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CO-EVOLVE

Promoting the co-evolution of human activities and natural systems for the development of sustainable coastal and maritime tourism

Deliverable 3.8.1

Review and analysis of coastal protection planning and management in touristic areas

Activity 3.8

Enabling factors for sustainable co- evolution in touristic areas - Mediterranean scale: Coastal protection measures

WP3

CNR-ISMAR

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1. Introduction

The Mediterranean coastal zones are normally associated with mass tourism which, in the last years, has significantly contributed to the urban development of coastal areas (Hall, 2001; Amelung & Viner, 2006): out of a total of 46.000 kilometres Mediterranean coastline, 25.000 km are urbanized (EU, 2013).

The overall amount of tourist arrival per year in the whole area is around 220 millions and today the Mediterranean coasts are the world's leading tourism destination, accounting more than one third of total world tourism. Forecast studies carried out by the World Tourism Organization (WTO) estimate that international tourist arrivals to the Mediterranean coast will amount to 346 millions in 2020.

In addition, tourism industry is clearly essential to most of the Mediterranean economies and four Mediterranean Countries - Italy, Spain, France and Greece- are among the world's top 15 tourism earners in 2001 (WTO, Tourism Highlights, 2003).

Three are the basic features of the coastal tourism in the Mediterranean: (1) it is concentrated on coasts; (2) it is heavily seasonal, mainly concentrated in summer months; (3) the European Mediterranean currently dominates the tourism markets.

However, this industry is undergoing a serious threat because of the beach erosion reducing their carrying capacity and affecting the tourist recreational appeals and opportunities, up to the development of important socio-economic effects for the coastal areas (Berrittella et al., 2006; Phillips & Jones, 2006).

Because the demand for coastal tourism is always growing together with the consequent environmental risks, the need for governance is to develop strategic and operational plans in order to balance the benefits from tourism economy with those coming from environmental sustainability and protection, also at the lights of climate change scenarios.

The present report represents the *Deliverable 3.8.1 – "Review and analysis of coastal protection planning and management in touristic areas"*, which is one of the three outputs expected from the "Activity 3.8 - Enabling factors for sustainable co- evolution in touristic areas - Mediterranean scale: Coastal protection measures".

The main goal of this deliverable is that of carrying out an analysis of coastal protection plans in different frameworks of the Mediterranean, addressing successes and failures of various approaches. Representative case studies have been identified based on morphological and meteo-oceanographic characteristics of the site and on the touristic activities practiced therein, identified according to the definitions and classifications

proposed by the working group responsible for Deliverable 3.16.

A review of the main EU directives and national and regional coastal plans is described in Section 2, focusing on ICZM policies and coastal management according to EU Water Framework and Flood Directives.

Section 3 reports the overview of the coastal defence measures in the Mediterranean Sea, with the description of some representative case studies. Finally, in the conclusions we provide a synthesis on the strengths and weaknesses in the actual coastal planning in relation to defence and protection.

2. Review of coastal protection plans

In the following sections, the general description of EU directives regarding coastal management and sustainable tourism respectively and their applications at national, regional and local scales will be analysed, with a particular focus on the adopted management plans and defence measures.

2.1 General description and application of EU directives dealing with coastal protection

2.1.1 Coastal Protection Management

The European Union has adopted the following legislative instruments to deal with the protection of the marine environment:

- Environmental Assessment Directives: Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA)
- the 2000/60/EC Water Framework Directive (WFD)
- the Recommendation on Integrated Coastal Zone Management (ICZM)
- 2007/60/EC Floods Directive (FD)
- the 2008/56/EC Marine Strategy Framework Directive (MSFD)

They offer a comprehensive and integrated approach to the planning and management for the protection of all the European coasts and marine waters.
In the following, some details on the cited directives are given, focusing on coastal management issues.

EIA and SEA. The EIA Directive (85/337/EEC) is in force since 1985 and applies to a wide range of defined public and private projects, which are defined in Annexes I and II. Focusing on coastal management issues, limitations of the EIA Directives is that coastal erosion may be considered, not in mandatory way, only in activities listed in Annex II including harbours, ports and fishing harbours, intensive fish farming; reclamation of land from the sea; coastal work to combat erosion and maritime works capable of altering the coast through the construction, for example, of dykes, jetties and other sea defence works, excluding the maintenance and reconstruction of such works; and marinas. Later, SEA Directive, adopted in 2001, allowed covering a wider range of activities respect to the EIA process. SEA can be applied to an entire sector or to a geographical area. Article 5 of the Directive states that

Member States of the area likely to be affected, in particular it lists the transboundary nature of the effects, the risks to the environment and the effects on areas or landscapes that have recognised international, Community or national protection status. This should help address sediment management and coastal erosion, however, and the extent to which this has been achieved would require an examination of SEAs carried out to date.

WATER FRAMEWORK. The Directive mainly regards the monitoring and management issues related to surface waters and groundwater quality, from an ecological and chemical points of view and the identification of pressures.

At the scale of river basin district, the Member States were required to develop a River Basin Management Plan (RBMP) including programme of measures (PoM) was required to be finalized at the end of 2010, becoming operational only by December 2012 following a classification of the measures in terms of priority areas of action. On 2016, the second river basin management plan was adopted by Italy, France, Croatia, Spain (partially), while Greece is still pending (http://ec.europa.eu/environment/water/participation/map_mc/map.htm; last updated: 28/10/2016).

Links to the official WFD implementation web sites of the EU Member states are found at http://ec.europa.eu/environment/water/water-framework/links/index_en.htm.

ICZM. The EU policy regarding ICZM has the status of a recommendation only. Member States were encouraged to develop and publish national coastal strategies in order to further promote sustainable development of coastal zones on the principles and elements set out in the Council Recommendation on Integrated Coastal Zone Management of 2002 and the Protocol to the Barcelona Convention on Integrated Coastal zone Management, ratified by the EU in 2010; in the latter Protocol, Member States (Spain, France, Italy, Slovenia, Greece, Malta and Cyprus) have committed themselves to undertake the necessary measures to mitigate the impact of coastal erosion.

The lack of a Directive on ICZM reflects the complexity of socioeconomic issues involved in coastal land use, differences in legal systems across Member States and the difficulty of defining acceptable management strategies for the different residents, users and interest groups involved with the coastal region.

Connections between ICZM and climate change adaptation are reported in the European Climate Change Policy (IPCC II), in particular focusing on the aspects of long-term and

cross-sectoral planning and the fact that natural dynamics have to be taken into account (Ecofys, 2006, Source; www.ecofys.com). Member States "should be encouraged to develop long-term strategies for coastal protection with a view towards 2100" and regarding flood risk and coastal erosion management, the report suggests that work on climate change in the coastal zone could be integrated with an understanding of the overall coastal policies in operation.

In the EU ICZM Recommendation, practical measures (preserve dune strength, maintain beach width, allow retreat of shoreline in a controllable way) as well as the elaboration of management plans are the indications to reduce coastal erosion and flooding, with the involvement of all relevant parties, local specificity and taking a long term perspective.

Various have been the initiatives to help EU Countries in the implementation of ICZM policies. For instance, the guidelines delivered by PEGASO project, funded under the EU Framework 7 programme 2010-2014, had the aim to assist Countries to strengthen or formulate national strategies for ICZM as required by the ICZM Protocol in the Mediterranean Sea.

In addition, in 2012, the Bologna Charter was signed by 25 European governments and the Inter-Mediterranean Commission of the Conference of Maritime Regions (CPMR), aiming at strengthening and affirmation of the role of Regions for management policies and coastal defence, through the development of macro-projects.

All around Europe, many have been the efforts to implement ICZM and many the lessons that could be taken from others' experiences. Through the OURCOAST portal (http://ec.europa.eu/ourcoast/index.cfm?menuID=4), the developed ICZM Database allows to access representative cases where the principles and tools of ICZM have been applied and are summarized.

The EU requested national reports on the implementation of the ICZM Recommendation by February 2006: this evaluation confirmed the validity of the ICZM principles and invite the State Members to further implement it in their Countries.

In 2010 the EU coastal Member States were invited to provide an update of the progress in implementing ICZM: at the link http://ec.europa.eu/environment/iczm/nat_reports.htm, the 2010 reports can be viewed and downloaded and generally show a significant improvement in the coordination between the different authorities and administrators, aiming to develop adequate and integrated coastal planning, for instance, for conservation and valorisation of the natural protected areas (Nature 2000); coastal zone monitoring; monitoring and control of reclamation sites of national interest; protection of water resources.

Coastal Area Management Programme (CAMP) is a EU programme, oriented at the implementation of practical national coastal management projects in selected Mediterranean coastal areas (Figure 1), applying the Integrated Coastal Zone Management (ICZM) as a major tool.

Figure 1 CAMP projects at the Mediterranean coastal areas and their status; Source: http://www.pap-thecoastcentre.org/index.php?lang=en.

FLOOD RISK. Floods Directive on the Assessment and Management of Flood Risks (2007/60/EC) requires to River Basin Districts to include measures to reduce the probability of flooding and its potential consequences thus becoming the operational instrument for flood risk management in its entire spectrum.

The production of flood risk maps and management plans represents the required steps to reduce the negative consequences of flooding on human health, economic activities, the environment and cultural heritage in the European Union and helps Member States by equipping them with suitable tools to reduce the risk of flooding and to limit the impact of floods.

The Directive is applied to all kinds of floods including coastal floods, also due to storm surges and tsunamis, on all of the EU territory and also required the identification by means of maps of the number of inhabitants potentially at risk, the economic activity and the environmental damage potential.

This Directive also covers floods from sea in coastal area, where erosion is recognised to be as an important factor to fight. According to Article 6 of the Directive, Member States may decide that, "for coastal areas where an adequate level of protection is in place, the

preparation of flood hazard maps shall be limited to" "floods with a low probability, or extreme events scenarios". Member States assign coastal areas at risk to the nearest or most appropriate river basin, while coastal waters are defined as one nautical mile from the coastline and extending, where appropriate, up to the outer limit of transitional waters. They required preliminarily identifying potential risk of flooding, developing flood hazard and flood risk maps and then developing there the management plans. EU Member States decided to use the same districts as for the Water Framework Directive (WFD); their location is available at the website http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer.

In 2012 and in 2014, all the Mediterranean Members, at hydrological basin/district scale, prepared the updated Preliminary Flood Risk Assessments (PFRAs), where effects of sea-level rise, and climate change adaptation were included, and Flood Hazard & Risk Maps (FHRMs), while the updated flood risk management plans (FRMPs) have been adopted (see Figure 2, downloaded at the site http://ec.europa.eu/environment/water/flood_risk/implem.htm, on 31/05/2017) at the end of 2015 for most of the all units of management in the Mediterranean Countries, except for Greece, whose plan is still pending. The plans must contain the identification of the areas exposed to significant flood risks, together with flood hazard and risk maps, the description of management objectives to reduce flood consequences, non-structural/structural prevention measures; costs-benefits analysis and planning actions in accordance with the WFD (Art. 7).

These three steps are to be repeated in a six- year cycle to ensure that long-term developments are taken into account.

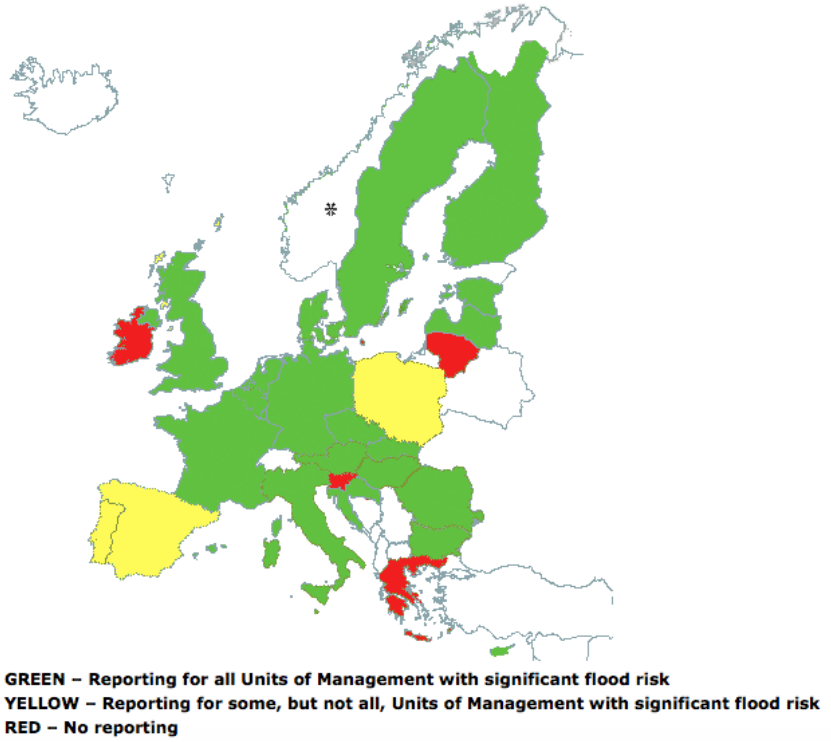

Figure 2 EU Countries where FRMPs are published; Source: http://ec.europa.eu/environment/water/flood_risk/implem.htm.

