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CO-EVOLVE

CO-EVOLVE

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

Deliverable 3.8.3

Guidelines and recommendations for coastal protection strategies and management options

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 present report pertains to the Deliverable 3.8.3 – "Guidelines and recommendations for coastal protection strategies and management options", foreseen as outputs from "Activity 3.8 - Enabling factors for sustainable co- evolution in touristic areas - Mediterranean scale: Coastal protection measures".

Guidelines for management, monitoring and modelling approaches will be described in the present document, where the outcomes of strategies and critical aspects related to their implementation resulting from the reviews performed in Deliverables 3.8.1 and 3.8.2 will be summarized.

Tools for efficient prediction and analysis of the effects of coastal management actions will also be included in the document, reporting an overview of the commonly adopted approaches for monitoring and modelling of coastal areas.

2. Towards a coastal management conjugating protection measures and beach sustainable tourism in the framework of climate change

Studies about the influence of coastal structures on the protected shoreline and the surrounded environment are largely present in literature and represent important tools for coastal engineering; examples are represented by the Coastal Engineering Manual (CEM) published by the United States' Corps of Engineers in 2001, and the Shoreline Management Guide (2005), from EUROSION project. In addition, national documents and local plans have been developed to implement EU Flood Directive and ICZM recommendations, although in dissimilar and fragmented ways (ref. to D3.8.1).

Coastal protection structures, as designed by engineers, aim to principally protect shoreline against beach erosion and hinterland from sea flooding. Indeed, management actions to decline to cope with against erosion and flooding generally includes plans for the design or reshaping of defence measures (Frampton, 2010) and it has only given passing consideration, as from the reviews of plans described in CO-EVOLVE Deliverable 3.8.2, to the beach value for amenity purposes, that could be influenced by the chosen protection technique. Inclusion of issues related to beach safety and amenity in beach management plans is significant in order to assess social-economical demands coming from the tourism development.

Therefore, the interaction between the engineering approaches to design protection measures and the beach appeal requirements by local community should represent an important issue to be considered in an integrated beach management.

As reported in CO-EVOLVE Deliverable 3.16.2 “Tourism Sustainability Toolkit”, specific indicators for the coastal protection measures as enabling factors for sustainable tourism development have been listed with the aim to quantify the effects of engineering practises on the beach appeal and amenity.

In particular, in addition to physical and territorial information, the indicator P.B1.8 reporting “Influence (positive or negative) of defence measures presence on tourist appeal of the area (low/medium/high influence based on interviews, questionnaire, etc.)” should be estimated by local administrators and different beach-users in order to evaluate the interactions between engineering and protection plans and the beach value in terms of touristic appeal.

At the scale of the Mediterranean Countries, the integrated management purpose to conjugate beach protection and development of sustainable tourism presents further pressures, connected to global climate change impacts and effects of growth of socio-economical interests along the coastline.

The Mediterranean basin has, in fact, been identified by the International Panel on Climate Change (IPCC 2001 and 2007) as a "hot spot" area "at risk of marine ingression, coastal erosion and land deterioration" (COM, 2009) and national and regional management plans (i.e. Italian guidelines for the coast protection) have been defined also in order to account adaptation and mitigation actions and take into account, for instance in the 2nd RBMP, the effects of climate change, in particular sea level rise, that increases the beach vulnerability.

At the same time, the Mediterranean is one of the most visited tourism areas in the World, accounting for 1/3 of international tourist arrivals worldwide, and almost 20% of the global cruise market (UNWTO, 2014). The coastal zones of Mediterranean countries were visited in 2014 by an estimated 215 million international and local visitors, and an averaged annual growth is estimated to be in the order of 4% per year, with peaks in Greece (+23%) and in emerging destinations as Albania and Serbia (+10%) and the arrivals numbers is expected to increase by an average of 2.9% a year over the period 2010 to 2030 (predictions by UNWTO Tourism Towards 2030, 2011).

These impacts represent part of the human and environmental pressures acting on the coastal area that Integrated Coastal Zone Management (ICZM) may help into addressing to provide a framework for management, although the legislative background developed in the past and adopted by the different Mediterranean Countries at national and local scales had been very different and fragmented. ICZM framework considers land use changes, conservation and preservation of coastal resources, in combination with the role of economic sectors such as fisheries and tourism, and would also integrate actions for climate change adaptation and mitigation.

Scenarios regarding coastal morphological evolution, climate change and tourism development present difficulties dealing with their characteristic timelines. Indeed, morphodynamics and climate change are relatively long- term, non- linear processes, with significant changes taking place over periods generally exceeding several years; tourism, on the other hand, can be more easily affected by short- term trends. Current challenges in the coastal management are represented by the definition of coherent approaches trying to compare longer- term changes in the physical environment and socio- economic variation.

In addition, an effective management of coastal areas should not only be based on an analysis of individual activities and their impacts, but also on the combined effects of sectorial activities on each other and on coastal resources (UNEP and PAP, 2009).

Attempts to define recommendations to implement integrated strategies and conjugate coastal protection and sustainable tourism growth in the scenarios of climate change are presented in the following sections.

3. Coastal planning approach to conjugate protection measures and sustainable tourism

ICZM is a continuous, proactive and adaptive process of resource management for sustainable development in coastal areas and follows different approaches to achieve goals and objectives within the constraints of physical, social and economic conditions, and within the constraints of legal, financial and administrative systems and institutions (Frampton, 2010).

Holistic beach management is one of the ICZM principles, that was well described in Bird's 1996 book ''Beach Management'' as being ''beach management [that] seeks to maintain or improve a beach as a recreational resource and a means of coast protection, while providing facilities that meet the needs and aspirations of those that use the beach.'' This approach seems to be properly suitable in the definition of a management strategy including coastal protection and tourism growth.

Indeed, under this approach, the interactions between the different beach systems that compose the ''beach environment'' (James, 2000) are important to be analysed also in order to manage one-factor impacting the others.

Adapting the integrated planning and management approaches for sustainable coastal tourism and coastal protection from erosion proposed by EU (i.e., PAP/RAC, 2009; IOC UNESCO, 2009) and in national or regional contexts as reviewed in Deliverable 3.8.1, recommendations for the definition of coastal protection strategies and management actions in the framework of sustainable tourism development are declined as reported in Figure 3.1, suggesting 4 action phases as described in the following subsections.

The proposed planning process is "step- by- step" with definite objectives and outcomes to be implemented and evaluated by means of articulated monitoring activities.

