Gulf of Lion case study – France and Spain: Planning the offshore gulf of Lion in regards with ecosystems

Task 2.2.2: Knowledge about interactions between Mediterranean ecosystems and maritime uses, with a specific focus on windfarm development in the Gulf of Lion area

FEM

OFB & IEO

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DISCLAIMER

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Public document

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Final report

Introduction

Co-funded by the European Commission and the Directorate General for Maritime Affairs and Fisheries (DG MARE), the European MSP-MED project (*Towards the operational implementation of MSP in our common Mediterranean Sea*; 2020-2022) supports the development of Maritime Spatial Planning (MSP)[1] in six EU Member States in the Mediterranean Sea (Spain, France, Greece, Italy, Malta, and Slovenia).

The project has two main objectives:

- support the implementation of national maritime spatial plans in the Member States;
- promote international cooperation in the Mediterranean basin to facilitate the implementation of MSP and to support coherent and coordinated planning.

Context

Work Package 2.2, dedicated to support Member States in the implementation of MSP, aims to provide a common and updated knowledge of the ecological stakes of the Gulf of Lion and their interactions with human activities. According to the importance of conducting a coordinated and coherent transboundary MSP process, the **Gulf of Lion case study** is being conducted by the French Office of Biodiversity (*Office Français de la Biodiversité* - OFB) and the Spanish Institute of Oceanography (*Instituto Español de Oceanografía* – IEO-CSIC) in partnership with the French Institute for the Energetic transition (*France Énergies Marines* – FEM), with three main objectives:

- Task 2.2.1 (OFB): To build and promote a global view of ecological stakes and their evaluation in the Gulf of Lion, especially related to cetaceans, sea turtles, seabirds and deep habitats[2];
- Task 2.2.2 (FEM): **To provide knowledge about interactions between Mediterranean ecosystems and maritime uses, with a specific focus on windfarm development in the Gulf of Lion area;**
- Task 2.2.3 (IEO-CSIC): To assess the effects of underwater noise pollution caused by intense activities, such as maritime transport and offshore fishing, on the pelagic component and especially cetacean species[3].

Objectives

This report presents all the work carried out under the task 2.2.2 "*Provide knowledge about interactions between Mediterranean ecosystems and maritime uses, with a specific focus on windfarm development in the Gulf of Lion area*" by FEM in collaboration with the OFB and the IEO-CSIC.

For this purpose, a collaborative work was carried out with the scientific and technical community through a series of technical meetings and interviews. While the main objective was **to provide knowledge on the interactions between**

[1] Since 2014, EU Directive 2014/89/EU establishes a framework for Member States' maritime spatial planning (MSP) by 2021.
[2] Assali C., & al., (2022): Knowledge synthesis about ecological stakes related to seabirds, marine mammals, sea turtles and deep habitats of canyons. EU Project Grant N°EASME/887390/MSPMED/EMFF-MSP-2019, 52 p + annexes
[3] Bou Cabo M., & al., (2022): Underwater noise studies in the Gulf of Lion region. Anthropogenic contributions to underwater noise due to maritime traffic and offshore windfarm operation. Deliverable 9 of the MSPMED project (887390 – MSPMED – EMFF-MSP-2019).47 pp

the marine ecosystems of the Gulf of Lion and the development of offshore floating windfarms, it was also entrusted to:

- Adapt the first steps of a method for study the cumulative effects on the Mediterranean Sea context and on offshore floating windfarms technologies in order to (i) benefit from feedback on the method's implementation and (ii) propose the basis for a subsequent implementation;

- Highlight the gaps of knowledge regarding the functioning of ecosystems and the risk of interaction;

- Expand the network of scientific experts on a cross-border scale;

- Encourage transboundary cooperation on the study, analysis and monitoring of the impacts of offshore floating windfarms.

Contents

Part 1 presents some background information on the Gulf of Lion area and on the development of offshore floating windfarms in the French area of the Gulf of Lion.

Part 2 details the method implemented and the tools used. The evolutions and adaptations of the method made during this work and their justifications are also presented here.

Part 3 presents the results and the associated limits link to the approach used in the MSP-MED project.

Finally, the fourth and last part highlights the main proposals for the evolution of the method and all the recommendations resulting from the work carried out with the experts to improve the consideration of the whole ecosystem in the study of interactions, in the actual context of development of offshore floating windfarms in the Mediterranean Sea.

1 Background

1.1 Gulf of Lion case study

The Gulf of Lion is a sub-system of the Mediterranean Sea, located between *Cap Creus* in the Spanish border and *Cap Croisette* in the south of Marseille (Monaco A., & al., 2009; Ulses C., 2005). It is characterized by a singular topography and hydrological regime governed in part by meteorological conditions. Its continental shelf extends over an area of approximately 14.000 km² and can extend up to 80 km from the coast. The continental shelf of the Gulf of Lion is low depth and bordered by a steep slope that sinks down to the plain of the Balearic Basin at a depth of 2.500 meters. This border between the continental shelf and the slope is regularly incised by numerous submarine canyons (Ulses C., 2005). Widely open to a deep basin, the Gulf of Lion shelf can be defined as a buffer zone between the coastal area and the deep ocean (Estournel C., & al., 2009). Like the rest of the Mediterranean Sea, the Gulf of Lion is subject to tidal currents of low amplitude. Oceanic circulation and sediment transport are largely influenced by winds, waves, and fluvial inputs (Ulses C., 2005). The chosen study area in MSP-MED corresponds with a quite large definition of the Gulf of Lion (fig. 1).

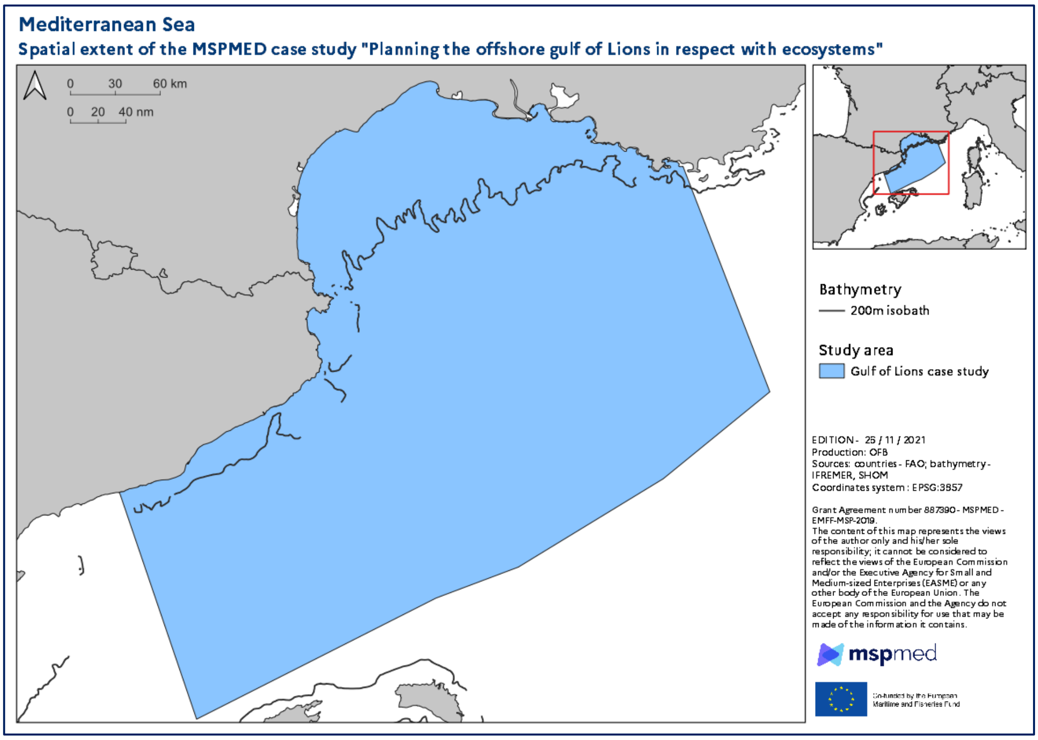

Figure 1: Spatial extent of the MSP-MED case study “Planning the offshore Gulf of Lion in respect with ecosystems” © OFB

1.2 Offshore floating windfarms in the Gulf of Lion

Several offshore floating windfarms are already deployed at sea for pre-commercial test or demonstration phases. The development of offshore floating windfarms is relatively recent and few case studies have been documented in France and Europe (Hywind Scotland[4], SEM-REV[5]). These technologies are designed for bathymetric constraints for average depths between 50 and 200 meters.

