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Draft Technical guidance document on integrated monitoring under the Ecosystem Approach

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I. INTRODUCTION

1 Setting the context

Through **Decision IG.17/6** the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (**Barcelona Convention**) have committed to progressively apply the Ecosystem Approach to the management of human activities with the goal of effecting real change in the Mediterranean marine and coastal environment.

At the 17th Meeting of Contracting Parties (**COP 17**) held in Paris in February 2012 the Parties through **Decision 20/4** on “Implementing the Ecosystem Approach Roadmap” validated the work carried out by MAP on the Ecosystem Approach (**EcAp**) with regard to the 11 ecological objectives, operational objectives and indicators for the Mediterranean, adopted the timeline for implementing the ecosystem approach until 2019 and established a six-year cyclic review process of its implementation.

The recent 18th Meeting of Contracting Parties (**COP 18**) held in Istanbul in December 2013, further mainstreamed EcAp into the Programme of Work of the Barcelona Convention and delivered as a major milestone **Decision IG. 21/3** on a specific list of good environmental status descriptions and targets and a process to achieve an integrated Mediterranean Monitoring and Assessment Programme by 2015 next to a detailed timeline on necessary steps to achieve good environmental status by 2020.

A specific timeline was adopted at COP18 for EcAp, building on the COP Decisions above, on the expert level work of the 2012-2013 held EcAp Correspondence Groups and the monitoring commitments and practices under the Barcelona Convention and its Protocols, on how to achieve an Integrated Mediterranean Monitoring and Assessment Programme by the 19th Meeting of the Contracting Parties (i.e. by the end of 2015).

An Integrated Correspondence Group (**Integrated EcAp CorGest**) was held in February 2013, that gave specific recommendations for the future Integrated Monitoring and Assessment Programme, agreed on a list of common indicators, which will form the basis of the Integrated Monitoring and Assessment Programme’s first phase and specific Correspondence Groups on Monitoring (**CORMON**s) were set up, with the aim to further specify the common indicators, discuss methodologies and parameters related to them and as such form the core of the Integrated Monitoring and Assessment Programme.

2. The common indicators

The Common indicators agreed, which are at the core of the future Integrated Monitoring and Assessment Programme:

1. Habitat distributional range (EO1);
2. Condition of the habitat’s typical species and communities (EO1);
3. Species distributional range (EO1);
4. Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles, marine macroalgae, zoobenthos, fish);
5. Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates);

6. Trends in abundance, temporal occurrence and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species);

7. Concentration of key nutrients in water column (EO5)[1];

8. Chlorophyll-a concentration in water column (EO5);

9. Location and extent of the habitats impacted directly by hydrographic alterations (EO7);

10. Length of coastline subject to physical disturbance due to the influence of man-made structures (EO8);

11. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater);

12. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9);

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

14. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9);

15. Percentage of intestinal enterococci concentration measurements within established standards (EO9);

16. Trends in the amount of litter washed ashore and/or deposited on coastlines (EO10);

17. Trends in the amount of litter in the water column including microplastics and on the seafloor (EO10);

18. Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds and turtles (EO10).

The latter common indicator related to ingested litter (Indicator 10.2.1. in Annex I of Decision IG. 21/3) is proposed to be analysed by the CORMON groups as a common indicator on a trial basis and further develop it based on available data, best practices and possible sub-regional pilots.

The CORMONs at the same time are mandated to discuss in line with the COP18 Decision 20/4 the possibility of inclusion of additional indicators, in light of scientific developments, best practices gathered, as well as the necessary data management needs of the Integrated Monitoring and Assessment Programme.

The current draft Technical Guidance Document on Integrated Monitoring under the Ecosystem Approach (the **Draft EcAp Monitoring Guidance Document**) aims to guide discussions in the CORMON groups and serve as the first basis of the Integrated Assessment and Monitoring Programme, with a focus on integrated monitoring of the proposed common indicators.

[1] As agreed by Integrated CorGest, EO5 common indicators will be complemented in line with ongoing practice of MEDPOL, with nutrient ratios, water transparency and oxygen concentration.

