EP

United Nations Environment Programme

UNEP(DEPI)/MED WG.395/4
12 May 2014

Original: ENGLISH

MEDITERRANEAN ACTION PLAN

Correspondence Group on Monitoring, Coast and Hydrography

Athens (Greece), 28 May 2014

Monitoring Guidance on Ecological Objective 8: Coastal ecosystems and landscapes

UNEP/MAP
Athens, 2014

Monitoring Guidance on Ecological Objective 8: Coastal ecosystems and landscapes

1. Introduction

In the Mediterranean, there is a particularly strong and increasing occupancy of the coastlines. Coastal zones play a key role in the economic development of regions and nations as they are a significant source of various goods and services. Coastal landscapes are continually being altered by the addition of the infrastructure needed to sustain residential, commercial, transport and tourist activities. Transformation of coastal landscapes in response to urbanization is not limited to the land. The intertidal zone and near shore estuarine and marine waters are also increasingly altered by the loss and fragmentation of natural habitats and by the proliferation of a variety of built structures, such as ports, marinas, breakwaters, seawalls, jetties and pilings.

From the morphological perspective the Mediterranean coastline is 54 % rocky and 46% of sedimentary types. The latter is characterized by important yet fragile ecosystems such as beaches, dunes, deltas and lagoons, highly exposed to coastal processes, i.e. erosion and extreme storms, or consequences of climate changes such as sea-level rise (UNEP/MAP/PAP, 2001).

The coastal zone is a dynamic area of natural change. Coastal manmade infrastructures cause irreversible damage to landscapes, losses in habitat and biodiversity, and strong influence on the configuration of the shoreline. Indeed, physical disturbance due to the development of artificial structures in the coastal fringe can influence sediment transport, reduce the ability of the shoreline to respond to natural forcing factors and fragment the coastal space.

Article 8 of the Protocol on ICZM (UNEP/MAP/PAP, 2008) clearly stipulates the establishment of a 100 meters coastal setback zone as the agreed measure that plays an important role in the preservation of natural habitats, landscapes, natural resources and ecosystems, and also, the prevention and/or reduction of the effects of coastal hazards. Moreover, its definition should be based on an integrated approach taking into account various physical coastal processes, ecosystem services, coastal resistance and exposure with regard to development activities, as well as settlements and infrastructure located along the coast (Rochette, J. et al., 2010).

Despite the known impacts on ecosystems, utilization of coastal resources shows no signs of levelling off. The use of hard coastal defence structures is predicted to increase in response to forecast sea-level rise and increased intensity and frequency of large storms (Michener et al., 1997). Long-term growth in world trade is likely to lead to more development of shipping-related infrastructure. As ships get larger and bring more containers, some ports will need to get bigger too. This can lead to expanding the port into adjacent land or reclaiming land from the sea (REMPEC, 2008). Moreover, spontaneous coastal urbanization by the tourism industry is an expanding driving force in the Mediterranean region.

One particularity of the EcAp (compared to the EU MSFD) is the inclusion of the Ecological Objective focusing on the coast and the merging (*EO8-The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved*). The latest reflects the aim of the Barcelona Convention to also include or cover coastal areas in the assessment, which became a legal obligation upon the recent entry into force of its Protocol on Integrated Coastal Zone Management (ICZM). Therefore, the EcAp Coast related common indicator is matchless to those proposed by the MSFD.
The Coastal Ecological Objective and the respective common indicator (i.e. “Length of coastline subject to physical disturbance due to the influence of manmade structures)

incorporate coastal dynamics as an integral part of the EcAp. Good Ecological Status (GES) with regard to EO8 is achieved when physical disturbances on coastline caused by manmade structures do not impair coastline integrity; Physical disturbances caused by manmade structures should be minimized. The term *coastline integrity* includes the integrity of coastal ecosystems, landscapes and geomorphology.

International standards methodologies and guidelines exist for the assessment and monitoring of some indicators relevant for Ecological Objectives of GES, such as in EO9 Contaminants or EO5 Eutrophication (subject to adaptation according to local and regional specifics) (European Commission, 2011a). This is not the case of those indicators related to EO8 Coastal Ecosystems; indeed, there is a general lack of technical guidelines and agreed methodologies adequate for the purpose of the ecosystem approach.

Accordingly, there is a need to establish the baselines that constitute the EcAp Common Indicator "Length of coastline subject to physical disturbance due to the influence of man-made structures". With this aim, a screening of available conceptual and methodological guidance documents coming from (i) regional and international policies and previous ecosystem assessment experiences, (ii) as well as research projects dedicated to coastal dynamics and coastal infrastructures and (iii) scientific papers dealing with the coastal fringe artificialisation (with special interest on those studies based on the Mediterranean region) has been conducted to clarify and harmonize basic conceptual and technical specifics baselines in response to the objectives pursued by the EO8.

1.1 Identification of issues to address: (i) *manmade structures* causing (ii) *physical disturbance*

Monitoring under this Ecological Objective is meant to address human activities causing coastal artificialisation by sealing the coast with the implementation of coastal structures. More concretely, the types of structures included by the term 'manmade structures' are: (i) Coastal defence (excluding soft techniques e.g. beach nourishment), (ii) Ports and marinas, (iii) Land claim (iv) Impervious surface in the hinterland (100 meters from the coastline).

