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MANTIS: Marine protected Areas Network Towards Sustainable fisheries in the Central Mediterranean

Work Package 4

Deliverable 4.4 – Overall conclusions and recommendations

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WP4 – Overall conclusions and recommendations
Deliverable 4.4.

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Abstract:

D 4.4. summarizes the main results of WP4 in terms of main conclusions and recommendations related to governance implementation of MMAs networks identified in the two case study areas (Strait of Sicily and Adriatic Sea). The suggested governance approach is based on a participatory approach, well defined strategic and specific management objectives and a robust monitoring system based on indicators. This latter will be mostly based on the ongoing monitoring programmes (MEDITS trawl survey, fisheries data collection, etc.) and integrated with new ad hoc data collection. Approaches for control and surveillance are also described as well as the types of tracking devices tools for fishing vessels monitoring and control.

Objectives:

To summarize the main outputs of WP4 related to the identification of a suitable governance model for networks of MMAs in the central Mediterranean Sea including the main provisions for the development of a monitoring, control and surveillance system in a full participatory approach.

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Introduction

Ecosystems are complex and dynamic natural units that produce goods and services beyond those of benefit to fisheries. Fisheries needs to be managed in an ecosystem-based context since they have a direct impact on marine ecosystems, which is also impacted by other human activities. The so-called “ecosystem approach to fisheries” (EAF) depends on the way in which fisheries management and ecosystem management, and their respective stakeholders interface.

The Convention on Biological Diversity (CBD) Aichi Targets call on the world to protect at least ten percent of coastal and marine areas by 2020. Aichi Target 11 stating that “by 2020, at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes”. This objective, reinforced by the UN’s 2015 Sustainable Development Goals, is however still far from being achieved and may not be enough, to ensure effective, global conservation of the marine environment.

In a recent review of Mediterranean MPA in relation to the Aichi Target 11, Amengual and Alvarez-Berastegui (2018) found that the latest estimation of protected surface waters was 7.14%, with only 0.04% declared as no-take zones (MEDPAN and UNEP-MAP-SPA/RAC, 2016). This coverage has been reached by including a range of national and international protection figures (Marine Managed Areas (MMAs): Natura 2000 sites (898 sites covering 2.37% of the Mediterranean), National MPAs (186 MPAs, covering 1.6%), Mediterranean fisheries protected areas (under the auspices of the General Fisheries Commission for the Mediterranean, 4 areas covering 0.7%) and international MPAs (Pelagos Sanctuary for Mediterranean Marine Mammals, 1 site, covering 3.47%, plus other site designations not evaluated). GFCM has declared 7 Fisheries Restricted Areas (FRAs), located in France, Italy, Cyprus and Egypt. These FRAs should protect sensitive sea bottom habitats and nursery grounds of target commercial fisheries species within a total area of 17.677 ha. Recently, GFCM has increased the extension of the FRAs to the waters deeper than 1000 m in the Mediterranean Sea, where towed dredges and trawl nets are forbidden.

Large scale MPAs are increasingly recognized to be important tools in mitigating the negative impacts of multiple human pressures and increase the resilience of the ecosystem to global change.

In the last decades, fisheries management has progressively included spatial management measures aimed to mitigate the destruction of the habitats and to improve the goods and services they provide (Apitz et al 2006; Pedersen et al. 2009). The legal basis for the implementation of network of FRAs in the Mediterranean is provided by the EU Mediterranean regulation 1967/2006 which refers to the protection of Nursery areas, spawning grounds or other areas to be protected from harmful effects of fishing. The Common Fisheries Policy (EU

reg. 1380/2013) claims for prohibiting or restricting fishing activities in areas where there is clear evidence of heavy concentrations of fish below minimum conservation reference size and of spawning grounds. To this aim EU Member States should identify suitable areas which may form part of a coherent network. Resolution GFCM/41/2017/5 on a network of essential fish habitats in the GFCM area of application is about the definition of a consistent network of essential fish habitats which would also consider sensitive habitats and to provide advice on how to implement the protection of this network, and enhance it from 2018, in order to effectively contribute to achieve the maximum sustainable yield and implement the ecosystem approach to fisheries management in line with the GFCM objectives.

Despite the implementation of offshore MMAs has progressed since the World Summit in 2002, a question remains on how these areas may be managed in a practical sense (Environmental Law Institute, 2016). This particular issue has not been comprehensively addressed, particularly in terms of ensuring compliance with, and enforcement of regulatory provisions. The situation is complicated by the fact that the levels of protection required may range from simply limiting fishing, and/or other human activities, to the complete prohibition of any forms of activity, use or extraction in the area(s) concerned (Miller et al., 2013).
Monitoring, control and surveillance (MCS) are the customary tools for compliance enforcement and combating illegal, unreported and unregulated (IUU) fishing. Their general purpose is to underpin implementation of agreed policies plans and strategies for management, as well as to augment fisheries regulations crucial to enforce protection of fish stocks and habitats and they have to be thought as integral functions of a fisheries management regime.

