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Marine Ecosystem Services Assessment to Support Marine Management, from Theory to Practice

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While economic valuation of ecosystem services (ES) is widely acknowledged as a tool to support decision-making processes, studies have also shown that there exists a literature blindspot on the effective use of economic valuation (Laurans et al. 2013; Marcone and Mongruel 2014). The VALMER project seeks to bridge this gap between theory and practice by looking at how ecosystem services assessment (ESA) can support marine management and planning. Natural scientists, economists and marine environment managers from various institutions undertook ESAs in six pilot sites over the two sides of the Channel. The objectives of this paper are to share some results of two French ESAs, and to discuss issues and perspectives of ESAs from a marine management perspective. This paper is based on an oral communication given at the 4th conference on *Progress in Marine Conservation in Europe 2015*, organised by the German Federal Agency for Nature Conservation (BfN), in cooperation with the German Oceanographic Museum.

1 The VALMER Project

VALMER was an INTERREG IV-A France (Channel) – England project. It gathered eleven partners from September 2012 to March 2015, and aimed at trying to answer the following question: "To what extent can the marine ESA inform and contribute to a more efficient management and governance of the marine environment?" At the science-management interface, the results and lessons learnt from the VALMER project are significant. This paper does not pretend to be exhaustive; it will merely share and compare the experience of two French pilot sites, and will emphasise the importance of starting from the management context and features.

2 Marine Ecosystem Services

Ecosystem services are the benefits people derive from ecosystems. If the origins of the ES approach are to be found in the 1970s, with then important milestones in the 1990s – particularly with the Costanza et al. (1997) paper on the value of the world's natural capital, it is the Millennium Ecosystem Assessment (MA 2005), which popularised it (Mongruel et al. 2015).

A major output of the MA is the classification of ES into four categories, namely the provisioning services, the regulating services, the cultural services and the supporting services (that allow the delivery of all others). With some adaptation and after LIQUETE et al. (2013), the VALMER project's team established the following list (table 1):

Table 1: Classification of Marine and Coastal ES (Source: MONGRUEL et al. 2015)

	Marine ES	**Specific components**
Provisioning services	Food provision	Fishing activities (either commercial or subsistence fishing) and aquaculture
	Water storage and provision	Water use for desalination plants, industrial cooling processes or coastal aquaculture
	Biotic materials and biofuels	Medicinal, ornamental and other industrial resources (oil and fishmeal); biomass to produce energy
Regulation and maintenance services	Water purification	Treatment of human wastes through dilution, sedimentation, trapping or sequestration, etc.
	Air quality regulation	Absorption by vegetal or water bodies of air pollutants like particulate matter, ozone or sulphur dioxide
	Coastal protection	Natural defense of the coastal zone against inundation and erosion from waves, storms or sea level rise
	Climate regulation	Sequestration by the ocean of greenhouse and climate active gases
	Weather regulation	Influence of coastal vegetation and wetlands on air moisture or the formation of clouds
	Ocean nourishment	Natural cycling processes leading to the availability of nutrients in the seawater for the production of organic matter
	Life cycle maintenance	The maintenance of key habitats that act as nurseries, spawning areas or migratory routes
	Biological regulation	Control of fish pathogens, biological control on the spread of vector borne human diseases
Cultural services	Symbolic and aesthetic values	Contribution to local identity, value of charismatic habitats and species such as coral reefs or marine mammals
	Recreation and tourism	Coastal activities (bathing, snorkeling, scuba diving) and offshore activities (sailing, recreational fishing, whale watching)
	Cognitive effects	Inspiration for arts and applications, material for research and education, information and awareness

Given the diversity of marine ES, it appears necessary to select some of them to be further studied: on which criteria could this be done?

3 Tailoring the Ecosystem Services Assessment to the Needs of Managers: Implementing the Triage Approach

Pendleton et al. (2015) explain how a triage process can support the definition of the goal of an ESA and its scope, as well as the identification of the tools and methods which would appear the most suitable to carry out the assessment. The main aim is to improve the uptake and usefulness of ESAs, through a transparent, collective, and step-wise approach.

Step 1 (see Figure 1, Pendleton et al. (2015)) guides discussions about the aim of the ESA, the main issues to be considered and the scope of the assessment. Once the general aim is agreed upon, step 2 allows refining the scope of the ESA, by selecting some ES that are perceived as particularly relevant, due to their potential change in value, their sensitivity to management measures and their potential to react to wider drivers of change on which local management would have little influence. Only then the reflection on methods and tools is undertaken, with step 3. Again, a series of questions supports the selection of methods, starting from the identification of meaningful metrics and taking into consideration available means and resources to ensure the feasibility of the suggested methods and tools.