It aims to set the policy, scientific context for CORMON discussions on the above, stating possible terms pertinent to monitoring, giving overarching recommendations for the formulation of the Barcelona Convention-UNEP/MAP integrated monitoring programme, with an indicative list of characteristics, pressures and impacts to be addressed in the ECAP integrated monitoring programme. It includes where possible information on current monitoring activities, reference to scale of monitoring, need for risk assessment, and a basis for discussion on setting background/reference values.

It does not address however specifics of assessment (to be discussed in CORMON groups in an integrated manner, building on agreement of specifics of the monitoring programme), GES definition, target setting (these are already covered by previous COP decisions) and measures (these will be addressed separately, in the COP18 foreseen EcAp Measures Gap Analysis) are also out of the scope of the current document. However, some considerations on these issues are included as long as they are needed for establishing monitoring.

The Draft EcAp Monitoring Guidance Document strongly builds on current monitoring practice, where available, and existing obligations for monitoring under the Barcelona Convention and in the absence of these on the applicable monitoring guidance of other International, Regional Bodies (in case these are not available either), on relevant scientific literature and/or scientific projects.

The strongest and longest history of monitoring in the Mediterranean, building on Article 12 of the Barcelona Convention is through the ongoing work of the Mediterranean Marine Pollution Assessment and Control Programme (**MEDPOL**), which has assisted to set their common regional policies with regard to pollution elimination/reduction and monitoring.

In the framework of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (**LBS Protocol of the Barcelona Convention**), in line with its Articles 8 and 13, and in the framework of the Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (**Dumping and Hazardous Wastes Protocol of the Barcelona Convention**), in line with its Article 9, MEDPOL has monitored and assessed pollution state and trends, as well as the biological effects of pollutants on the Mediterranean Sea. For this purpose MEDPOL has coordinated the preparation and the implementation by the countries of the regional pollution monitoring programme in line with the above.

In addition, data streams of other Barcelona Convention-UNEP/MAP components have also started to arise in recent years and the need for a more horizontal, integrated monitoring programme has become clear, in line with the overall EcAp principles and Decisions IG.17/6. and IG. 21/3 described above and in line with the relevant provisions of the Protocols of the Barcelona Convention, setting out monitoring obligations. These include Articles 3, 7, 20 and 21 of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (**SPA and Biodiversity Protocol**), Articles 16, 18 and 27 of the Protocol on Integrated Coastal Zone Management in the Mediterranean (**ICZM Protocol**), Articles 5 and 9 of the Protocol Concerning Cooperation in Preventing Pollution from Ships and, in cases of Emergency, Combating Pollution of the Mediterranean Sea (**Prevention and Emergency Protocol of the Barcelona Convention**) , and Articles 19 and 21 of the Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and Seabed and its Subsoil (**Offshore Protocol**).

Furthermore, monitoring and EcAp relevant monitoring data collection has been undertaken in the previous years, both in the national, regional and international context, including by the European Union (**EU**) Member States and EU Institutions /Agencies, next to other regional competent organizations such as the Secretariat of the General Fisheries Commission for the Mediterranean (**GFCM**), and through the Convention on the Conservation of Migratory Species of Wild Animals (in the Mediterranean context the most relevant is the work of **ACCOBAMS**).

3. Setting the scientific context

In order to achieve the policy objectives previously described, from a scientific point of view, the future Integrated Assessment and Monitoring Programme should respond to the following needs:

a) The scope kept focused on the Integrated EcAp CorGest proposed common indicators, allowing also flexibility to reflect scientific development and data availability by having common indicators on a trial basis;
   Using as much as possible a common template, outlining specifications for the common indicators, as well as their links with the specific Ecological Objectives in line with the above and practices of other Regional Sea Conventions;
b) Monitoring, and assessment activities (including the assessment of the health risk associated with the quality of bathing waters), as well as data quality assurance, data collection and handling, reporting and data management policies and procedures, to be functionally harmonized with those adopted by regional, international and global bodies and organizations, such as by other UN Agencies and programmes and the EU;
c) Monitoring and assessment of environmental effects associated with energy production and maritime transport, in cooperation with other competent international and regional bodies;
d) Follow-up closely on the monitoring suggested under SAP BIO and SPA and Biodiversity Protocol of the Barcelona Convention in relation inter alia to a monitoring system of endangered and threatened species to be established, as well as adequate monitoring and survey of the effectiveness of marine and coastal protected areas; addressing links between fisheries and biodiversity monitoring requirements, in a cost-efficient manner;

The philosophy underlying the holistic approach to achieve the above, which is inclusive of marine pollution, coastal zone degradation and biodiversity, is that all monitoring activities are integrated in a single, well-defined aim – that of achieving a particular level of environmental quality in a specified ecosystem. This means that common practices have to be adopted across all types of monitoring activities and data management.