Designing and assessing an optimal management framework for the MMAs network: key conclusions and recommendations

Overall, when defining MMAs, it is important to identify the main management goal and the specific objectives. The scope of MMA might vary from protection aimed at nature conservation, to fisheries related protection (spatial or temporal) to support the recovery of commercial fish stocks, or even to other goals (e.g. species management area, cultural heritage).
In the case of MANTIS, the MMAs networks are components of fisheries management plans where goals and attributes are defined in the broad context of fisheries sustainability and accounting for the ecosystem approach to fisheries management. MANTIS project aims at identify the more suitable MMA combination to optimize the exploitation of target demersal stocks in two key fishery areas of the central Mediterranean: the Strait of Sicily and the central-North Adriatic.
The main relevant components in the process of establishment of a MMAs can be summarized

as follows:

1. Stakeholders involvement
2. Strategic plan and management objectives (ecological, social, economic)
3. Governance structure
4. Management measures
5. Monitoring Control and Surveillance programme
6. Implementation of the plan

Legal framework for the implementation of a MMAs network in the Strait of Sicily and Adriatic Sea

The legal framework supporting the implementation of MMAs in the two case study areas is based on the main following EU regulations and GFCM recommendations (from D 4.1):

Policy framework	Types of area	Legal fisheries management regime	Objectives	Examples	
				Non-Mediterranean waters	Mediterranean Sea
World Summit on Sustainable Development **Convention on Biological Diversity,** Council Decision 93/626/EEC	Coastal MPAs	National strategies, plans or programmes for the conservation and sustainable use of biological diversity.	To protect at least 10% of coastal and marine areas of particular importance for biodiversity and ecosystem services.	MPAs	MPAs
Marine Strategy Framework Directive Directive 2008/56/EC of the European Parliament and of the Council	Several types of spatial protection measures and MMAs (e.g. national, regional and international)	CFP Art. 11 and 18 Spatial management measures under RFMO	To ensure the Good Environmental Status of all European seas by 2020, and specifically to contribute coherent and representative	Proposal by Portugal under the MSFD Programme (9) of measures to extend the national bottom trawling ban in	Not designated yet

Policy framework	Types of area	Legal fisheries management regime	Objectives	Examples	
				Non-Mediterranean waters	Mediterranean Sea
of 17 June 2008			networks of marine protected areas, adequately covering the diversity of the constituent ecosystems.	the Portuguese EEZ to all foreign fishing fleet, in order to protect the seabed from adverse impacts of fishing activity.	
Mediterranean Regulation Council Regulation (EC) N. 1967/2006 of 21 December 2006	*Posidonia oceanica* and other marine phanerogams. Coralligenous habitats and mäerl beds. Depths beyond 1000 m. The use of towed gears shall be prohibited within 3 nautical miles of the coast or within the 50 m isobath where that depth is reached at a shorter distance from the coast.	Mediterranean Regulation – Articles 4;5;6;8;13	Various measures to conserve and manage living aquatic resources or maintain or improve the conservation status of marine ecosystems, including: - Establishment of fishing protected areas - Restrictions and prohibitions concerning fishing gears, and certain areas	Not applicable	Ban on the use of towed dredges and trawl nets fisheries at: 1) depths beyond 1000m 2) within 3 nautical miles of the coast or within the 50 m isobaths. Protection of marine phanerogams beds, coralligenous and maerl habitats from towed gears. FRAs

Policy framework	Types of area	Legal fisheries management regime	Objectives	Examples	
				Non-Mediterranean waters	Mediterranean Sea
	Nursery areas, spawning grounds or other areas to be protected from harmful effects of fishing.				
Mediterranean and Black Sea under GFCM Resolution GFCM/41/2017/5 on a network of essential fish habitats in the GFCM area of application	Fisheries Restricted Areas (FRA) (e.g. areas closed to demersal fisheries)	GFCM	To protect nursery and spawning grounds, in addition to measures included in management plans; To protect vulnerable marine ecosystems		FRA in the Strait of Sicily: established to protect juveniles of hake and deep-water rose shrimp and support stocks recovery (12) Ban of any towed demersal fisheries below 1000m depth (13)