[4] http://marine.gov.scot/datafiles/lot/hywind/Environmental_Statement/Environmental_Statement.pdf

[5] https://sem-rev.ec-nantes.fr

1.2.1 Offshore floating windfarms technologies

Whether they are fixed or floated, wind turbines are all made with an aerial part which transformed the mechanical energy of the wind into electrical energy. They have three blades facing the wind and rotating around a horizontal axis (SER., & FEE., 2018).

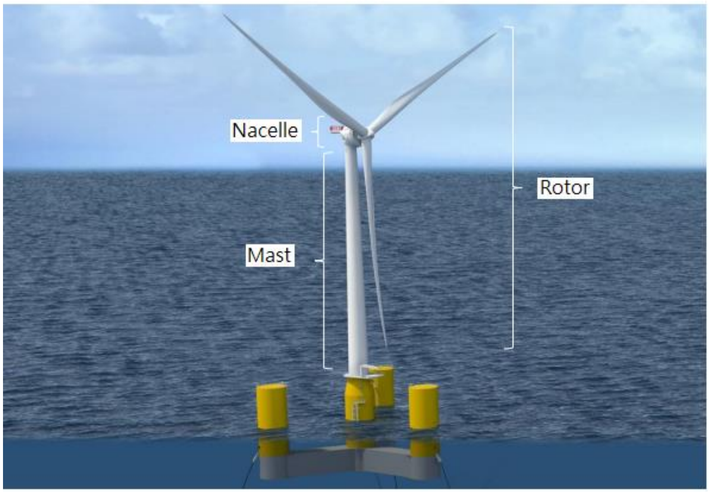

Figure 2: Illustration of the offshore windfarm Haliade™ 150 © GE/Naval Energies

This **aerial structure** is made of three main elements (fig. 2):

- A mast (held at sea by a floating system in the case of offshore floating windfarms);

- A nacelle containing the structural elements and electromechanical components (generator, etc.);

- A rotor with 3 blades fixed on a hub (SER., & FEE., 2018).

In the case of offshore floating windfarms, the wind turbines are supported on floats anchored on the seabed by lines. There are three main categories of **floating systems** (fig. 3):

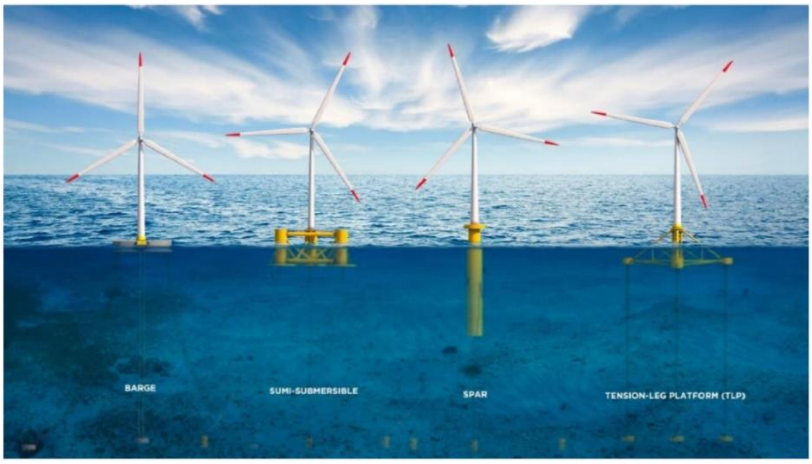

Figure 3: Illustration of the different categories of floating infrastructures © WindEurope

- The **semi-submersible platforms** and **barges**: The float is stabilized on the surface of the water by its shape (in the case of the barge) or by a set of submerged volumes (in the case of the semi-submersible platform). These infrastructures are often heavy and large to ensure the stability of the float with a shallow draught. A system of anchor lines is used to keep the whole in position (Defingou & al., 2019);
- The **Tension-Leg Platform** (TLP): The float is held below the water surface by an anchoring system that pulls it down to the bottom and ensures its stability (Defingou & al., 2019). The vertical anchoring system allows the infrastructure to be maintained on site but it is subject to high physical stresses due to the pre-tension of the lines and the drifting effort (SER & FEE., 2018);
- The **Single Point Anchor Reservoir** (SPAR): Often cylindrical, the float is immersed in a large height of water and stabilized by its weight (lower part of the float is weighted). A simple anchor line is used to hold the

structure in place (Defingou & al., 2019). This type of infrastructure is only possible in depths greater than 100 meters (SER., & FEE., 2018).

Except the TLP which anchors the float directly into the ground (Taut-leg), the anchor lines are not tensioned (Defingou & al., 2019) and can be catenary or semi-tensioned (semi-taut) (fig. 4).

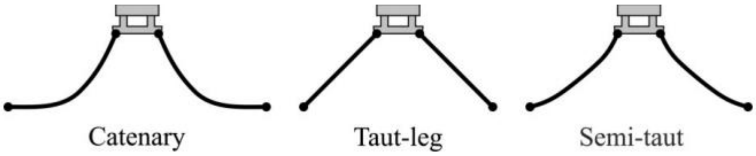

Figure 4: Illustration of the different categories of anchoring © ASME

Different types of materials can be used for these **anchor lines**: steel link chains, synthetic fibres (polyester or nylon) or steel cables. Usually, these anchor lines consist of two successive segments: a **synthetic fibre** that runs through the entire water column and a **weighted chain** that stays on the bottom. The first portion of chain provides the link between the float and the weighted chain, which is itself attached to the ground anchoring system (SER., & FEE., 2018). The nature of the seabed and the required holding capacity will condition the use of a particular type of **anchor**: burial anchor, gravity anchor (mostly used for semi-submersible platforms and barges), suction piles[6] (used for TLP models) and driven piles for fixed infrastructure (fig. 5) (Defingou & al., 2019).

Figure 5: Illustration of the different types of anchors. From left to right: Burial anchor © Vryhof, Gravity anchor © Saipem, Suction piles © Actéon, Pile driver © Menck AG

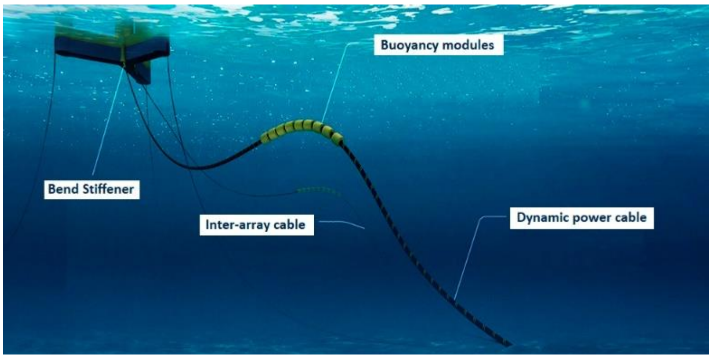

Figure 6: Illustration of the inter-array cable or dynamic power cable and its buoyancy modules and bend stiffener (stiffener located at the connection to the floating system) © RTE

The wind turbines are connected to each other by a set of **inter-array cables**, also called "**dynamic power cables**". These cables transport the energy produced by the wind turbines to the electrical substation, which is itself connected to the electrical grid by a submarine cable and then underground (onshore connection) (Defingou & al., 2019). These cables also contain the optical fibres needed to transmit information (production data, alerts, etc.). A metal frame protects the cable from various shocks and abrasions and its characteristic S-shape is provided by **buoyancy modules** (fig. 6). This limits the efforts on the cable caused by float movements. While the first part of the dynamic power cable passes through the entire water column, the second part of the cable is deposited on the seabed. The junction area with the seabed is protected by a protective sleeve (SER., & FEE., 2018).