<u>Terms pertinent to monitoring</u>

Monitoring for the purpose of the ecosystem approach (**Monitoring**)

Monitoring can be defined as the systematic measurement of biotic and abiotic parameters of the marine and coastal environment, with a predefined spatial and temporal schedule, having the purpose to produce datasets that can be used for application of assessment methods and derive credible conclusions on whether the desired state or target is achieved or not and on the trend of changes for the marine and coastal area concerned. In this frame, monitoring includes the choice of the elements to measure, the location of sampling sites, the periodicity of sampling, the collection of field samples and data from other observation techniques, processing of the samples in the laboratory and of alternatively gained data (e.g. satellite imagery) and the compilation and management of the data. Development of assessment methods and classification of status as good or less than good is not included although closely related to monitoring. In a nutshell, monitoring for the purpose of the ecosystem approach should provide the data to allow assessment methods to classify a marine and coastal area as reaching or failing to reach Good Environmental Status.

Integrated Monitoring for the ecosystem approach

Integrated monitoring for the ecosystem approach is considered as the one providing data:

a) For the calculation of the different applicable indicators and the assessment of the different ecological objectives

b) Fulfilling the monitoring requirements of different pieces of legislation applying in the region

c) Covering the monitoring needs of more than one Contracting Party

d) Collected in a comparable way between Contracting Parties

Monitoring Programme

Monitoring programme refers to all substantive arrangements for carrying out monitoring. It includes general guidance with cross-cutting concepts, monitoring guidelines, data reporting and data handling arrangements. The ecosystem approach monitoring programme should therefore include a number of scheduled and coordinated activities to provide all the data needed for the on-going assessment of environmental status in relation to the achievement of Good Environmental Status, and related environmental targets.

Monitoring guidelines

A technical guidance on methods and standards for sampling, analysis and quality control/assurance. Contracting Parties can either use/modify their existing methods, or where no appropriate monitoring and assessment systems exists, develop new systems that will incorporate all the requirements of the monitoring programme. Depending on Contracting Parties existing monitoring programmes and unique regional characteristics the proposed methodology will need to be tailored to specific circumstances or to maintain a comprehensive approach.

Monitoring manual

A detailed document including pragmatic advices, specific methodologies, tools and approaches for parameter collection, indicator calculation and interpretation, to support a monitoring programme.

Monitoring strategy

A concrete plan on how to collect all the data specified in a monitoring programme. It is a function of:

- Project objectives
- Size and characteristics of area to be assessed
- Existing monitoring
- Number and types of parameters
- Specificity, sensitivity of monitoring techniques
- Sampling frequency and duration and spatial resolution

- Magnitude of natural variability (e.g. higher in an isolated water body, lower in the open sea)
- Available resources (capital and manpower)

II. MONITORING GUIDANCE RELEVANT TO ALL ECOLOGICAL OBJECTIVES

1. Overarching recommendations for the formulation of the MAP integrated monitoring programme

These recommendations address the design of the integrated monitoring programme by discussing and recommending principles on how to prioritize and chose what to monitor and not the explicit parameters to monitor.

Adequacy (overarching recommendation 1)

The overarching properties of the ECAP Integrated Monitoring Programme are presented below. Essentially the Integrated Monitoring Programme should be able to provide all the data needed to assess whether GES has been achieved or maintained, the distance from and progress towards GES, and progress towards achieving environmental targets.

Consequently, monitoring should cover relevant biotic and abiotic elements in order to quantify pressures associated with activities and assess effectiveness of measures in relation to the targets set. Monitoring should provide the data to calculate/estimate the relevant criteria and indicators adopted in the ECAP process. Some of these criteria and indicators require biotic (e.g. Abundance of perennial seaweeds and seagrasses) some abiotic data (e.g. Physical, hydrological and chemical conditions of the habitat) while others pressures' data (Trends in the amount of litter washed ashore and/or deposited on coastlines).