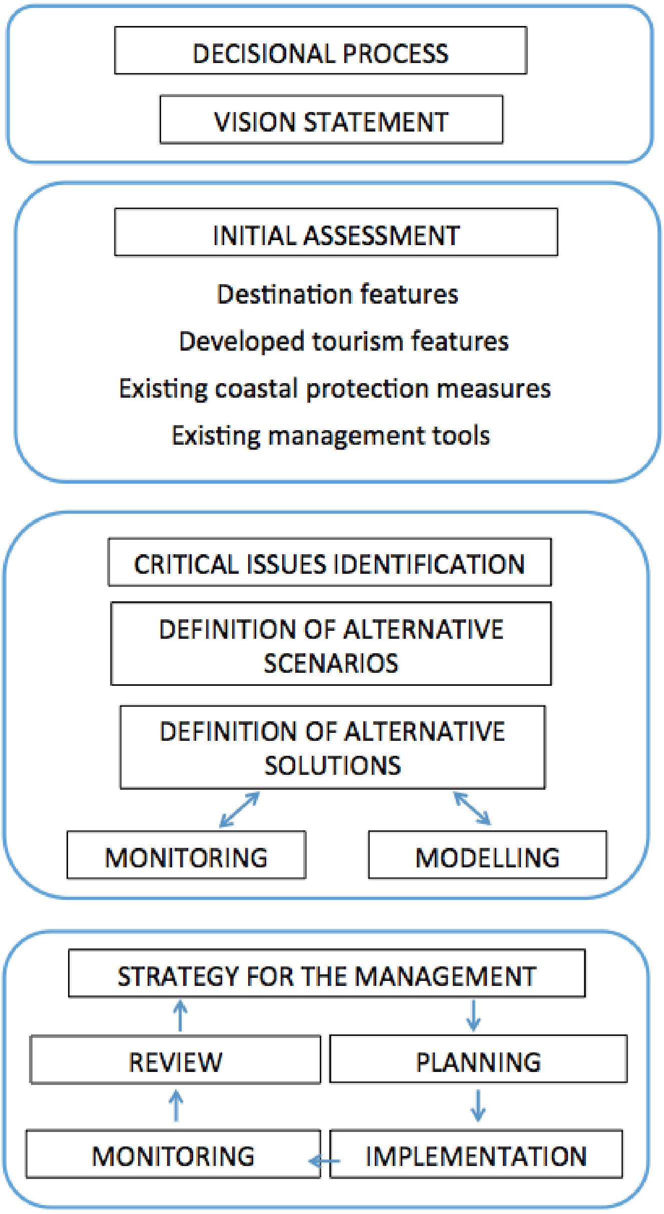


Figure 3.1 Outline of the strategy for the management of actions to conjugate coastal protection measures and sustainable tourism development.

3.1 Preliminary considerations

3.1.1 Decisional process

The first act in the proposed planning process is the definition of the “Destination”, i.e. the place “which is marketed or markets itself as a place for tourists to visit” (Beirman, 2003).

Public sector leadership must come to agreement and define an approach to launch their planning initiative. An agreement to plan should be developed and signed by local governors that are actively involved, providing human and financial resources.

The decision-making process needs to involve the administrative and the private sectors and the ordinary citizens and should be supported by a strong political will. Finally, a Project Team to carry out the process will be defined.

3.1.2 Vision statement

At this stage, local administration might define the vision and goals of tourism development and the correlated actions for coastal management, both in the area of the Destination and hinterland.

A strategy document, including the long-term land use, the coastal zone and the extended economic zone as the key macro level environmental elements essential to sustainability, would be disseminated to stake-holders and citizens and beach-users, showing the overall objectives of the proposed planning. The vision statement would deal with issues as maintaining the Beach Carrying Capacity, i.e. the maximum number of people that can use an environment before an unacceptable decline in quality of the ‘‘recreational experience’’ (Silva et al., 2008), increasing of a sustainable tourism, and integrating environment into development decision-making.

3.2 Initial assessment

This phase includes the analysis of active physical and human factors, which might strengthen public awareness of coastal issues and the need to take actions in coastal areas.

The capitalization of knowledge and resources already acquired in the field of coastal protection by research and field experiences (Figure 3.2) is strongly required in order to develop connections between science/knowledge and decision-making plans constituting administrative constrains and involve local and national stakeholders at the scale of management of coast and maritime environment.

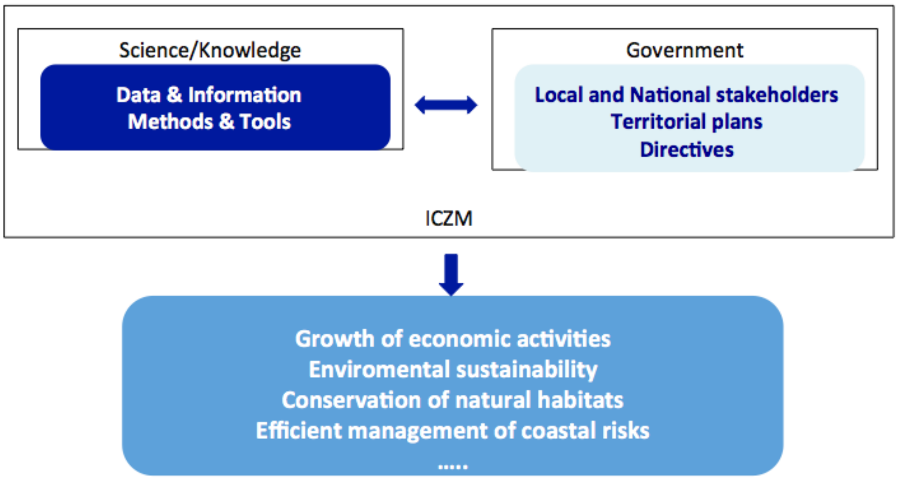


Figure 3.2 Outline of connections between science/knowledge and decision-making plans to develop ICZM strategy.

3.2.1 Destination features

Basic data about the Destination should be found out locally, with the involvement of all local sources of information, such as administrative agencies, citizen observations, and research groups. All the analysed information should have feasibly a coherent scale, in order to give a right definition and knowledge of the studied territory by different points of view, such as physical, ecologic, touristic, demographic, cultural and socio-economic. Forecast of the territorial response to the climate change scenarios is also important to be addressed in order to properly define adaptation and mitigation programmes to sea level rise and variation in temperature and rainfall rate. Territorial tools such as Geographic Information System (GIS or Web-GIS) could also help into the collection of the available data.

Specific indicators as the ones listed in Section 6.1 for monitoring and modelling approaches might be provided and collected to characterize the Destination and allow an accurate definition of coastal protection strategy for the development of sustainable tourism.

In addition, indicators listed in CO-EVOLVE Deliverable 3.16.2 "Tourism Sustainability Toolkit" could be helpful to describe some destination features; some of those could also be adopted in the analysis in order to achieve a better knowledge of the Destination area, such as:

- Size, density and proportion of the population living in coastal areas (year average and peak month)
- Extreme events hitting the coast per year (number)
- Coastal flooding events per year (number)
- Estimated sea level rise (low, medium, high)
- Land occupied by artificial surfaces within the first 500m of coast (in %)

3.2.2 Developed tourism features

This step addresses more in details information on the description of the general overview of local tourism and of its key features in terms of sustainability and impacts on the coastal environment. Components, characteristics and national and international trends of the tourism market along the analysed coastline might be presented with the description of the current status of coastal tourism. Specific issues and constraints might be also identified and addressed with the solutions reported in the proposed planning strategy. Also, the identification of the coastal areas with high/higher potentials for becoming successful tourism destinations might be included in the analysis, as well as an overview of the institutional and policy framework involved in the coastal tourism activities.