Cables providing the submarine link between the offshore production area (electrical substation) and the onshore connection can be **buried** (buried in a trench previously drilled in the seabed using a plough, a water injection plough -

[6] According to the definition of the Renewable Energy Union (SER, Syndicats des Énergies Renouvelables) and France Wind Energy (FEE, France Énergies Éoliennes): Suction piles consist of a metal cylinder open at the bottom and closed at the top installed on the seabed thanks to a pump system that creates an under pressure (SER., & FEE., 2018).

soft seabed - or a trencher - hard seabed) or covered with **external protection** to reduce the risk of damage (riprap, concrete mats, protective shells, etc.) (fig. 7).

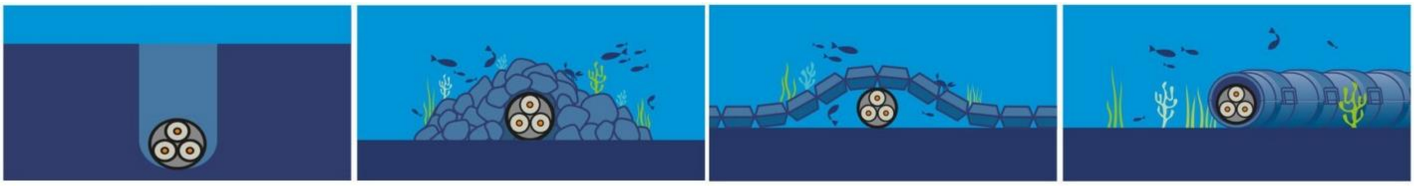

Figure 7: Illustration of the different type of cable protection. From left to right: Buried, Riprap, Concrete mats, and Protective shells © RTE

Finally, the offshore electrical substation raises the voltage of the energy produced by the offshore floating windfarms so that it can be injected into the onshore electrical network (with the submarine cable). This substation also allows the transmission of all necessary information for the proper functioning of the offshore windfarms (meteorological data, site safety, wind turbines functioning, etc.). It is based on a fixed structure, and it is generally located closer to the coast (fig. 8).

Figure 8: Illustration of the offshore electrical substation of Westermost Rough (England) © Chantier de l'Atlantique

1.2.2 Offshore floating windfarms projects in the Gulf of Lion

In 2015, France is committed to a program for the development of offshore floating windfarms through the Energy Transition Law for Green Growth and initiated the development of pilot offshore floating windfarms. 3 projects have been proposed in the Mediterranean Sea (fig. 9):

- EOLMED next to *Gruissan* (4 wind-turbines – commissioning planned for 2023);
- EFGL next to *Le Barcarès* and *Leucate* (3 wind-turbines – commissioning planned for 2023);
- PGL next to *Port-Saint-Louis-du-Rhône* (3 wind-turbines – commissioning planned for 2023).

In 2017, France adopted a Strategy for the Sea and the Coastline which sets out its ambitions for the development of offshore renewable energy (ORE) in France and in the Mediterranean Sea. Under the auspices of the specialized "floating windfarms" commission of the Maritime Council of Mediterranean Coast[7] and in consultation with local stakeholders, 4 areas suitable for the development of **commercial offshore floating windfarms (COFW)** were proposed and integrated into the MSP through the maritime spatial plans (called strategic document or DSF in France). After 6-month of public debate (July-Oct 2021), 3 areas have been selected for the development of the 2 COFW planned by the French State in the Mediterranean Sea (fig. 9):

- Area 1: area selected for the first COFW (area of 296 km²);
- Area 2: area selected for the second COFW (area of 312 km²);
- Area 3: optional area selected for the second COFW (area of 364 km²).

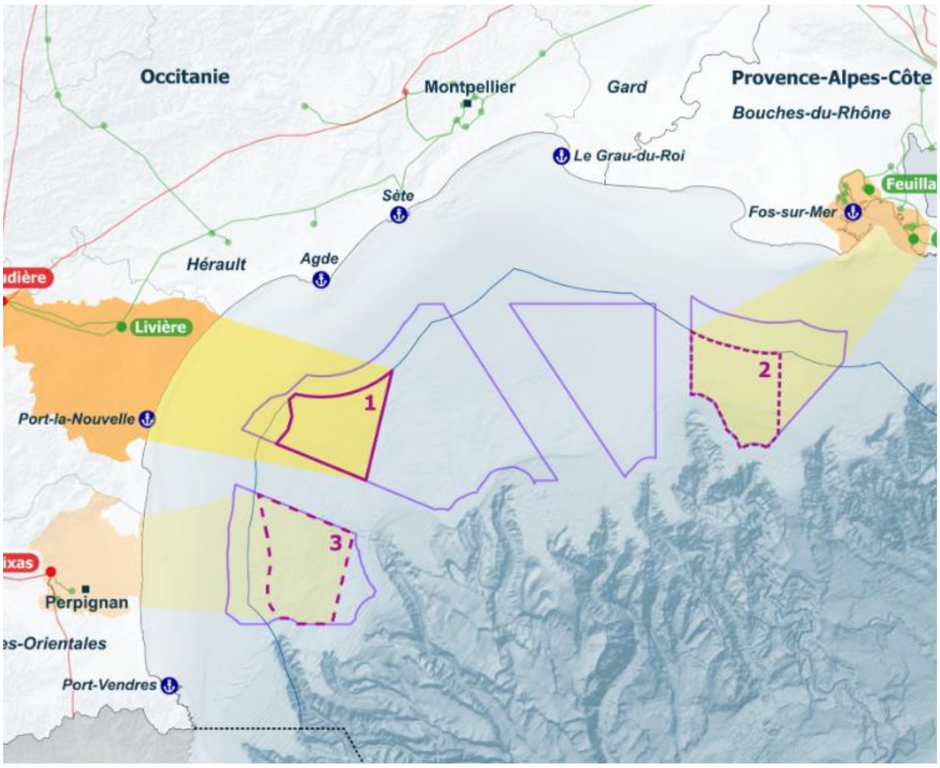

Figure 9: Map of the 3 areas selected for the development of two commercial offshore floating windfarms in the Mediterranean Sea © Ministère de la transition écologique

These areas have similar characteristics of depth (60 to 120 meters) (Débat public., 2021). Today, although there is information on the size of the **pilot offshore floating windfarms**, the types of floats and technologies (power of the wind turbines, etc.) that will be deployed in these **commercial offshore floating windfarms** are still unknown. Therefore, the number of infrastructures and their footprint can only be estimated (table 1).

It should be noted that the two planned **commercial offshore floating windfarms** aim at an initial energy power of 250 MW each, before the extension to 500 MW. The number of offshore floating infrastructures will, therefore, be determined according to this first objective of 250 MW and will depend on the power of the wind-turbines that will be implemented. In France, the power of the wind-turbines planned for the commercial offshore fixed windfarms (in the Channel Sea – Normandy and Brittany) varies between 6 and 8 MW[8]. However, in France and on a global scale, technologies are constantly evolving, and the energy power of wind-turbines is tending to increase. For example, this

[7] Maritime Council is a consultation body in charge of use, development, protection and enhancement of the coastline and sea. It is composed of representatives of the government, local authorities, public establishment, coastal and maritime professionals, civil society and environmental protection associations.
[8] https://www.ecologie.gouv.fr/eolien-en-mer-0#scroll-nav__3

is the case of the Haliade-X wind turbine[9], which can provide up to 12 MW, suggesting that the final number of wind-turbines implemented may be decreased link to current estimations (Débat public., 2021).