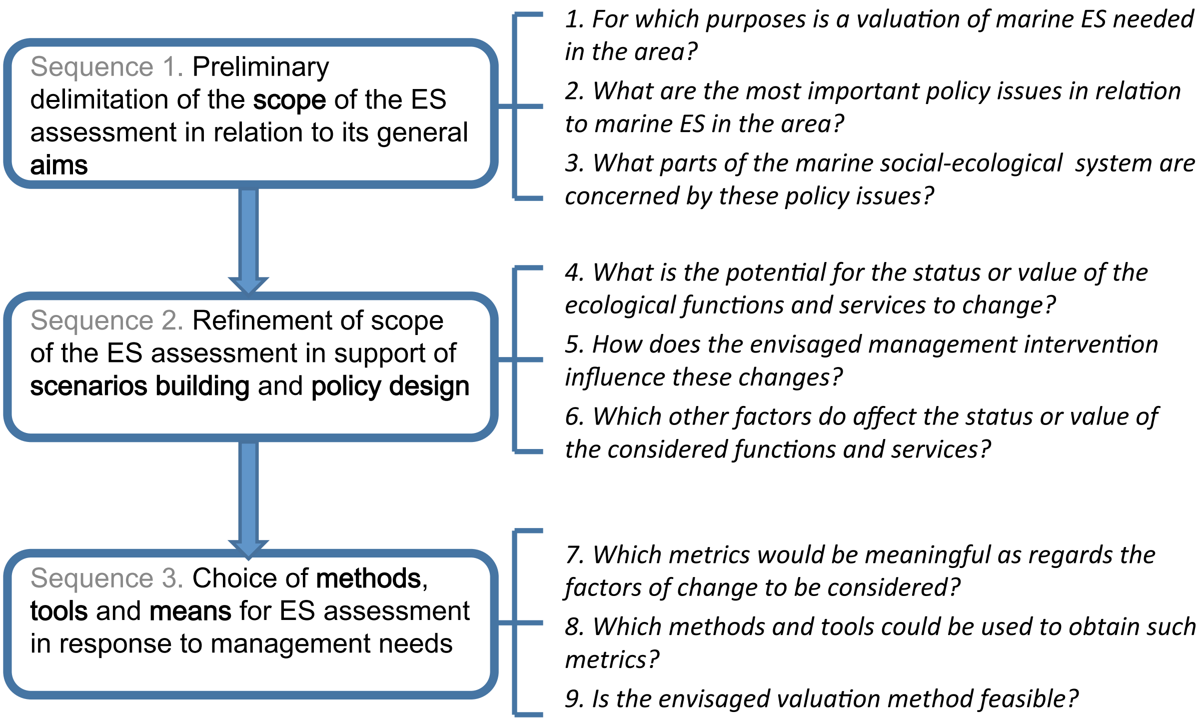

Figure 1: Triage process (Source: Pendleton et al., 2015)

As a result, the ESAs of the six VALMER pilot sites were very different from one another, with aims on improving knowledge, designing or comparing management options, raising awareness, and methods ranging from Bayesian belief networks, travel costs, choice experiment, to multi-criteria analyses and others. Nevertheless, a common feature was that almost all sites studied a bundle of ES.

Two contrasting French experiences are presented and discussed in the next part, the Parc naturel marin d'Iroise (PNMI) and the Golfe normand-breton (GNB), through the lenses of what the triage highlighted: the need to tailor the ESAs to the users' needs.

4 Two Contrasting Marine Ecosystem Services Assessments

4.1 ESA in the Parc naturel marin d'Iroise

This part mostly relies on Vanhoutte-Brunier et al. (2016).

4.1.1 Background

The PNMI was created in 2007. The management plan of the Park was adopted in 2010. This means the MPA is relatively well established, with defined long-term goals and means to reach them. A marine nature park is a multi-objectives type of marine protected area (MPA), with conservation goals as well as sustainable development ones.

In the PNMI, the Molène's archipelago hosts the widest field of brown macroalgae species (also called kelps) of the French coastal waters. This productive habitat is an essential shelter to many marine mammals, birds, fish, and algae species. Alongside this rich biodiversity, the *Laminaria digitata* and *Laminaria hyperborea* are exploited by about fifteen boats. This harvest represents up to 60 % of the national production. Moreover, there is a growing demand from the industrial sector, looking for alginates used in agribusiness and cosmetics. Thus, this *Laminaria* field embodies the tradeoffs that conservation and sustainable development trigger.