In Table 1, the links to the plans approved by the different districts of the EU Mediterranean States are listed, that will be briefly analysed in the following sections.

Country	District	FRMPs
Croatia		http://www.voda.hr/sites/default/files/dokumenti/nacrt_plana_upravljanja_vodnim_podrucjima.pdf
France	Rhone-Mediterranèe	http://www.rhone-mediterranee.eaufrance.fr/gestion/inondations/pgri.php#PGRI
	Corse	http://www.corse.developpement-durable.gouv.fr/IMG/pdf/PGRI_Corse_VF.pdf
Greece http://www.ypeka.gr/Default.aspx?tabid=252&language=el-GR	STILL NOT PRESENT	
Italy	Eastern Alps	http://www.alpiorientali.it/index.php?option=com_content&view=article&id=389&Itemid=416
	Po Basin	http://pianoalluvioni.adbpo.it/il-piano/
	Northern Appenines	http://www.appenninosettentrionale.it/dist/?page_id=6
	Serchio	http://www.autorita.bacinoserchio.it/pianodigestione_alluvioni
	Central Appenines	http://www.abtevere.it/node/920
	Southern Appenines	http://www.ildistrettoidrograficodellappenninomeridionale.it/index.html
	Sardinia	http://www.regione.sardegna.it/pianogestionerischioalluvioni/
	Sicily	http://www.artasicilia.eu/old_site/web/bacini_idrografici
Malta		http://energywateragency.gov.mt/en/Documents/Management%20Plan%20for%20Extreme%20Events.pdf
Spain http://www.magrama.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/planes-gestion-riesgos-inundacion/	Catalunya	http://aca-web.gencat.cat/aca/appmanager/aca/aca?_nfpb=true&_pageLabel=P524002632214315266712 55
	Mediterranean Andalucía	http://www.juntadeandalucia.es/medioambiente/site/portalweb/menuitem.7e1cf46ddf59bb227a9ebe205510e1ca/?vgnextoid=61b3713f5e782510VgnVCM1000001325e50aRCRD&vgnextchannel=9136461af55f4310VgnVCM1000001325e50aRCRD
	Ebro	http://www.chebro.es/contenido.visualizar.do?idContenido=42699&idMenu=4800
	Balearic Islands	http://www.caib.es/sacmicrofront/contenido.do?mkey=M0808011112185729323&lang=ES&cont=60907
	Jucar	http://www.chj.es/es-es/medioambiente/GestionRiesgosInundacion/Paginas/Planesdegesti%C3%B3n.aspx
	Segura	http://www.chsegura.es/export/descargas/planificacionydma/planriesgoinundaciones/docsdescarga/01_PGRI_MEMORIA.pdf

Table 1 Links to the flood risk management plans (last updated 01/06/2017).

Marine Strategy. The 2008 Marine Strategy Framework Directive provides an opportunity to frame *sustainable erosion management* practices. The Marine Strategy does not explicitly address the issue of coastal erosion, but could pose restrictions to measures for erosion control, if these affect the good environmental status of the marine environment. Especially the designation of *strategic sediment reservoirs* should be taken up as an important component of marine planning.

Currently, the NATURA 2000 sites, defined under 92/43/CEE “Habitat” Directive, are often used as sources to supply sediments and to compensate chronic deficits of sediments, allowing the natural dynamic to operate within these sites leading to the replacement of one habitat.

2.1.2 Sustainable tourism

The European Commission is currently developing a strategy to provide Europe with complementary tools to foster a smarter, more sustainable and inclusive coastal and maritime tourism in Europe, where participation from interested stakeholders is of outmost importance. After a public consultation in 2012 (http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/tourism/summary-report-consultation-on-tourism-in-the-eu_en.pdf) on the formulation of the Communication on Challenges and Opportunities for Maritime and Coastal Tourism in Europe, the resulted most relevant touristic activities for the development of a competitive and sustainable coastal and maritime strategy for Europe seemed to be non-beach related tourism activities (e.g. heritage based tourism, cultural tourism, gastronomic events) and yachting, boating and cruising. Eco- tourism, beach-based recreational tourism and nautical sports followed in the list of preferred activities with potential to promote the sector attractiveness.

Seasonality and sustainability threats were identified as the main challenges ahead for maritime and coastal tourism in Europe, while the need to guarantee the sustainability of the sector was a clear priority for the survey participants, with the protection of the physical and natural environment of coastal regions by supporting sustainable economic and social measures whilst mitigating adverse impacts.

During years, different aspects regarding sustainable tourism have been treated by EU policy actions. In particular, on the quality of coastal waters, within the Water Directive (REF), "good status" for all the form of waters must be achieved for all European Members by 2015.

Regarding the quality of the beaches and their conservation, the EU Directive on the Conservation of Natural Habitats, Fauna and Flora establishes a community wide network of Special Areas of Conservation and Special Protected Areas. It is a key means of achieving the principle of environmental integration and ultimately sustainable development (NATURA 2000, http://europa.eu.int/comm/environment/nature), particularly adapted to the growth of ecotourism activities. In addition, the Strategic Environmental Assessment Directive (2001/42/EC) ensures that environmental consequences of certain plans on regional and local levels are identified and assessed during their preparation and prior to their adoption.

2.2 Overview of the available National Plans

Croatia has been chosen as case study for harmonization of national legal and institutional framework with ICZM Protocol in the GEF MedPartnership project. Within the CAMP Project, the Kastela Bay, (near Split) was developed in 1988 and was one of the first area-specific activities of MAP -initially called Country Pilot Projects (CPPs) and afterwards expanded to become MAP- CAMP Projects.

In 2012 Croatia launched the process of preparation of the Marine Strategy, as requested by the EU's Marine Strategy Framework Directive. The first assessment completed was the "Initial assessment of the state of marine environment in the Croatian Adriatic". After the sign of the ICZM Protocol for the Mediterranean, which requires the preparation and adoption of national coastal strategies, the Croatian Government decided to prepare a joint Marine and Coastal Strategy for Croatia.

In 2015, the Croatian Government has been finalising two other important strategic documents: the regional and the spatial development strategy plans.

Through project COASTANCE (MED programme) Guidelines for integrated coastal zone management of Dubrovnik Neretva County have been developed while, through the EU project COASTGAP, a Joint Action Plan has been carried out in order to direct developing conditions for the Blue Growth in the Mediterranean.

On July 2016, the Croatian Government adopted the new RBMP (http://www.voda.hr/hr/plan-upravljanja-vodnim-podrucjima) for the two river basin districts, only one for coastal areas (Adriatic district). In the PoM, technical actions mainly regard water quality and use for agriculture, not including any hydromorphological measures and measures against erosion. The plan, although including the development of monitoring programme for surface waters also on coastal areas, contains few information on climate change and adaptation measures.

Croatia is in line with the deadlines for EU-Flood Directive, publishing in 2016 the FRMP, as an integral part of the RBMP. The Water Act establishes the complete water management framework in Croatia and Croatian Water - Hrvatske Vode (CW) as a legal entity for water management, also by means the existing measures defined in National Flood Defence Plan and Annual Maintenance Programme of Regulation and Flood Protection Systems.
Under the Ministry of Agriculture, CW acts as political body by elaborating acts and legislation and developed the FRMP that lists the measures (existing, additional non-structural, and structural measures, as the construction and reconstruction of flood protection infrastructure) that have to be adopted in order to reduce flood risk in Croatia. Each measure is linked with the competent institution responsible for its implementation and is described only in general term, not referred to a specific location.

France adopted in 2012 the National Marine and Coastal Strategy for the integrated management of the coastline, and a first action program with the aim of reinforcing knowledge of the coastline and encouraging the establishment of local strategies to adapt the territories to changes in the littoral. In 2010, the report showing the progress of the ICZM implementation describes, among the others, the management of the Basin of Thau, with some difficulties, as the lack of clarity in the maritime policy and in the indicators to be used.
As a follow-up to the first program of actions (2012 – 2015), a new program has been adopted in 2017. It presents a summary of the actions carried out under the previous program; a description of common principles and policy recommendations for coastline management; the list of the actions identified for the period 2017-2019, organized in 5 axes:

-Develop and share knowledge on the coastline (Axis A);

-Develop and implement shared territorial strategies (Axis B);

-Develop experimental approaches to littoral territories to facilitate spatial recomposition (Axis C);

-Identify the methods of financial intervention (Axis D);

-Communicate, raise awareness and train on the issues of coastline management (Cross-cutting).

France has established several agreements with neighbourhood states such as Italy, Monaco, Spain, and important efforts have been developed by regions such as PACA (Provence-Alpes-Côte d'Azur) for the Mediterranean French coastline, even though ICZM management has not been totally transferred to regions.

The 2nd RBMP in France was adopted on December 2015, identifying 12 river basin districts, among which the Rhone Mediterranean district (http://www.rhone-mediterranee.eaufrance.fr) and the Corse district (http://www.corse.eaufrance.fr) cover the coastal Mediterranean areas, with 46 coastal water bodies.

Extensive co-ordination process between the different sectors and stakeholders and numerous national guidelines have been extensively developed for most of the WFD topics (monitoring, ecological and chemical assessment methods, groundwater assessment, exemptions), while some technical weaknesses, for instance in the biological assessment methods and in the monitoring data availability to define pressures, are present. France has applied a national approach in the methodologies for establishing the surveillance and the operational monitoring schemes, with 24 and 15 stations respectively on the two Mediterranean districts. The surveillance monitoring provides information on the general status of water bodies, with the objective of collecting enough data to study the aquatic ecosystems in the long term, and in particular to assess the impacts on those ecosystems by the changes induced by human activities and climate change. On the other hand, the operational monitoring should analyse pressures and impacts in order to assess the improvements of the status of water bodies after the implementation of the programme of measures.

In ***Greece***, there is no specific equivalent legislation dealing with ICZM, but the most important legislations with regard to environment and planning are the General Framework for Spatial Planning at national level (Joint Ministerial Decision, 2008); Regional Spatial Plans (4 Ministerial Decisions, 2003) for Northern Aegean, Southern Aegean, Crete and Ionian islands Regions; 8 more Regional Spatial Plans (8 Ministerial Decisions, 2003) for the other coastal Regions; L. 2971/2001 on Coasts and Beaches and National Framework for Spatial Planning of Coastal Areas & Islands; 3 Special National Frameworks for Renewable Energy, Industry and Tourism, the latter defining actions for marine and coastal tourism development, mainly regarding rental boats; scuba diving; growth of nature tourism in protected areas, including the national marine parks of Zakynthos and Sporades.

All these frameworks were expected to incorporate and specify the objectives and targets of ICZM at national and regional scales.

Regarding WFD implementation (http://wfd.ypeka.gr/?mylang=greek), Greece has 14 River Basin Districts, all including coastal areas, and 5 of these are transboundary river basins.

Regarding the plan implementation, the delay is probably due to technical issues, as well as legislative and administrative barriers and socio-economic constraints. The lack of WFD-

compliant data, since information come from the old monitoring network, which was obsolete, fragmented and incomplete. Other issues regard the harmonisation between the plans and the development of common approaches, to ensure efficient use and adequate contribution from different users/stakeholders.
The publication (http://cdr.eionet.europa.eu/gr/eu/floods) of the PFRA and FHRMs occurred in 2012 in line with the EU requirements; but at the time of the present report, the Greek FRMP is not yet published.