		Offshore floating windfarms projects in the Gulf of Lion					
		Pilot offshore floating windfarms			Commercial offshore floating windfarms		
		EOLMED	EFGL	PGL	Area 1	Area 2	Area 3
Area		Not applicable			296 km²	312 km²	364 km²
Hold		8.15 km²	6.17 km²	Unknown	Depending on the energy power of the wind-turbines, probably between 50 (commercial park) and 100 km² (extension)		
Depth		60 m	70 m	Between 95 and 100 m	60 to 120 m	65 to 120 m	75 to 105 m
Distance from the coast		18 km	16 km	17 km	Approx. 50 km		
Number of wind-turbines		4	3	3	Depending on the energy power of the wind-turbines		
Floats	Type	Barges	Semi-submersible platforms	TLP	Unknown		
	Description	Barge with a square section open in the center and extended by a damping skirt to limit the sea movements	Platform with 3 cylindrical columns, including for two of them a ballast system that ensures stability	Triangular structure linking 3 immersed cylinders held vertically by a TLP anchor			
	Size (L x l)	~ 43 x 43 m	~ 95 x 80 m	~ 80 x 80 m	Unknown		
	Height	8 m underwater and 16 m emerged	10 m underwater and 14 m emerged	25 m underwater and 15 m emerged	Unknown		
Anchoring	Number of lines	8 lines/floats	3 lines/floats	3 lines/floats	Unknown		
	Maximum anchor radius	600 m toward the coast + 1430 m toward the sea	600 m	Not applicable	Unknown		
Inter wind-turbines distance		1.3 km	750 m	900 m	Approx. 1 to 1.5 km		
Wind-turbines (approx.)	Diameter	145 m			Unknown		
	Height of the mast	100 m			Unknown		
	Total height	180 m (mast + blades)			Unknown		
	Blade length	70 to 75 m			Unknown		

Table 1: Synthesis of characteristics and dimensioning of offshore floating windfarms projects (pilot and commercial) in the Gulf of Lion © Débat public., 2021; EFGL., 2018; EOLMED., 2018; website of EFGL[10] and PGL[11] projects; website of French ministry of ecological transition[12]

[9] https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine
[10] https://info-efgl.fr/
[11] https://www.provencegrandlarge.fr/
[12] https://www.eoliennesenmer.fr/facades-maritimes-en-france/facade-mediterranee/deux-projets-en-mediterranee

2 Materials and method

2.1 Material

The assessment of interactions between *"marine ecosystems" vs. "offshore floating windfarms"* relies on scientific knowledge and expertise. The method implemented in MSP-MED project is based on the establishment of working groups. Several technical meetings were organized jointly for tasks 2.2.1 and 2.2.2 that were carried out between June and December 2021. All the technical meetings were conducted online. To facilitate the exchange and the collection of information, the online collaborative tool named "MURAL" was used[13]. This is a virtual tool that facilitates the organization and compilation of information from brainstorming. With no limits with respect to the number of participants, MURAL made it possible to carry out online post-its technical meetings where each participant was free to contribute to the technical meeting with post-it notes, in addition to speaking.

2.2 Methodological framework

The method implemented in the MSP-MED task 2.2.2 is based on a method for assessing the cumulative effects of activities at sea, presented in Brignon & al., (2022). This methodological approach was developed in 2018 by a national working group (bringing together French public or semi-public research institutes and agencies, academics and public researchers for each component of the marine ecosystem and pressure) to assess the cumulative impacts of pressures generated by human activities on marine ecosystems. The approach includes the consideration of offshore windfarms and all human activities which will, by cumulative effect, increase the pressures generated by the offshore windfarms at several scales (local and regional). This working group, called WG ECUME, applied this method to the assessment of two offshore fixed windfarms projects in France (Normandy): Fécamp and Courseulles-sur-Mer in the Eastern Channel.

Based on common methodological standards for impact assessments, the methodological framework proposed by Brignon & al., (2022) is divided into 5 phases, of which only the first 2 have been implemented in the MSP-MED project (fig. 10):

- Objectives and scope;
- Preliminary analysis;
- Scenarios definition;
- Scenarios assessment;
- Scenarios comparison with the Good Environmental Status (GES).

[13] Link to MURAL website: https://www.mural.co/

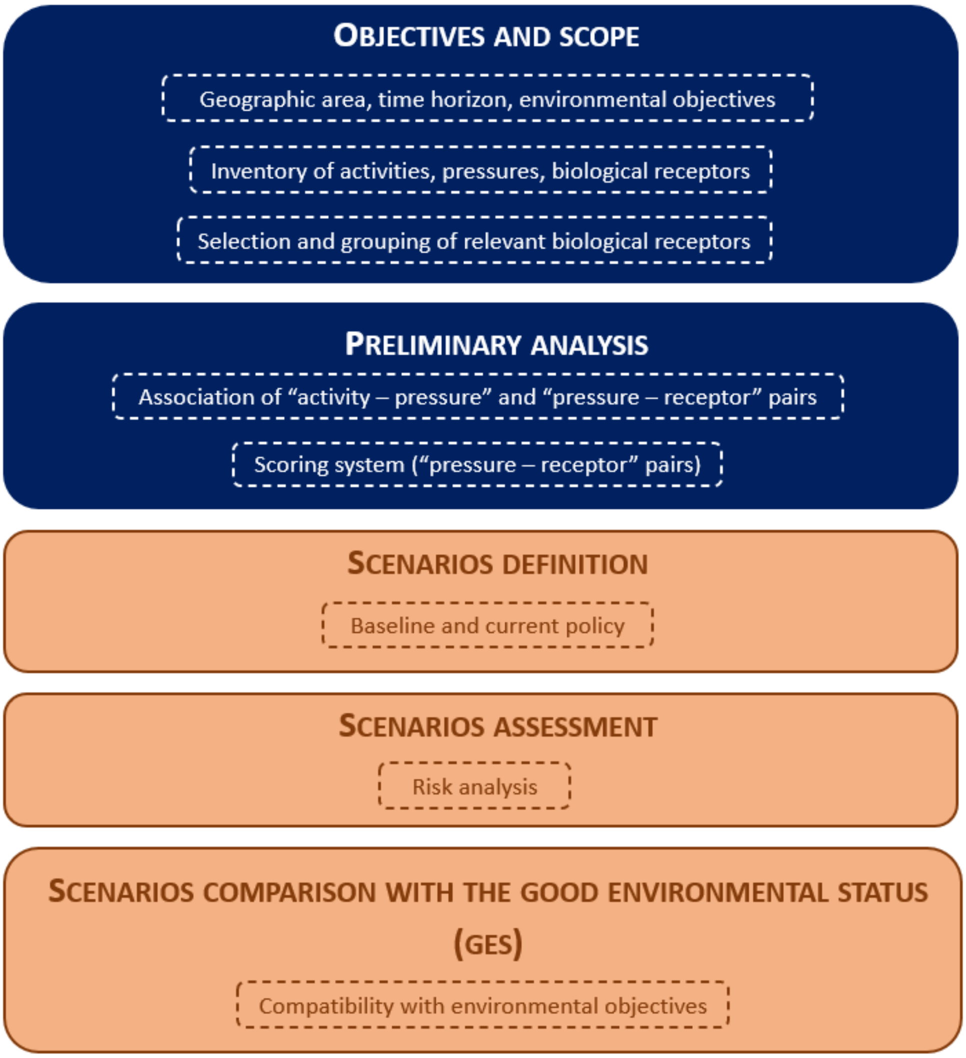

Figure 10: Illustration of the cumulative impact/risk assessment. Phases implemented for the MSP-MED project are indicated in blue © from Brignon & al., 2022

2.2.1 Objectives and scope

The first phase of the method aims to frame the assessment and provide information on the geographical area of interest, the time period, the environmental objectives and issues, the activities carried out, the types of projects and technologies envisaged, etc. This first step is concretely translated into the implementation of an inventory of the three components of the impact chain **"activity – pressure – biological receptor"** leading to three different lists:

- A list of **activities** presenting all activities related to the development of offshore windfarms for all steps of the life cycle: prospecting, construction, operation, and decommissioning;
- A list of anthropogenic **pressures** based on the MSFD typology and adapted from La Rivière & al., (2016) for physical pressures on marine benthic habitats and Quemerais & al., (2020) for physical, chemical and biological pressures;
- A list of **biological receptors**[14] potentially impacted by the pressures generated by offshore windfarms and derived from the habitats/species identified in the impact studies and completed by the scientific experts. The habitats/species inventoried are classified according to 4 groups: "*benthic communities and habitats*",

[14] Species, habitats or groups of living organisms susceptible to be subject to a pressure from human activity

"*ichthyofauna*", "*marine mammals and sea turtles*", "*flying fauna*". The selection and grouping of receptors are carried out by a group of experts according to different criteria (morphological, behavioural, ethological, socio-environmental, etc.).