The rules regarding kelp harvesting are defined by the 'Algae Committee' which gathers representatives from kelp harvesters, State services, processing industries and a scientist. The decisions enter into force after having been validated by the regional Prefect. The PNMI has a responsibility on producing knowledge on the state of ecosystems and trying to conciliate development and conservation (Frangoudes & Garineaud 2015).

4.1.2 Objective of the ESA

Through the VALMER project, and implementing the triage approach, the PNMI team seized the opportunity to compare management options of kelp fields.

4.1.3 Methods

Through step 2 of the triage, the following ES delivered by kelp fields were scored as priorities:
i. provisioning services from kelp for industrial sectors (food, medicine, cosmetics) and commercial fisheries (abalone, fishes, crustaceans),
ii. support and regulation services linked to the maintenance of habitat for many commercial and emblematic species and
iii. cultural services for ecotourism and symbolic value of emblematic species and traditional activities.

The assessment was undertaken through a dynamic spatialised simulation model that encompasses
i. a kelp population model sensitive to environmental conditions,
ii. a bio-economic model describing kelp harvesting and
iii. a module assessing ecological functions and providing ES indicators.

In combination with a multicriteria grid to assess the effects of management on ES and scenarios to be implemented in the model, the ESA should enable the MPA managers to compare contrasting scenarios on the level of ES provided by kelp forests.

Stakeholders participated to the elaboration of the conceptual model, which describes how the socio-ecosystem works, what the interlinkages between the 'institutional framework', 'activities' and 'kelp ecosystem' are, as well as relationships within the three 'boxes'. They were then consulted along the development of the dynamic simulation model at critical stages, to validate some data or choices.

4.1.4 Some Results

Table 2 shows some results of the kelp fields' ESA: for each ES, the goal was to have state, supply and demand indicators. These results come from collected data and produced ones by the model.

Table 2: Results of the Initial Assessment of Kelp Ecosystem Services (Source: Vanhoutte-Brunier et al. 2016)

		State	**Potential supply**	**Actual supply**	**Demand**
Support & Regulation Service	Key habitat supporting: - strong biociversity - commercial species - emblematic species grey seal, bottle-nose dolphin, European shag	Total biomass: 510'000 tons MSFD & WFD	Life cycle maintenance capacity	No. of individuals: 130 35 531	MSFD & WFD
Provisioning Services	Kelp harvesting and alginates	Total biomass: 510'000 tons	Maximum sustainable harvest: 180'000 tons	Production: 52'000 tons CPUE: ~ 4.6 tons/hour	No. of kelp harvesters: 25 No. of months of activity: 23 Wage/min. wage: 2.7 Net return: 42'500€
	Commercial fisheries abalone, European lobster, seabass, pollock				
Cultural Services	Ecotourism (sealife watching) grey seal, bottle-nose dolphin, European shag	No. of individuals: 130 35 531		No. of individuals: 130 35 531	
	Ecotourism (sealife watching) grey seal, bottle-nose dolphin, European shag	Presence of sp. with recreational value: yes yes yes		No. of tourists: up to 3'000 per mesh	No. of tourists: up to 3'000 per mesh
	Local identity trough traditional activity (kelb harvesting)	Presence of kelb harvesting activity: yes		No. of cultural activities: 2 museums, 1 fest	No. of visitors in cultural events: 20'000

4.1.5 Challenges and Prospects

Main challenges have to do with daily management issues, such as relationships with the stakeholders on sensitive topics – 2014 had been a difficult year for the kelp harvesters due to several exceptional storms. Timing was a major constraint, and did not allow supporting the decision-making process for the 2015 harvesting rules: instead, it enables specifying some rules which have been already agreed upon, or testing effects of some of them (e.g.: quotas). Eventually, the construction of the model was as inclusive as possible but stays a very technical process, developed by actors not totally endowed with powers on the definition of rules. Confidence in the model had to be sought and built to make the model legitimate. Beyond the dynamic simulation model, the VALMER project has provided through the ES approach a framework for discussion, allowing stakeholders to enlarge their view of the system functioning and related issues. Testing scenarios showed the interest in implementing conservation measures, even strong ones: this is very useful to the management team. Finally, the ESA has the potential to support a mid-term evaluation and/or a revision of the PNMI's management plan, which lasts until 2025.

4.2 ESA in the Golfe Normand-Breton

This part is mostly based on Dedieu & Morisseau (2015); Morisseau et al. (2015a), Morisseau et al. (2015b).