The term 'manmade structures' typically refers, solely, to coastal defence and ports (and indirectly to land claim). However, landward impervious surfaces also exert a physical pressure leading to direct impacts affecting the integrity of the coast (see Annex 2). Accordingly, including the monitoring of the impervious surface into the Coastal common indicator should aims at identifying proximity to reach GES on EO8.

Therefore, coastal segments are said to be "artificialised" when all or part of the 100 meter area on both sides (i.e. land and sea) are subject to transformation by Man, modifying their original physical state.

Below, detailed description of the 'manmade' typologies included into the Coastal indicator:

(i) **Coastal defence structures**, so called coastal protection, means all artificial or man induced structures along the coast, with the basic function of providing shelter to the segment of the shoreline, which they protect. Consequently, the protection is limited to the segment. The presence of coastal defence structures is almost always accompanied with accelerated downcoast erosion. Therefore, coastal defence structures do not stop beach erosion, but transfer the problem to another location (Frihy and Deabes, 2012; Özhan, E., 2002). Coastal defence are usually classified as hard and soft techniques. Even if soft techniques are also responsible of *physical*

disturbance, the coastal common indicator only refers to *manmade structures* (i.e. structural techniques), thus soft techniques (e.g. beach nourishment) are not covered by this indicator. A detailed list of the structures included for monitoring under the common indicator is recorded in Tab 1.

Tab 1. Coastal defence typologies. Source: adapted from Bulleri and Chapman, (2010).

Type of structure	**Action and purposes**	**Positioning / Orientation respect to the shore**	**Position respect to the sea surface**[1]	**Wave exposure**
Breakwaters	Reduce the intensity of wave forces in inshore waters; used for protecting ports, harbours and marinas and as coastal defences	Not connected to shore parallel or fish tail	Emergent;	Exposed
Seawalls Bulkheads	Reduce the impact of waves on shore; used as a tool against coastal erosion and as a constituent of ports, docks and marinas	Onshore parallel on open coasts[2], but variable in enclosed waters	Emergent	Exposed to sheltered
Groynes	Reduce along-shore transport of sediments; used in coastal defence schemes, often in association with breakwaters	Connected to shore perpendicular	Emergent; low crested; submerged	Exposed
Jetties	Reduce wave- and tide-generated currents; used for developing, ports, harbours, marinas and as constituents of coastal defence schemes	Connected to shore perpendicular	Emergent; low crested; submerged	Exposed
Pilings	Sustain infrastructure, such as bridges, piers, docks and for the mooring of vessels	Onshore to offshore	Emergent	Exposed to sheltered

(ii) Ports and marinas: refers to construction consisting of an ensemble of seawalls and landfills used in various ways (car park, road, shops, boatyard, etc.). This ensemble delimits a contained body of water designed to offer shelter to boats of various sizes and functions (fishing, pleasure boating, business, etc.). Under this class of manmade structure we include:

(i) Infrastructures with a surface area greater than 1 ha;

(ii) and ports of refuge (i.e. harbour without a harbour master with a surface area generally smaller less than 0.5 ha.)

(iii) Land reclamation is defined as the gain of land from the sea or coastal wetlands e.g. for recreation, agricultural purposes, industrial use and harbour expansions. It means also infringements on natural beach or dune dynamics and beach or dune replenishment, (i.e., measures which aim to protect the coastal zone against flooding, damages by waves and erosion).

(iv) Impervious surfaces refer to non-permeable surfaces associated with urban areas: residential, commercial, transport facilities, and tourist resorts. Basically, determines if the landward boundary (buffer of 100m from the coastline) is artificial or natural.

1.2 Evaluation of impacts

[1] Submerged breakwaters, groins and jetties (i.e. low-crested structures) are considered soft coastal defence measures and are excluded in this study.

[2] These are breakwaters connected to the coast at one end.

Assessments of the state of ecosystem components (or Ecological Objectives) are informed by the impacts upon them which arise from each pressure. Coastal infrastructures exert direct pressure on the integrity of coastal ecosystems.

Coastal manmade structures and linear and ongoing urban sprawl represent a physical barrier between the terrestrial and marine environments affecting the natural dynamics of this transitional ecosystem (reduction or elimination of the needed space for dynamic environmental processes). Indeed, coastal artificialisation interferes and/or inhibits the natural fluxes and interrelations among habitats, species, as well as the flow of matter and energy.

Sealing the coast, not only represent a physical disturbance to the inter-relationships between the marine and terrestrial parts of the coastal zone, but a physical damage usually irreversible. Land reclamation from the sea destroys an underwater habitat by building over or enclosing a body of water (OSPAR, 2008a). Additionaly, hard coastal defence structures introduce new artificial hard substrata into areas that are often characterised by scarce natural rocky reefs. They can be extensively and rapidly colonised by algae and epibenthic fauna (Airoldi et al., 2005; Bulleri and Chapman, 2010). Moreover, high number of artificial hard coastal structures in proximity can act as “stepping stones”, disrupting natural barriers to species distribution and providing new dispersal routes that permit the invasion of non-indigenous species, including pests (Airoldi et al., 2005; OSPAR, 2009).