Once established, these lists allow the experts to make "**activity - pressure**" and "**pressure - receptor**" associations, leading to "**activity - pressure - receptor**" impact chains.

2.2.2 Preliminary analysis

The preliminary analysis allows the most relevant **"pressure - receptor" pairs** to be prioritized and selected, which is necessary to define priorities for action using a scoring method. This scoring allows to the identification of sensitive habitats/species for which a qualitative assessment of potential effects is possible. When the uncertainty is too large and the qualitative assessment of potential effects is not possible, this method however makes it possible to identify the "pressure - receptor" pairs for which scientific knowledge is too low. It can also be used to guide the need for improved knowledge and research. The prioritization method proposed by Brignon & al., (2022) is based on three scores:

- The "sensitivity" score (1- 10), reflects the level of **sensitivity (S)** of a biological receptor to a pressure independently of its real value, considered during the impact assessment phase;
- The "knowledge" score (1- 10), reflects the level of scientific **knowledge (K)** about the interaction between pressure and receptor;
- The "conservation status" score (1- 10), representing the **conservation status (St)** of the receptor. This score is derived by the concept of "focal" species advocated in several assessments of the impact of human activities on marine ecosystems.

The definition of the priority "pressure - receptor" pairs (high potential effect or scientifically established) is obtained by multiplying the three scores.

2.3 Implementation in MSP-MED

According to the objective of providing knowledge on the interactions between marine ecosystems and offshore floating windfarm projects in the Mediterranean Sea, only the first two phases of the assessment framework proposed by Brignon & al., (2022) have been implemented: "*objective and scope*" and "*preliminary analysis*". These first steps allow the identification of impact chains, which is an essential preliminary step in understanding potential impacts and assessing possible ecosystem responses. Already implemented for offshore fixed windfarms in the Eastern Channel and North Sea, this method also has the advantage of providing a sufficiently broad methodological framework to be applied to offshore floating windfarms in the Mediterranean ecosystems of the Gulf of Lion. Based on the same steps as those proposed by the original method, the work carried out in MSP-MED is articulated in these two main phases:

- Phase 1: Objectives and scope
    - Inventory of activities, pressures and, biological receptors
    - Selection and grouping of relevant biological receptors
- Phase 2: Preliminary analysis

- Association of "activity – pressure" and "pressure – receptor" pairs
- Scoring of each "pressure – receptor" pairs

Contrary to work carried out on the Eastern Channel, which was based on advanced offshore windfarms projects for which the geographical areas and technologies were known, few information is available on the offshore floating technologies that will be deployed in the Gulf of Lion. The Mediterranean context, which is very different from the context of the Eastern Channel, justify the carrying out of a dedicated work. It has led to the definition of a new group of experts different from the original group that participated in the development of the original method.

2.3.1 Objectives and scope

According to the objective of supporting cross-border cooperation between France and Spain in the Gulf of Lion, cross-border working groups were set up for 2 of the 4 ecological compartments: "*marine mammals and sea turtles*" and, "*flying fauna*". As the approach implemented for MSP-MED project is still at a prospective reflexion (no precise geographical area, unknown type of technology, etc.), only the marine megafauna was addressed at a cross-border scale. In total, 168 scientific experts from France and Spain were invited to participate in the MSP-MED project and 53 answered to our requests for effective participation or punctual support:

- ***Flying fauna*** (15 experts – FR/ES);
- *Marine mammals and sea turtles* renamed "***cetaceans and sea turtles***" (20 experts – FR/ES);
- ***Benthic communities and habitats*** (4 experts – FR);
- *Ichthyofauna renamed "**pelagic habitats**"* (10 experts – FR) finally divided in two sub-groups:
    - *Fish and cephalopods (6 experts)*
    - *Planktonic communities (4 experts)*;
- ***Offshore floating windfarms and technology*** (4 experts – FR).

The geographical area corresponds to the case study area and includes the French and Spanish parts of the Gulf of Lion. However, most of the results are relevant at a larger Mediterranean scale. The anthropogenic activities addressed are those related to offshore floating windfarms, as the technology envisaged in the Mediterranean Sea due to the characteristics of its continental shelf and its bathymetry.

a. Inventory of activities, pressures, biological receptors

The initial list of pressures carried out as part of this preliminary inventory step comes directly from the work carried out by Brignon & al., (2022). This list results from the typology of pressures defined in the framework of the MSFD and adapted from La Rivière & al., (2016) for physical pressures on marine benthic habitats and Quemerais & al., (2020) for physical, chemical, and biological pressures.

The list of activities and biological receptors is based on the impact studies of the pilot offshore floating windfarms projects in the Mediterranean Sea to identify (i) all the activities inherent to the development of this type of offshore floating windfarms and (ii) the habitats/species that have been identified through impact studies as likely to be affected by the pressures generated by these projects. As the Spanish part of the Gulf of Lion does not include any (tests or commercials) offshore windfarms projects, the impact studies used are only those related to projects located in the French part of the Gulf of Lion.

b. Selection and grouping of relevant biological receptors

To facilitate the identification of "activity - pressure" and "pressure - receptor" pairs, the MSP-MED works were then divided into two axes:

- axis 1: study of « activity – pressure” interactions;

- axis 2: study of “pressure – receptor” interactions.

Experts are mobilized for the first time at this step to select and group together the relevant receptors. Similar work is also carried out for the activities, to remove any redundancies observed within the same step (e.g., some vessels operating in the area may be grouped together within "maritime traffic" activity).

axis 1: Study of « activity – pressure” interactions

First technical meeting of the *"offshore floating windfarms activities and technologies"* working group to select and group activities inherent to the development of offshore floating windfarms

⬇

ACTIVITIES LIST

axis 2: Study of “pressure – receptor” interactions

First technical meeting of the French Spanish *“flying fauna”* and *“cetaceans and sea turtles”* working group and French *“benthic communities and habitats”* and *“pelagic habitats”* working group to select and group biological receptors.
To limit solicitation of the scientific experts engaged in the cross-border technical meetings, the objectives of tasks 2.2.1 and 2.2.2 (*see introduction*) were mutualized. This first technical meeting also aimed to identify knowledge gaps on a cross-border scale, especially regarding at-sea distribution and abundance of mobile species (Assali & al., 2022)

⬇

RECEPTORS LIST

2.3.2 Preliminary analysis

a. Association of “activity – pressure” and “pressure – receptor” pairs

axis 1: Study of “activity – pressure” interactions

A series of interviews with the experts mobilized during the first technical meeting was carried out to validate the list established and to propose a first association of the “activity – pressure” pairs.

A participatory and collaborative workshop was then carried out to validate and complete the identified “activity – pressure” pairs

⬇

“ACTIVITY – PRESSURE” PAIRS

axis 2: Study of “pressure – receptor” interactions

This second technical meeting aimed to validate the list of receptors and to define the “pressure – receptors” pairs.