Some specific indicators to describe the developed tourism typology and its features are proposed in CO-EVOLVE Deliverable 3.16.2 “Tourism Sustainability Toolkit”; some of those could be also adopted in the analysis at this stage in order to achieve a better knowledge of the Destination area, such as:

- Number of tourists on peak day
- Number of second homes per 100 homes in coastal zones
- % of tourist infrastructure (hotels, other) located in coastal zones
- % of area designated for tourism purposes
- % of total coastal capacity used (average and peak)
- Ridgeline or coastline continuity (% intrusion on ridge and coastline)
- Total tourist numbers (mean, monthly, peak) (categorized by their type of activity)
- Number of tourists per square meter of key site (e.g., at beaches, attractions), per square kilometre of the destination, - mean number/peak period average
- Water use (total volume in litres or m^3 consumed and litres per tourist per day)

- Number of shortage incidents per year, or number of days per year where there are water supply shortages
- Volume (m^3) of litter collected per given length of shoreline

3.2.3 Existing coastal protection measures

The analysis of the physical dynamics causing coastal erosion and sea flooding is carried out at this step with a focus on the description of the adopted coastal protection measures and their recognized effects on tourism development. Also, the knowledge of the management steps of the area might help in understating complex processes and their interactions one with each other.

Recent practises from regional agencies (for instance, Languedoc-Roussillon, Cataluña and Emilia Romagna regions) are the development of GIS or Web-GIS database that also contains information on the adopted techniques (ref. to Deliverable 3.8.1 for a detailed description) to protect coastline, together to other physical information.

Specific indicators to describe the protected beach and the typology of defence measures as enabling factor for sustainable tourism development are proposed in CO-EVOLVE Deliverable 3.16.2 "Tourism Sustainability Toolkit"; and some of those could be also adopted in the analysis in order to achieve a better knowledge of the Destination area, such as:

- Length of protected and defended coastline (km)
- % of tourist area and infrastructure with sea defences
- Cost of erosion prevention and repair measures per year (€)
- Typology of coastal defence measures (to be selected from the list of the defence techniques described in Report 3.8.1)
- Cost for the maintenance of defence measures per year (€)
- % of sites where coastal protection measures limit access to beach
- Number of dredging operations needed per year
- Volume (m^3) of sediments dredged per year
- Cost of dredging operations per year (€)

In addition, the participation of local agencies and administrations, stakeholders and citizens is advisable in order to estimate the influence of the developed coastal protection measures on the destination appeal or beach amenity. Means permitting a deep insight of the area are the existing field campaigns, with the aim to monitor the protected coastline and the effects of defence actions, and interviews to tourists, asking for an estimation of beach values and critical issues.

3.2.4 Existing management tools

The analysis of existing coastal planning management systems is the object of this planning step, focusing on the proposed technical, environmental, social, cultural and economic actions of plans to be yet implemented within the next years, or that are already implemented. Plans of protection measures to preserve coast from erosion and sea flooding are generally part of RBMS plans or ICZM strategies, as reviewed in Deliverable 3.8.1, although generally not being characterized by spatial and temporal homogenous resolutions in their implementation.

Specific indicators helping in the definition of this step are also proposed in CO-EVOLVE Deliverable 3.16.2 “Tourism Sustainability Toolkit”, in Governance issue, such as:

- Existence of a coastal planning management system
- Number of environmental, social, cultural and economic actions recommended in plan
- % of environmental, social, cultural actions recommended in plan which have been implemented

3.3 Critical issue identification and analysis of solutions

This third step represents the clue point of the planning process aiming to identify critical issues either in coastline protection and development of sustainable tourism in a context of climate change.

In particular, the following analysis is carried out with the identification of critical tourism development issues, leading to alternative socio-economical scenarios, and critical coastal protection issues, giving to alternative solutions in terms of defence measures.

3.3.1 Critical issues identification

The definition of critical issues requiring planned strategies and actions in order to conjugate beach protection measures and tourism development is the object of this step in the process outline. The growth of coastal tourism and the achievement of of satisfactory recreational services on coast, which is one of the major touristic uses of beaches and their hinterland, largely depend on the coast amenity (Ergin et al., 2006). It is related to physical parameters, such as Beach Carrying Capacity, wave-induced hydrodynamics, coast type, sediment colour, landward and seaward slopes, water transparency, sea agitation, etc., and human parameters, such as access type, safety, environment, disturbance/ noise. Parameters such as these and the other ones as discussed later, in Section 4.1, might build the basis for coastal classification in relation to the diffused tourism types.

Assessment of touristic (recreational) value of a coastal stretch in relation to coastal protection measures, in addition to availability of services and facilities, represents a suitable methodology with the aim to help coastal managers to decide where and how to cope with natural and anthropogenic induced hazards affecting the beach’s value and functionality. Two types of approaches are possible and are both often advisable to be performed together: interview and survey campaigns.

Interview approach might be essential to define critical issues regarding tourism in already protected or to be protected coast. Common approach is Contingent Valuation method (Ciriacy-Wantrup, 1947) based on consultations where population and tourists are asked directly what value they place on the availability of a resource, facilities and services, perceptions of the risk on the beach connected to climate change and policies to combat erosion and flooding.

Examples of this method application in the Mediterranean were described by Lamberti & Zanuttigh (2005) and Rulleau et al. (2011), and were applied to evaluate beach values respectively at Lido di Dante (Italy) and along Languedoc-Roussillon coastline (France), identifying beach economic values from recreational point of view and their variation when risk induced by erosion and flooding has to be accounted. In addition, preferences for different types of defence structures should be stated in order to support beach management activities for coastal-defence purposes, also delineating critical issues in the harmonization of tourism development and protection measures.

Outcomes from survey campaign should focus on specific indicators as discussed in Section 5, in order to give a complete overview of the destination area, specifying problems and drawbacks of protection measures (see also Deliverable 3.8.1 in Section 3.2).

After having performed an investigation by means of interviews and/or surveys following previous described steps, critical issues in coastal protection and management might be addressed for (i) amenity/recreational considerations and (ii) human safety considerations. Both the objectives could be achieved by means of planned actions and strategies acting on physical parameters characterizing the coastline under climate change scenarios.

(i) Maintenance activities on the coast for tourism management purposes can also be undertaken to address some of the beach-character issues as discussed above, including the width and slope of the beach, the sediment and water quality. Steep beach slopes can cause access problems to tourists, while conservation of sufficient beach extension is important to ensure the maximum beach carrying capacity. Actions such as sediment nourishment and slope re-profiling might be yearly carried out. Other actions are also advisable, such as maintenance operations on defence structures, actions to adapt them to improve recreational purposes, or to re-establish specific beach levels for providing required standard of protection against the risk of flooding or erosion (i.e., beach crest width or dune elevation).

(ii) Human safety and health have to be guaranteed in touristic coastal areas also considering climate change impacts. Indeed, when risks are high, safety of tourists might be improved with planned coastal defence measures, with new actions or modification/increment of the already present ones. Additional protection measures should be included in management scheme, such as warning signs to limit public access over and around structures (CIRIA, 1996, 2007).

Local administrators and stakeholders should cooperate to assess this step, in order to evaluate all the aspects to be included in the planned strategies.