Landscapes are affected, by the aesthetic impacts and for the alteration of geomorphological processes. Beaches erosion is a highly complex process involving natural and human influences. Coastal erosion and accretion are natural processes; however, they may become a problem when exacerbated by human activities or natural disasters. In addition to their undesirable esthetic effects, the fundamental problem associated with these structures is that they cause beach erosion on their lee or downdrift sides which may extend beyond the project area. In most cases erosion at this sector might need additional structures. This process may be repeated and continues to cover the entire coastline, referred to as a chain reaction (Frihy and Deabes, 2012).

Other anthropogenic pressures inducing coastal erosion are due to human activities and developments that take place far away from the coast (building of dams, flow diversion, afforestation works, sand and gravel mining from river beds). Moreover, recent studies show that relative and climatic variability are some of the major causes of coastal erosion in the Mediterranean (Alpar, 2009; Simeoni and Corbau, 2009; Snoussi et al., 2008 among others) and these impacts are likely to exacerbate in the future.

Besides the direct impacts on coastal integrity (EO8) coastal manmade structures have the potential to cause direct and indirect impact on any part of the ecosystem, e.g. change in the hydrography: EO7, introduction of indigenous species: EO2, etc. Interactions between the structural components of the ecosystem are fundamental for assessing ecosystem processes and functions. A synthetic view of the overall impacts of manmade structures is presented in Annex 2.

1.3 Analysis of relevant policies and/or regulations of Mediterranean countries

The methodologies required for assessment and monitoring of the Mediterranean coastal environment need to take into account and, where appropriate, be based upon those applicable under existing national legislation and, where relevant, information, knowledge and approaches developed by Mediterranean countries.

The relevance to take into account national and regional legislation regarding coast protection and planning is twofold: (i) To understand the baseline policy context and identify current experiences of surveying and mapping coastal artificialisation of the coastline (see section 1.4) and (ii) to inform about progress towards GES. It is worth recalling, that the target on EO8 indicator is an operational target on impact, thus it is associated to concrete implementation measures related to specific human activities (i.e. appropriate management measures) to minimize negative impacts.

Regarding the national legislation, all Mediterranean littoral States have undertaken some measures to try and protect their coastal zones from overdevelopment, or development that is socially and environmentally damaging. In spite of well-reasonable and carefully drafted regulations, the pressure has continued to increase (Markandya et al., 2008). The report UNEP/MAP/PAP, (2000) introduce the state of Mediterranean national legislations. The document gathers and summarizes the outputs of a questionnaire relating to the coastal zones' integrated planning legislation addressed by the PAP/RAC to Mediterranean countries.

At regional level, according to the Article 8 of the ICZM Protocol, the Parties: (*a) Shall establish in coastal zones, as from the highest winter waterline, a zone where construction is not allowed. Taking into account, inter alia, the areas directly and negatively affected by climate change and natural risks, this zone may not be less than 100 meters in width subject to the provisions of subparagraph (b) below. Stricter national measures determining this width shall continue to apply.* The rationale to include this article in the Protocol is twofold: to prevent and/or minimize the extent of the linear development along the coastline and to adapt to expected climate changes in the coastal zone (in particular sea level rise). Indirectly, this provision also aimed to minimize coastal erosion (Sanò et al., 2010, 2011).

Aware of the implementation difficulties and political sensitivities of the setback issue, the Mediterranean countries have adopted several exceptions to the establishment of the setback zone along their coastline, as it is stipulated in Article 8. *(b) May adapt, in a manner consistent with the objectives and principles of this Protocol, the provisions mentioned above: 1) for projects of public interest; 2) in areas having particular geographical or other local constraints, especially related to population density or social needs, where individual housing, urbanisation or development are provided for by national legal instruments.*

Moreover, all conducted activities and established facilities addressed to national defense, (as is stipulated in article 4.4[3]) have full right to be established within the 100 m strip and do not fall under the scope of the Article 8. In addition, it is necessary for the Parties to enact a specific national legal instrument regarding this issue. However, a majority of the Mediterranean countries have well established legislations and specifications for national defence and security activities within the 100 m strip and grant them special exemption (Rochette, J. et al., 2010) (see Tab. 2)

[3] Issues of national security, defence activities and facilities within coastal areas are clearly stipulated in the Article 4.4 of the ICZM Protocol: "*nothing in this Protocol shall prejudice national security and defence activities and facilities... such activities and facilities should be operated or established, so far as is reasonable and practicable, in a manner consistent with this Protocol"*.

Tab 2. Examples of National legislations in relation to 'projects of public interest'. Source: (SHAPE project)[4]

	Legal provision	Year of issue	Description of provision	Permitted facilities
Turkey	Coastal Law 3621/3830	**1990**	Facilities aimed at the protection of the shoreline or the use of the coast for the public interest may be developed in the "shoreline buffer zone" within 100 metres in accordance with legal permits issued by land-use planning authorities.	Piers, ports, harbours, berthing structures, quays, breakwaters, bridges, seawalls, lighthouses, boat lifts, dry berths and storage facilities, salt production plants, fishery installations, treatment plants and pumping stations, etc.
Algeria	Law 2002-02, Article 16.	**2002**	Adaptation allowed from min. 100 to max. 300 metres of the coastal setback zone in the interest of activities requiring immediate proximity to the sea. Differences between activities related or not to a public interest are not clarified.	Roads in the coastal zone where they are normally prohibited (within an 800 metre strip from the seashore).