In ***Italy***, the coast management is quite fragmented, with the involvement of a large number of authorities (at national, regional and local scales) and stakeholders.
Italy lacks a uniform national ICZM strategy (Martino, 2016) and an attempt of integrating initiatives for coastal management is evident at national scale, adopting the National strategy for Biodiversity, and at sub-national scale, even though with different approaches and grades of maturity, i.e. decennial Plan for the coastal management (Emilia-Romagna, 2007); the Programs for intervention in defence of the Regional coast and the Program "Marine Habitats" for the sustainable development of the marine ecosystems (Lazio, 2008 and 2009 respectively); Plans of the National Park of the Tuscany Archipelago and of the Regional Park of Maremma (Tuscany); plans for Regional Landscape (Sardinia) the coastal defence, supporting, for instance, regional nourishment projects, plans for vulnerable area risk and hydrogeological structure plans, and annual reports on coastal system and its management.
"The National Guidelines for the coast protection: coastal dynamics management" was elaborated in 2016 by the National Table on Coastal Erosion (http://www.erosionecostiera.isprambiente.it) with the aim to:

- define phenomena responsible of coastal erosion in order to start a process of rebalancing the cycle of sediments; compare the various coastal erosion problems with the possible re-balancing, protection or adaptation solutions taking into account the effects of climate change;
- provide guidance for the evaluation of erosion;
- provide guidance for the management of coastal dynamics;
- provide guidance for the management of the resource "coastal sediments" for the defence of the coast;
- provide guidance and environmental issues associated with coastal defence works;
- provide parameters and methods for acquisition of physical and environmental data on sediment deposits for their management;

- -provide guidance on maritime public domain and buffer zones.

At the end of 2014, CAMP-Italy started as the first multi-area project involving 3 Regions (EMR, Tuscany, Sardinia) with 5 areas, in the following subsections better described.

The 2nd RBMP was adopted by the Government on October 2016. All the 8 river basin districts include coastal areas and cover more than one region. The Italian plans draw heavily on previous plans named “Piani di Tutela delle Acque” (Water Protection Plans) prepared at regional level and dated from 2004 to 2009, before the EU Directive. The approaches and methods used by regions to define monitoring programme and technical issues (classification, impact on human activities, economic analysis) vary within the different plans. Another limit of the Italian plans are the extension of the districts, much greater than spatial competence of the river authorities, responsible of the plan implementation since temporarily designated as the RBD authorities; this results into plans only partially covering the river basin district territory.

For the flood risk management, the Italian experiences of major flood and landslide disasters (Polesine in 1951, Vajont in 1963, Florence in 1966, Sarno in 1998) have been essential in shaping the country’s flood risk governance. It took almost two decades to reach political consensus on the law 183/89 that adopts river basins as planning and management units and includes key principles for coastal flood and erosion risk planning and management. Later, the European Flood Directive was transposed into Italian law by Legislative Decree 49/2010 and has set in motion a new phase of the national flood risk management policy that the Flood Risk Management Plan (PGRA) for each river basin district, seeing the participation between all Administrations and Managing Bodies, stakeholders and public in general.

The proposed measures have a common flood risk mitigation strategy focused primarily on priority objectives for the achievement of which are defined strategies that complement the previous planning and programming (PAI, AdP, etc.) of the hydrogeological basin. The 5 objectives concerns the reduction of risk exposure; the improvement of the performance of the existing defensive system; to ensure accurate monitoring as well as widespread ordinary and extraordinary beach maintenance; to defence cities and metropolitan areas; to assure much larger space to rivers/sea. A further key commitment may also be to reduce risk exposure, disincentive urbanization in perimeter areas and / or finding alternative housing solutions or structural adjustment works on existing buildings. Due to the EU Flood Directive, an update of the flooding risk area maps of the previous plans was needed in order to include coastal areas.

Spain developed in 2005 the Spanish Strategy for Coastal Sustainability (SCS) under the principles of Integrated Coastal Zone Management (ICZM) and improving the state of the coast at the Spanish national level. A broad national was finally delivered as a coastal planning instrument at the regional and provincial level in late 2007, designed to address coastal policies within the Spanish maritime-terrestrial public domain (MTPD).

In mid-2012, the government initiated a process of rewriting the Coastal Law that was approved in 2013 as Protection and Sustainable Use of the Coastline and Amendment of the Coastal Law.

Since the Spanish Government is interested in developing Marine Affairs Strategies, the management of coastal zone mainly regards Autonomous Regions. Under the intra-ministerial regulation tool "Instrucción de Planificación Hidrológica" (IPH), procedures are defined for the planning process following the Flood Directives and monitoring and classification of the ecological and chemical status of surface waters. In the Mediterranean Sea, Spain has 5 national river basin districts that submit the 2nd River Basin Management Plans. Coastal areas are including in these plans, where significant pressures in the coastal water management affect around 30% and almost 400 monitoring sites are available. Measures addressing hydromorphological pressures mainly are adopted in the basin Catalonia Basin (one of the most touristic coastline), including habitat restoration, dredging and actions on protection structures, although the complete assessment systems for coastal and transitional waters still lacks.

Flood Directive was transposed into Spanish law by means of Royal Decree 903/2010, in order to evaluate and manage flood risks in Spanish districts. Most of the FRMPs (16 river basin districts) were approved by the Government on 15 January 2016, while for the Balearic Islands the plan was approved on April 2016, for the Catalonia and the Canary Islands the approval process is still pending at the time of the present report. The content of the FRMPs includes, in addition to hazard maps and flood risk maps and to the criteria to evaluate the significant potential risk of flooding, a summary of the programs of measures, indicating the priorities among them and the Public Administration responsible of the actions, highlighting preventive measures, structural or non-structural, as improvement in the prediction of extreme events.

The law specifically includes a series of projects that have to undergo the simplified environmental assessment, in particular coastal works designed to contrast erosion and maritime works, which may alter the coast.

2.3 Overview of the Regional/Local measures

Croatia. Through project COASTANCE, Guidelines for integrated coastal zone management of Dubrovnik Neretva County was developed by experts from PAP/RAC, aiming to treat urban sprawl, tourism development and near-shore illegal construction; municipal, industrial and ship-generated pollution of coastal waters; protection for extremely rich biodiversity and underwater landscape required; aquaculture development needed. A Coastal Area Management Programme (CAMP) project is carried out in Kastela Bay. According to the proposed measure in the FRMP, stations for monitoring of erosion will be installed in the Neretva Delta and in Lake Vransko for the monitoring of saline water intrusion. The potential effects of sea-level rise including inundation, flooding, saltwater intrusion, and coastal erosion have small consequences for Croatia, except for some towns, like Rovinj, Pula, and Split, currently suffering from surge flooding (Baric et al., 2008). The effects on coastal erosion is also expected to be negligible on flooding because the majority of the beaches, formed by steep sand and gravel deposits, are resistant to erosion, except for the island of Susak and an area of Nin town.

More detailed information on coastal protection management (for instance, in the River Basin Management and Flood Risk Management Plans, Plans of Measures) is difficult to be acquired since all the documents are released in Croatian.

France. For the Languedoc-Roussillon region, the coastal sustainable development plan and the "strategic orientations for the management of erosion in Languedoc-Roussillon" defined in 2003 applied ICZM measures and the State and the Region have integrated a coastal strand into the State-Region Project Contract 2007-2013. This report distinguishes two solutions to contrast coastal erosion: the first, aiming to stabilise the high tide line in order to preserve and protect background issues; the second, aiming to increase the adaptation to the natural phenomenon with the displacement or abandon of the issues.

According to the RBMP of the Rhone Mediterranée district, 19% of the coastal area is heavily modified and the proposed measures (especially for the Delta of Rhone) are quite exhaustive in terms of hydromorphological measures (sediment management, removal of structures, bypass channels, lowering of river banks, dredging) and land-use planning. However, the basis for the selection of hydromorphological measures is not clear, because the hydromorphological measures are not clearly linked to water uses and pressures, but, in addition, the impact of climate change, only mentioned in the previous plans, is evaluated as

possible additional pressure on water resources in the 2nd plans, and an attempt to include its effects in the plan of measures (2015-2021) is present.

Many proposed measures regarding the coastal areas are related to the development of a comprehensive study or master plan to conserve aquatic environments (Delta of Rhône, Touloubre, Orb) and of the management of uses and attendance at a natural site (Gulf of Saint Tropez), the restoration of the sediment balance and the development of operation to recreate the morphology of the coastline at the scale of the sedimentary cells (area of Etang de Berre, Hérault) and the performance of wetland restoration operations (Thau).

In 2015, the Rhone-Mediterranean basin published its FRMP, formed by 2 Volumes: in the first, 31 territories with a high risk of flooding (TRI) were defined and one or more local flood risk management strategies were described to be developed by the stakeholders. In Volume 2, specific objectives for the identified TRIs were described in order to increase the safety of population exposed to flooding risk, in particular for coastal areas, as PACA, Languedoc coastal watershed and for Delta of Rhone, characterized by strong summer tourist attraction especially in coastal communities (annual accommodation capacity is estimated in more than 25.000 people). The principle (generic) measures regard the identification (census/diagnoses of the structures, etc.) and promotion of a unique protection system, and the preservation of existing defence structures, the implementation of a common tool to improve the monitoring, forecasting and management crisis by watershed. For the Delta of Rhone, proposed measures are in coordination to the SYMADREM programme (http://www.symadrem.fr), aiming to the development of a mixed protection measure against the flooding of the Rhone and a strategic retreat of the coastal dikes in the area of Port Saint Louis.

Ajaccio, Gran Bastia and Marana are the 3 identified large Flood Risk Area (TRI) in the Corse basin, where coastal floodings are the second (or third) types of flooding events: Sanguinaires vallyes, Saint Antoine creeks, Bastia, Lido de Marana, Biguglia watershed. Generic description of the non-structural measures to reduce the territory vulnerability to risk of flood, marine submersion and coastal erosion, such as urban adaptation, development of monitoring and warning systems, preservation of natural dynamics of watershed, also preventing erosion trends.

Italy. The local initiatives developing in the framework of CAMP Projects are of special interest for ICZM, such Marina di Massa, (Sicily), Marina di Sarzana (Liguria), Goro Po mouth, Marina di Ravenna (Emilia Romagna).

In the RBMPs, 489 coastal surface water bodies are identified, that are affected up 7% by significant (chemical) pressures (Sardinia, South Italy). The districts of the South Italy strongly lack in monitoring stations, both for surveillance and operational programmes. While Eastern Alps and Northern Apennines districts, that include Venice lagoon, the Northern Adriatic and Tyrrhenian Seas, present the higher number of monitoring stations. Analysing the proposed PoM in the plans, most of the described actions generally comes from previous adopted plans (sometime with a reference to them), while not always a timetable is present. Measures related to hydromorphology, including dredging, restoration of degraded bed structure and sediment management on the coast, are reported in the majority of the plans, while climate change impacts are included in general terms in the plans, or only in relation to agricultural water uses.

Looking at the main touristic areas (see Appendix I – Overview of coastal tourism development in the Mediterranean) of the Country, some Regions as Sardinia includes in their FRMPs documents (annexes) completely dedicated to coast management, with the description and analysis of the identified coastal units and the definition of strategic measures to deal with coastal erosion and flooding. For example, the plan of measures of the regional plan of Sardinia includes the restoration of coastal pinets in some areas (Alta Gallura, Nurra Sassarese, Ogliastra, Baronie) and protection and safety increase of cliff (Castelsardo) or beaches (Cala Gonone, Porto Torres, Alghero).

The PoM coming from the FRMP of the Po District includes actions to be performed on the designated Significant Risk Areas (ARS) along the coast in the Emilia-Romagna and Veneto regions (between the Deltas of Po and Reno rivers) and regards the monitoring and improvement of the efficiency of existing defence structures (detached breakwaters, groins), the restoration of dunes as dynamic system to fight beach erosion and reduce flooding during sea storms. The listed measures also include sand nourishment, maintenance of watershed and estuaries, promotion of the retreat of touristic structures and of the development of free-access beaches (amount of 20% of the entire coastline). For the Central Alps district, that includes the Venice lagoon and Veneto coastline, soft defence measures are listed in the plan, including sand nourishment every 10 years at Pellestrina, Lido di Venezia, Jesolo, Cortellazzo, and at the delta of Piave river, building of coastal structures as groins and breakwaters at Rosolina and Bibione; all these measures are in accordance with the recent Plan of the Coast of the Veneto Region (https://www.regione.veneto.it/web/ambiente-e-territorio/difesa-dei-litorali), approved at the end of 2016. In addition, reference to measures for the protection of Venice lagoon under

the Italian law 798/84 is added in the plan.

***Malta*.** ICZM principles have only been recently introduced in the Maltese Islands, primarily within the spatial planning system. For instance, Ghajn Tuffieha bay is part of an extensive area of coastal cliffs that has been scheduled under the planning system. The goals of the Conservation Order there applied have taken into consideration the recreational potential of the site for tourism purposes and could be addressed as an example of sustainable coastal management where conservation and tourism goals can be reached harmoniously within a highly sensitive area.