Coordination and coherence (overarching recommendation 2)

Contracting Parties should, as much as possible follow agreed monitoring approaches, particularly within the same sub-region. Ideally, they would monitor a common regional set of elements, following agreed frequencies, comparable spatial resolution and agreed sampling methods. Joint specifications and use of other observation data in the region, such as satellite imagery, also contribute to coordination. Such coordinated approaches would also result in coherence i.e. the same biotic and abiotic components would be monitored in similar habitats and points in time. It would also facilitate comparable assessment results and associated classification of the state of similarly impacted areas belonging to different Contracting Parties. Ultimately, coherent monitoring programmes will facilitate the application of coherent mitigation measures so that measures taken by one Contracting Party would facilitate and not prevent the achievement of GES in other Member States. Ideally, differences in monitoring strategies would only be justified by demonstrating important differences in the biological and physicochemical characteristic (e.g. species, habitats and pressures) between two or more marine and coastal areas.

Data architecture and interoperability (overarching recommendation 3)

A coherent integrated monitoring programme would ideally result in the collection of data for a regional set of common parameters. In order to achieve common datasets and interoperability of data, data sources will need to ensure that they are capable to deliver data using the same interface format. To achieve common data sets and to avoid duplication of work, existing databases and data flows at international and regional level should be taken into account, which already provide a pool of regionally interoperable data.

The concept of adaptive monitoring programme (overarching recommendation 4)

New or previously unknown pressures may emerge in a marine and coastal area and/or existing pressures may decrease or be eliminated. Climate change, a pressure itself, is affecting the intensity and impact of other pressures and drastically changes the structure and functions of marine and coastal ecosystems and in line with the recommendations of the Integrated CorGest should be addressed in a horizontal manner in relation to all common indicators.. Environmental state may degrade in an area, requiring investigative monitoring to identify causes. The frequency, intensity and the whole rationale of monitoring programmes may need adjustment to better respond to a changing situation. E.g. an acute pollution event (oil spill) will require more intense monitoring in the years following the event and introduction of an alien species may require additional and targeted monitoring. Also technical progress may require adjustment of monitoring programmes (e.g. new sampling devices). The ECAP implementation has a 6 years cycle but more frequent adjustment of monitoring programmes is needed. The first 2 years of the Integrated Monitoring and Assessment Programme thus will focus only on a core set of common indicator monitoring, where data and practice is the most mature.

Linkage between monitoring and assessment needs, including the use of risk-based approach and where appropriate the precautionary principle (overarching recommendation 5).

Resources are never infinite and are usually very limited. The ECAP Road Map requires the establishment of a regional integrated monitoring programme but this doesn’t mean that it has to monitor everything, everywhere and with the same frequency. As such, areas that are under higher pressures and the biota that are known to be more sensitive should be identified, and monitoring efforts should me prioritised in the areas that risk not to achieve or maintain GES. These areas should be monitored more frequently in relation to those quality components at risk to achieve/maintain GES and associated relevant pressures than other areas that have maintained GES for a long period of time and are under less pressure. Furthermore, increased monitoring effort may be needed in areas that are close to the boundary of GES in order to increase confidence in assessment and, consequently, in the decision to take measures.

The precautionary principle requires that measures should be taken even in areas where there is uncertainty if the status is good or less than good. This uncertainty may be due to limited understanding of what GES is for certain areas. The implications of the precautionary principle in monitoring are that these areas of uncertain status may require research and investigative monitoring in order to allow for a more confident assessment of status in the near future.

Risk-based approach to monitoring

In the risk-based approach (Cardoso *et al.* 2010) a pragmatic prioritization is made, which enables general statements about environmental status at large scales while keeping monitoring requirements manageable.

This risk-based approach is particularly effective for Ecological Objectives that are spatially patchy and where pressures are applied at specific locations. It is recommended to map the pressures that most likely have the largest impacts, and the vulnerability of various properties of the ecosystem. Cardoso *et al.* (2010) recommend prioritization by prior assessment of:

i. the distribution of the intensity or severity of the pressures across the region at large;
ii. the spatial extent of the pressures relative to the ecosystem properties possibly being impacted;
iii. the sensitivity/vulnerability or resilience of the ecosystem properties to the pressures;

iv. the ability of the ecosystem properties to recover from impacts, and the rate of such recovery;
v. the extent to which ecosystem functions may be altered by the impacts; and
vi. where relevant, the timing and duration of the impact relative to the spatial and temporal extent of particular ecosystem functions (e.g. shelter, feeding, etc.).