Policy framework	Types of area	Legal fisheries management regime	Objectives	Examples	
				Non-Mediterranean waters	Mediterranean Sea
Common Fisheries Policy EU reg. 1380/2013	Fisheries Stock Recovery Areas	CFP – Art. 8	To prohibit or restrict fishing activities in areas where there is clear evidence of heavy concentrations of fish below minimum conservation reference size and of spawning grounds. To this aim: – EU Member States should identify suitable areas which may form part of a coherent network – The European Commission may be empowered to establish such biologically sensitive protected areas in a multiannual plan.	MS still have to identify these areas	MS still have to identify these areas
National Legislations	MPA, Fish Stock Recovery Areas; MMA; real time closures; etc.	National fisheries legislation (often only applicable to national fleet)	Various types of instruments with their objectives: - National MPAs for conserving species or habitats of national interest		Italian MPAs according Italian laws n. 979/1982 and n. 394/1991

Policy framework	Types of area	Legal fisheries management regime	Objectives	Examples	
				Non-Mediterranean waters	Mediterranean Sea
			- National fisheries reserves/boxes to protect juveniles, spawning grounds etc.		

Stakeholders involvement through a participatory approach

The designation, implementation, and management of MPAs should consider conservation outcomes as well as socioeconomic impacts and financial and institutional sustainability (Pascual, 2016). The implementation of marine areas often creates conflicts among stakeholders, as access to valued ecosystems, localities, and stocks is prohibited or heavily curtailed. These conflicts, in return, may affect the social, economic, and institutional dimensions, which are critical to the success of MMAs.
The participatory approach is one of the main element of the so called "responsive management" that has been studied and evaluated in different EU research projects.

In particular, the EU FP7 project ECOFISHMAN (ended in February 2014), developed a new management system, called Responsive Fisheries Management System (RFMS), which transfers the responsibility for (fisheries) management to resource users. Three main actors are identified: a) authority, the entity entrusted with the final responsibility for resource management which specifies the measurable objectives to be reached; b) operators, organised group of resource users (e.g. association of fishermen with fishing rights in a given fishery); c) auditor, entitled to evaluate whether the contract between the authority and the operators has been fulfilled in the sense that the outcome targets listed in the (potential) management plan have been achieved.
The involvement of relevant stakeholders will enhance the achievement of such a structured responsive system. This aspect has been further exploited by the SOCIOEC project which recommended to involve stakeholders in a proper evaluation of the potential effects of a (new) management measure and/or framework. Strong stakeholders' involvement should be envisaged in the different stages of the analysis, from a) setting the scene (definition of the nature and scale of the "problem") to b) giving inputs for scenarios to c) evaluating results of simulations and giving feedback for potential improvements. Stakeholder involvement is also essential in the pre-screening of the acceptability of the management framework proposed: higher is the acceptability higher is the compliance and the effectiveness of a management

measure.
During the project a questionnaire was distributed to relevant stakeholders of the two MANTIS case study areas (Strait of Sicily SOS and Adriatic) during the two introductory meetings held in Mazara del Vallo and Ancona (see deliverables 2.1 and 2.2 - Introductory meetings reports). Fishers and fishers representatives were asked to provide their perception on topics related to the state of fisheries, fishing activities and the main management issues, MPAs, and stakeholders' involvement in decision-making.
The results suggest a worse perception on the state of fisheries in the SoS compared to the Adriatic. Authorities, researchers and MPA staff seem to perceive a worse condition of the state of fisheries compared to the fishing sector, however all stakeholders agree in stating a degradation of fisheries in the last ten years. Bad fisheries management and excessive fishing effort were considered as the main threats in both regions, while pollution was strongly perceived only in the SoS and climate change only in the Adriatic. Illegal fishing was also perceived as a big threat in both areas. Main conflicts occurred between artisanal fishers and divers both in the Adriatic (especially Croatia) and in the SoS, and between Maltese professional fishers and recreational ones and shipping.

Concern for illegal fishing arose often while answering to different questions: for instance, while most fishers do consider MPAs as a useful tool to protect biodiversity and fish stocks they also strongly believe they are not efficient against illegal fishing, on the contrary, they often attract illegal fishing, both from recreational fishers and from poachers. Improved monitoring and control measures were thus considered necessary not only by researchers, but by most fishers too, especially in Malta and Croatia. The general perception is also that MPAs don't help reducing conflicts among users since they cause overcrowding of fishing activities in an area. The introduction of seasonal fisheries closures was considered the best approach both in the Adriatic and in the SoS. In the Adriatic, spatial closures were also recommended. The enforcement of current fisheries management measures was recommended in both areas (in particular stopping illegal fishing and introducing controls and bans on recreational fishing), while in the SoS increasing the minimum reference size for target species was also requested. Adriatic fishers were not very responsive to the issue of involvement in co-management, in fact the majority of them didn't answer the question. In the SoS, the majority of fishers stated not having being involved in co-management initiatives, however answers were similarly balanced between those who believed it important to involve the sector and were willing to be involved, and those that had the opposite opinion. In particular fishers from Malta wished for more involvement of their sector by the Department of Fisheries and Aquaculture in the definition of management measures.