Spain. Andalucia had its own pioneer ICZM Strategy in 2007 (supported by the University of Cadiz), then other Spanish regions also have developed coastal plans, with a more inland orientation, including the Mediterranean Balearic Islands and Catalonia regions. Also some local initiatives developing CAMP Projects are of special interest for ICZM such as Levante de Almeria, Mar Menor (Murcia coast), and Sitges where a Consortium (http://ec.europa.eu/ourcoast/index.cfm?menuID=4&articleID=212), composed of 3 Regional Government Administrations, aims, among the others, to develop ICZM specific projects, also to fight coastal erosion and the effects of climate change.
The main measures on Mediterranean Spanish coasts coming from the WFD implementation aim to conserve beach and preserve its quality along the most touristic areas (e.g., Barcelona, Terragona, Girona), restoring coastal defence structures and to map the *Poseidonia oceanica* meadows. In Andalucia, a very exahustive plan is adopted, where for instance surveys of the dikes, their effects on the morphology of the beaches, and of the sand supply (nourishment) are reported in the Inventario de Presiones. In the Plans of Measures, climate change effects are accounted for along the Malaga coast (Sol Oriental) and in order to adapt defence structures along Almeria coastline. Similar approaches among the plan developments are observed and this aspect may help users/stakeholders in their land plannings. The Ebro district plan also includes the management of the Delta of Ebro, with a specific plan ("Plan Integral de Protección del Delta del Ebro") proposing measures to preserve the area including the crest rise of barriers and of dunes and the building of submerged structures, in order to reduce wave actions and trap longshore sediment transport. In Valencia Region, there is no specific Plan on ICZM. Some recent instruments related with coastal management are the Territorial Strategy of the Valencia Region, approved in 2011, where Title VI devotes to the coast and includes aspects of great interest

for ICZM. Although the established criteria are recommendatory, in practice some of them are resulting binding in the approval of new urban plans. In addition, the Territorial Action Plan for the Green Coastal Infrastructure, currently in public information stage, is a urban planning tool which seeks to preserve those areas of the green infrastructure that do not have a specific protection regime and adequate to its territorial value.

In the PoMs of the Spanish Mediterranean districts required by the Flood Directive, together to the general definition and information for each assigned ARSs, specific description of the measures is reported to reduce coastal flooding and the area where these measures should be applied. Examples are the plan of the Balearic Islands district, where an annual investment for emergency works to reduce coastal risk flood was estimated of 1 million euros per year. Planned measures are the restoration of the dunal system with the gateway repair operations, replanting of vegetation, recharge of sediments in eroded areas (Alcudia, Sonserra de Marina, Esgrau, Ibiza, Playa d'Embossa y Playa de Sesfi); the removal of coastal structures in disuse or poor conditions and the recovery of floodable wetlands; the maintenance of natural reefs; the mantainance of existing coastal works, as coastal walls, promenades, levees, piers, that reduce the runoff. Another example is the Jucara district, where an annual investment to reduce coastal risk flood was estimated equal to 10 million euros per year. In the coastal area, characterized by high recreational appeal, the defined actions are the restoration of the dunal system (Costa Norte de Valencia, Marjal dels Moros; Puerto de Sagunto) and of the gravel coast (Marjal dels Moros; Puerto de Sagunto); beach regeneration (Cabo de Cullera-Cabo de San Antonio; Puerto de Oliva, Cabo de Cullera-Cabo de San Antonio, -Punta de la Escalereta, Punta de Moraira) by means of nourishment; a controlled coastline retreat (Cabo de San antonio-Punta de Moraira; Puerto de Javea). In the Delta of Ebro, restoration of the dunes and sand supply in order to hold the line and reduce erosion are the two principles proposed actions to reduce flooding.

The Mediterranean Andalucia unit presents its FRMP, in accordance to the Plan de Protection del Corredor Litoral de Andalucia (2012) and reports general measures to protect coast from flooding, with no explicit reference to specific actions or sites where applied them.

At the end of 2016, Catalunya Region published the FRMP that is still in phase of review and approval at the moment of this report. In the attached PoM, maintenance and improvement of the capacity of the coast to dissipate wave energy and absorb the flood are proposed at sites like Alcanar, Mont-Roig del Camp – Cambrils, Vila-Seca, Tarragona – Altafulla, Torredembarra - Roda de Barà, Sitges – Viladecans, Maresme, Tossa de Mar, Girona Centre, where the flood risk is estimated high. The main planned measures to protect the

littoral consist in removing or reparing outdated barriers and obstacles, maintaining dunes and natural reefs, improving the state of the vegetation and plant vegetation in estuaries, supplying sand to beaches under erosion, and other specific actions to improve the natural conditions of the coastline while restoring the coastal ecosystem functions. Other possible actions to restore the coastline and the breaker zone in the sea are wetland restoration, rehabilitation of dunes, controlled retreat of the coastline, beach nourishment, construction of artificial dune and reefs.

2.4 Discussion on the adopted coastal protection management plans

Several human activities are commonly carried out along coastline and in the sea, involving social, environmental, economical, technical and urban aspects, adding complexity into the coastal planning and protection management.

The legislative background developed in the past and adopted by the different Mediterranean Countries at national and local scales are very different, therefore the management policies of this complex area result very dissimilar. A synthesis of the existing plans adopted by Mediterranean Countries for coastal planning and management is reported in Table 2, where the available information on the implemented regional policies are listed at NUTS2 levels, except basin plans on River Management and Flood Risk, implemented at district scales for the majority of the Countries.

The analysis of the coastal management instruments performed in the previous subsections showed the effort made by State Members in the Mediterranean to implement the EC directives, although it remains a slow long-term process with varied interpretations and understanding. The implementation of ICZM is still an on-going process and at an experimental stage in the Mediterranean Sea, with France, Croatia and Greece developed an equivalent ICZM strategy or coastal management plans, while in the other Countries, the process is still under development. EU policy on ICZM has the status of a recommendation only, hence, the lack of a coherent responsibility chain at national and local scale delays the advances in ICZM implementation (COM, 2007; COM, 2010).

Country	Mediterranean regions	Regional plan	Coastal defence plan	ICZM plan
Croatia		National Law on coastal planning (1994)		
France	Languedoc-Roussillon	Sediment management plan (2011)	Coastal sustainable development plan (2003)	
	PACA			
	Corse			
Italy	Liguria	Territorial plan for coastal coordination	2004	
	Veneto	Technical Directive for sand nourishment (2010)	Guidelines (2016)	2013
	Friuli-Venezia			
	Emilia-Romagna	Littoral State (2000, 2007, 2012)	Coast Plan (1981, 1996)	Guidelines for ICZM (2005)
	Toscana	Hydrogeological structure ICZM plan	2004	
	Marche		2005 and updates in 2015	ICZM plan (2004)
	Lazio	Plan for nourishment	Guidelines	Monitoring ICZM Centre
	Abruzzo	Plans for vulnerable area risk (2006) and nourishment (2006)	2003	
	Molise	Coast Safety Plan (2011)		
	Campania	Erosion plan		
	Puglia	Territorial landscape plan (2010)	Coast Plan (2011)	
	Basilicata		Coast Plan (2016)	
	Calabria	Integrated management plan	2005	2006
	Sicilia	Hydrogeological structure plan	2004	
	Sardegna	Regional landscape plan (2006, 2013)	Plan Action Coast (2013)	Guidelines (2013)
Malta		National Storm Water Project (2010)	Coastal Management plan (2005)	
Spain	Cataluña	Landscape Protection, Management and Planning Law (2005)		2004
	Valencia	Spatial Planning and Landscape Protection Law (2014)		Territorial Strategy (2011) Plan for the Green Infrastructure (2017)
	Balearic Islands	Strategic T Decree regulating minimum beach safety and protection measures (2005) Tourism Plan (2015)		Strategy for ICZM (2004)
	Andalucia	Territorial Plan (2011)		2007
	Murcia	Strategic Tourism Plan (2015)		Strategy for ICZM (2016)

Table 2 Overview of the plans for Croatia, France, Italy, Malta and Spain.

Attempts to define and apply indicators to account for the state of implementation of ICZM policies have been performed (Ehler, 2003; UNESCO-IOC, 2003; Olsen, 2003; UNESCO-IOC 2006; Pickaver et al., 2004, Sardà et al., 2005) and applications at the different scales for the EU Mediterranean Countries have been carried out (Sanò et al., 2006; Portman et al., 2012), showing assessment and monitoring of the ICZM in the Countries. Some literature reports exemplary cases of ICZM applications (Table 3).

However, absence of coordination and cooperation among Authorities/Countries involved in indicator development leads to too much repetition and inefficiency, due to lack in data sources, scale of measurements, thresholds and limits.

Regarding the WFD and FD, all the communities, except Greece and two Spanish regions, are in line with the EC requirements in terms of plans on River Basin Management and Flood Risk. In the attached PoMs, maintenance of dunes and natural reefs, sand nourishment/dredging and the improvement of the efficiency of the existing defence structures are the more common proposed measures, together with the improvement of monitoring systems and natural dynamics and the coastline retreat. Rarely, a specific indication to the sites where carrying out these measures was given, as well as an estimation in their validity in time.

Finally, looking at the involved competent authorities and water legislation as reported in the cited plans, one can conclude that it is very difficult to deal with all these legislative authorities and water management responsibilities. This contributes to make the implementation of ICZM and of all the Directives on Coastal management a relevant challenge for stakeholders at all levels.

ICZM implementation		
Country	**Site**	**Reference**
Greece	Nestos Delta	Koutrakis et al., 2011
France	Sete-Marseillan General	Ferreira et al., 2009 Deboudt et al., 2007
Italy	Lido di Dante Riccione Liguria Tarquinia	Ferreira et al., 2009 Koutrakis et al., 2011 Koutrakis et al., 2011 Koutrakis et al., 2011
Spain	Catalan coast	Sardà & Mora, 2005 Ariza et al., 2008
Mediterranean Sea		Koutrakis et al., 2011

Table 3 ICZM implementation: sites where it is applied and reference.

3. Coastal defence measures in the Mediterranean Sea

3.1 General trends of morphodynamics and climate change

Erosion and accretion are natural processes, responsible for shoreline changes to take place over different ranges of time scales. Coastal erosion is one of the most serious challenges for many Mediterranean Countries, where more than 25% of the coasts is subjected to erosion, the highest value among all the European coastal patterns (see coloured bars in Figure 3), although the sea forcings (due to waves, tides, storm surge, wind) on beaches are roughly smaller in comparison to other oceanic coastlines.

In the Mediterranean Sea, coastal erosion/accretion may occur in response to small-scale (short-term) events, such as storms, annual wave action, tides and winds, or in response to large-scale (long-term) events that may significantly alter sea levels (rise/fall) and tectonic activities that cause coastal land subsidence or emergence.

Naturally dynamic, coastlines are often subjected to cycles of erosion, important feature of their ecological character. Ocean forcing agents, as wind, waves and currents, can easily move the unconsolidated sand in the coastal areas, inducing rapid changes in the shoreline position.

Human activities along the coast (land reclamation, port development, shrimp farming, massive tourism and shipping), within river catchments and watersheds (river damming and diversion) and offshore (dredging, sand mining) in combination with these natural forces often increase the coastal erosion rate and reduce opportunities for coastal zones to achieve socio-economic and ecological roles.

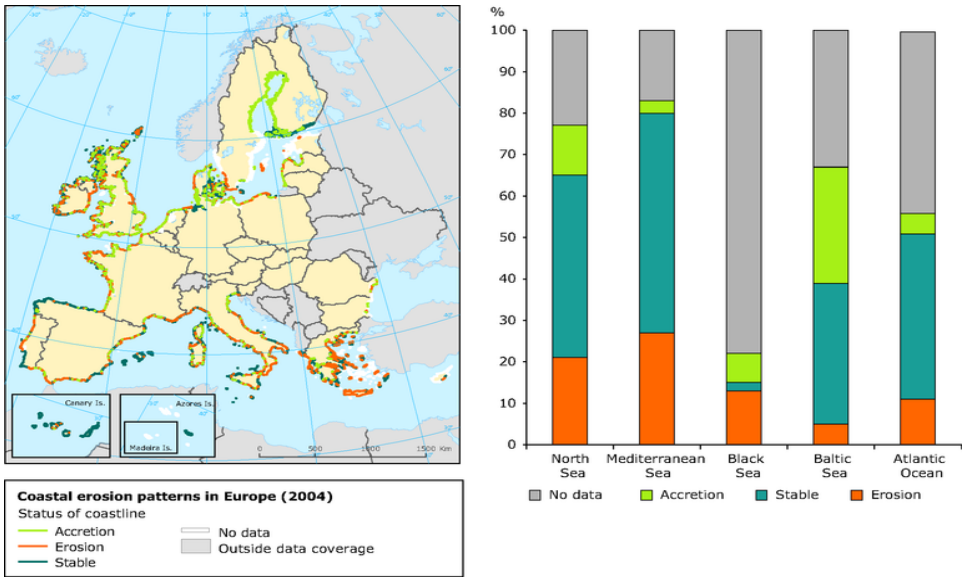

Figure 3 Coastal erosion patterns in Europe: coastline patterns and bars for the European Seas; Source: EUROSION project (2005).

