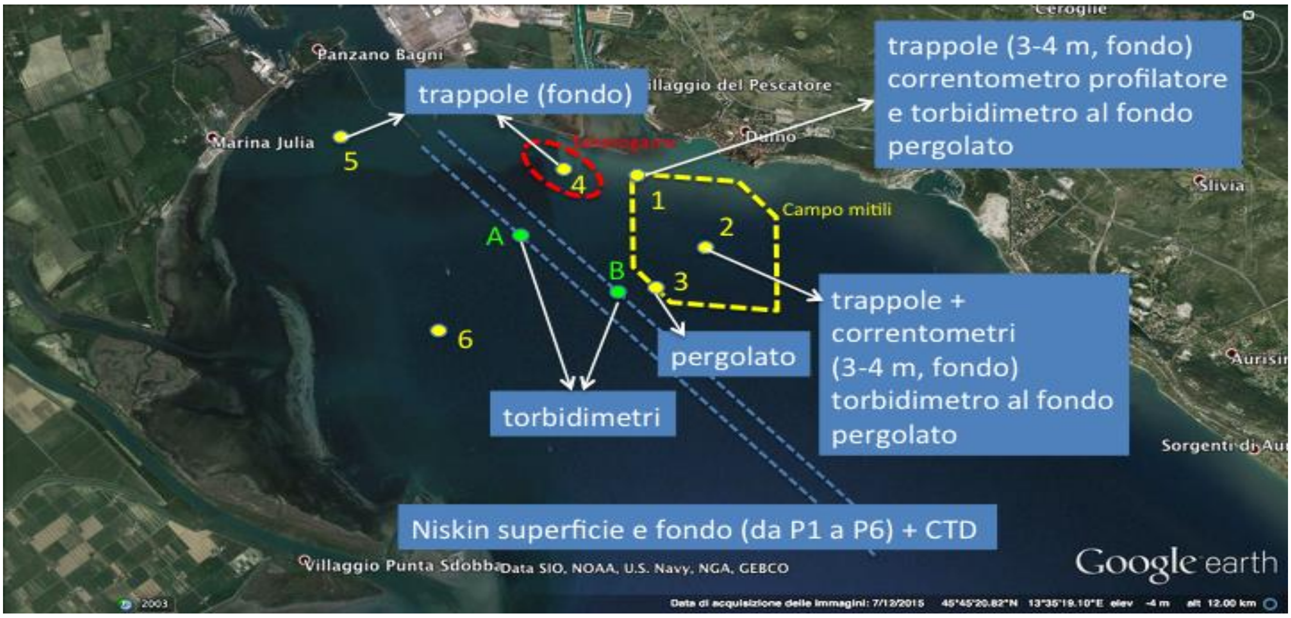

Figure 5: A synoptic annual description of main hydrological process and biogeochemical parameters representative of ex-ante setting prior to the installation of LNG terminal coastal infrastructures, produced by 3D Hydrodynamics model (TELEMAC-3D) coupled with DELWAQ.

4. Lessons learnt and/or recommendations

The pilot project for the area of Port of Monfalcone in Italy, has highlighted the necessity for use of very high resolution and 3D hydrological modelling in order to capture significant changes in hydrological processes due to new planned coastal and marine infrastructures whose dimension usually ranges from 1 to 5 km. Such hydrological modelling requires very specific in-situ monitoring programmes to calibrate and validate their outputs and simulations with in-place new planned infrastructures are also required to estimate the extension of the area where significant and permanent changes to hydrological processes are to occur. A hydrological process change has been regarded as significant if it varies beyond its natural variability which can be assessed by long time series of data. In the area of Port of Monfalcone such long time series are available so this point did not represent a critical one for the project but this is not always the case. The forecast of potential impacts on seabed or water column habitat beyond the area where hydrological changes are foreseen to occur, is a challenging task and more specific and detailed studies along with improved biogeochemical modelling will be required to accomplish it.