Management goals and objectives

Objectives are very important part of management plan, however in long term perspective the planning should start not by definition of objectives, but with the vision definition. Vision is defining the long-term status, which should be reached followed by goals, objectives, targets and activities. Understanding the difference between the terms Vision, Goals, Objectives, Tasks – is key for planning and eventually for fulfilling the Vision.

Planning typically starts with a vision and a mission. Then managers develop a strategy for realizing the vision and mission; their success and progress in achieving vision and mission will be indicated by how well the underlying goals and objectives are achieved.
A vision statement usually describes some broad set of goals (for instance “healthy and diverse marine ecosystems through science-based conservation and management”, “marine environments that are resilient in the face of change”, etc.).
Goals are typically outcome statements, while objectives are very precise, time-based, and measurable actions that support the completion of goals. Goals and objectives are an essential element in planning and are a key referent points in many aspects of managing and controlling. The definition of the objectives should be very clear, logical, and precise and time bounded in order to make the proper assessment and achieve proper results, which could be later used for reassessment of management plan and self critique if the objectives are not reached.
Objectives must be SMART - Specific, Measurable, Achievable, Realistic, and Time-Bound (Doran, 1981). If objectives miss one of the SMART definitions, it is huge weakness for every strategic planning and assessments of results.

In setting MMAs for the two case study areas, the primary objectives are connected to the achievement of sustainability goals (MSY-based) for demersal fisheries through the protection of areas/habitats playing a key role for stock productivity (e.g. nurseries). Secondary objectives could be possibly based on development of regional identity, increase tourism, conservation of cultural heritage, creation of new attraction, possibilities for recreation, research on nature and conservation of landscape.

Management measures

Bio-economic models have been applied in WP3 to simulate the adoption of alternative management measures, e.g. alternative configurations of area closures and/or other technical measures, both on the main stocks and fleets. WP3 will also evaluate the possible effects of management measures on the redistribution of fishing effort, including small scale and recreational fisheries as well as the possible congestion of zones remaining fully open to all fisheries (e.g. increase in conflicts between fishermen and with other users of the sea). The alternative management scenarios tested in WP3 were also based on stakeholder’ preferences. The results arising from the questionnaire analysis were considered together with main perceptions and management suggestions arising from the introductory meetings, who have seen the participation of different stakeholders including professional fishers (mostly from trawl fishery) in Mazara del Vallo, Ancona, Split and Chioggia. A full description of the management measures suggested can be found in D 4.1.
Mazara del Vallo (trawlers, Strait of Sicily): Fishers agreed with respecting the fisheries restricted areas recently established in the northern side of the SoS, and provided information to identify essential fish habitat for the project target species in the southern side of the SoS,
Ancona (trawlers, central Adriatic) spatial and seasonal closures were supported by the fishers attending the meeting,
*Split (trawlers, central Adriatic)***:** stakeholders supported the enforcement of spatial measures on Jabuka Pit and of a permanent trawling ban in South Adriatic at depths over 500 m, in order

to protect adult spawners

Chioggia (bottom trawlers Northern Adriatic): According to participants, management of fisheries in the Northern Adriatic should have specific measures, different from other areas, due to its particular characteristics (very shallow, fishes reaching adult stage at small sizes). Additional spatial management measures are not considered appropriate in this area since nursery grounds of target species occur in coastal lagoons and within 3 miles from coast, where fishing is already banned.

Governance structure of a MMA network

The implementation of a MMA can only be ensured by defining a governance structure in which the roles and responsibilities related to the management, monitoring and control activities in the implementation are clearly defined.

The governance structure that is proposed for the two case study areas reflects the latest approaches in terms of co-management and responsive management (Sampedro et al 2017; ECOFISHMAN project) where stakeholders are widely involved in the management, control and monitoring phases (see D 4.2).

Figure 1 below illustrates the organs and stakeholders concerned, the roles and flow of information that will characterize the governance structure of a MMA.