The variation in scale of both environmental conditions and impacts of pressures means that assessments of GES could begin with sub-areas of both greatest vulnerability and highest pressures. If the environmental status in these areas is "good", then it can be assumed that the status over the larger area is good (Cardoso *et al.* 2010). In contrast, if the environmental status in the sub-areas is not "good", then monitoring and assessments would be conducted stepwise at additional sites along the gradients of pressure or vulnerability. The size of the appropriate steps along the gradient will depend on the nature of the gradient and the way the environmental conditions are degraded. It may vary significantly with different cases (Cardoso *et al.* 2010).

2. Consideration of the differences in scientific understanding for each Ecological Objective (overarching recommendation 6).

It is widely acknowledged that for some ecological objectives the level of scientific knowledge is more developed than for others. E.g. contaminants and eutrophication are already addressed, to some extent, by the existing regulations and some specifications exist on what GES is for these ecological objectives. For some ecological objectives such as noise and biodiversity much less knowledge exists and they have not been previously addressed or they have been addressed in a different context. The limited knowledge for some ecological objectives should trigger specific monitoring efforts, starting from investigative monitoring that will be built on the state of the art scientific developments.

<u>Overarching properties of the ECAP integrated monitoring programme</u>

Need to provide information for an assessment of the environmental status and for an estimate of the distance from, and progress towards, good environmental status

Need to ensure the generation of information enabling the identification of suitable indicators for the ECAP environmental targets.

Need to ensure the generation of information allowing the assessment of the impact of the prospective measures to be defined by the Contracting Parties in accordance with the ECAP Road Map

Need to include activities to identify the cause of the change and hence the possible corrective measures that would needed to be taken to restore the good environmental status, when deviations from the desired status range have been identified.

Need to provide information on chemical contaminants in species for human consumption from commercial fishing areas.

Need to include activities to confirm that the corrective measures deliver the desired changes and not any unwanted side effects.

Need to aggregate the information on the basis of marine sub regions

Need to ensure comparability of assessment approaches and methods within and between marine sub regions.

Need to develop technical specifications and standardized methods for monitoring at regional level, so as to allow comparability of information.

Need to ensure, as far as possible, compatibility with existing programmes developed at regional and international level with a view to fostering consistency between these programmes and avoiding duplication of effort, making use of those monitoring guidelines that are the most relevant for the marine region or sub region concerned.

Need to include, as part of the initial assessment, an assessment of major changes in the environmental conditions as well as, where necessary, new and emerging issues.

Need to address, as part of the initial assessment, the pertinent elements listed in the following Tables including their natural variability and to evaluate the trends towards the achievement of the ECAP environmental targets, using, as appropriate, the indicators established and their limit or target reference points.

Table 2.1 Characteristics

Physical and chemical features

— Topography and bathymetry of the seabed,

— annual and seasonal temperature regime, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time,

— spatial and temporal distribution of salinity,

— spatial and temporal distribution of nutrients (DIN, TN, DIP, TP, TOC) and oxygen,

— pH, pCO2 profiles or equivalent information used to measure marine acidification.

—Topography of coastal ecosystems and landscapes

Habitat types

— The predominant seabed and water column habitat type(s) with a description of the characteristic physical and chemical features, such as depth, water temperature regime, currents and other water movements, salinity, structure and substrata composition of the seabed,

— identification and mapping of special habitat types, especially those recognized or identified under regional convention protocols, directives and agreements or international conventions as being of special scientific or biodiversity interest,

— habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference. This may include areas subject to intense or specific pressures or areas which merit a specific protection regime.