It is not possible to establish how effective the different instruments as the setback policies and other regulations have been in protecting coastal zones. There is no detailed assessment of the extent of violation of the setback rule (Markandya et al., 2008). To this regard, the monitoring strategy proposal for the assessment of the EO8 status represents an opportunity to fill this data gap.

1.4 Practices and lessons related to monitoring and mapping manmade structures

Article 16 of Part Three of the Protocol, in particular, identifies the functional tools for integrated management as appropriate mechanisms for coastal monitoring and observation, existing or newly established. In detail, it highlights the need to maintain regularly updated national inventories of coastal zones regarding information on resources, activities, institutions, legislation and planning tools. In this context, the monitoring and observation of coastal areas must be developed within a network of cooperation and organization along the Mediterranean, scientifically and institutionally. To this end, the Protocol refers to the need to identify, between the Contracting Parties, tools and reference procedures for the standardization of the information contained in the national inventory. The observation of coastal zones is interpreted as a structured repertoire of available information regarding the status and trends of coastal areas, so as to be made accessible to local communities and all relevant territorial stakeholders, both public and private (Rochette, J. et al., 2010).

Coastal monitoring became an important and functional activity, essential to coastal planning and management. In spite of that, monitoring often lacks standardised procedures and is frequently based on a time scale that is not compatible with the processes under act, failing to provide information that can effectively support decision-making.

At local scale, some ongoing initiatives are monitoring artificialisation and morphological evolution of the coast (see Tab 3).

[4] http://www.shape-ipaproject.eu/download/listbox/WP3%20action%203.2%20-%20reports%20on%20setback%20requirements/Explanatory%20report%20on%20Article%208.pdf

Tab 3. Some Mediterranean examples of web based dissemination of geospatial data related to coastal monitoring.

Region (Country)		Structures included	Viewer
Balearic islands (Spain)	SACosta	Based on NOAA 2002 classification	http://gis.socib.es/sacosta/composer
French Mediterranean coasts	MEDAM (French Mediterranean Coasts. Inventory and Impact of Reclamations from the Sea)	Port; Port of refuge; Landfill; Artificial beach (horseshoe shaped beach); Groyne; Pontoon; River mouth dykes.	http://www.medam.info/index.php/en/medam-module-donnees-chiffrees
Costa di Tosca (Italy)	ResMar	Coastal defence; ports	

2. Monitoring Strategy

The monitoring of the Coastal Common Indicator entails an inventory of: (i) the length and location of manmade coastline, (ii) the surface area reclaimed (ha) and (iii) the surface impervious area in the coastal fringe (100m from the coastline). Therefore, monitoring should focus, in particular, on the location, the spatial extent and the types of coastal structures. Accordingly, the monitoring parameters are spatial metrics. Due to the strong spatial component of the indicator concerned, space and airborne earth observation systems are the most suitable tool to conduct the monitoring strategy of the EO8 common indicator.

Physical disturbance due to manmade structures induce different degrees of impacts according to the nature and particularities of the coastline concerned. Therefore, it is highly recommended to compile auxiliary data (e.g. coastline typology[5], wetlands, etc.) to predict those coastal segments more vulnerable to the physical presence of manmade structures. Incorporating these ancillary data provides robustness to the indicator and offers a linkage between monitoring and assessment needs (e.g. determination of thresholds).
To analyze the beach response to the presence of manmade structures, the monitoring of the morphological evolution of the coast could be a secondary and complementary monitoring effort for those Contracting Parties interested. However, the monitoring guidance provided in this document does not cover this issue and only focuses on the monitoring of coastal fringe artificialisation.

2.1 Considerations regarding manmade structures monitoring methods

The application of Earth Observation data for coastal monitoring has been the subject of numerous studies during the past 10 years. Examples include flood risk mapping, pollution monitoring, waves, coastal erosion, nearshore bathymetry and marine water quality monitoring. The clear advantage in using satellite data for monitoring the coastal environment is the facility to provide repeat surveys for large (and often inaccessible) areas.

Coastal manmade structures can be easily detected from remote sensing imagery. The only constrain is the need of high resolution data. Traditionally, airbone-based data has been used to detect and map manmade structures. However, newly available, very high resolution (VHR) satellite images can provide a cost-effective source of such information. One of the primary advantages of VHR imagery over moderate resolution imagery, like Landsat, is the ability to identify specific components of the built environment. The typical size of individual components in the built environment is generally between 10 and 20 meters (Small, C., 2009). Sensors with spatial resolutions of 10 meters begin to resolve individual features like

[5] Principal morphological and sedimentology characteristics of the coastline

buildings and smaller roads. Sensors with sub-meter resolution generally allow recognition, identification, and in some cases description, of these features (Deichmann, U. et al., 2011).