On hard and soft rock coasts, the erosion rate is generally small and manly caused by wave attack, where waves generated by boats and ships can erode unprotected shorelines or accelerate the erosion in areas already affected by natural erosional processes. Along microtidal sedimentary coast, erosion is mainly induced by human interference in the coastal zone.

Deliverable *D3.2.1 "Coastal morphodynamics in Mediterranean touristic areas under climate change conditions"* reports the beach evolution patterns for the main touristic regions at NUTS2 and NUTS3 levels and presents a geodatabase synthetically describing the morphological features of the EU Mediterranean Countries on the basis of monitoring results.

In comparison to the other European Oceans, the low tidal range of the Mediterranean suggests that they will be more vulnerable to sea-level rise (SEAREG, 2005; CIRCE, 2011) than the other seas (Nicholls and Klein, 2005; Zanuttigh, 2016): at the Ebro and Rhone deltas, and at the historical city of Venice, significant problems of erosion, salt water intrusion and flooding often occur, especially in the major deltas where a decrease in sediment availability and subsidence due to water pumping are important.

In the Mediterranean Sea there are regions with global mean sea level increases of more than 6 mm/year, and with decreases of more than -4 mm/year: Figure 4 reports a map with the trends in sea level rise across Europe based on satellite observations during the period 1992-2004 (EEA).

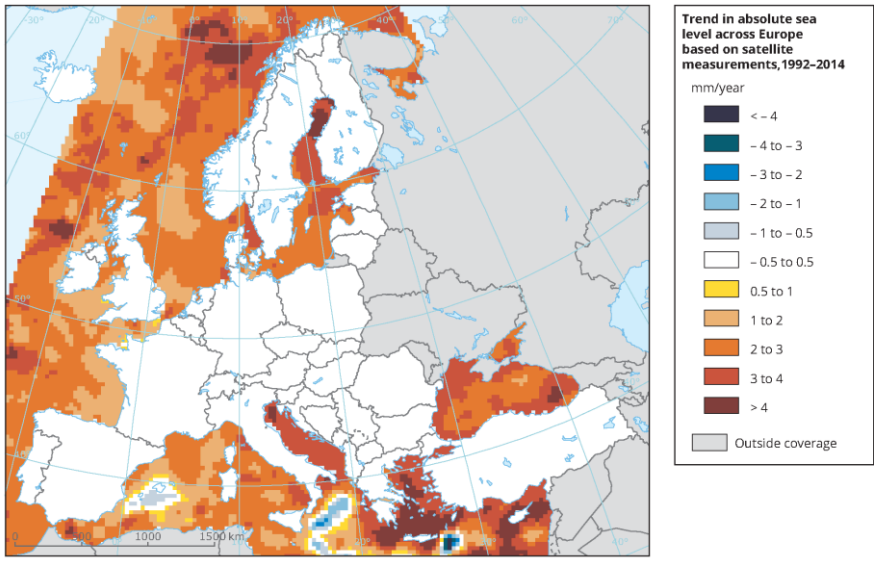

Figure 4 Trend of sea level rise based on satellite measurements (1992-2004) in mm/y; Source: EEA.

The eastern Mediterranean has been subject to a high sea level rise during the past decade at a rate up to 20 mm/year in the Levantine basin. Sea level rise of 5-10 mm/year is also observed in the Algerian-Provencal basin as well as in the Tyrrhenian and Adriatic seas. The north Ionian Sea, on the other hand, shows an opposite trend, i.e., a sea level drop of around -5 mm/year.

Absence of any mitigation and protection plans at regional and national scales of the Mediterranean Countries has been estimated to induce significant damage costs by MareMed project (2013): a webGis map in Figure 5 shows that Italian Northern Adriatic regions (Veneto, EMR, Fruili) and Provence-Alpes-Côte d'Azur would be the most damaged areas by climate change impacts and with the higher damage costs.

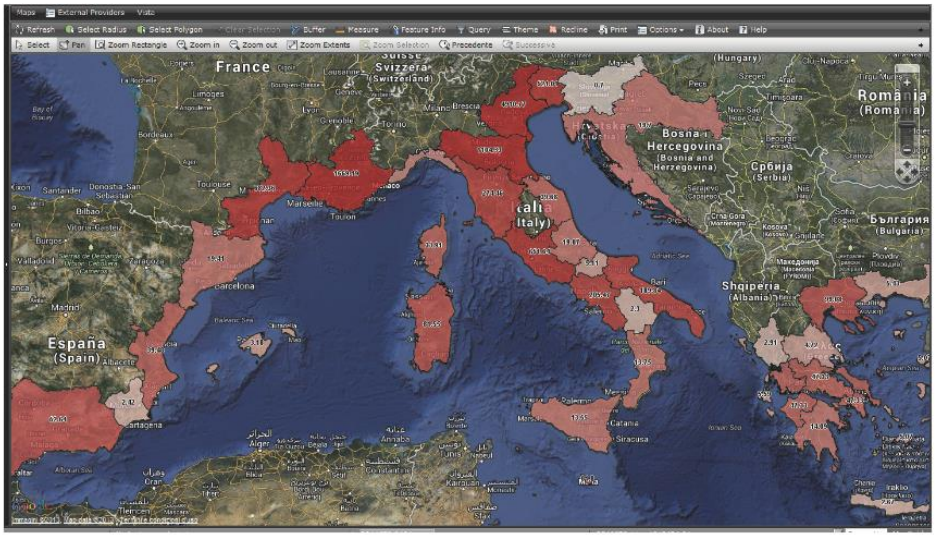

Figure 5 Damage costs of climate change on the Mediterranean coastal areas at regional scale; Source FACECOAST WebGIS (www.facecoast.eu).

From a morphological point of view, human interventions along coastlines and sea waters can be applied following four different management policies, according to EUROSION project: (1) no active intervention; (2) holding the line, (3) managing realignment and (4) advancing the line.

Typically, in coastal areas with a touristic interest, actions (2) or (4) including the building or maintenance of new or existent artificial defences or sand nourishment allow that the position of the shoreline remains.

3.2 Description of coastal defence measures

There are two main categories of coastal protection and defence structures, namely hard and soft techniques. On the basis of the list reported by EUROSION (2005), the listed typologies have been identified as the most popular along the Mediterranean coastlines and hereafter briefly described in the following subsections, focusing on their design aspects and impacts on environment and social-economical activities connected to the growth of a sustainable tourism.

3.2.1 Hard techniques

Breakwater

Breakwaters are protective shore-parallel structures placed offshore the surf zone. Generally the detached structures are most commonly constructed of stone materials such as concrete or rocks, which aim at absorbing the wave energy before the waves reach the shore and allowing filtration flow through the permeable layers.

In relation to their crown level over the still water level, one refers to emerged (positive freeboard) and low-crested and submerged (null or negative freeboard) breakwaters, the last ones regularly overtopped by waves.

Breakwaters are generally constructed as long continuous structures in which gaps might be necessary for water exchange and preserve sea quality and allow boat passage. Figure 6 reports a scheme (Sciortino, 1995).

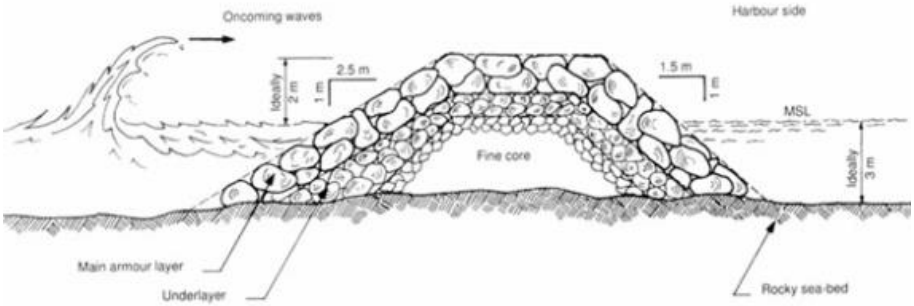

Figure 6 Scheme of typical layout and cross sections; source: Sciortino, 1995.

Generally, well-designed breakwaters reduce erosion rate of the protected beach, and for this reason, they are the most common technique in the Mediterranean Sea to moderate

loss of beach area and protect them, especially where “sun-bath” tourism is mainly developed.

EU-funded DELOS Project (Environmental Design of Low Crested Coastal Defence Structures – LCSs) was carried out in 2007 and described the potentially socio and environmental impacts of hard coastal structures, in particular low crested breakwaters.

The crown elevation over the still water level is one of the key design parameters that are responsible, together with the barrier width and permeability and the spatial arrangements of the structures, of the environmental and social-economical impacts of the structures (Airoldi et al., 2005; Lamberti et al., 2005; Martin et al., 2005; Moschella et al., 2005).

Regarding the quality of the protected beach, barriers generally induce steepening of the bottom profile seawards and generate accretion leewards, up to tombolo and salient development (Figure 7). The reduced wave agitation behind structures, preventing/reducing coastal flooding, may cause small particle deposition (siltation) and reduce the quality of seabed, up the development of algal blooms (eutrophication and turbidity).

Reflected or diffracted waves concentrate their energy in local hot spots, inducing local/toe scour and threatening the same structure stability.

Figure 7 Tombolo development behind the emergent barriers, built as coastal defence.

In relation to their design characteristics (i.e., crest level, structure permeability and gap width), breakwaters can determine sea water level set-up behind the structures that, if significant, generates strong return currents due to large pressure gradients that can become very dangerous for bathing and swimming activities.

In relation to recreational impacts, rubble-mound breakwaters are generally colonised by mussels and oysters and allows the development of the epibiota, becoming an attractive for shellfish harvesting. In addition, structures can be accessed by diving, snorkelling, although their visibility reduces the economical value of the coastal landscape in relation to their crown elevation.

Life time of the structures is generally designed equal to 20-30 years; so maintenance activities are rare and often reduced to repositioning of barrier materials after a severe winter season in order to restore crown elevation and width, and usually occur before the beginning of summer.

Groin

Groins (Figure 8) are structures that extend perpendicularly from the upper foreshore into water. Usually constructed in groups called groin fields, their purpose is to trap and retain sand, nourishing the beach compartments between them.

They are also often built to delimitate a breakwater continuous line. Groins may be made of wooden or rocky materials. Their extension interrupts the longshore littoral transport, leading to up-drift beach accretion. However, sand accumulated between groins contributes to a sediment deficit down-drift and coastal erosion issues are usually shifted to other downstream locations.

As the breakwaters, the groin visibility decreases the landscape value of the protected beaches, although shellfish harvesting and fishing activities are induced by their presence.

Lifetime of these structures is generally designed equal to 20-30 years; so, as for barriers, no impacts connected to maintenance activities are observed.

Figure 8 System of beach defence with groins in Pellestrina (IT); Source: DELOS (2005).

Revetment

Revetment (Figure 9) is, together with seawall, a shore parallel structure at the transition between the low-lying (sandy) beach and the (higher) mainland or dune sloping.

Revetments are low-cost solution for coastal erosion defence and are characterized by a gentle slope (1:2 or 1:4), thereby enhancing wave energy absorption and minimising reflection and wave run-up. The surface of a revetment might be either smooth or rough. The older wooden revetment consists of posts wooden slats, while modern revetments have concrete or shaped blocks of stone laid on top of a layer of finer material.

Figure 9 Revetment.

Revetment presence influences the nature of the sea front that may lead to further changes in the foreshore ecosystems, but it generally decreases the release of sediments from the section it protects, for which reason a negative impact on the sediment budget along adjacent shorelines is observed.

The revetment slope is suitable neither for recreational use nor for the landing or hauling of small fishing boats. Consequently, this kind of structure should not be adopted where the beach is used for recreation or fishing activities.

Seawall

Similar to revetments, seawalls (Figure 10) are characterized by nearly vertical walls at the foot of possible cliffs or dunes, with height often equal to difference between beach and surface level of the mainland. In many cases adjacent at the crest of a seawall, a horizontal stone covered part is present (e.g. boulevard, roads).

Figure 10 Seawall.

They are primarily used to resist wave action and to reduce flood, while do not protect the shore in front of them, but fix the location of the coastline.