5. References

Copernicus Marine Environment Monitoring Services – CMEMS http://marine.copernicus.eu/

TELEMAC 3D - http://www.opentelemac.org

Common Indicator 16: Length of coastline subject to physical disturbance due to the influence of man-made structures (EO8)

Case Study title: Implementation of indicator on length of artificialized coastline for Italy: continental part, Sardinia and Sicily[37]

Author(s): Giordano Giorgi[1], Tania Luti[1], Luca Parlagreco[1], Tiziana Cillari[1], Patrizia Perzia[1] Saverio Devoti[1]
[1]ISPRA - Italian National Institute for Environmental Protection and Research, Via Vitaliano Brancati, 48 – 00144 – Roma, Italy

1. Brief introduction

Coastal defence structures, ports and marinas were identified with GIS procedures using georeferenced aerial photographs of 2006 and 2012. As a reference coastline for the calculation of length of artificialized segments, the Italy coastline was chosen in 2006. The length of artificial coastline was calculated as the sum of segments on the reference coastline identified as the intersection of polylines representing manmade structures with the reference coastline, ignoring polylines representing manmade structures with no intersection with reference coastline.

The minimum distance between coastal defense structures was set to 10 m in order to classify such segments as natural, i.e. if the distance between two adjacent coastal defense structures is less than 10 m, then all the segment including both coastal defense structures is classified as artificial. The final product was constituted by the polylines and polygons of coastal defence structures, ports and marinas and by the three different polylines on the reference coastline for continental Italy, Sardinia and Sicily with each segment classified as natural (green color) or artificial (red color) (Figure 1). All products are represented using WGS84 as Geographic Reference Systems and shapefile format.

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[37] Project EcAp-ICZM founded by Italian Ministry of Environment.

Figure 6: The Italian coastline with artificial and natural segments (2006).

2. Methodologies used for the collection and analysis of the data

The methodology adopted was divided into the following phases:

- Imagery data selection and preparation of data for photointerpretation
- Information layer update through photointerpretation
- Processing of the "effective" coastline and identification of coastal defense structures
- Index calculation for 2006 and 2012

As regards the first phase, 2006 ISPRA reference coastline was selected and AGEA aerial photographs for 2006 and 2012 have been extracted to cover the entire Italian coastline and properly projected in agreement with 2006 ISPRA reference coastline. This last step required a considerable about 2 months and hardware resources. Coastal defense structures included in the 2006 ISPRA reference coastline were mapped to the classification scheme proposed by UNEP/MAP IMAP Monitoring Guidance and E08 factsheets. All polygons identified by photointerpretation were archived in a geodatabase that is compatible with shapefile format.

3. Results of the Indicator Assessment

The final results for 2006 and 2012 and trends 2006-2012 are represented in Table 1.

Table 1: Summary of results on the length of artificialized coastline for Italy

	LENGTH (KM) ***2006***			**PERCENTAGE** ***2006***		**PERCENTAGE** ***2012***		***TREND 2006-2012***
	total	natural	artificial	natural	artificial	natural	artificial	artificial

ITALY – Continental	3844.985	3058.103	786.882	79.53	20.47	79.02	20.98	+0.51%
SICILIY	1177.769	1003.140	174.629	85.17	14.83	85.01	14.99	+0.16%
SARDINIA	1512.145	1444.395	67.749	95.52	4.48	95.46	4.54	+0.06%
TOTAL	6535.899	5505.638	1029.261	**84.25**	**15.75**	**83.89**	**16.11**	**+0.36%**

4. Lessons learnt and/or recommendations

A key concept was represented by choosing a reference coastline on which coastal defence structures, ports and marinas are to be projected. Such reference coastline should represent a reasonable compromise between proper resolution and being up-to-date. Proper resolution should assure the possibility to detect changes due to new coastal defence structures. If a reference coastline is too recent most if not all of coastal defence structures will be included in the baseline and trends will be biased by such choice. Photointerpretation procedures also play a crucial role in the identification of polygons which represent infrastructures and a well-trained GIS expert team is a pre-requisite to carry on the all work in a consistent and reasonable time period. The sole photointerpretation work to cover all Italian coastline amounts to 6 months by 4 GIS experts.

It is strongly advisable that such common procedures should be agreed at Mediterranean level in order to end up with a consistent picture among countries.