Biological features

— A description of the biological communities associated with the predominant seabed and water column habitats. This would include information on the phytoplankton and zooplankton communities, including the species and seasonal and geographical variability,

— information on angiosperms, macro-algae and invertebrate bottom fauna, including species composition, biomass and annual/seasonal variability,

— information on the structure of fish populations, including the abundance, distribution and age/size structure of the populations,

— a description of the population dynamics, natural and actual range and status of species of marine mammals and reptiles occurring in the marine region or subregion,

— a description of the population dynamics, natural and actual range and status of species of seabirds occurring in the marine region or subregion,

— a description of the population dynamics, natural and actual range and status of other species occurring in the marine region or subregion which are the subject of regional conventions, protocols, directives or international agreements,

— an inventory of the temporal occurrence, abundance and spatial distribution of non-indigenous, exotic species or, where relevant, genetically distinct forms of native species, which are present in the marine region or subregion.

Other features

— A description of the situation with regard to chemicals, including chemicals giving rise to concern, sediment contamination, hotspots, health issues and contamination of biota (especially biota meant for human consumption),

— a description of any other features or characteristics typical of or specific to the marine region or sub-region.

Table2.2 Pressures and impacts

Physical loss

— Smothering (e.g. by man-made structures, disposal of dredge spoil),

— Sealing (e.g. by permanent constructions).

— Change in land use of coastal ecosystems and landscapes.

Physical damage

— Changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal of dredge spoil),

— Abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring),

— Selective extraction (e.g. exploration and exploitation of living and non-living resources

on seabed and subsoil).

Other physical disturbance

— Underwater noise (e.g. from shipping, oil and gas activities, underwater acoustic equipment),

— Marine litter,

— Beach cleaning by mechanical means, sand mining, beach sand nourishment.

Interference with hydrological processes

— Significant changes in thermal regime (e.g. by outfalls from power stations),

— Significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction).

Contamination by hazardous substances

— introduction of non-synthetic substances and compounds (e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs),

— Introduction of synthetic compounds (which are relevant for the marine environment such as pesticides, anti-foulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances),

Systematic and/or intentional release of substances

— Introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment, as permitted in accordance with other regional obligations and/or international conventions.

Nutrient and organic matter enrichment

— Inputs of fertilizers and other nitrogen and phosphorus-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition),

— Inputs of organic matter (e.g. sewers, mariculture, riverine inputs).

Biological disturbance

— Introduction of microbial pathogens,

— Introduction of non-indigenous species and translocations,

— Selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing).

3. Alternative monitoring approaches that could be of value for an effective monitoring of the spatial scale relevant to the MAP ECAP

3.1. Moorings and buoys

Moored and free-floating buoys have a long history of use in oceanography and coastal sciences, measuring a large variety of important physical, chemical and biological variables such as salinity, temperature, turbidity, dissolved oxygen, trace metals, pCO2 and others, depending on the number of instruments they can handle.

Data can be measured at high frequency at strategic sites and at different depths owing to sophisticated profiling equipment. Data are then transmitted in real-time to land-based observatories via communication satellites. The efficiency of buoys has been considerably increased owing to advanced technology including solar storage batteries, data logging controller, environment-friendly antifouling coatings. The ARGOS buoy network provides data from buoys which are periodically sinking to depth and transmit the data when surfacing.

Offshore spatial spatial coverage is provided. Periodic visits for maintenance and cleaning of instruments is required. Provides point measurements over the water column.

3.2 Ships of opportunity / FerryBox system

The use of volunteer merchant vessels to gather oceanographic data is an important cost-effective component of any monitoring programmes. As for the moorings, ships of opportunity can be fitted with various instrumentations to collect data related to physical, chemical and biological oceanography. As an alternative to often expensive and time-consuming research vessels, merchant fleet and specifically ferries offer a regular line sampling frequency across a wide range of water types. The so-called FerryBox system consists of an automatic flow-through system pumping sea water on the side of the ship and propelling it in an internal loop at constant velocity to conduct the various measurements. The FerryBox community is continuously increasing and represents ca. 20 different institutions in Europe. More details on the system and the operating companies can be found at http://www.ferrybox.org.

Offshore spatial coverage is provided. Transect measurements at one depth level (surface or sub-surface), use of fishery vessels for sampling.