2.1.1 Available methodologies

Available methodologies suitable for the monitoring needs are not detailed here but rather introduced in general terms together with some practical recommendations. Fig 1 illustrates some examples of the capabilities and visualization of remote sensing imagery to detect coastal manmade structures.

- **VHR**: A major breakthrough for the application of remote sensing for operational applications has been the latest generation of very high resolution (VHR) optical satellites with a pixel size of 1 meter or less (see Tab 3). VHR images can resolve individual elements such as buildings, transport infrastructure or pipelines. They also more closely resemble standard air photos. In contrast to more traditional satellite data VHR images can be interpreted visually even with minimal training (Deichmann, U. et al., 2011).

Tab 3. Optical satellite imagery useful for monitoring coastal manmade structures source: Modified from Deichmann, U. et al., (2011)

	Detail	**Color**	**Size of image (length of one side)**	**How often on the same place on Earth**
Satellite	**Spatial resolution [m] (at nadir)**	**Spectral resolution**	**Swath Width [km]**	**Orbit repeat cycle (max. revisit time) [days]***
GeoEye	0.41	Panchromatic	15.2	3
	1.65	Red, Green, Blue, Near Infrared		
WorldView-1	0.5	Panchromatic	17.6	(1.7)
Quickbird	0.6	Panchromatic	16.5	1-3.5
	2.4	Red, Green, Blue, Near Infrared		
EROS-B	0.7	500-900 (pan)	7	
Ikonos	0.8	Panchromatic	7	3 (?)
	4	Red, Green, Blue, Near Infrared	11	14 (1-3)
OrbView-3	1	Panchromatic	8	16 (3)
	4	Red, Green, Blue, Near Infrared		
KOMPSAT-2	1	Panchromatic	15	(5)
	4	Red, Green, Blue, Near Infrared		
Formosat-2	2	Panchromatic	24	(1)
	8	Red, Green, Blue, Near Infrared		
Cartosat-1	2,5	Panchromatic	60	(2-3)
SPOT-5	2.5	Panchromatic		
	10	Red, Green, Near Infrared, Mid Infrared	60	(2-3)

However, an important factor, which must not be forgotten, is the relative high economic cost of data. Both commercial datasets and the acquisition and digitization of data by the end user might be substantial expense factors especially with increasing accuracy of the data.

To this regard, the integration and accessibility of worldwide high resolution satellite data by the development and provision of virtual globes, such as Google Earth™, Microsoft® Virtual Earth™, Nasa World Wind or ArcGIS® Explorer resolves the difficulty of the economic constrain of commercial imagery. The integration and accessibility of worldwide high resolution satellite data, their intuitive user interface, and the ability to integrate own data combined together with a high performance support their success (Deichmann, U. et al., 2011). Even if their options for geospatial analysis are limited, the use of these geographic information platforms (available for non-geospatial experts and available free of charge) represents a satisfactory alternative for the purpose of the monitoring and mapping needs under EO8. However, these spatial platforms integrate a mosaic of imagery at different temporal resolutions. To mitigate the adverse effects of their implicit temporal heterogeneity, the use of auxiliary data and techniques is highly recommended (see section 2.4).

- Aerial photograph: due to their high spatial resolution this techniques has been widely used for coastal monitoring and land use planning. They allow easily visual interpretation and digitalisation of coastal manmade structures. Probably, the most remarkable strength in the context of EO8 monitoring needs is the possibility they offer for temporal trends analysis (or determination of reference conditions). Therefore, they complement VHR space imagery.

- Laser scanners: the use of laser scanners has been increasing lately. This technology may be transported on board of a plane or placed on a boat combined, for example, with a multibeam echosounder. This makes it possible to acquire detailed measurements of a structure (both emerged and submerged parts) over large areas and short times (Pranzini, E. and Rossi, L., 2013).

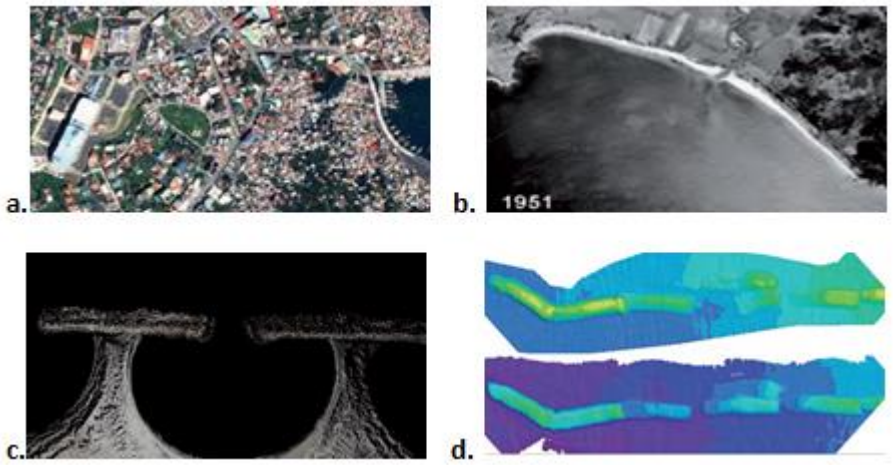

Fig 1 **a)** Pan-sharpened Quickbird imagery Source (source: Deichmann, U. et al., (2011); **b)** Historic aerial photograph of Taravo beach illustrating evolution in the past decades (orthophotos© IGN); **c)** Laser scanner survey of a beach (by Geocoste for Politecnico di Bari). Source: Pranzini, E. and Rossi, L., (2013); **d)** Submerged groin survey using Multibeam Reson 8125 (top) and Odom ES3 (below). Source: Pranzini, E. and Rossi, L., (2013).