3.3.2 Definition of alternative tourism scenarios

In order to find the better solutions to the identified critical issues, different potential scenarios for tourism development in the studied coastal areas should be selected and discussed with the involvement of local stakeholders. A time scale of ten years is commonly adopted for tourism development (PAP/RAC, 2009) to be examined in order to choose the one more suited for that particular Destination. Generally, the scenarios could present a “conservative” form, with focus on the conservation of resources and strict regulations for tourism development, and a “liberal” form with fewer constraints for tourism development.

3.3.1 Definition of alternative technical solutions

Understanding the coast recreational values with interviews and surveys by tourists and residents provides information on the influence of the adopted coastal-defence measures on touristic beach perception, with the opportunity to account and accommodate recreational requirements in the alternative technical solutions of the defence design scheme. In many cases this effort represents a minimal impact on the overall cost that can nevertheless greatly enhance the quality and efficiency of the planned actions. Consulting population and tourists in the identification of different technical schemes for coastal protection is also likely to lead to improved public perception and acceptance of a scheme (CIRIA, 2007).

3.3.2 Monitoring and modelling

Once critical issues have been identifies and possible alternative scenarios and solutions have been defined, the adoption of a planned strategy might be tested and verified by means of monitoring and modelling approaches, giving different degrees of accuracy in temporal and spatial estimations as the following:

- Analysis of historical trends of physical, ecological, socio-economical and touristic indicators, when available from maps, charts, documents, research projects, private communications;
- Field monitoring, by means of different direct or remote tools for the observations;
- Numerical and physical modelling of the actual state of the area and of the possible alternative solutions under different scenarios, also including hindcasting and forecasting approaches to estimate forcings.

The different approaches will be deeply described in Section 5. A comparative analysis should be performed in order to help coastal managers in the choice of the optimal actions to be planned at the destination.

3.4 Strategy for the management

This phase is composed by iterative stages, with feedback loops connecting the various steps. Indeed, after the implementation of actions to carry out the planned strategy, monitoring could address a review stage with modifications in the implemented strategy.

3.4.1 Planning

This step consists in the definition of strategic objectives, for which actions and indicators to be monitored should be also defined. An example is shown in Table 1, presenting the development of policies and goals, the selection of concrete sets of actions and the definition of indicators in order to monitor the achievement of the prefixed results in terms of coastal protection and tourism development over time. The action plan might also include a description of the current situation, together with the previous adopted plans and monitoring outcomes.

Table 1 Identification of the strategy: an example of definition of goal, actions and indicators to be monitored.

Goals	Actions	Indicators
Conserving Beach Carrying Capacity of the Destination	Building winter sand berms Maintenance operations of existing structures Planned nourishment every 2/5 years	Shoreline detection Beach width

Coherence between the approved territorial plans, coming from the implementation of European Directives, and national or regional decrees and proposed planning strategy for the implementation of tourism, should be achieved at this step of the planning process.

Different institutional levels, both vertical and horizontal, might join tables of discussion regarding the strategies to be planned for the development of sustainable tourism in accordance to coastal protection plans.

Mid- to long-term planning actions for climate change effects adaptation of coastal zones might be in line with the EU Directives (i.e. 2007/60/EC) and promoted the development of (i) Territorial Action Plans for adapting coastal zones to climate change, against erosion effects and submersion risk; (ii) Sediment Management Plans for both o shore and littoral deposits exploitation; and (iii) Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) Protocols to assure the right procedures to act along coastline; (iv) Beach Carrying Capacity Assessment (CCA).

3.4.2 Implementation

This step represents the moment(s) in which the planned actions are carried out and put into effect. The action achievement could be planned in a unique moment or with a scheduled frequency, generally induced by cyclic typology of protection measures such as beach nourishment or dune regeneration.

3.4.3 Monitoring

Monitoring the morphological evolution of the coast and its hydrodynamics and ecological response to protection measures is an essential phase of ICZM framework and represents a critical step in the success of a strategic planning for sustainable tourism development process. It should be put into practice by public administrations in charge of land and marine spatial planning and protection and economical growth.

The majority of EU Countries along the Mediterranean Sea (refer to Sect. 3.3.1 in D 3.8.1) recently developed (or started to develop) articulated observatories to collect territorial information on the coastal environment in GIS database, although a general lack in measures standardization is present, while generally national networks of stations cover hydrodynamics information by means of buoys and sampling gauges.

The state of health and safety of a coastal area can so be assessed through a planned monitoring campaign, as well as the response to defence strategies for beach protection and attractiveness.

Availability of structured data coming from articulated monitoring campaigns generally lacks or is hard to achieve, resulting into difficulties to understand reasons of malfunctioning or to guide optimization actions, for example by means of numerical comparison of design options.

Article 16 of Part Three of ICZM Protocol signed at Barcelona (referred to Section 2.1 in Deliverable 3.8.1) identified the “functional tools for an integrated management as appropriate mechanisms for coastal monitoring and observation”; in details, suggested actions include:

- the maintaining of regular update of national dataset of coastal zones, in particular information on resources, activities, institutions, policies and planning tools

- the development of a network of cooperation and organization among the Mediterranean countries, both scientifically and institutionally, up to provide standardized procedures to collect and store territorial data inventories.

Periodic reports to decision makers, stakeholders, and the public might describe the performance of the adopted coastal strategy. Frequency in monitoring surveys, to be performed in winter and summer (the latter causing some impacts on beach tourism) should be assessed in relation to the processes/critical events to be observed. For instance, generally the efficiency of a defence structure in relation to shoreline protection could be estimated with 5 years of detailed studies, while 10 or longer years are adequate for coastal planning projects (RESMAR project).

3.4.4 Review

The review of planned actions consists of comparing actual outcomes coming from field monitoring with expectations reported in the strategy document. Indeed, results might be reviewed at regular intervals, and compared with desired design outcomes.

This process must be used as a guide to reinforce strengths of the chosen solutions and reduce drawbacks, eventually defining next goals and objectives for the site, in a feedback loop.

4. Management strategies to cope coastal erosion and the tourism development

Management strategies to cope with coastal erosion as defined by DEFRA (2001) and reported in Eurosion (2004) are five: (1) Do nothing; (2) Managed retreat or realignment; (3) Hold the line; (4) Move seaward; (5) Limited interventions.

While the approaches are largely studied from engineering and management point of views (Villares et al., 2006; Roca et al., 2008; Roca et al., 2012), hereafter a description of the impact of these strategies on coastal areas where tourism is developed is briefly given, with the limits connected to physical and socio-economical features of each site in the Mediterranean area.

Some previous work has been carried out in the field of public perceptions regarding coastal erosion management mainly for the approach of holding the line (Villares et al., 2006; Roca et al., 2008), revealing the good opinion in hard and soft engineering measures shared by residents as solutions to protect coast, as well as for the approach of managed realignment schemes (Roca et al., 2012).