⬇

“PRESSURE – RECEPTOR” PAIRS

b. Scoring of each « pressure – receptors” pairs

This fourth and final step of “pressure – receptor” pair only concerns axis 2: **Study of “pressure – receptor” interactions**.

The third technical meeting aimed to characterize the interactions inherent in the previously identified “pressure – receptors” pair and to present the scoring method. As in the first technical meeting, the objectives of tasks 2.2.1 and 2.2.2 (*see introduction*) were common. It was therefore also addressed the current limitations to inform ecological criteria used to feed evaluations and spatial location in the Gulf of Lion (Assali & al., 2022).

A fourth and final technical meeting was held to assess sensitivity and knowledge scores and offered a concluding discussion of the whole methodology. It also allowed to provide recommendations to consider potential interactions in every step of the offshore floating windfarms projects within appropriate temporal and spatial scales.

2.3.3 Main methodological adaptation

To answer to the specific objectives of the MSP-MED project, some adaptations of the original method were made. The modifications resulting from the exchanges and recommendations made by the experts during technical meetings are presented in the results section (*see part 3.1*):

- The division of the work into 2 axes: “activity – pressure” interactions and “pressure – receptor” interactions;
- The organization of a specific working group on "offshore floating windfarms activities and technologies";
- The adaptation of the activity selection and grouping step to keep only the most relevant ones;
- The subdivision of the "*pelagic habitats*" working group into two distinct working sub-groups “***fish and cephalopods***” and “***planktonic communities***”.

The adaptation of the original method for MSP-MED project as well as the articulation of this method with the work undertaken (technical meetings and interviews) are summarized below (fig. 11).

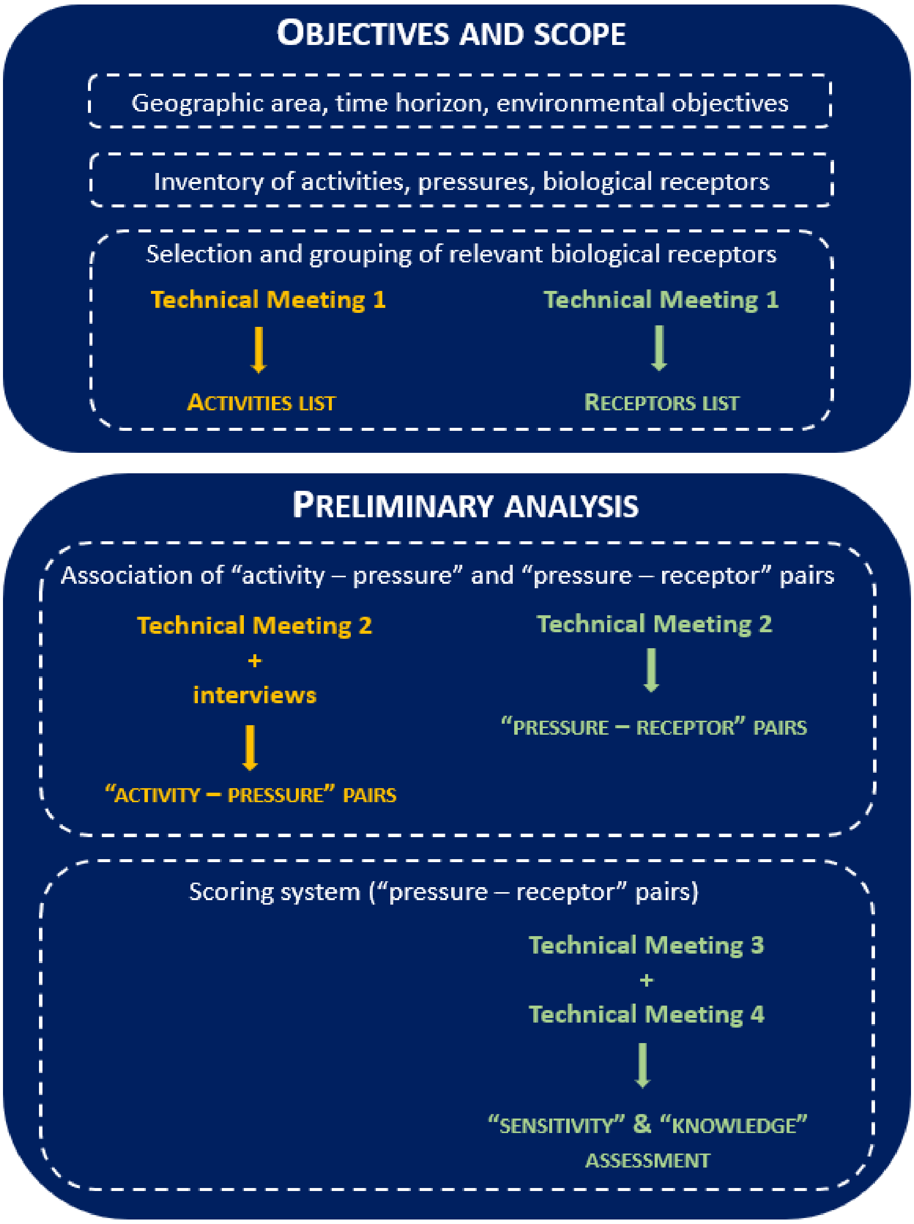

Figure 11 : Illustration of the methodology implemented for the MSP-MED project © France Énergies Marines

3 Results and limits

The MSP-MED project's approach is **prospective**; no pilot or commercial offshore floating windfarms exist in the Mediterranean Sea. The study scenario proposed to the different working groups is therefore **poorly accurate**: vast study area (the Gulf of Lion), multiple technologies (e.g., barges, TLP, etc.), consideration of the entire windfarm life cycle (prospecting, construction, operation, and decommissioning), etc.

The objective of the MSP-MED project is rather to undertake a **risk-based approach** to **identify** and **characterize** all **potential interactions** than properly evaluate interactions. The high number of "activity – pressure" and "pressure – receptor" pairs is justified by the precautionary principle implemented during the technical meetings, where all possible scenarios were considered by the participants.

Most of the work was focused on the **identification and characterization of potential interactions** and it was also tried to be focused on the specificities of offshore floating windfarms. The attribution of knowledge, sensitivity and ecological stake scores were carried out by some working groups according to the limits imposed by the implementation of a prospective approach.

The **lists** (activities, pressures, receptors) and **potential interactions** are the result of a **prospective approach** and a **bibliography based on case studies carried out in geographically distinct sites in France and Europe,** they are not **universal and absolute**. The **environmental conditions are specific** to the site studied, as are the state of conservation and the sensitivity of the habitats/species.

Following this preliminary approach, **it will be essential to carry out in-depth interaction assessments at the scale of each site or area, considering its specificities** including the characteristics of the site (bathymetry, currents, etc.), receptors (species, habitats, etc.) and pressures (technologies, etc.).

3.1 Results

3.1.1 List of activities, pressures, and receptors

a. Activities list

A list of more than 146 **activities** related to offshore floating windfarms has been set, summarizing all activities that may generate pressures on marine ecosystems. These activities can be classified in 4 categories:

- ***Prospecting and pre-construction***: 33 activities;
- ***Construction***: 48 activities;
- ***Operation***: 37 activities;
- ***Decommissioning***: 28 activities.

This preliminary list was submitted to the "*Offshore floating windfarms and technology*" working group during the first technical meeting. The discussions allowed to:

(i) group together some activities that were too detailed (e.g., "installation of a suction pile" replaces the initial activities "positioning and depositing the suction pile", "caisson driving", "depression and water evacuation" and "caisson uncoupling" where each step of the installation of a suction pile had been described);

(ii) merge some activities that are repeated during the same work phase (e.g. geophysical and geotechnical surveys);

(iii) detail and/or add some missing activities (e.g. "anchor lines" detailed in two separate activities "Anchor line - steel" and "Anchor line - synthetic fiber").