2.1.2 Mapping tools and methods

Geographic information systems (GIS) provide the platform for information integration, analysis and dissemination.

- Image processing

Image processing systems are specialized tools to manipulate satellite data. Raw images will need relatively complex procedures to geometrically and radiometrically correct images to improve location accuracy and enhance the ability to identify features on the map.

- Detection of manmade structures

Images can be analyzed visually or quantitatively using machine assisted algorithms to extract information from the imagery in an automatic way. Visual or manual techniques (i.e. delineating image features on the computer screen) are still the procedures most used to detect and map coastal manmade structures. Automatic processing of the VHR imagery implies complexity due to sophisticated requirements and typically do not works very well on very high resolution satellite images, thus this is still very much a research area (Deichmann, U. et al., 2011).

Visual interpretation and manual digitalization can also be used to delineate the overall extent of built-up areas. However, one efficient and rapid method to generate a digital map of urban extent from VHR imagery is by means of a built-up area index which can be derived using automated computer techniques. It uses an algorithm that evaluates the textural characteristics of different areas in a satellite image (Pesaresi et al., 2008). The strength of the built up area index is that when applied in relatively sparsely settled urban areas with VHR imagery, the approach can capture single buildings or clusters of buildings similar to information that is typically found on maps at 1:10000 scale. It is thus an improvement over land cover maps that usually provide information at coarser than 1:25,000 scale (Pesaresi et al., 2008). Therefore, the latest can hardly capture sparse and spontaneous coastal urbanization.

- Mapping

A proposal of the cartographic representation of the elements concerned (i.e. coastal defence, ports and marinas; land claim and impervious surfaces) is summarized below. Basically, two different approaches are suggested according to the metrics involved: (i) length of coastline (meters) and (ii) area occupied by those structures.

(i) Linear representation: a simple and satisfactory way is to keep the baseline coastline and symbolize manmade coastal segments differently than the ‘natural’ coastline; thus, maintaining the original shape of the coastline. However, manmade coastal segments could have associated a table of attributes storing relevant information e.g. type of coastal defence (cross-shore, long-shore structures), port characteristics (commercial, leisure, etc.). Alternatively, different symbols could be used to differentiate coastal defence typologies (see Fig 2.a).

Finally, other possibility is to digitalize the exact location of the coastal defence (by delineation its shape) independently from the coastline. This approach offers more accuracy but it is time consuming (see Fig 2.b).

Fig 2. a) Example of cartographic representation of coastal defence and ports in Egypt. (Source: MEDINA Project[6]); b) Coasta Toscana (Source: ResMar Project[7])

(ii) Area representation: land claim and urban-built up should be represented according to their spatial footprint. Therefore, a polygon approach is recommended. It is worth to mention that the 'land claim' class could be interpreted as impervious surfaces class. To avoid this uncertain, historical imagery is needed. Differentiated symbology is needed to discriminate land claim from urban built-up. An example of the land claim spatial representation is offered by MEDAM geoportal (see Fig 3).

Fig 3. Inventory of manmade coastline and areas reclaimed (French Mediterranean coast). Source: MEDAM[8]

2.2. Considerations regarding the appropriate scale of monitoring

In comparative terms, the assessment of environmental coastal issues requires a detailer monitoring scale than the offshore waters approach (e.g. subregion level). This is especially true when coping with coastal infrastructures detection. The spatial coverage where manmade structures can be found only involves a coastal fringe of 200 meters in amplitude (offshore structures are covered by other EcAp indicator). Moreover, some of the elements required to monitor are structures of a few meters in length and/or amplitude (e.g. groynes, seawalls, etc.).

For the assessment purpose, ideally the appropriate scale would be at the level of coastal water bodies[9]. Thereafter, if needed, the scanned data (i.e. meters of coastline affected, or

[6] www.medinageoportal.eu/
[7] http://www.res-mar.eu/
[8] http://www.medam.info/index.php/en/
[9] As required by the Water Framework Directive (European Commission, 2000)

hectares reclaimed or occupied by impervious surfaces) can be added to higher levels (e.g. administrative boundaries or Mediterranean subregions). The MEDAM inventory[10] offers a good example of this bottom up approach by recording the length of manmade structures and the area occupied by land claim at different spatial levels: water body, town, departement, region and country.

2.3. The frequency of monitoring and location of sampling sites

Although each coastal section and each process responsible for shaping it requires specific procedures for surveying and for data analysis, operation time scales must be set. Monitoring manmade structures data should be update at least every six years. This shall lead to a homogeneous level of knowledge, which will make data comparison and transfer/exchange of project and management experiences more effective.