When seawalls are used in areas with significant wave action, they may accelerate beach erosion induced by wave reflection downward to the toe. These structures are most appropriate where fishing and boating are the primary uses of the shore, and gently sloping areas for sunbathing or shallow-water swimming are not essential.

Sand bags

Geotextiles are permeable fabrics, which are able to hold back materials while water flows through. They could be used to form geosynthetic tubes or sandbags (Figure 11) consisting of a woven geotextile material filled with a slurry-mix, generally composed by dredged material (e.g. sand) from the nearby area or concrete material. They are very flexible and cheap solution to prevent beach from retreating (Martinelli et al., 2011) but, due to their low (null) permeability, they could increment local erosion. They are useful as buried revetment under the dune face, where they will form a final line of protection after the overlaying sand has been eroded by storm waves.

They have no environmental benefits except that they are temporary structures, easily removed with no significant long-term impacts on the physical or natural environment.

Figure 11 Sandbags.

Gabion

The gabions are metal cages filled with rocks and are stacked to form a simple wall.

They are used to protect a cliff or area in the short term only, since they are easily damaged by powerful storm waves and the cages tend to rust quite quickly. Gabions have the advantage of ease of use and are relatively cheap but their life duration is short.

3.2.2 Soft techniques

Nourishment or sand supply

Beach nourishment (Figure 12) is the process of dumping or pumping sand from elsewhere onto an eroding shore and increase of sand volumes via the supply of exogenous sand.

This process doesn't stop beach erosion and might be repeated (after 3-5 years) to conserve shoreline. It is often used together with coastal barriers in beach restoration schemes to limit or avoid the need of maintenance and can be regarded as a natural way of combating coastal erosion by artificially replacing a deficit in sediment budget. Sand supply may be achieved through the direct placement of sediment on the beach, through trickle charging (placing sediments at a single point), or through pumping.

Figure 12 Off-shore sand nourishment in 2002 on Riccione (IT) beach; Source: www.arpae.it.

Three types of nourishment can be identified: (i) backshore nourishment, occurring at the foot of dunes to prevent dune erosion and breaching during storms; (ii) beach nourishment, to increase recreational use of the beach; and (iii) shoreface nourishment, to strengthen the coastal profile.

When sediment supply is not locally available and has to be imported from another place in the emerged part of the foreshore or under the water line (underwater nourishment).

Nourishment restores and widens the recreational beach at high costs (20-30 €/m^3, Ferretti et al., 2003), but the process of nourishment may damage, destroy or otherwise hurt marine and beach life, altering the biota (both on the beach and in the dredging area) and may conduct to a decay in the populations of migratory, nesting and overwintering shorebirds that feed on intertidal invertebrates.

The sand added to the beach is often different from the natural beach sand, characterized by different diameter sand grains and colour, that influence the value of the coastal landscape and the observed morphodynamics (faster erosion process and sediment suspension), with changes in the shape of the cliff and seabed profiles and development of a too muddy beach.

In addition, noise and others operation-by products can be strongly influenced the beach use during their temporary operations (honestly not conducted during the touristic season) when a short-term increase in the turbidity of the nearshore areas is observed from the dewatering of the slurry leading to a reduction of the photosynthesis activity.

Sand by-passing

Artificial sand bypassing (Figure 13) is a man-induced transfer (pumping) of sand accumulated up-drift by coastal infrastructure (jetty fillets, shoals, or navigation channel) to the downdrift beaches to mitigate the problems associated with the beach erosion. Most sand bypassing operations are done in association with navigation dredging when the sand removed from the navigation channel is placed directly on downdrift beaches or in the nearshore zone.

Figure 13 Sand pumping; Source: http://www.theworld.ae/

This technique has been implemented by a number of harbour authorities in Europe since volumes of sand trapped by harbour breakwaters (resp. dams) are generally considerable. Similar consequences to nourishment on environmental and economical values of the beach subjected to sand by-passing are identified, more related to supplied sediment quality and increment of the erosion rate.

Sand by-passing effects such as pollution, landscape changes, noise and others can strongly influence the beach use during their temporary operations (usually not conducted during the touristic season) and their impacts should be deeply investigated in the Environmental Impact Assessment (EIA) studies.

Beach drainage

In this 'soft' shore protection method, a drainage system (Figure 14) is installed under the beach face and parallel to the coastline to enhance beach accretion by artificially lowering the groundwater table. Beach drainage decreases the volume of surface water during backwash by allowing water to percolate into the beach, thus reducing the seaward movement of sediment.

This system is adapted when erosion mainly occurs cross- shore and non significant long-shore drift occurs.

It is especially suitable for low tidal range sand beach sites with a high amenity value and subjected to low to moderate wave energy attacks. Beach drainage also leads to drier and coloured sand, more appreciated for recreational activities. The technique is relatively new and experience lacks to assess its performance. It is characterized by high maintenance costs, since storm erosion of beach could damage the system.

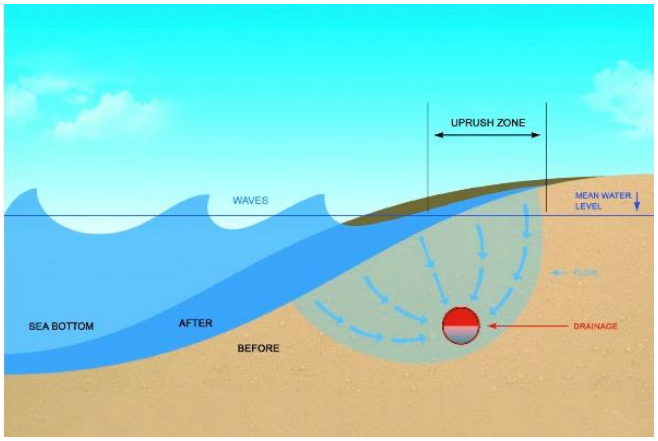

Figure 14 Scheme of the beach drainage system; Source: http://www.ecoplage.fr/en/technology/beach-drainage.html.

Dune fencing

Dune regeneration basically involves artificially creating new sand dunes along the coastline to act as a buffer between the land and the sea. Sand dunes occur naturally but are under

threat because they are fragile and people walk all over them, ride horses and motorbikes on them and destroy the dune ecosystem. Dune regeneration involves creating or restoring sand dunes by means of wind-blown accumulation of drifted sand located in the supra-tidal zone. Wind velocity is reduced by way of porous fences made of wood, geo-textile, plants, which encourages sand deposition.

Figure 15 Dune fencing.

Dunes might provide a barrier and absorb wave energy during storm events and severe floods. During dune regeneration, the land needs to be carefully managed so that any new vegetation that is planted is appropriately protected from trampling by humans. This could involve temporarily fencing off the dunes or by providing wooden walkways.

Sand fences limit public access to the dunes and beach, and can be visually intrusive, interfering with the recreational use of the beach. On the other hand, fence presence along the dune toe controls public access and limits trampling of vegetation along the seaward edge of the dunes, helping to stabilise the fore-dunes and to extend the dune habitat. They can also improve the visual impact of other forms of coastal defences, e.g. breakwaters that might otherwise influence from the coastal landscape.

Designed Artificial Reef

Recently, artificial reef has been designed and installed in the Mediterranean Sea, still in a testing stage to study their feasibility and efficiency on the Mediterranean coasts and habitats. Reef Ball (1997) is a designed artificial reef used to restore ailing coral reefs and to create new fishing and scuba diving sites. They are used for beach protection, freshwater, mitigation, and many other uses too. Made of a special, marine friendly, concrete, they are

designed to mimic natural reef systems, and used around the world to create habitats for fish and other marine and freshwater species.

Vegetation planting and/or stabilisation

The activity consists of colonisation or stabilization of coastal soils by vegetation whose roots bind sediment, making it more resistant to wind erosion. The natural dune grasses act to reduce wind speeds across the surface, thereby trapping and holding sand. They grow both vertically and horizontally as the sand accumulates (Figure 16).

Figure 16 National Park of Circeo (IT); Source: http://www.isprambiente.gov.it/.

Vegetation adapted to dune is generally very fragile and require integral protection and daily care to the dune system.

Transplanting and management of appropriate dune grasses to the dune face will have no damaging impact on the natural environment of the receiving area, but can be harmful to the borrow area. Over harvesting of transplants from any area can give rise to increased local erosion. This may be most significant for sand couch grass, as the borrow area will necessarily be a foredune susceptible to wave over-washing and wind erosion.

Seagrass meadow planting

Posidonia oceanica meadows is considered the most important and well-studied seagrass species of the Mediterranean Sea, as a positive “bioindicator” of the quality of coastal seawater, also because this plant plays a protective role against coastline erosion and at the same time could stimulate tourism activities, respect for the ecosystem and international synergies. The role of Posidonia meadows consists of sediment and shoreline stabilization,

achieved by slowing down water motion and current flow and by reducing wave energy and sediment suspension. The Posidonia meadows are only found in the Mediterranean Sea, and cover a surface ranging between 25.000 and 45.000 km^2, i.e. 25% of the basin area in a depth lower than 50 metres (MEDCOT project).

Mudflat recharge

This activity consists of supply of existing mudflats with cohesive sediments in intertidal regions. This is achieved via trickle charging (like during sand nourishment), rainbow charging, and polders and may be jeopardized by accelerated sea level rise.

This is a quite complex and not rapid process in comparison to beaches, since muddy sediments need time to dewater and consolidate and sediments might be protected from waves and tidal currents, while they are settling and dewatering.

Beach scraping

Beach scraping consists of artificial re-profiling of the beach when sediment losses are not severe enough to warrant the importation of large volumes of sediments. Re-profiling is achieved using existing beach sediment.

It is among the cheapest techniques, as it does not require importing sand. However, the process may have to be carried out several times before the right profile is found. It is also restricted, as beach drainage systems, to those beaches where cross-shore erosion is dominant and storms not heavy.

3.3 Adopted coastal defence measures at the scale of Mediterranean

3.3.1 Materials and methods

In order to have an overview of the coastal protection measures commonly adopted at national and regional scales in the EU Mediterranean Countries, a brief description of the available materials and methods, mainly in the form of webGIS, helping to identify used defence techniques, is reported in the followings.

Croatia. A database, accessible only to authorized users from the Ministry of Construction and Physical Planning of Croatia, is available (in Croatian) at https://ispu.mgipu.hr, reporting maps on maritime zones, with space purpose and use planning, sea and river harbours and protected areas of natural values.

France. For the Mediterranean regions Languedoc – Croussillon, Provence- Alps-Cote d'Azur (PACA) and Corse, metadata file concerning coastal defences, in particular rubble-mound structures, as groins and breakwaters, are displayable (only) at the website http://www.medam.org, as derivable of the project French MEDiterranean Coasts. Inventory and Impact of Reclamations from the Sea, aiming to assess the ecological and landscape impacts of reclamation and "artificialisation" on French Mediterranean coastal regions.

Figure 17 Examples of MEDAM GIS database: areas where beach tourism (right, Languedoc - Croussillon littoral) and niche tourism (left, Niche) are developed. In red lines, general information on man-made constructions, in black lines, rubble-mound structures (breakwater, groin).

A database concerning soft and ecologic management (fences and dunes rebuilt) in the Coastal Zone Observatory of the Department of Herault and in the State-Region (Project Contract 2007-2013) is available at the website http://littoral.languedocroussillon.fr/Cartographies-des-amenagements-de-protection-douce-et-de-l.html.

Greece. At the websites http://www.mspcygr.info/ and http://ct-thalhor.aegean.gr/flexviewers/PMA/, webGIS database are available for Greek coasts but only limited access is reserved to authorized users.

Italy. The GIS database by the EU-ADRIPLAN project contains coastal information on the Northern Adriatic Sea, among the others, regarding beach erosion trends, NATURA 2000 sites distribution and touristic traffic in the Mediterranean Sea.

Information are available at registered users at the website http://data.adriplan.eu/layers/?limit=20&offset=0&category__identifier__in=msp_coastDefenceSand).

Almost all the Italian coastal regions implemented a GIS or WEBGIS database with, among the others, information on coastal morphology, erosion patterns and defence measures. Examples are available at the following websites:

IT Regions	Links
Emilia Romagna	https://applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=costa
Veneto	http://idt.regione.veneto.it
Lazio	http://www.cmgizc.info/index.php?option=com_content&view=article&id=14&Itemid=175&lang=it
Puglia	SIMOC (Sistema Informativo Monitoraggio Coste) at http://193.204.49.142/simoc
Campania	http://webgis.difesa.suolo.regione.campania.it:8080/difsuolo_coste/map.phtml
Sardegna	www.osservatoriocostesardegna.eu
Toscana	http://apps.geot.it/geotresmar/mapContent.aspx?envid=1

Table 4 Links to some italian regional webGIS containing information on coastal morphology, erosion patterns and defence measures.