Regarding the prospective approach lead, the prototypes and various models of floating technologies have been included in the list of activities (SPAR models, midarch-water, etc.) but have not been considered for the study of potential interactions. To reduce the number of activities and to improve results clarity, some activities that are redundant from one phase to another (e.g., ROV surveys or geophysical surveys) have been grouped together to facilitate the identification of interactions. This type of grouping is only possible for some activities and since intensity of pressures generated by the activities has not been assessed in this prospective approach. It is therefore a general approach by large group of activities for the study of interactions (in blue) coupled with a detailed list of activities (35 in total) by phase (table 2 and see detailed table in annex 1):

	Phases of offshore floating windfarms life cycle			
Activities	P	C	O	D
Buoys / Floating platforms (barge and semi-submersible)	x		x	
TLP floating platforms			x	
Anchor lines - Steel	x		x	
Anchor lines - Synthetic fibres (nylon, polyester)			x	
ROV inspection (umbilical + module)	x	x	x	x
Geophysical surveys	x		x	
Geotechnical surveys	x			
Magnetic surveys	x		x	
Depositing and pulling the anchor (burial anchor)		x		
Drilling (for hard substrate - suction pile, driven pile)		x		
Installation of suction pile and associated tensions-leg		x		
Hydraulic piling (driven pile)		x		
Scouring protection		x		
Fixed foundations			x	
Dredging		x		
Excavation		x		
Burying		x		
Cable protection (Concrete mats, Riprap, Protective shells)		x		
Midarch water			x	
Ballasting / De-ballasting of floating platforms		x	x	x
Maritime traffic	x	x	x	x
Air traffic		x	x	x
Human intervention (divers, infrastructure maintenance, etc.)		x	x	x
Blade			x	
Nacelle			x	
Mast			x	
Cathodic protection			x	
Anti-corrosion coating			x	
Inter-array cable			x	
Buoyancy modules			x	
Bottom connector (TDP, Touch Down Point)		x		
Day and night lighting (lights and infrastructure back-lighting)			x	
De-burying				x
De-protection				x
De-construction				x

Table 2: Activities list established by MSP-MED working group for all phases of offshore floating windfarms life cycle (P, Prospecting; C, Construction; O, Operation; D, Decommissioning)

b. Pressures list

No working group focused specifically on the establishment of a list of pressures. However, during the different technical meetings, some pressures were detailed or renamed by some working groups to facilitate the identification and characterization of interactions. To maintain consistency between the working groups and between the pressures defined by Brignon & al., (2022) and those used in the MSP-MED project, the typology of pressures has been kept and sub-categories have been proposed by some working group. Some pressures, considered too detailed, have been merged (e.g., chemical pollution) and the distinction between the aerial and underwater compartments was removed. The final list of proposals from all the working groups suggests 18 main pressures (table 3) and the associated detailed sub-pressures by working group (in grey):

<table>
<tr><th colspan="4">Pressures</th></tr>
<tr><td colspan="4">Loss of habitat</td></tr>
<tr><td colspan="2">Habitat coverage
(Benthic communities and habitats)</td><td colspan="2">Avoidance behavior
(Flying fauna)</td></tr>
<tr><td colspan="4">Changes of habitat</td></tr>
<tr><td>Clamping
(Benthic communities and habitats)</td><td>Reef effect
(Fishes and cephalopods; Offshore floating windfarms and technology)</td><td>Habitat addition
(Offshore floating windfarms and technology)</td><td>3D distribution
(Flying fauna)</td></tr>
<tr><td colspan="4">Extraction of substrate</td></tr>
<tr><td colspan="4">Material deposition</td></tr>
<tr><td colspan="4">Changes in hydrodynamic conditions</td></tr>
<tr><td colspan="4">Changes in turbidity</td></tr>
<tr><td colspan="4">Changes of temperature</td></tr>
<tr><td colspan="4">Noise emissions</td></tr>
<tr><td colspan="2">Acoustic
(Fishes and cephalopods; Cetaceans and sea turtles)</td><td colspan="2">Vibration
(Fishes and cephalopods; Cetaceans and sea turtles)</td></tr>
<tr><td colspan="4">Electromagnetic emissions</td></tr>
<tr><td colspan="4">Light emissions</td></tr>
<tr><td colspan="4">Drop shadow
(Fishes and cephalopods; Planktonic communities; Benthic communities and habitats)</td></tr>
<tr><td colspan="4">Chemical pollution</td></tr>
<tr><td colspan="2">Direct / Indirect effects
(Flying fauna)</td><td colspan="2">Trace elements / Organic compounds
(Benthic communities and habitats)</td></tr>
<tr><td colspan="4">Organic enrichment</td></tr>
<tr><td colspan="4">Hypoxia</td></tr>
<tr><td colspan="4">Introduction of individuals genetically different from local species</td></tr>
<tr><td colspan="4">Dispersal of non-native species</td></tr>
<tr><td colspan="4">Collision</td></tr>
<tr><td colspan="4">Obstruction to movement</td></tr>
<tr><td colspan="4">Barrier effect
(Flying fauna)</td></tr>
<tr><td colspan="4">Human activity</td></tr>
<tr><td colspan="2">Link to offshore floating windfarms activity
(Flying fauna)</td><td colspan="2">Link to changes of uses
(Flying fauna; Benthic communities and habitats)</td></tr>
</table>

Table 3: Pressures list established by the MSP-MED working group

c. Receptors list

The inventory of **receptors** has led to a list of more than 900 species and 40 habitats. This preliminary receptor list summarizes the species/habitats potentially impacted or likely to interact with the development of pilot offshore floating windfarms according to the information collected in the impact assessments:

- ***Cetaceans and sea turtles:*** 27 species (21 cetaceans and 6 sea turtles);
- ***Flying fauna:*** 239 species (139 birds, 77 seabirds and 23 bats);

- ***Benthic communities and habitats:*** 425 species (173 polychaetas, 133 crustaceans, 86 molluscs et 15 echinoderms) and 42 habitats;
- ***Pelagic habitats:*** 245 species (fish, cephalopods, etc.).

This preliminary receptor list was initially reduced to the species at stake (sensitive species, species with a high heritage value, common species in the Gulf of Lion, etc.) identified through additional bibliography to facilitate discussions.

The criteria for selecting and grouping species/habitats to reduce the number of receptors varied from one ecological component to another and depended on characteristics of the concerned component as well as knowledge availability. These criteria covered a broad range of topics: species occurrence and distribution, community structure and size range, population demography, biodiversity index, abundance and biomass, trophic level of the ecosystem, vulnerable species, species behavior (foraging at sea, crossing the Gulf of Lion during migration, etc.), key species, or species sensitivity, particularly those for which the development of offshore floating windfarms represents a significant additional constraint to the maintenance of their populations.

Based on these different criteria, several approaches were carried out in the different working groups and resulted in a final list of 66 receptors (table 4 to 7):

- ***Cetaceans and sea turtles:*** Species approach
  The selected species are those most likely ones susceptible to interact with offshore floating windfarms regarding to their frequency of use of the continental shelf (*Common bottlenose dolphin* or *Loggerhead Sea turtles*) and/or their abundance in the Gulf of Lion. Species identified by the scientific community in the context of the French public debate on the development of **commercial offshore floating windfarms** have also been added.
- ***Flying fauna:*** Group of species approach
  Some bird species are retained (*Northern Gannet*), while other species are grouped so that they can be integrated and valued in the study of interactions despite the lack of knowledge (case of bats in particular, whose behavior at sea, and more particularly in the Gulf of Lion, is unknown). A pool of species based on conservation status and level of knowledge of the species (behavior, occurrence, geographical distribution, etc.) is proposed in parallel of the list of receptors.
- ***Benthic communities and habitats:*** Habitat's approach
  The list of habitats defined by the experts is based on the list of the Mediterranean benthic biocenosis (Michez., & al., 2014) adapted to the context of the Gulf of Lion and supplemented by specific habitats (hydraulic dunes, canyon heads, etc.) or with facies (funicular facies). The habitats are consider related to the pressures according to three groups: habitats in the connection area, habitats in the implantation area and area of influence. A pool of species based on various species protection criteria (protected species, threatened species, etc.) is proposed in parallel to the list of receptors for being used in the operational implementation of the impact assessment.
- ***Pelagic habitats:*** According to experts and regarding the specificities and characteristics of the *pelagos*, the "pelagic habitats" working group was subdivided into two sub-groups: "*fish and cephalopods*" and "*planktonic communities*".
    - *Planktonic communities*: one group, one receptor
      Regarding to the level of knowledge and the prospective approach, experts defined the planktonic communities as a receptor on its own.
    - *Fish and cephalopods*: Ecological and ethological approach

The receptor list established by the experts allows any fish/cephalopod species to be integrated into broad functional categories. It is based on three eco-stages[15] (benthic on hard substrate, benthic on soft substrate and pelagic) associated with the different stages of the life cycle of each species (eggs and larvae, juveniles, in transition, adults).