4.2.1 Background

The GNB covers 6,300 km², with bays, vast shores, harbours, numerous islands, rocky, muddy and sandy bottoms. Marine habitats are very diverse, and uses too. Indeed, there are fishing activities, shellfish culture, recreational activities, tourism and extraction of aggregates, as well as new developments such as aquaculture and offshore windfarms. Conflicts over the use of the marine environment exist and might become more important in the future. There are different MPAs in the GNB, but the whole zone is a proposed marine nature park, which would have the means to consider environmental protection in relation to the diversity and trends of maritime activities, at a relevant scale. Being a proposed MPA implies that there is a team in charge of improving knowledge about ecosystems, uses and cultural elements, and of constructing a collective – with all stakeholders – strategic vision for this area, while waiting for a governmental decision to create the marine nature park. Currently, the GNB does not have a management plan, or governance bodies, in contrast with the PNMI situation described in 4.1.

4.2.2 Objective of the ESA

The goals of the ESA in the GNB were to i/ draw an initial diagnosis of ES delivered by all benthic habitats and ii/ anticipate future changes, while maintaining a common culture with stakeholders about the issues and prospects for the area. They result from the management features of the GNB: the need to improve global knowledge before targeting specific stakes, and the need to continue developing a collective dynamic to prepare the future discussions and decisions involving the stakeholders.

4.2.3 Methods

In order to draw an initial diagnosis of ES produced by benthic habitats, four approaches were undertaken.

Substantial work was carried out in order to analyse the links between the benthic habitats and ecological functions on one side, and benthic habitats and ES on the other side. Methods included literature review, cartographic information and expert judgment. Various tools and methodologies were then developed in order to characterise the current state of some of the marine ES.

Through historic and economic analysis, a diagnosis about the ecosystems and stocks that support the fishing activity in the GNB was made. Firstly, through 'depletion corrected average catch' models, sustainable levels of fishing were calculated for 9 species of the GNB. Secondly, the dependence of fleets to the GNB area and to species was studied, in order to define which ones were the most vulnerable to ecological and economic changes.

An ecosystem-based activity accounting was undertaken, so as to link the efforts made by society to protect ecological processes that allow the production of ES, and the benefits society derive from these ES, with accounting indicators. Looking at these accounting indicators together with biophysical ones related to the state of the ES should enable to know if the monetary value of production is sustainable (Martin et al. 2015).

To improve knowledge on the effects of cumulative pressures and their potential impacts on the level of ES, modules of the InVest model (see www.naturalcapitalproject.org/invest/) have been used. Three steps were pursued to quantify and map cumulative risks:

i. mapping pressures coming from human activities;
ii. mapping habitats and
iii. through expert judgment, moving from a level of pressure to a risk of impact (Cabral et al. 2014).

In parallel to these 4 approaches, a participative scenario-building exercise was undertaken so as to co-construct possible futures about the level of two ES (fish provisioning from open-seas and recreational activities at the foreshore) in relation with general economic trends and the state of marine waters. Workshops gathering the VALMER team project and stakeholders were carried out over a year to this effect.

4.2.4 Some Results

The ecological approach produced matrices on habitats-functions and on habitat-services in the GNB, as well as the most recent and exhaustive habitats mapping of the area (Figure 2).

Among the findings of the focus on fishing, are the levels of sustainable fishing for 9 species, and the evidence that while some were able to recover after a collapse due to overexploitation (e.g.: scallops), others are still not recovering, such as clams. Of the 617 boats registered within the GNB area in 2012, 408 spent more than 50 % of their time in the GNB. Dependencies on species are available in Morisseau et al. (2015b).

The ecosystem-based activity accounting showed that the means society devotes to maintaining ES in the GNB are up to 125,000 EUR, with a major part of this budget (112,000) dedicated to sewage water treatment. This finding questions allocation of efforts. Results are shown in Morisseau et al. (2015b).