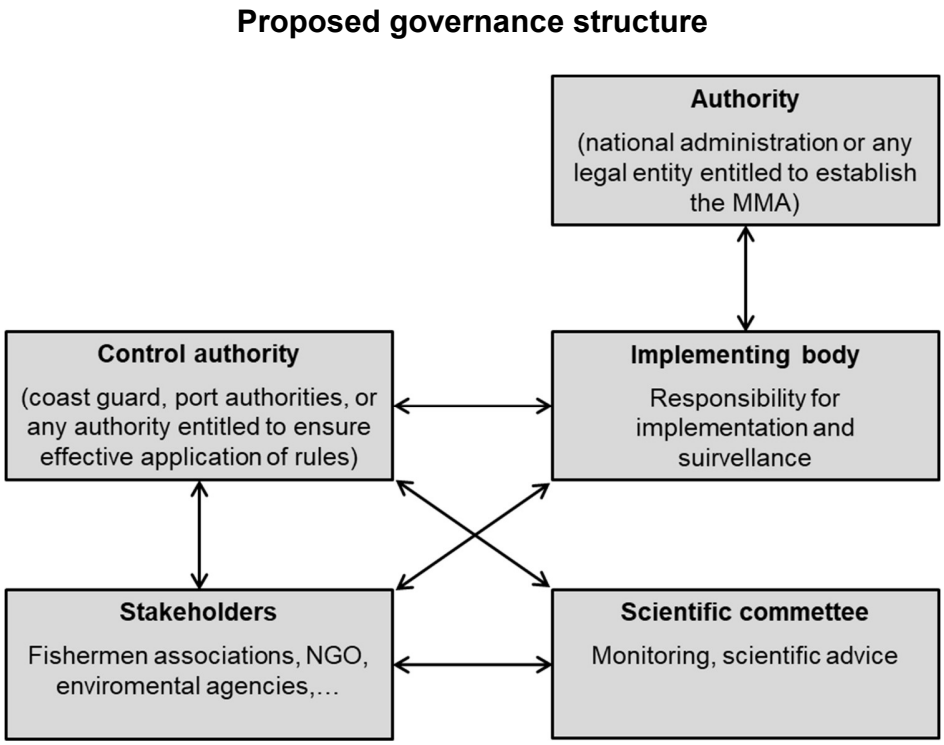

Fig.1 The governance structure proposed for the two case study areas (from Sampedro et al 2017; ECOFISHMAN project)

The *authority* is an organizational entity enacting authority in pursuit of the management objectives decided for a MMA. It represents the interests of the public, and it is ultimately responsible for the establishment, general strategy and the financial support of a MMA.
At the time of establishment of a MMA, an *Implementing Body* should be appointed (which may take the form of a Consortium and may be made up of representatives of the main recipients of the MMA, eg. category associations and other stakeholders). The Implementing Body is responsible for coordination, management and administration. The Implementing Body will play the role of filtering between the Authority and the recipients of the MMA, namely the fishermen, who will have to implement the measures and, to a certain extent, also monitor the actual application of the same measures. Fishermen, in fact, could be required to cooperate through supervisory actions (eg. sentinels) with the Coast Guard, whose task is to carry out controls on the area so that the measures provided for are respected.
A key role in the governance of the MMA will be the monitoring activities, aimed at verifying the results of the implementation of the proposed measures. In this respect, it is crucial to identify, at the same time of the establishment of the MMA, the responsible body (*Scientific Committee*) of the monitoring. The designated Scientific Committee will be responsible for monitoring the key indicators identified as being able to measure the achievement of the objectives and to produce progress reports. The main purpose of the Scientific Committee is to evaluate whether, or the extent to which, the outcome targets have been achieved.
The Governance structure of MMA network was presented and discussed during the II general meeting hold in Rome (7-8 May 2018); some changes were made in figure 1, with the addition of functional relationship among all the stakeholders involved in the management, control and monitoring phases.

Monitoring, control and surveillance

MCS can be summarized as follows:
Monitoring: continuous requirement for measurement of fishing characteristics and resource yields, which implies supervising and observing relevant activities with appropriate reporting;
Control: regulatory conditions under which the exploitation of resources may be conducted;
Surveillance: degree and types of observations required to maintain compliance with the regulatory control simposed on fishing activities (Flewwelling P., 2012).
A framework for monitoring of MMAs in the Adriatic Sea and the Strait of Sicily can be found in Deliverable 4.2. D 4.3 focuses on control and surveillance issues.

In its entirety, MCS is a key element in the MMAs enforcement which comprise a range of actions, legal steps and processes to counter non-compliant activities. In general, education improves appreciation of, and insight into, why regulatory measures are necessary.
As emphasised by Sumaila et al. (2006), the probability of detection is usually linked to the probability of non-compliant activities taking place. Therefore, low detection probability often encourages non-compliant activities. Equally, low deterrence enhances the likely profits of non-compliant activities. A MCS system for MMAs includes a regulating entry to and exit from such

areas for designating activities.
Since the actions required have relevant costs, they should be derived from clearly-identified objectives, most notably in respect to regulating, and/or monitoring, closed area access.
A key feedback element is the need for a robust compliance evaluation process to identify systemic MCS successes, opportunities, weaknesses and strengths. Compliance evaluation outcomes can then be used to formulate, or adapt, future management plans and regulatory provisions.
Selecting any particular MCS approach for MMAs requires careful consideration of a number of key factors. These include the followings:

- spatial and/or temporal constraints;
- the types of fleets/fisheries involved;
- the regulatory requirements of the measures being enforced;
- a stakeholder participatory approach defined;
- the types of "entry conditions", monitoring access and the possible forms of on-going 'surveillance' to determine activities being undertaken in a closed areas.
- the types of surveillance actions to be implemented to maintain compliance with the regulatory controls imposed on fishing activities

Monitoring plan

The overall policy goal of adopting a network of MMAs for fisheries purposes in EU marine waters is to substantially improve the exploitation of fish stocks toward the goals set by the

Common Fisheries Policy in term of biological and socio-economic sustainability, stakeholder inclusions and minimization of the impact on the ecosystem. Further objectives should be identified also taking into account the preferences of local stakeholders. In the case of the two study areas, North Adriatic and Strait of Sicily, the MMA networks will be designed to protect mainly the most important nursery areas of a set of target species and improve the productivity either of stocks or fishing fleets.
In this regard, the efficacy of the identified MMAs for reducing fishing mortality rates, protecting juvenile or undersized animals, and enhancing productivity depends by the following main aspects (see D 4.2):

(1) the degree of fish movement across closed-area boundaries (spillover effect),
(2) the spatial distribution and quantity of displaced fishing effort,
(3) the relative catchability (cpue) of the target stock(s) outside the closures,
(4) the level of protection afforded to undersized animals taken by the fishery,
(5) the effect on the overall sustainability of commercial stocks,
(6) the impact on the ecosystem,
(7) the socio-economic implications.

Other relevant aspects to be considered in a MMAs monitoring program are the spatial and temporal scale of data collection and analysis. This means defining the area to be monitored, the spatial and time resolution for the collection of the different types of data and finally the resolution of the outputs produced (e.g. indicators).
For each of the above mentioned factors the more suitable indicators were identified in D 4.2. They were selected also considering the type and amount of data that will be possible to gather in the field and the associated budget constrains (Table 1).

Table 1. Objectives, indicators and data of a MMAs network monitoring program. Data are provided at different time scales: *m: one month*, *q:quarter*, *y: year*. In bold the frequency of calculation of indicators

Monitoring objectives	**Indicators**	**Data**				
		Survey CPUE by age/size	Commercial CPUE by age/size by fleet segment	VMS/AIS	Catch of commercial fleets	Socio economic and governance variables
1. Spillover from MMAs	Temporal trend in cpue of target stocks by size/age class	***y***	***q***			
2. Fishing effort trend	Spatial trend			***m***		
	Temporal trend			***m***		
	Fleet size,					***y***
	Effort					***y***
	Capacity Physical Productivity (CFP)					***y***
	Vessel Physical Productivity (VFP),					***y***
	Days at Sea					***y***
3. Level of protection afforded to undersized specimens	Proportion of juveniles protected by the MMA network	***y***		***m***		
4. Fisheries sustainability	Indicator 3.1.1 MSFD: F/Fmsy of commercial stocks	***y***	***y***		***q***	
	Cpue of commercial by-catch species	***y***	***q***		***q***	
	Cpue of non-commercial species	**y**				

5. Ecosystem impact	Proportion of seabed significantly affected by trawling (Indicator 6.1.2 MSFD)			***q***		
	Proportion of selected species at the top of the food web (Criterion 4.2 MFSD)	***y***				
	Selaceans abundance (Criterion 4.3 MSFD: *Abundance / distribution of key trophic groups/species*)	***y***	***y***		***y***	
	Discard rate of target stocks		***q***			
6. Socio-economic sustainability	ROFTA					***y***
	GAV					***y***
	NEP					***y***
	Net Profit per vessel					***y***
	CR/BER					
	Landing (total and by vessel/day)					***y***
	Landing value (total and by vessel/day)					***y***
	Revenue (total and by vessel/day)					***y***
	Revenue per day					***y***
	Average market price of landings					***y***
	Fuel cost by vessel/day					***y***
	Employment					***y***
	Gross value added per FTEs					***y***
	Gross value added per vessel					***y***
	Average wages					***y***
	Days at sea					***y***
7. Governance	Amount of illegal fishing within the MMA			***q***		
	Violation of regulations (n. and types of infringments)					***q***

	Management costs and enforcement costs					*q*

6. Socio-economic sustainability	ROFTA	Socio-economic data analysis	3	DCF
	GAV			
	NEP			
	Net Profit per vessel			
	CR/BER			
	Landing (total and by vessel/day)			
	Landing value (total and by vessel/day)			
	Revenue (total and by vessel/day)			
	Revenue per day			
	Average market price of landings			
	Fuel cost by vessel/day			
	Employment			
	Gross value added per FTEs			
	Gross value added per vessel			
	Average wages			
7. Fishers commitment	Amount of illegal fishing within the MMA	VMS data analysis	1	DG PESCA - MIPAAF
	Violation of regulations (n. and types of infringments)		1	NATIONAL AUTHORITIES
	Management costs and enforcement costs		2	

Technical skills and human power required for MMAs monitoring

Monitoring in the two case study area requires specific skills in collection and analysis of

fisheries data. Skills, human power and source of raw data from the already existing monitoring programs required for the calculation of descriptors listed in table 1 are indicated in table 2.