Even more important is to prioritize the possibility to analyze trends and to detect areas of higher development of coastal infrastructures. To this regard, historical survey prior to any reclamation (i.e. aerial photographs) is of paramount importance to capture and digitalized the original coastline (on the basis of old maps) prior to any reclamation.

In regard to the appropriate location of sampling sites, monitoring should not be limited to concrete coastal lengths, but should cover the entire Mediterranean coastline of each Contracting Party. However, taking into account that coastal defence, ports, marinas and land claim are usually found in the vicinity of coastal urban centers and touristic resorts, special attention should be given to those hotspots coastal segments in order to properly detect and monitor coastal structures.

2.4. Collection of field samples and data from other observation techniques

Besides Earth Observation data, potential source of data useful to validate and to enhance the accuracy of the monitoring effort are: detailed plans of constructions (e.g. Ports, Marinas, touristic resorts, etc.); Local urban plans, and national or local land use data.

[10] Meinesz A., Blanfuné A., Chancollon O., Javel F., Longepierre S., Markovic L., Vaugelas de J. et Garcia D., 2013. Côtes méditerranéennes françaises: inventaire et impacts des aménagements gagnés sur la mer. Ed. Lab. ECOMERS, Université Nice Sophia Antipolis, 156 pp.et publication éléctronique: www.medam.org.

Reference

Airoldi, L., Abbiati, M., Beck, M.W., Hawkins, S.J., Jonsson, P.R., Martin, D., Moschella, P.S., Sundelöf, A., Thompson, R.C., and Åberg, P. (2005). An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coast. Eng. *52*, 1073–1087.

Alpar, B. (2009). Vulnerability of Turkish coasts to accelerated sea-level rise. Geomorphology *107*, 58–63.

Bulleri, F., and Chapman, M.G. (2010). The introduction of coastal infrastructure as a driver of change in marine environments. J. Appl. Ecol. *47*, 26–35.

Deichmann, U., Ehrlich, E., Small, E., and Zeug, G. (2011). Using high resolution satellite data for the identification of urban natural disaster risk (GFDRR (Global Facility for Disaster Reduction and Recovery)).

European Commission (2011a). Relationship between the initial assessment of marine waters and the criteria for good environmental status.

European Commission (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Frihy, O., and Deabes, E. (2012). Erosion chain reaction at El Alamein Resorts on the western Mediterranean coast of Egypt. Coast. Eng. *69*, 12–18.

HELCOM (2010). Towards a tool for quantifying the anthropogenic pressures and potential impacts in the Baltic Sea marine environment. A background document on the method, data preparation and testing of the Baltic Sea Pressure and Impact Indices.

Markandya, A., Arnold, S., Cassinelli, M., and Taylor, T. (2008). “Protecting coastal zones in the Mediterranean: an economic and regulatory analysis.”J. Coast. Conserv. *12*, 145–159.

Michener, W.K., Blood, E.R., Bildstein, K.L., Brinson, M.M., and Gardner, L.R. (1997). Climate change, hurricanes and tropical storms, and rising sea level in coastal wetlands. Ecol. Appl. *7*, 770–801.

OSPAR (2008a). Assessment of the environmental impact of land reclamation (OSPAR Commission).

OSPAR (2008b). Assessment of the Environmental Impact of the Construction or Placement of Structures (other than Oil and Gas and Wind-farms) (OSPAR Commission).

OSPAR (2009). Assessment of the impact of coastal defence structures (OSPAR Commission).

Özhan, E. (2002). Coastal erosion management in the Mediterranean: an overview (Split: UNEP/MAP/PAP).

Pesaresi, M., Gerhardinger, A., and Kayitakire, F. (2008). A Robust Built-Up Area Presence Index by Anisotropic Rotation-Invariant Textural Measure. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens. *1*, 180–192.

Pranzini, E., and Rossi, L. (2013). The role of coastal evolution monitoring in “Coastal erosion monitoring. A network of regional observatories” (Florence).

REMPEC (2008). Study of Maritime Traffic Flows in the Mediterranean Sea.

Rochette, J., Puy-Montbrun, G., Wemaëre, M., and Billé, R. (2010). Coastal setback zones in the Mediterranean: a study on Article 8-2 of the Mediterranean ICZM Protocol.

Sanò, M., Marchand, M., and Medina, R. (2010). Coastal setbacks for the Mediterranean: a challenge for ICZM. J. Coast. Conserv. *14*, 33–39.

Sanò, M., Jiménez, J.A., Medina, R., Stanica, A., Sanchez-Arcilla, A., and Trumbic, I. (2011). The role of coastal setbacks in the context of coastal erosion and climate change. Ocean Coast. Manag. *54*, 943–950.

SHAPE Establishment of coastal setback: An explanatory report on Article 8-2 of ICZM Protocol Issues to be considered.

Simeoni, U., and Corbau, C. (2009). A review of the Delta Po evolution (Italy) related to climatic changes and human impacts. Geomorphology *107*, 64–71.

Small, C. (2009). The Color of Cities: An Overview of Urban Spectral Diversity. In Global Mapping of Human Settlements, (Taylor & Francis),.