1. Do nothing and abandonment of the area admit no investment in actions or coastal defence measures. This strategy could be positive in terms of development of natural tourism, since nature is allowed to take its course, while it could have negative effects on the development of beach tourism, yachting and cruising tourism with the loss of sand, namely Beach Carrying Capacity (Coccossis and Mexa, 2004) and the absence/instability of fixed structures designed for mooring and nautical services. Indifferent impact, instead, is reserved to cultural tourism.
2. Managed retreat or realignment plans for retreat and adopts engineering solutions that accommodate natural processes of adjustment, allowing the sea to gain ground in the emerged zone in a managed way, with the identification of a new coastline further inland. Soft and more sustainable defence against flooding are generally adopted, but this approach is not considered suitable for widespread adoption, especially in urbanized areas, given that some cities, towns and infrastructures require rigid protection. Therefore, this strategy could be positive in terms of

development of natural tourism, but negative for the other types of tourism and for similar reasons as previously discussed.

3. Hold the line is an approach largely adopted along the Italian and Spanish urbanized coasts. Soft coastal protection measures such as beach nourishment and sand supply and the construction of defensive structures, as breakwaters, seawalls, groins, have the objectives to improve or maintain the beach protection also defending its Beach Carrying Capacity. This approach is commonly suitable to develop and sustain all the types of the analysed tourism, except natural tourism, although questions on the efficiency of traditional sea defences and their response to climate changes (DELOS, 2006; OURCOAST, 2011; THESEUS, 2013) also in the Mediterranean Sea, together to the lack of effectiveness, environmental impact and high economic cost, represents new arguments against hold-the-line policies.
4. Move seaward approach includes the realization of defence measures seaward of the coast, in order to increase the beach extension and move the coastline seaward. This approach represents the most radical strategy, in Europe adopted in Dutch polders, whereby ground is recovered from the sea and humid areas. Few examples are present along the Mediterranean coastline, generally associated to uncontrolled processes of drying up of wetlands for human use (Spain). This approach, although rarely applied in the Mediterranean Countries, could promote beach tourism, and help in the other types of tourism.
5. Limited interventions allow combined actions by human efforts and natural processes to reduce coastal risk. This approach develops with the maintenance of natural defences (i.e. with dune management) and measures aimed at public safety, such as flood- and landslide-warning systems. Positive influence with regards to the development of natural tourism, this approach could be considered Indifferent for the other typologies of tourism, since its effects are strictly related to the adopted measures.

Figure 4.1 reports a scheme of the management strategies as defined in Eurosion project (2004) and the typologies of tourism developed in the Mediterranean, as classified in Deliverable 3.16.1 of CO-EVOLVE project. Impacts of each strategy on the tourism are synthetically reported in the Table as positive (+), indifferent (/) and negative (-).

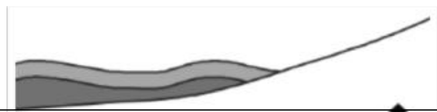
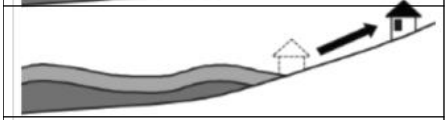
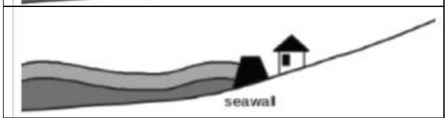
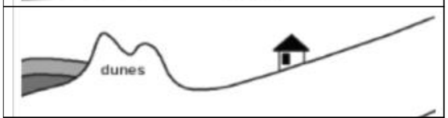
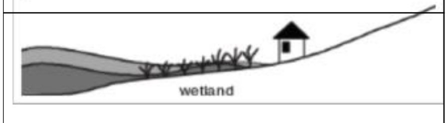
Management strategies to cope with coastal erosion and tourism development		Beach tourism	Cruise tourism	Cultural tourism	Yachting	Natural tourism
	Do nothing	-	-	/	-	+
	Managed realignment	-	-	/	-	+
	Hold the line	+	+	/	+	-
	Move seaward	-	/	+	-	+
	Limited intervention	/	/	/	/	+

Figure 4.1 Impact between management strategies to cope with coastal erosion (as defined by DEFRA, 2001; Source: Eurosion, 2004) and development of different types of tourism.

4.1 Positive and negative effects of protection measures

The general influence of the above described management strategy to cope with coastal erosion on the development of tourism is strictly connected to the typology of adopted defence measures for the specific site.

Recent research and monitoring outcomes (DELOS, 2006) report how human infrastructures acting on the longshore transport rate could have both positive (Figure 4.2) and negative (Figure 4.3) effects on the protected beach and the adjacent areas.

Well-designed breakwaters and groins, largely adopted in the Mediterranean Countries, can give a recreational value to the protected beach and increase its appeal and amenity. For instance, the development of waves for surfers and safe basin/harbours for marina berths are two positive effects of hard engineering structures. In addition, detached breakwaters can increase beach extension, causing an increase of the Beach Carrying Capacity; together with submerged artificial reefs, they can provide habitat for benthic species (flora and fauna) and improving biodiversity up to become attractive for fishing, scuba diving and snorkelling. Breakwaters can also provide leeward calmer waters, suitable for safe mooring and berthing procedures for vessels in ports.

Figure 4.2 Selected positive effects of protection measures on coastal tourism; Source: from web.

But adverse effects are also experienced after the building of protection structures. Hard structures for instance can cause downdrift erosion on adjacent beaches, and a negative impact on landscape value and the beach recreational use is generally observed with the building of barriers and seawalls.

Breakwaters can cause a decrease in water and sediment quality since they favour leeside deposition of mud, affecting sea transparency, up to the development of tombolo and salient formations. They can also capture litter from boats, making the beach area both unpleasant and unsafe. Also hydrodynamics can be affected by detached emergent structures, inducing the development of strong currents (namely rip-currents) around the ends of breakwaters and between the gaps, these currents being dangerous for swimmers and sunbathing tourists. These offshore structures, although well signalled with flags or buoys, can be in addition a hazard for navigation and water sports, such as surfing. Also soft measures such as nourishment and sand supply can have adverse influence on beach appeal and amenity, for instance modifying colour and dimensions of native beach sediments or changing the backshore and foreshore steepness.