Spain. At the website of the Spanish ministry of Environment, http://www.mapama.gob.es/es/costas/servicios/guia-playas/default.aspx, general information on Spanish (Mediterranean) beaches are available. For Regions, in Catalunya information are available at the website http://www.icgc.catwhil, while in Andalucia, http://laboratorioredIam.cica.es/.

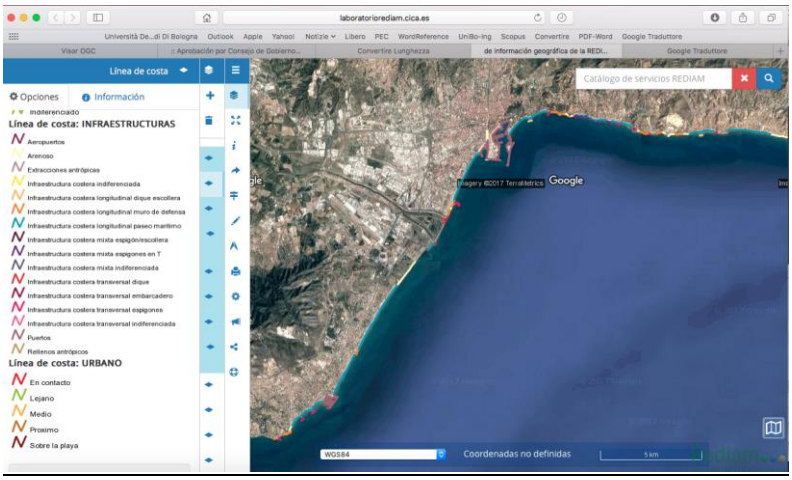

Figure 18 Screenshots of the Andalucia webGIS at http://laboratorioredIam.cica.es/.

3.3.2 Overview of the coastal protection measures adopted in EU Mediterranean Countries

In the past decades, especially in the years 70's-90's, defence of coastal settlements in the Mediterranean Sea was mostly addressed through hard protection techniques: in the 70's, the construction of seawalls and revetments caused significant beach erosion, while, later, in 80's-90's, groins and detached breakwaters were adopted, frequently triggering down drift erosion, therefore justifying more coastal rock structures (Pranzini, 2017) and preserving the economical value of beach.

Under the project EUROSION (2005), the map of the artificial coastline (Figure 19) was realized, where hard defence measures to protect beaches were adopted. Except for some Regions on the North-East Adriatic Sea and In Spain and South Italy, coastal defence measures characterized the whole coastline in the Mediterranean, mainly in France and North Italy.

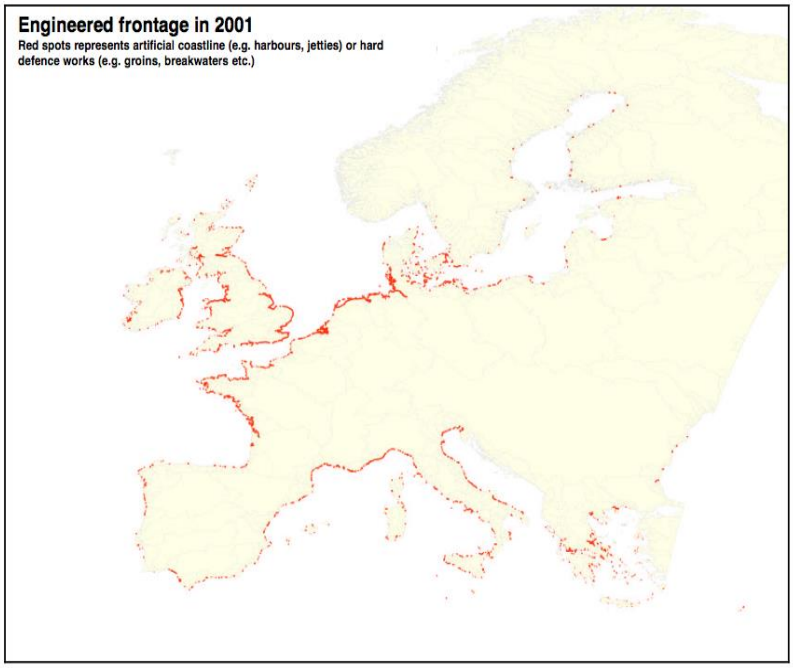

Figure 19 Map of the artificial coastline and hard defence structures in Europe; Source: EUROSION (2005).

Table 5 reports the protected coastal length for the NUTS2 Mediterranean regions, showing how the Northern Regions as Fruili Venezia Giulia, Laguedoc-Roussilion, Liguria, Veneto, Emilia Romagna, where almost 60% of the coastlines results protected according to EUROSION database.

The significant presence of hard defence structures is observed in several Mediterranean areas characterized by sandy beaches and high urban development, especially in Northern Italy, Spain and France. This development had relevant socio and environmental implications (Lamberti & Zanuttigh, 2005) and induced measures to decrease the barrier crest elevation over the mean sea level, still paying attention in a new influence in design due to sea level rise, increasing storm surge and wave forcing. In addition, the plans of measures in FRMP and RBMP addressed through the adaptation or repair of the existent defence structures (Burcharth et al., 2014), to better reduce flooding and erosion risks.

Well-designed defence structures generally reduce erosion rate of the protected beach, and often are combined to sand supply, dredging and nourishments solution in the framework of ICZM policy development. Breakwaters and groins are the most common technique in the Mediterranean Sea to moderate loss of beach areas and protect them, especially where “sun-bath” tourism is mainly developed. Their construction strongly modified the cross- and long-shore sediment transport inducing significant variations on water and sediment quality

and therefore on the socio-economic and ecological features of a protected site, enabling or not sustainable tourism in relation to recreational activities, as explained in Section 3.2 for each described measures.

Among the proposed measures to reduce beach erosion and flooding risk, all the plans cited in the previous Section refer to sand nourishment as one of the defence measures that has the advantage of maintaining the beach system in a near-natural condition and providing ecological benefits (Dean and Rosati, 2010). In Spain, this technique was very widespread, with a volume of nourished sand of 5 million m^3 per year, while in the other Countries (only France and Italy, where information were available) minor average volume amount (0.7 and 1.25 million m^3 per year) was used, preferring the construction of defence-detached structures.

Although this technique is nowadays becoming much more adopted in the Mediterranean Regions, it is often applied as a strategy of remedial rather than a preventive measure: an overall long-term planning, coastal management, regular monitoring of the coastline should be included in the planning of this typology of measures as part of ICZM policy.

One of the other proposed measures to protect coasts in the adopted plans is the dunes regeneration and protection. Indeed, the extensive touristic attraction of the Mediterranean sandy beaches caused in the past years the expansion of buildings and infrastructures often too close to the sea shore, reducing the dune systems, that in the Mediterranean are smaller and more scattered in comparison to those of the Atlantic coast. Recently, measures to protect the existent dunes on one hand, and to regenerate destroyed dune systems by means of plantation actions on the other hand, have been put forward.

Innovative coastal defence solutions in alternative to classical rubble-mound barriers have being experimented in some study sites, as Riccione (reefball, other innovative structures), Procida Island and Ebro Delta (beach drainage), Livorno (geotextiles).

Country	Mediterranean Region	Coast length (km)	Protected coast (km)	Protected coast (%)
IT	Friuli-Venezia Giulia	116.9	79	67.6
IT	Abruzzo	139.3	86	61.7
IT	Liguria	357.5	209	58.5
FR	Languedoc-Roussillon	325.1	184	56.6
IT	Veneto	196.5	108	55.0
IT	Emilia-Romagna	169.3	80	47.3
FR	PACA	1035.1	439	42.4
IT	Marche	185.8	75	40.4
IT	Campania	459.9	149	32.4
IT	Lazio	351.5	102	29.0
ES	Valencia	496.8	143	28.8
CY	Kypros / Kibris	66.7	19	28.5
ES	Cataluña	578.7	152	26.3
IT	Molise	31.3	8	25.6
ES	Andalucia	872.3	221	25.3
GR	Dytiki Ellada	859.3	201	23.4
IT	Calabria	699.4	156	22.3
GR	Sterea Ellada	1491.8	313	21.0
IT	Sicilia	1531.6	320	20.9
IT	Toscana	584.5	112	19.2
IT	Puglia	836.8	157	18.8
GR	Anatoliki Makedonia Thraki	436	64	14.7
ES	Murcia	175.3	21	12.0
GR	Attiki	1047.9	124	11.8
GR	Ipeiros	313.5	37	11.8
GR	Kentriki Makedonia	821.8	84	10.2
GR	Peloponnisos	1164.1	93	8.0
GR	Thessalia	697.3	54	7.7
IT	Sardegna	1737.3	127	7.3
MT	Malta	172	12	7.0
GR	Guadeloupe	557.7	32	5.7
ES	Baleares	1038.9	51	4.9
FR	Corse	1041.8	49	4.7
GR	Ionia Nisia	1065.9	37	3.5
GR	Voreio Aigaio	1311.3	38	2.9
GR	Kriti	1148.3	31	2.7
GR	Notio Aigaio	3423.2	88	2.6
IT	Basilicata	70.5	1	1.4

Table 5 Protected coast length in the Mediterranean NUTS2 regions; Source: EUROSION (2005).

4. Representative case studies of coastal protection measures

Several experiences on design, performance monitoring and maintenance of the coastal protection structures, i.e. breakwaters, groins, and the other typologies described in Subsection 3.2, and of the soft defence techniques, as sand nourishment and dune stabilization, are reported in literature (scientific papers, technical reports, documents) and in the deliverables of the many research projects for the Mediterranean Sea.

In the following tables, some representative case studies of the most common defence techniques adopted in the Mediterranean Regions are reported, focusing on the typologies of developed tourism of the area and on the adopted measures to protect beaches.

In particular, Table 6 shows examples of sites where hard protection structures or a combination of their construction with soft measures were adopted and monitored.

In Table 7 and Table 8, examples of soft measures are listed, in particular focusing on sand nourishments and dune stabilization respectively.

The information on defence measures of the reported cases and many others as described in D3.8.2 “Thematic Atlas of coastal protection plans and measures in Mediterranean touristic area” will go to implement the database developed under the Activity 3.2.2 – “Mapping of coastal morphodynamics descriptors in Mediterranean touristic areas”.

Defence structures				
Country	**Site**	**Tourism**	**Protection measures**	**Reference**
Cyprus	Dolos Kiti	Beach	Breakwater, Groins	EUROSION
Greece	Rhodes Island	Beach	Groins	Anagnoistou et al., 2011
	Lakkopetra	Beach	Breakwater	EUROSION
	Messalogi Lagoon	Natural	Groins	EUROSION
France	Littoral Hèrault	Beach, Natural	Breakwater, nourishment	Sourisseau J., 1989, Brunel et al., 2014
	Saint-Aygulf	Beach	Breakwater, nourishment	Chavand and Migniot, 1992
	Valras-Plage	Beach	Breakwater, nourishment	Rihouey et al., 2009
	Petite Camargue	Natural	Groins	EUROSION
	Gulf of Lion	Beach	Seawall	Samat et al., 2007
Italy	Pellestrina	Beach, Cultural	Groins, Breakwater, Nourishment	DELOS; Bezzi et al., 2009
	Lido di Dante	Beach	Breakwater, Nourishment	DELOS; Zanuttigh et al., 2005
	Marina di Massa	Beach, Marina	Seawall, Groins	EUROSION
	Goro mouth, Po Delta	Natural	Groins, Revetment, Dune restoration, Nourishment	EUROSION
	Giardini-Naxos	Beach, Cultural	Revetment	EUROSION; Lanza&Randazzo. 2013
	Lido di Ostia	Beach	Breakwater, Nourishment	DELOS, Tomasicchio, 1993
	Procida Island	Beach, Natural	Drainage, Breakwater	EUROSION
	Marina di Ravenna	Beach, Marina	Breakwater, Groins	EUROSION, Utizi et al., 2016
	Marinella di Sarzana	Beach, Natural	Breakwater, Groins, Nourishment	EUROSION
	Tarquinia	Beach	Groins, Nourishment	Koutrakis et al., 2011
	Livorno	Beach	Geotubes	Aminti et al., 2010
	Tyrrenian Coastline	Beach	Breakwater	D'Alessandro et al., 2011
Malta	Xemxija Bay	Beach, Marina		EUROSION
	Ghajn Tuffieha Bay	Beach		EUROSION
Spain	Malaga	Beach	Groins, Nourishment	Manno et al., 2016
	Castellón plain	Beach	Groins, Breakwater	EUROSION
	Sitges	Beach, Marina	Groins, Breakwaters, Seawalls	EUROSION
	Mar Menor	Beach	Groins, Nourishment	EUROSION
	Catalan coast	Beach	Breakwater, Groins	Gacia et al., 2007; Marchand et al., 2011

Table 6 Sites with hard defence structures in the Mediterranean Countries and typology of developed tourism.