3.3. Continuous Plankton Recorder (CPR)

The CPR is a plankton sampling instrument designed to be towed from ships. The CPR is towed at a depth of approximately 10 metres. Water passes through the CPR and plankton is filtered onto a slow-moving band of silk. In the laboratory CPR samples are analyzed in two ways. The Phytoplankton Colour Index (PCI), a semi-quantitative estimate of phytoplankton biomass, is determined for each sample. Then, microscopic analysis is undertaken for each sample, and individual phytoplankton and zooplankton taxa are identified and counted. CPR can sample larger areas than other phytoplankton and zooplankton devices such as bottles and nets. Data on biomass that are needed for many indicators can easily be taken while taxonomic identification needed for other indicators needs the same skills and human power as with any other sampling method.

CPR has also been used to monitor micro-litter in the water column. However the CPR samples at approximately 10m depth and so will not sample floating debris.

Offshore spatial coverage is provided. The device needs to be towed from a special vessel with a specific speed.

3.4. Underwater video & Imagery

Video can be used to take images of both the sea-bed and the water column. Video cameras can be tethered to oceanographic vessels as well as other non-research vessels (ferries, fishing vessels, ships of opportunity). Depending on the quality of the images recorded they can provide information on the structure of the seabed, the composition and abundance of macroscopic benthic biota and the composition and abundance of macroscopic pelagic biota. Non-living items, such as litter, can also be recorded. The technique performs well in terms of resolution and information content but not so good in relation to workload and areal coverage.

Offshore spatial coverage is provided. This is better applied to benthic habitats and biota. Taxonomic resolution is not always comparable to the one achieved by traditional tools (e.g. grabs, corers), applicable to surveys of marine litter including image acquisition and recognition technology.

3.5. Underwater acoustics

Hydroacoustics (echo sounding or sonar), is commonly used for detection, assessment, and monitoring of underwater physical and biological characteristics. The very efficient transmission of sound in water makes this remote-sensing technique highly effective in most aquatic ecosystems and under many environmental conditions providing a valuable complement to capture-based sampling techniques.

Sonars can be used for the detection of animal and plant populations and provide some information on their abundance, size, behavior and distribution. They are already widely in use in the marine environment both by fishermen and by fisheries scientists for the investigation of fish populations. Hydro-acoustic surveys provide for non-intrusive methods for quantifying the abundance and distribution of fish. Advances in acoustic technology, and especially data analysis software, have made this survey method even more powerful in recent years. While there are limitations in terms of species identification, acoustic surveys used in conjunction with other methods or as a relative measure, provide a quantifiable metric over the years.

Validation should occur simultaneously through the use of high resolution sonar imaging, underwater cameras, and other methods.

Sonars are also used for habitat mapping (mainly depth, bottom roughness and hardness reflecting differences in sub-stratum types). More recently, the combination of different hydro-acoustic methods (i.e. single beam echo-sounder, multi-beam sonar and side scan sonar) enables the spatial classification of the seafloor and its vegetation. The resulting 3 D images are of the same quality and precision as those found in the field of biomedicine.

Recording of sounds produced by marine animals (mainly mammals) could possibly provide info on their population abundance, their movements and location of their habitats. A related project is running in Catalonia: http://listentothedeep.com/.

Offshore spatial coverage provided. Taxonomic identification is not always at the species level.

3.6 Remote sensing

Earth Observation (EO) from satellite provides information at unprecedented time scales over large and distant areas of the marine and coastal areas in a real cost-effective way, where only few observations can be conducted by traditional methods using oceanographic vessels. Satellite remote sensing techniques also grant consistent methodologies while capturing the regional and local variability at a frequency nearly compatible with the dynamics of marine and coastal processes. Such kind of synoptic observations have made important contributions to monitor the state of the marine environment in terms of its physical and biological properties and is increasingly used to foster sustainable management of the marine and coastal resources, including fisheries.

Optical sensors on-board satellite (e.g. MERIS on ENVISAT; http://envisat.esa.int/instruments/meris) relates to the 'color' of the sea surface, which varies with the concentration and composition of a large variety of living and non-living material in suspension. An important quantity is the concentration of chlorophyll, an omnipresent pigment in all phytoplankton species commonly used as an index of phytoplankton biomass. Other products of interest include total suspended matter, pigmented fraction of dissolved organic matter, as well as some indication of phytoplankton functional groups. Data can be accessed freely through space agencies or via specific web sites such as the Environmental Marine Information System from the Joint Research Centre (http://emis.jrc.ec.europa.eu).