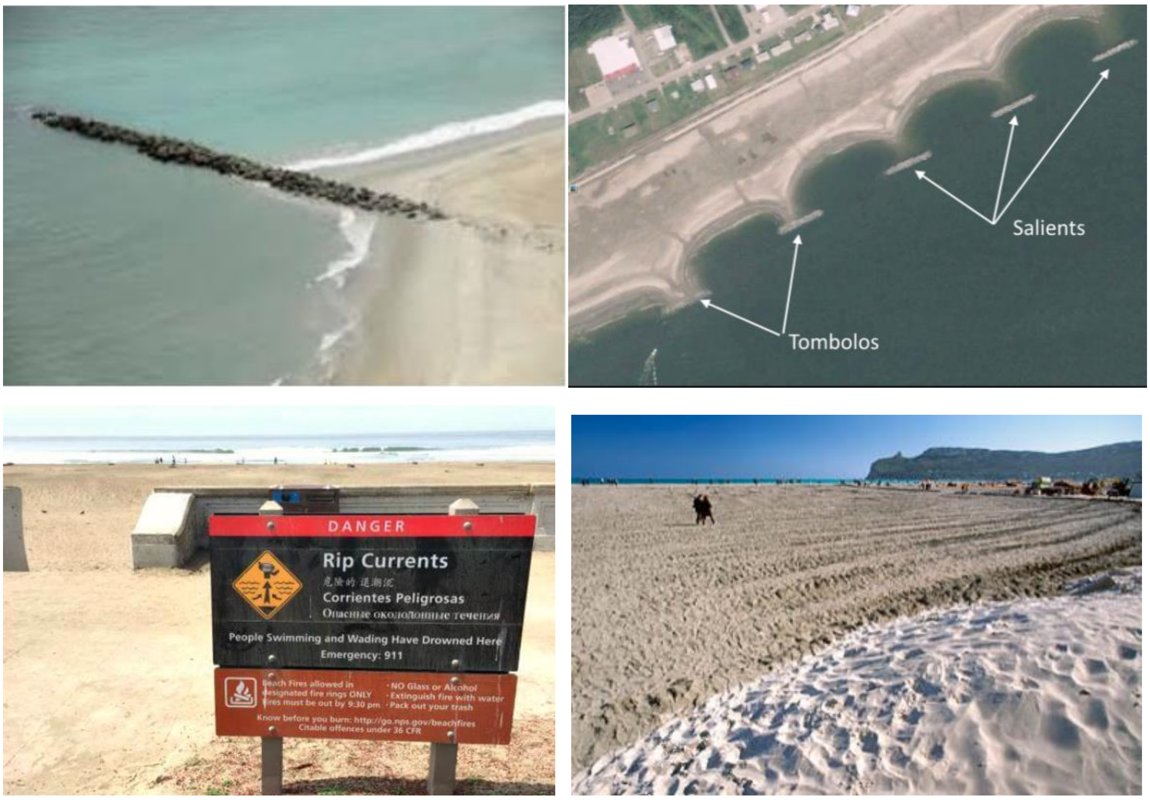


Figure 4.3 Selected negative effects of protection measures on coastal tourism; Source: web.

The main problems of existing protected coasts are related to the past ('80-'90 years) tradition to build separate and disconnected defence plans and this custom results nowadays into a decrease of positive response, a main exposure to erosion and flood of surrounded areas and a consequent reduction in beach recreational values for tourism and economical activities.

Understanding all the physical and environmental features of the site involving hydrodynamics and morphodynamics, together with articulated monitoring activities, is the advised good practice in order to plan and manage coastal protection measures as enabling factors for the development of sustainable tourism, and to avoid the diffusion of adverse effects connected to a incautious planning of the protection strategy.

5. Tools for prediction and analysis of the effects of coastal management actions

5.1 Physical indicators to estimate the effects of coastal protection actions in terms of sustainable tourism

Coastal dynamics and effects of protection actions are commonly measured and estimated/forecasted by means of field monitoring campaign and modelling implementation respectively.

In particular, the two different approaches may aim to describe the coastal processes and estimate the influence of a coastal management action, i.e. a new realization or the modification of coastal defence measures, on the development and growth of sustainable tourism.

The selection of relevant, practical and measurable indicators is one of the most important components of an accurate planning approach. Good indicators might have characteristics such as measurable, cost-effective, grounded in theory, sensitive, responsive and specific (IOC-UNESCO, 2009).

Suggestions on physical indicators to be monitored and modelled, in order to achieve information on the performance of coastal management measures, consist of:

- Bathymetry and morphology, including emerged and submerged beach profiles, shoreline position, dunes, and sediment transport
- Hydrodynamics conditions, i.e. information on water elevation, wave field in deep waters, in shallow waters and wave transformation induced by structures, currents, run-up over beach, storm surge
- Extreme events conditions, especially for water elevation and waves
- Water quality, in terms of concentration of suspended sediments and chemical characteristics
- Sediment quality, both of submerged and emerged beach
- State of the existing defence structures, i.e. level of damage, seabed interaction
- General beach users' perception of safety level of the beach, i.e. analysing the flood risk maps (implemented after Flood Directive) and estimating recent flooding recurrence and impact on the area

- General beach users' perception of amenity level of the beach, through interview, questionnaires and long-term surveys, for instance to quantify indicators as proposed in D3.16.2.

5.2 Overview of the monitoring tools commonly used in the Mediterranean Sea

5.2.1 Direct observations

Topobathymetric survey:

- Emerged beach and dunes: charts, geodetic positioning (GPS receivers), RTK mode geodetic GPS instruments; their data processing results in cartography and (3D) Digital Terrain Model (DTM)
- Submerged beach: geodetic positioning (GPS receivers), single beam and multi beam echosounders; their data processing results in bathymetric charts

Hydrodynamics:

- Waves: directional buoys, generally forming national monitoring networks (Table 2), Acoustic Doppler Current Profiler ADCP (towed behind a ship, moored or anchored to the seabed or to a ROV)
- Currents: ADCP, shallow and deep water drifters, current-meters
- Sea level: ADCP, radar and ultrasonic hydrometers
- CTDs (Conductivity-Temperature-Density)

Table 2 Website links for EU Med national wave monitoring networks in real time.

Country	
France	http://esurfmar.meteo.fr/real-time/html/dyfamed.html http://candhis.cetmef.developpement-durable.gouv.fr
Greece	http://www.poseidon.hcmr.gr/onlinedata.php
Italy	http://dati.isprambiente.it/dataset/ron-rete-ondametrica-nazionale/
Spain	http://www.puertos.es/en-us/oceanografia/Pages/portus.aspx

Sediment transport/morphological trend:

- Optical instruments (laser, backscatter)

- Acoustical instruments (ADV, ABS, ADCP)
- Bed load and suspended sediment samplers
- Coloured tracers
- Comparison of bathymetric charts or DTMs to estimate the erosional or accretional volumes

Water quality:

- Volume samples to measure concentration of chemical substances as reported in the WFD, water turbidity, pH, total suspended solids (TSS);
- CTD sensors, measuring conductivity, temperature and density of a sea water column

Coastal and maritime structures survey:

- geodetic positioning (GPS receivers), RTK mode geodetic GPS instruments

5.2.2 Remote observations

Topobathymetric survey:

- Satellites
- LIDAR (Laser Imaging Detection and Ranging), aerial photography; their data processing results in cartography and (3D) Digital Surface (DSM) and Terrain Model (DTM)

Hydrodynamics:

- Currents: satellite (ENVISAT and TOPEX/JASON radar altimeters)
- Run-up, submerged beach bar: camera observations (video monitoring system) with time continuity, spatial homogeneity and tiny impact infrastructures

Suspended sediment/plumes/ chlorophyll:

- Satellite (Sentinel-2): high spatial and temporal resolution ocean colour of coastal waters

Coastal and maritime structures survey:

- Drones with high definition cameras (photogrammetry approaches) for 3D topographical survey of coastal structures

- LIDAR, Laser scanner survey
- Aerial photography

5.3 Overview of the modelling tools commonly used in the Mediterranean Sea

5.3.1 Mathematical models

Mathematical models solve analytical description of the processes based on empirical evidences, and are often used to have rapid estimation of the coastal dynamics indicators.