Table 2. Skills, human power and source of raw data required for the calculation of each monitoring descriptor.

Monitoring objectives	Indicators	Skills and human power		Source of data
		Skills	Man / months	
1. Spillover from MMAs	Temporal trend in cpue of target stocks by size/age class	Time series analysis	2	MEDITS / SOLEMON
2. Track fishing effort displacement	Spatial trend	VMS data analysis	3	DG PESCA - MIPAAF
	Temporal trend			
3. Level of protection afforded to undersized specimens	Proportion of juveniles protected by the MMA network	Spatial analysis	3	MEDITS / SOLEMON
4. Fisheries sustainability	Indicator 3.1.1 MSFD: F/Fmsy of commercial stocks	Stock assessment	2	DCF
	Cpue of commercial by-catch species	Time series analysis	1	MEDITS / SOLEMON & DCF
	Cpue of non commercial species			
5. Ecosystem impact	Proportion of seabed significantly affected by trawling (Indicator 6.1.2 MSFD)	VMS data analysis	3	DG PESCA - MIPAAF
	Proportion of selected species at the top of the food web (Criterion 4.2 MFSD)	Time series analysis	3	MEDITS / SOLEMON /DCF

	Selaceans abundance (Criterion 4.3 MSFD: Abundance / distribution of key trophic groups/species)			
6. Socio-economic sustainability	ROFTA	Socio-economic data analysis	3	DCF
	GAV			
	NEP			
	Net Profit per vessel			
	CR/BER			
	Landing (total and by vessel/day)			
	Landing value (total and by vessel/day)			
	Revenue (total and by vessel/day)			
	Revenue per day			
	Average market price of landings			
	Fuel cost by vessel/day			
	Employment			
	Gross value added per FTEs			
	Gross value added per vessel			
	Average wages			
7. Fishers commitment	Amount of illegal fishing within the MMA	VMS data analysis	1	DG PESCA - MIPAAF
	Violation of regulations (n. and types of infringments)		1	NATIONAL AUTHORITIES
	Management costs and enforcement costs		2	

Control and surveillance plan

The roles and responsibilities related to the management, monitoring and control activities in the implementation are clearly defined and involved different stakeholders.
Figure 2 below illustrates the organs and stakeholders concerned, the roles and flow of information that will characterize the MSC in a participatory management system; in detail:

- Monitoring: involves the collection, measurement and analysis of data including catch, fishing effort, discards, socio-economic aspects; the final outcome of the monitoring activities is to verify the results of the implementation of the proposed measures (see D. 4.2). The designated Scientific Committee will be responsible for monitoring; fishers should collaborate with the Scientific Committee and be fully involved in data collection through sharing and providing data, using new monitoring technologies and tools and participating to data analysis and discussion of the results obtained.
- Control: the regulatory conditions under which the exploitation of the resource within the identified MMAs is conducted including penalties for non-compliance. Responsive Fisheries Management System establishes mechanisms to involve stakeholders in decision-making and in the implementation of the measures and, to a certain extent, also monitor the actual application of the same measures. Fishers, in fact, could be required to cooperate through supervisory actions (eg. sentinels) with the Coast Guard, whose task is to carry out controls on the area so that the measures provided for are respected.
- Surveillance: involves the regulation and supervision of fishing activity to ensure that national/international legislation and terms, conditions of access, and management measures are observed. The Implementing Body will be responsible for surveillance as well as coordination, management and administration; it should take the form of a Consortium and may be made up of representatives of the main recipients of the MMA, eg. category associations and other stakeholders.