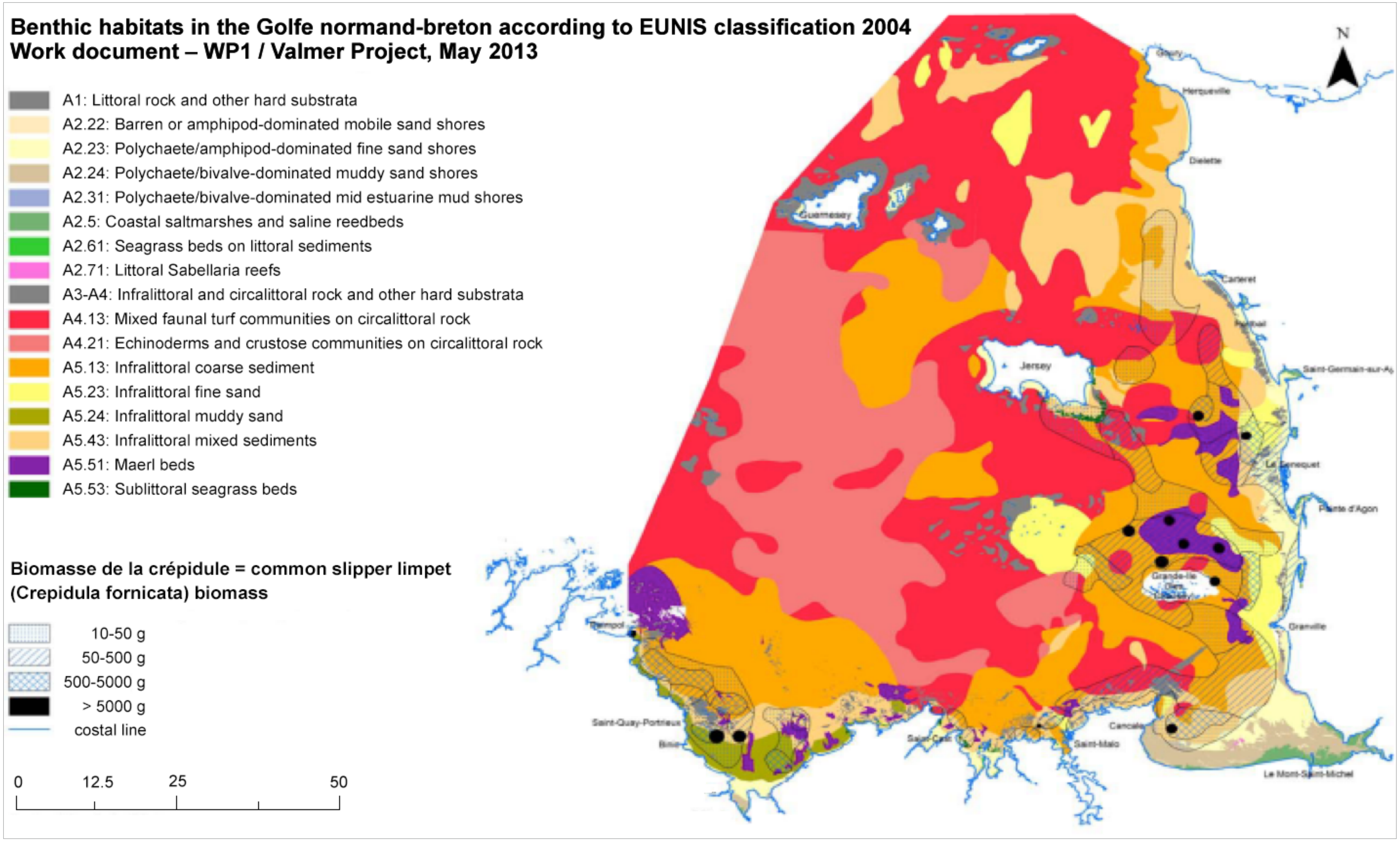

Figure 2: Benthic Habitats of the GNB (Source: Schoenn, 2013)

A map of the risks of cumulative impacts for benthic habitats of the GNB was produced andtells us that risks are more important next to ports and by the coast – where most activities are concentrated. Also, maps representing the potential capacities of habitats to deliver ES were realised, showing for example that cultural services are more intense by the coast – related to the number of visitors (Morisseau et al. 2015b).

Results from the scenario-building exercise are described in Dedieu & Morisseau, (2015b), and the relationships between the scenarios and the ESA are analysed in Morisseau et al. (2016). Basically, although the two processes were led separately and simultaneously, bridges were built towards the end of the project, by focusing on specific ES (e.g.: on the provisioning of shellfish).

4.2.5 Challenges and Prospects

The diversity of methods and tools deployed caused certain difficulties in the GNB, which makes this case study particularly interesting. There was indeed a challenge to develop or strengthen the links between the four approaches and the scenarios, so as to make a coherent story useful to managers.

VALMER gathered, produced and organised lots of information about ecosystems and ecosystems services in the GNB, a broad overview that should be very helpful to the elaboration of a management plan once a marine nature park would be created.

5. Conclusion

If challenges regarding these two ESAs lie in scientific and technical developments (e.g.: dealing with uncertainties, with lack of knowledge on the links between marine ecological functions and services), the choice has been made here to deliver feedback from a marine management point of view. In both cases, the necessity and relevance of involving the stakeholders was highlighted, knowing that this requires significant time and educational effort. The two ESAs followed very different paths, accordingly to their respective contexts. However, they both improved knowledge on ES and shaped a framework for discussions, beyond their first goals. This is also very important from a management standpoint.

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