Example to estimate wave overtopping is recent EU project EurOtop released in 2007 with updatings in 2016 extensive manual (Allsop et al., 2016) where methods to predict wave overtopping of sea defences and related coastal or shoreline structures are reported, revising prediction given by previous documents as Rock Manual (2007), the Revetment Manual by McConnell (1998), British Standard BS6349, the US Coastal Engineering Manual (2006). Wave run-up over beach can be determined using empirical equations reported in the Shore Protection Manual (USACE 1984) or in the Coastal Engineering Manual (2002).

Examples to evaluate the longshore sediment transport are the CERC equation (1950) in CEM Manual (2002) as a function of the wave height (in the break zone), period and obliquity. Improved versions of the CERC equation include grain size and beach slope in the model and the Bijker formula (1971) that models bed load transport and suspended load transport.

5.3.2 Physical models

Physical models performed in laboratory facilities at appropriate scales (small, medium and large scales) are a valuable tool for coastal engineers and managers, since they help in the knowledge of the complex hydrodynamic processes occurring in the nearshore waters when waves interact with structures and coast, such as run-up, wave overtopping, flooding. Physical models provide reliable and economic engineering design solutions and are advisable for the preliminary research on wave-related coastal processes under different scenarios and the preliminary design of wave related coastal protection schemes and the testing of alternative design options, providing immediate, measurable and repeatable answers and insights. Wind, waves and currents can be reproduced satisfactorily in 2D or 3D facilities (i.e. wave flume and wave basin respectively), generally equipped with instruments such as wave gauges, ADPC, pressure sensors, DOP, PIV, and high-definition cameras. Important laboratory facilities at the service of coastal management in the Mediterranean are placed at Barcelona (Spain), at Ancona, Bari, Bologna, Florence, Padua (Italy).

5.3.3 Numerical models

Numerical models have been increasingly adopted during the last decades since a well-calibrated model can help in providing accurate, fast and relatively cheap predictions.

Numerical models for water waves can be classified as depth averaged models, such as spectral wave, mild-slope equations wave models, and depth (wave) resolved models, such as and Boussinesq models 2D/ 3D Navier-Stokes equations models with different turbulence closures. Depending on the processes and on the environment to be reproduced, the following categories of models are preferred by modellers, which can simulate, in addition to hydrodynamics, equations of sediment transport, shoreline evolution and concentration diffusion by means of commercial and open source solvers.

The first category of models mainly reproduces the large-scale coastal dynamics, simulating sea-atmosphere interaction, wave generation and propagation from offshore to inshore zones, the wave-induced hydrodynamics and sediment transport processes.

Example of the most diffuse commercial models is MIKE21 suite (©DHI Group), including MIKE 21 SW, a spectral wind-wave model, which describes the propagation, growth and decay of short-period waves in nearshore areas; MIKE 21 HD that solves 2D hydrodynamics simulating the water level variations and flows in response to different forcings; effects of wave-induced hydrodynamics can be admitted with the module coupling with MIKE21 SW; MIKE 21 EMS and PMS, based on elliptical and parabolic approximation respectively, governing the refraction, shoaling, diffraction and reflection of linear water waves propagating on gently sloping bathymetry.

Open-source models are recently adopted, also thanks to EU recommendations, by local administrations as well as scientists and code developers. Examples are third-generation spectral wave models, for instance SWAN (Booij et al., 1999) and WaveWatch III (Tolman and Group, 2014), largely coupled to 2D or 3D hydrodynamics modules, such as ROMS (Regional Ocean Modeling System, Shchepetkin and McWilliams, 2005; Haidvogel et al., 2008) and SHYFEM (Umgiesser et al., 2004), to simulate wave-current-atmosphere interactions. Also TELEMAC (Benoit et al., 1996) and DELFT3D (Lesser et al., 2004) suites, both comprising spectral, hydrodynamics, sediment transport and water quality modules, are often preferred as valid open-source models to own-made implementation and modification of code solvers and intensively parallelized.

The module MIKE 21 ST is designed for the assessment of the sediment transport rates and related initial rates of bed level changes of non-cohesive sediment (sand) due to currents or combined wave-current flow; it can be coupled to wave-hydrodynamics DHI modules (Figure 5.1) to reproduce effects of waves and currents on the sediment transport.

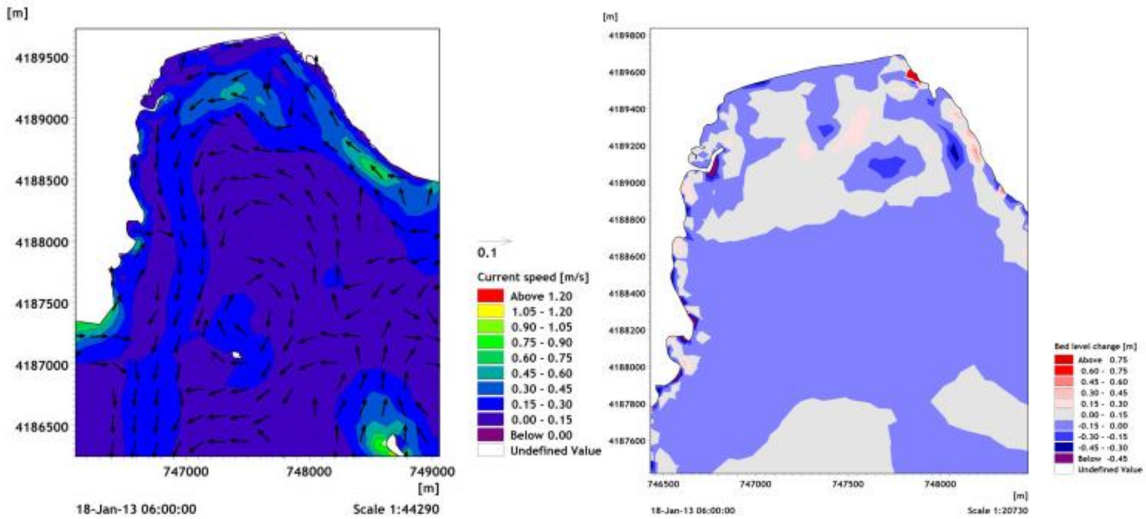


Figure 5.1 Coupled wave-hydrodynamics-sediment transport application by means of MIKE21 in the Varkiza Bay, Greece, under extreme events (Kostas et al., 2017).

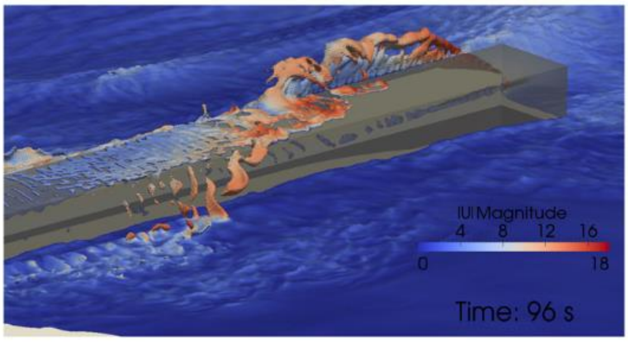


Figure 5.2 Computed velocity on a caisson obtained by OpenFOAM (from Higuera et al., 2014).