Physical changes of the coastal ecosystems and habitats in particular terrestrial can be surveyed by the use of satellite images or aerial photography. For the changes of land use, sediment dynamics and alike the use of CORINE Land Cover datasets are available for specific time series which allows to follow trends for instance. Land cover products are created by GlobCorine or other, e.g. MODIS multispectral data, following descrete Corine land cover categories corresponding with the INSPIRE Directive.

Offshore spatial coverage is provided here. Passive optical and thermal sensors are of limited use under cloud cover and low sun angle. The taxonomic resolution is restricted to phytoplankton functional groups.

3.7. Autonomous Underwater Vehicles (AUVs) and Gliders

The development of AUV technology for marine and coastal studies has increased considerably over the last decade as an alternative to costly and heavy logistic demand of research vessels. AUVs are free-swimming torpedo-shaped devices remotely operated from the surface within the range of the telemetry system onboard.

Owing to a number of propulsion techniques most often powered by rechargeable batteries, AUVs can cover large distance (ca. 10 miles) at various depths to provide a 3D view of the water column. Gliders are specific AUVs propelling themselves using buoyancy-based techniques, increasing the underwater autonomy of the vehicle for observations of longer time-scale features. The scientific payload of AUVs and gliders can be set with physical and bio-optical instruments measuring water quality variables (such as nutrients and contaminants), phytoplankton biomass, in addition to physical and geochemical properties such as temperature, oxygen, conductivity. They can also transport video-cameras to get pictures of organisms (mostly pelagic) and/or debris and also detectors of passive acoustic signals. The European Gliding Observatories (EGO; http://www.ego-network.org/) has been set up to promote the use of glider technology in marine and coastal studies, to share data, and to provide technical advices and training.

Offshore spatial coverage is provided. The cost depends on the onboard instrumentation. Considerable technical expertise is required.

IV. COST BENEFIT ANALYSIS

<u>Costs, benefits and governance of the monitoring programmes</u>

The Ecosystem Approach Process is including the need to take into account the importance of the cost and benefits of the monitoring programmes.

It is key to ensure that the EcAp Integrated Monitoring and Assessment Programme will be cost-effective. In order to achieve this, the following recommendations could be drawn from existing best practices:

(a) specific work is required for prioritization (both at theme and indicator level) of the monitoring programmes to address the most significant risks and to respond to assessment/management needs;
(b) one key criterion for prioritization is the relevance of criteria and indicators for measures / pressures as they directly link back to the management element;
(c) finding more innovative and efficient ways of doing the monitoring will be key assets to meet the EcAp monitoring requirements in a context of both environmental and economic constraints ;
(d) country cooperation (bilateral or sub-regional level) possibilities should be explored, as a potential cost-efficient execution of the monitoring programmes (opportunity for the EU to contribute to cost-efficiency through the Copernicus marine core services by offering data products in relevant resolutions for national and regional uses in support of the Ecosystem Approach Process could be investigated);
(e) as part of these potential integrated multi-disciplinary monitoring programmes there will be a need to maximize the use of existing resources (e.g. ship time), by improving the efficiency of existing programmes (i.e. use of spare capacity).
(f) potential to use monitoring by industry of the environmental effects of their activities (following initial impact assessments) can be further explored as an effective way to assess the nature and extent of environmental impacts within marine waters (if such

monitoring is done to specified standards, is quality assured and provides data that are compatible with other monitoring programmes, then it could reduce the costs to Contracting Parties);

(g) Decision-making tools may also help design effective and efficient monitoring programmes (e.g. to determine the spatial and temporal resolution needed or possibilities for integration of techniques).

(h) Governance of monitoring programmes is organised (e.g. clear attribution of responsibilities, allocation of resources etc). There should be also clear coordination arrangements in case of various administrations playing a role in the implementation of the monitoring programmes. The answer to these questions will allow streamlining existing resources, increase transparency and enhance accountability amongst other benefits.

Next to ensuring the usage of cost-efficient methods and further identifying possibilities for maximizing the cost-efficiency of the monitoring programme, it is also key to ensure that the implementation of the Integrated Monitoring Programme will be possible all over the Mediterranean basin. For this, it will be key to assess the country capacities, noting the starting point of relevant monitoring programmes already in practice.