Snoussi, M., Ouchani, T., and Niazi, S. (2008). Vulnerability assessment of the impact of sea-level rise and flooding on the Moroccan coast: The case of the Mediterranean eastern zone. Estuar. Coast. Shelf Sci. *77*, 206–213.

UNEP/MAP (2012). Initial Integrated Assessment of the Mediterranean Sea: Fulfilling Step 3 of the Ecosystem Approach Process.

UNEP/MAP/PAP (2000). National Legislations and Proposals for the Guidelines Relating to Integrated Planning and Management of the Mediterranean Coastal Zones (Split).

UNEP/MAP/PAP (2001). White paper: coastal zone management in the Mediterranean. (Split).

UNEP/MAP/PAP (2008). Protocol on Integrated Coastal Zone Management in the Mediterranean (Split: Priority Actions Programme).

Annex I

Rationale of the chosen elements under the concept "manmade structures" causing physical disturbance

However, in the context of the analysis of pressures and impacts undertaken by the Initial Assessment, the Marine Directive lists a number of pressures on the marine environment, which are related to human activities. In regard to physical loss and physical damage, the guidance document European Commission, (2011a) identifies a set of elements included by the term 'manmade structures' (see below).

For the purpose of the EO8, only those elements listed in Tab 2 specific to coastal activities are selected, i.e. (i) Coastal defence, (ii) Ports and marinas, (iii) Land claim. The remaining two elements from Tab 2, i.e. (iv) Placement and operation of offshore structures (other than for energy production) and, (v) Submarine cable and pipeline operations) are out of the scope of this common indicator and covered by the Common Indicator 9 (i.e. "Extent of marine area affected by permanent physical alterations") under the EO7.

Tab.2

Manmade structures defined by the MSFD to conduct the pressure assessment
(i) Land claim, (ii) Coastal defence, (iii) Ports, (iv) Placement and operation of offshore structures (other than for energy production) and (v) Submarine cable and pipeline operations

The same manmade structures listed in Tab. 2 are integrated and mapped by the Baltic Sea Pressure Index (BSPI) (HELCOM, 2010). It is worth mention that the BSPI also includes the layer 'Bridges and coastal dams' under the list of human activities related to the pressure 'physical loss'. Likewise, several reports assessing the impacts of manmade structures have been produced by the OSPAR Commission based on this classification of manmade structures (OSPAR, 2008a, 2008b, 2009, among others).

Moreover, the same structures are include in The initial assessment of the Mediterranean (UNEP/MAP, 2012) under the list of pressures 'physical disturbance'. The main difference is the inclusion of the impervious surface in the coastal strip (i.e. 'Non-permeable surfaces associated with urbanization') as part of the group of pressures causing physical disturbance. Accordingly with the objectives of GES pursued by EO8, the inclusion of the 'imperviousness of coastal fringe' is determinant to cover those impacts affecting the natural dynamics of the coastal area.

Annex II: Overall impacts of manmade structures (linking E

	PRESSURES			**IMPACTS and EO correspondence**								
	Physical disturbance		Interference with hydrological processes	Coastal space fragmentation	Landscape: aesthetic impacts	Influence sediment transport, erosion.	Reduce the ability of the shoreline to respond to natural forcing factors	Modification of bathymetry and/or wave propagation patterns	Habitat loss (marine & terrestrial)	Non-indigenous species and translocations	Seabed integrity	Contaminants: increase runoff from impervious surface, ports (synthetic compounds, etc.)
Man-made structures	Smothering Sealing	Siltation Abrasion Extraction	Thermal regime Salinity regime	EO8	EO8	EO8	EO8	EO7	EO1/EO8	EO1/EO2	EO6	EO9
Coastal defence	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	
Ports and marinas	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Land claim	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**			
Impervious surface in the hinterland	**x**		**x**	**x**	**x**	**x**	**x**		**x**			**x**

Annex III
Indicators Monitoring Fact Sheets on Ecological Objective 8: Coastal ecosystems and landscapes

ECOLOGICAL OBJECTIVE 08: The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved

Indicator No as of COP18 Decision	Common Indicator	Operational Objective	State or impact	DESCRIPTION Parameters and/or Elements, matrix	Assessment Method	Monitoring Guidelines	Sampling and Analysis Reference Methods	QA/QC	Recommendations /Additional Data needed
8.1.4	Length of coastline subject to physical disturbance due to the influence of manmade structures	8.1 The natural dynamic nature of coastlines is respected and coastal areas are in good condition	Impact	Parameter: - Length of manmade coastline (e.g. km) - Total surface area reclaimed (ha)	Mapping of manmade structures[11] located in the coastline and coastal fringe. Calculate the rate of artificial coastline by coastal water bodies.		MSSD, indicator[12] nº23: "Share of artificialised coastline"		- Morphological evolution of the coast; - Coastline typology (Principal morphological and sedimentology characteristics of the coastline);

[11] Coastal manmade structures include: (i) coastal defence (hard techniques) (ii) Ports and marinas; (iii) land claim; (iii) impervious surfaces in the coastal fringe linear (buffer of 500m from the coastline).

[12] Methodological sheets of the 34 priority indicators for the Mediterranean Strategy for Sustainable Development (2006). Plan Blue