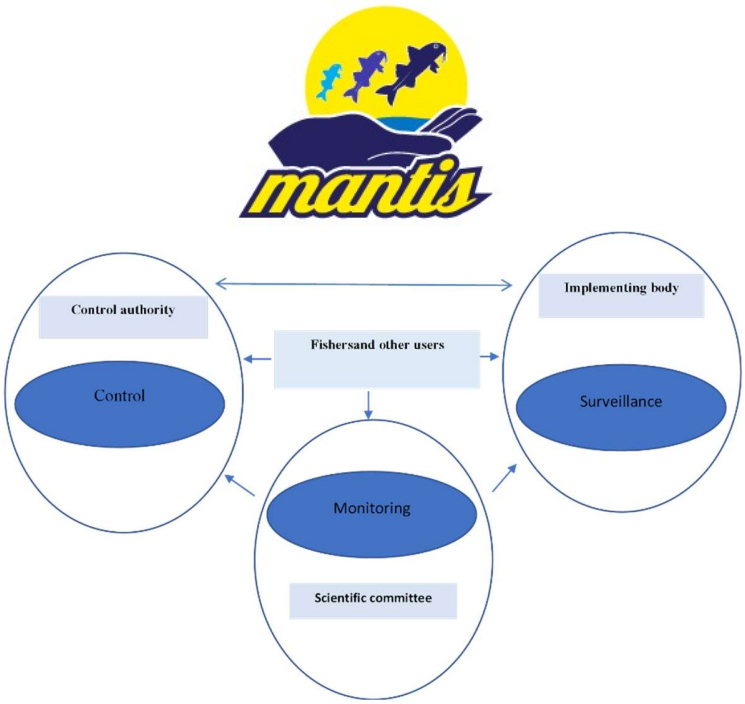

Fig. 2 – MSC in a participatory management system

Enhanced public participation in the fisheries management process brings a number of advantages as compared to a centralized and top-down system. Among these the two followings can be mentioned:
- Less costs for the development and implementation of MSC systems because costs stemming from public control are reduced;
- More compliance from stakeholders and therefore, more possibilities to achieve the established management goal.

Technological tools for control and surveillance of MMAs

One of the most powerful tools to deter illegal fishing activities in or around an MMA consists on the use of vessel monitoring devices and systems: e.g. global positioning systems (GPS), VMS, and AIS. VMS devices securely transmit the location of a fishing vessel during a fishing trip. AIS is more affordable, contributes to safe navigation, and the data are public. However vessel operators can turn off or tamper with AIS systems, but such “spoofing” behaviour at sea is detectable and can be a warning flag for illegal activity. Requiring all industrial fishing vessels as a condition of their fishing permit to have an installed and operating remote monitoring device such as VMS or AIS on board would aid enforcement of remote MMA requirements. For near-shore MMAs, enforcement officers may employ on-shore, line-of-sight surveillance methods or utilize at-sea enforcement vessels to detect violations.
Vessel monitoring data in combination with electronic logbooks can be used to identify the fishing grounds where the products landed by a given vessel have been caught (Russo et al., 2018).
The Copernicus Maritime Surveillance (CMS) service, implemented by EMSA, provides earth observation satellite images to support a better understanding and improved monitoring of activities at sea. The service is available to support authorised users in a wide range of

operational functions, including fisheries control, law enforcement, and marine environment monitoring. Fishing vessels are detected using two types of images: 1) SAR (Synthetic Aperture Radar) sensors use microwave frequencies to retrieve backscatter measurements from the detected surface below. By measuring the roughness of the sea surface, resulting images display features which stand out against the background; 2) Optical images can provide a wealth of information in different spectral bands. Optical radiometers cannot capture images during the night or in cloud cover conditions.
Remote Electronic Monitoring (REM) is a new method to monitor the catch directly on the fishing vessel. It uses several interlinked monitoring and observing apparatuses; 1) CCTV video cameras, to record catch and processing activity; 2) geographic position systems (GPS), to record vessel location; 3) hydraulic winch pressure sensors; and 4) drum revolution counters to determine when vessels' nets are in the water; instead, on-board PCs with linked, removable hard drives to record data . Such technology uses more than just CCTV cameras. This system is important to control all of the fishing activities occurring in a vessel. Video data files are prohibitively large to stream live, so gathered data is usually stored on a removable hard drive which is swapped over at suitable intervals, rather than sent via satellite. The imagery can then be used to obtain information on catch handling, discarding practices and catch composition; to gather scientific data; to verify self-reported information; or in monitoring for compliance with regulations.

Finally, Fishery and Oceanography Observing System (FOOS) have been recently adapted to fit specific research needs in terms of real time monitoring of fishing activities. This device transforms fishing vessels into monitoring systems able to gather a large range of environmental and fishery information (Carpi et al., 2015; Patti et al., 2016). These tools have been used by CNR both in the Adriatic Sea and in the Strait of Sicily on few fishing vessels to gather spatial data on their fishing activity. The FOOS was designed to be networked through satellite and/or General Packet Radio Service (GPRS) or Universal Mobile Telecommunications System (UMTS) modems depending on the distance from the coast and to be able to receive and transmit data in real time to a land-based station (Patti et al., 2016).

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