Shoreline evolution and drift evaluation mainly induced by wave actions are numerically estimated by means of models solving one-line or two-lines beach theory; for the Mediterranean studies, codes as GENESIS (GENEralized Model for SImulating Shoreline

Change), XBEACH (Roelvink et al., 2009; Roelvink et al., 2010) or DHI-LITPACK are applied to a diverse variety of situations involving almost arbitrary numbers, locations, and combinations of groins, jetties, detached breakwaters, seawalls, and actions such as sand nourishment and dune evolutions.

The second category of models is depth resolved models, numerically solving hydrodynamics field in 2 or 3 dimensions and adopting common approximations to closure the Reynolds turbulence stress estimation, i.e. two-equations k-epsilon or k-omega approaches. Studies of alternatives in coastal structures sections are usually carried out by means of Eulerian approaches, giving the choice to estimate forcing on complex structures, i.e., floating platforms and devices, or porous media flow through breakwaters, groins and revetment to evaluate hydrodynamics and environmental wave-induced features in coastal zone to be considered in engineering and management designs.

Recent applications of experimental design and verification of structures have been performed by using OpenFOAM solver (Higuera et al., 2014, Figure 5.2) and FLOW-3D (by Flow-Science) models, as well as the famous FLUENT (by ANSYS) and STAR-CCM+ (by CD-Adapco) commercial softwares.

5.4 Example of applications in the EU Mediterranean Countries

Example in literature of long-term field monitoring in the Mediterranean Countries is described in Brunel et al. (2013) for the Gulf of Lion, France, where shoreface sediment budget was estimated for the 20 century (1895-1984-2009) by means of seismic THR surveys and high-quality bathymetric data. Dassenakis et al. (2012) reports the description of technologies used in remote sensing in Greece and the general applications in a comprehensive manner addressed to scientists. Traditional field surveys of bathymetry and of the beach extension by means of multibeam sensors as well as global positioning system had been carried out by Emilia Romagna, Italy (Montanari & Marasmi, 2012) where a certain frequency and typologies of indicators are monitored in order to estimate sand volume and therefore beach evolution.

Numerical models, especially after the development of parallel coding that characterized the last decade, can represent a useful and accurate tool to be used by local administrators in the planning of estuaries and coastal zones, including the management of water resource, flood prevention, coastline exploitation and water environment assessment.

Complex large-scale models can run in operational way to hindcast and forecast hydrodynamics and atmosphere parameters; examples in the area of the Mediterranean Sea are the large-scale system for the entire Mediterranean Basin (MFS, Mediterranean Forecasting System, Pinardi et al., 2003), which provides initial and boundary condition fields to nested high-resolution systems (Federico et al., 2017; Gaeta et al., 2016), the 3D Kassandra forecasting system (Ferrarin et al., 2013, Figure 5.3) born for the prediction of storm surges in the Mediterranean and Black Sea, TRITON 60-hours wave forecast for Aegean and Ionian Seas. Other complex operational predictions are provided by a coupled Ocean-Atmosphere-Wave-Sediment Transport Modeling System COAWST (Warner et al., 2010), with recent implementation in the Mediterranean as along Catalan coast (Palomares et al., 2016), in the Northern Adriatic Sea (Russo et al., 2013; Brando et al., 2015) and on Gulf of Lion (Renault et al., 2012).

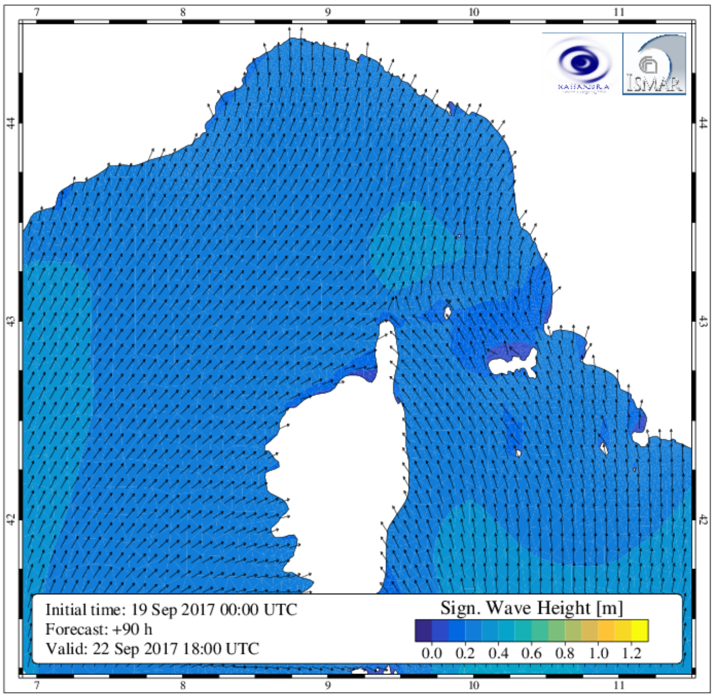


Figure 5.3 3D Kassandra forecasting systems for storm surges in the Mediterranean Sea: 3-day forecast of wave field in the Northern Tyrrenean Sea.

On the other hand, the numerical prediction of coastal morphological change under extreme events or after beach restoration or nourishment is a more challenging task (Vousdoukas et al., 2009), since model validation/calibration requires extensive field data, while very few systems are suitable to produce operational predictions of beach erosion (Ciavola et al., 2011).

By means of numerical modelling, alternative technical solutions can be reproduced and the performance of the possible interventions is generally compared in order to define the optimal protection measure also in relation to tourism development and under the forcing of different extreme scenarios, easily reproduced in the models. In this way, estimation of computed effects of climate change can help to reduce coastal hazards under possible scenarios.

6. Conclusions

Guidelines for management, monitoring and modelling approaches have been described in the present document, where the outcomes of strategies and critical aspects related to their implementation resulting from the reviews performed in Deliverables 3.8.1 and 3.8.2 have been summarized.

Coast has a significant value for the tourism industry and this makes its protection management important for the connected social-economical activities. Indeed, beach protection under different pressures of climate change is one of the principal challenges that, not only engineers, but also coastal managers, might deal with, since they should carried out a delicate balance between economic, social and environmental features of the coast.

A “step-by-step” approach for the definition of an integrated planning strategy have been proposed and described in the framework of sustainable tourism development, with the aim to conjugate the design of coastal protection measures in a tourist area. The 4 steps constituting the approach have been declined, as preliminary considerations, initial assessment, critical issue identification and analysis of solutions, and strategy for the management.

The interaction between the engineering approaches to cope with coastal erosion and design protection measures and the beach appeal requirements for the development of the different typologies of coastal tourism is turned out to be an important issue to be considered in an integrated beach management. In particular, the approaches of “Holding the line” and “Managed retreat” are commonly adopted in urban and touristic areas, and engineering actions including reshaping of the exiting heard structures or the implementation of soft measures, as sand nourishment and dune restoration, have been resulted as the most suitable ones for touristic activities.

Tools for efficient prediction and analysis of the effects of coastal management actions have been also included, reporting an overview of the commonly adopted monitoring and numerical tools.

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