Sand nourishment			
Country	**Site**	**Tourism**	**Reference**
Greece	Kameiros, Rhodes	Beach	Karambas, 2011
France	La Croisette (1963): 0.12 Gulf of Lion Nice	Marina, Cultural Beach, Natural Marinas, Beach	Anthony, 1997 COASTGAP; Brunel et al., 2013 Cohen&Anthony, 2007; Anthony et al., 2011
Italy (ISPRA Report, 2012)	Pellestrina (1999): 4.0 Cavallino (1999): 2 Riccione (2002): 0.25 Francavilla (2006): 0.15 Punta Marina (2007): 0.19	Beach, Cultural Beach, Cultural Beach, Marina Beach Beach	DELOS, 2005, Bezzi et al., 2009 COASTGAP; SHAPE SHAPE; Miccadei et al., 2011 Utizi et al., 2016
Spain	Malagueta, Malaga (1990): 2.7 Benidorm (1991): 0.7 Valencia	Beach, Natural Beach Beach, Cultural	Malvárez et al., 2002 Aragonès et al., 2015 Yepes and Medina, 2005

Table 7 Sand nourishment in the Mediterranean Countries: average volume (Million m^3 per year) and examples (also in SAFE project and in Hanson et al., 2002).

Dune regeneration/protection			
Country	**Site**	**Tourism**	**Reference**
Croatia	Neretva Delta Mljet	Natural Natural	- -
France	Gulf of Lion Vaccares, Rhone Delta Espiguette Perpignan	Beach Natural Natural Beach, Natural	Durant, 2001; Gervais et al., 2012 http://www.conservatoire-du-littoral.fr/siteLittoral/117/28-vaccares-13_bouches-du-rhone.htm, http://www.conservatoire-du-littoral.fr/siteLittoral/23/28-espiguette-30_gard.htm, Curr et al., 2000
Greece	Evrotas Delta Kyparissia Bay	Natural Natural	- MEDASSET (2015)
Italy	Goro Mouth, Po Delta Vendicari (Sicilia) Rosolina, Po Delta Golfo di Follonica	Natural Natural Natural Beach, Natural	Simeoni, 2002 http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=VenetoCoast.pdf Aminti et al., 2002
Spain	Albufera, Valencia Formentera Ebro Delta Catalunia Cadiz	Beach, Natural Beach Natural Beach	Almonacid-Caballer et al., 2016 Sanjaume & Pardo, 2005 Ministerio De Medio Ambiente, 2001 Garcia-Lozano – Pintò, 2017 Gomez-Pina et al., 2002

Table 8 Dune regeneration/protection measures in the Mediterranean Countries: examples and their reference.

5. Influence of coastal protection measures as ESS for coastal tourism

The analysis carried out in the previous Sections shows the importance of an integrated coastal management approach when accounting for complex environmental dynamics and socio-economical interests, especially regarding sea-land protection plans and tourism growth actions.

Different typologies of coastal tourism are proposed in the Deliverable D3.16, also according to the study proposed by ECORYS (2013), identifying natural, beach, cultural, marinas and cruising tourism (Appendix I).

The presence of coastal protection measures in a touristic site has generally relevant influence into the site appeal and the development of recreational activities.

The Mediterranean coastlines are, for a large part, protected by human-made structures and measures. These enabling factors may provide tourists, in relation to the recreational activities they are interested/involved in, direct or indirect benefits, depending on the typology of the adopted protection measures. For instance, measures like nourishment or dune protection carry direct benefits in the sun-bathing or natural tourism activities; on the other hand, the construction or maintenance of breakwaters or revetments rarely influence sun-bathing activities in a direct way, due to large spatial and temporal scale effects, while they have positive effects in snorkelling or scuba diving activities.

Table 9 correlates, for each tourism typology, the relevance of coastal protection techniques as enabling factors for touristic activities, namely reporting aspects where the adopted measures have influence.

For instance, in the case of marina tourism, sailing is enabled by the presence of hard protection measures (breakwaters, revetment, seawalls) and sand bypassing that influence hydrodynamics patterns inside and around marinas (currents, wave transmission and diffraction) and navigability (sand by-passing, nourishment).

Despite the enabling effects of coastal protection measures, some drawbacks of not well-designed measures or coastal planning, as explained in Section 3.2, may not positively influence tourism development. Negative effects of coastal protection measures can be the development of tombolo/salient structure or the generation of rip-currents, extremely dangerous for swimmers (as possible consequence of breakwaters construction), or minor accessibility to the beach (as possible consequence after seawall building). Therefore, efforts by authorities and stakeholders to implement ICZM recommendations are always desirable and suitable.

Touristic activities	Aspects enabling coastal tourism	Coastal defence measures enabling coastal tourism
Natural tourism		
Observe plants	Presence of dunes and vegetation	Dune regeneration, seagrass meadow planting
Observe birds	Presence of dunes, vegetation and birds	Dune regeneration/protection
Observe fish	Presence of fish, mussels; Modification/increase in biodiversity in the area	Innovative measures (reefballs), breakwaters, groins
Quietness and relaxation	Protection from flood risk; hydrodynamics (currents, wave transmission, set-up), beach quality	Breakwaters, groins, nourishment, dune protection
Landscape	Structure visibility, water quality, sediment/beach quality	All the measures
Beach tourism		
Swimming	Sea quality, hydrodynamics (currents, wave transmission, set-up) Spatial arrangement of structures (length, width, gaps)	Breakwaters, groins, sand bags, gabions, beach scraping
Sun bathing	Beach extension and maintenance, sediment quality, spatial arrangement of structures (length, width, gaps), morphodynamics (sediment currents, erosion trends)	Breakwaters, groins, sand bags, gabions, nourishment, beach-drainage, beach scraping
Cycling, Walking, Running	Beach quality, beach extension	Nourishment, seawalls, revetments
Snorkelling, scuba diving, water-skiing, kayaking, fishing	Sea quality, hydrodynamics (currents, wave transmission, set-up)	Breakwaters, groins, sand bags, gabions
Landscape	Structure visibility, water quality, sediment/beach quality	All the measures
Cultural tourism		
Accessibility to the site	Protection of infrastructures on the coast from erosion and flooding risk	Revetment, seawalls, breakwaters, nourishment
Landscape	Dunes, sediment/beach quality	Revetment, seawalls, breakwaters, nourishment
Marinas		
Sailing	Hydrodynamics (currents, wave transmission and diffraction), navigability	Breakwaters, revetment, seawalls, sand bypassing
Cruising		
Accessibility to the site	Protection of infrastructures on coastline from erosion and flooding risk	Revetment, seawalls, breakwaters, nourishment

Table 9. Influence of coastal defence measures to coastal tourism management, Left column: activities developing for typologies of tourism; Central column: descriptors strongly influencing tourism; Right column: typologies of coastal defence measures.

In addition to the general indicators proposed in Deliverable 3.16.2 “Tourism Sustainability Toolkit”, we provide here a Table that may be helping to address the definition of indicators accounting for the management and the impact of defence measures as enabling factor for sustainable tourism development.

Adapted from indications by WTO (2003), European Commission (2007) and European Union (2016), the following indicators may help to identify whether a defence measure may represent an enabling factor for the sustainable tourism and how this function could be promoted.

Indicators	***Comments***
Existence and typology of a coastal planning management	*e.g. plans/measures from Flood Directive, MSPL, ICZM, national and regional legislation*
Length of protected and defended coastline (km)	
% of tourist area and infrastructure with sea defences	*In the selected coastal area/site, the typology of developed tourism may be identified according to indication by D3.16.1*
Cost of erosion prevention and repair measures (€/y)	
Beach nourishment: sand volume and extension of the restored beach (m^3 and m^2)	
Typology of coastal defence measures and their spatial extension	*e.g. hard or soft techniques, following the list shown in Section 3.2 and their influence area*
Cost for the maintenance of defence measures (€/y) and its expected temporal programming	
% of sites where coastal protection measures limit access to beach/sea	
Sea-land activities of the protected area and interaction of the defence measures with them (high/medium/low)	*Examples of the sea-land activities are recreational (tourism/ sun-bathing/ fishing/diving/boating) and transport (port/marinas/road) uses*
Influence (positive or negative) of defence measures presence on tourist appeal of the area	*Influence on environment (for example, water quality, structure colonization, biodiversity, increase of tourist safety), recreation (for example, increment of fishing/diving/boating activities), beach quality (increment of tourist number or variation of tourist density on the beach)*

Table 10. Specific indicators for the enabling factor of the coastal protection measures.

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Appendix I – Overview of coastal tourism development in the Mediterranean

The beach tourism in the Mediterranean represents more than 80% of the total GVA in coastal and maritime industry, according to data by ECORYS (2011), with 26 billion €, in comparison with cruise tourism (9 billion €) and yachting/marina tourism (19 billion €).

Different typologies of coastal and maritime tourism, are proposed by the Deliverable D3.16, also according to the study by ECORYS (2013):

- beach tourism, mainly constituing mass tourism
- city/cultural tourism, not directly having beach interactions
- cruise tourism
- yachting/marinas, partially constituting niche tourism
- nature/ecotourism, mainly constituing low-profile tourism

In order to focus the analysis and the review of protection plans and describe some representative case studies also in relation to the developed tourism typologies, in this Appendix, some tables reported information on tourism at NUTS2 levels, and in particular on mean tourist arrival per year (Table 12) and the number of yacht marinas (Table 11).

Country	Mediterranean Region	Number of yacht marinas
France	Languedoc-Roussillon	36
	PACA	88
	Corse	23
Italy	Liguria	41
	Veneto	28
	Friuli	22
	Emilia-Romagna	6
	Toscana	30
	Marche	7
	Lazio	25
	Abruzzo	2
	Molise	5
	Campania	35
	Puglia	35
	Basilicata	2
	Calabria	18
	Sicilia	75
	Sardegna	76
Spain	Cataluña	56
	Valencia	49
	Baleares	76
	Andalucia	27
	Murcia	21

Table 11. Number of yacht marinas in Mediterranean Regions; Source http://www.portbooker.com/it/posto-barca.

Country	Mediterranean Region	Coast length (km)	Mean tourist arrival per year (in millions)	Density of tourists per coastline (1000 person/km)
Croatia	Jadranska Hrvatska	5820	12.4	2.1
France	Languedoc-Roussillon	325.1	8.8	26.9
	PACA	1035.1	17.1	16.5
	Corse	1041.8	2.7	2.6
	Guadeloupe	557.7		
	Guyane	556.5		
Greece	Anatoliki Makedonia, Thraki	436	0.8	1.8
	Kentriki Makedonia	821.8	3.4	4.1
	Thessalia	697.3	1.0	1.5
	Ipeiros	313.5	0.6	1.8
	Ionia Nisia	1065.9	1.9	1.8
	Dytiki Ellada	859.3	0.7	0.8
	Sterea Ellada	1491.8	0.6	0.4
	Peloponnisos	1164.1	1.2	1.0
	Attiki	1047.9	4.1	3.9
	Voreio Aigaio	1311.3	0.5	0.3
	Notio Aigaio	3423.2	4.4	1.3
	Kriti	1148.3	3.8	3.3
Italy	Liguria	357.5	4.4	12.2
	Veneto	196.5	17.3	87.8
	Friuli	116.9	2.2	18.7
	Emilia-Romagna	169.3	9.7	57.5
	Toscana	584.5	12.8	21.8
	Marche	185.8	2.4	12.7
	Lazio	351.5	11.0	31.2
	Abruzzo	139.3	1.5	10.7
	Molise	31.3	0.1	4.8
	Campania	459.9	5.3	11.4
	Puglia	836.8	3.4	4.1
	Basilicata	70.5	0.7	9.6
	Calabria	699.4	1.5	2.1
	Sicilia	1531.6	4.5	3.0
	Sardegna	1737.3	2.6	1.5
Spain	Cataluña	578.7	22.2	38.4
	Valencia	496.8	10.1	20.3
	Baleares	1038	10.4	10.0
	Andalucia	872.3	19.8	22.7
	Murcia	175.3	1.4	7.8

Table 12. Arrivals at tourist accommodation establishments by NUTS2 Mediterranean Regions; Source: EUROSTAT (2015).