Cetaceans and sea turtles
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)

Table 4: Receptor list established for "Cetaceans and sea turtles" ecological components by the MSP-MED working group

Flying fauna
Migratory bats
Foraging bats
Passerines
Raptors
Anatidae & Rallidae
Shorebirds
Loons
Wader species
Herons and allies
Cormorants
Shearwaters
Gulls
Terns
Hydrobatidae
Razorbills
Puffins
Skua sp.
Northern Gannet, *Morus bassanus* (Linnaeus, 1758)

Table 5: Receptor list established for "Flying fauna" ecological components by the MSP-MED working group

[15] An eco-stage is a stage in the development of a species during which it occupies a particular habitat. This eco-stage may concern a few stages or the entire life cycle of a species.

Benthic communities and habitats
Biocenosis of supralittoral sands
Biocenosis of mediolittoral sands
Biocenosis of the mediolittoral detritic
Biocenosis of mediolittoral rocks
Biocenosis of superficial muddy sands of calm mode
Biocenosis of infralittoral rocks
Biocenosis of rough sands and fine gravels tossed by the waves
Biocenosis of sands and gravels under the influence of bottom currents
Biocenosis of the *Posidonia oceanica* meadow
Biocenosis of high-level fine sands
Biocenosis of well calibrated fine sands
Biocenosis of infralittoral algae
Biocenosis of the *Cymodocea nodosa* meadow
Biocenosis of the meadows with *Zostera noltii* and *Zostera marina*
Perennial brown algae (ochrophytes, kelp, cystoseires)
Biocenosis of coastal terrigenous muds
Biocenosis of the offshore rock
Biocenosis of coastal detritic
Coralligenous biocenosis
Biocenosis of muddy detritic bottoms
Biocenosis of offshore detritic bottoms
Biocenosis of bathyal muds
Facies of soft mud with *Funiculina quadrangularis* and *Aporrhais serresianus*
Biocenosis of bathyal detrital sands with *Gryphus vitreus*
Biocenosis of bathyal rocks
Underwater structures caused by gas emissions (pockmark)
Hydraulic dunes
Canyon heads
Benthic species

Table 6: Receptor list established for "Benthic communities and habitats" ecological components by the MSP-MED working group

Pelagic habitats	
Fishes and cephalopods	***Planktonic communities***
Benthic soft substrate – eggs and larvae	Planktonic communities
Benthic soft substrate – juveniles	
Benthic soft substrate – in transition	
Benthic soft substrate – adults	
Benthic hard substrate – eggs and larvae	
Benthic hard substrate – juveniles	
Benthic hard substrate – in transition	
Benthic hard substrate – adults	
Pelagic – eggs and larvae	
Pelagic – juveniles	
Pelagic – in transition	
Pelagic – adults	

Table 7: Receptor list established for “fish and cephalopods” and “planktonic communities” ecological components by the MSP-MED working group

For more details on the receptor lists and the iterative process that led to their definition, the detailed tables and technical meeting reports are available in the annexes (annex 2 for tables and annexes 3 to 6 for report).

3.1.2 “activity – pressure” pairs

Due to the restrictions caused by the COVID-19 pandemic, the originally technical meeting planned with the “*Offshore floating windfarms and technology”* working group could not take place on the planned date. A "continuous" technical meeting was therefore planned over a week. Two physical workspaces and a virtual one (on MURAL) presenting the main activities identified above were made available to France Energies Marines collaborators (fig. 12).

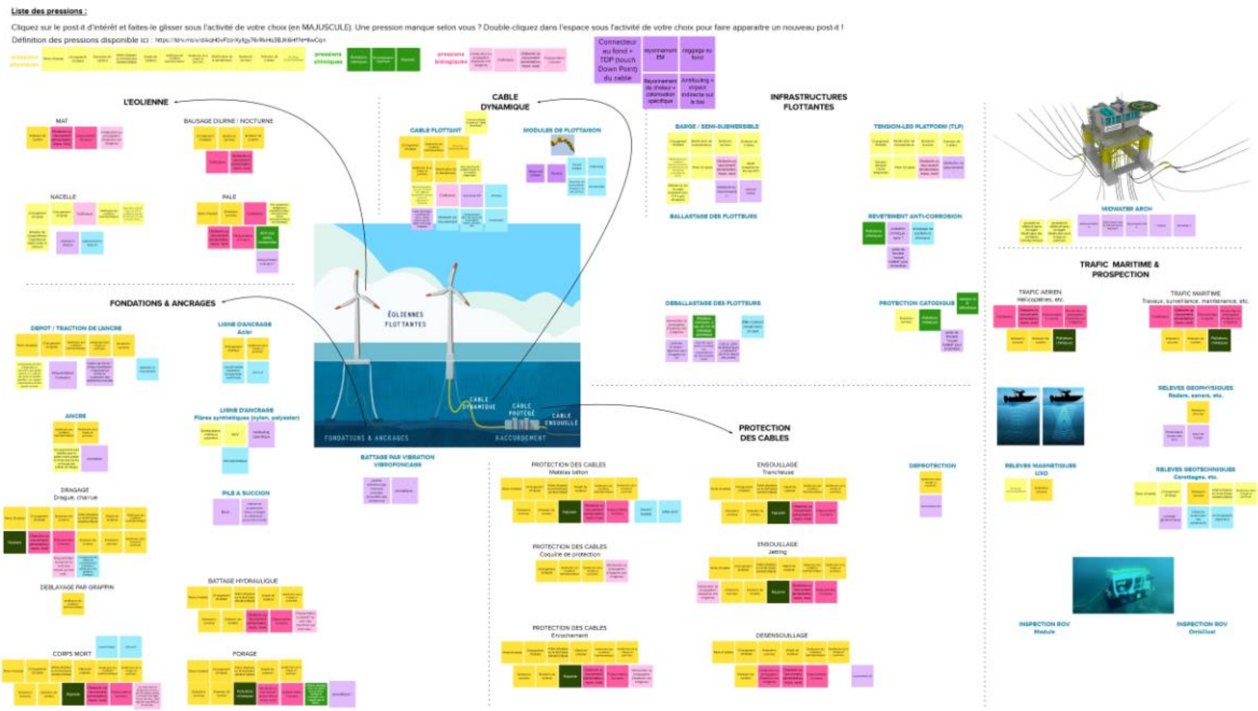

Figure 12: Screenshot of the online workspace provided (on MURAL) to identify the activity-pressure pairs

214 “activity – pressure” pairs were identified (table 8) by the “*Offshore floating windfarms and technology*” working group and a wide range of FEM collaborators (annexes 3 to 6 for report).

Methodological and prospective table derived from a risk-based approach. Cannot be applied to a specific site or defined project

Activities	P	C	O	D	Loss of habitats	Changes of habitats	Extraction of substrate	Material deposition	Changes in hydrodynamic conditions	Changes in turbidity	Changes of temperature	Noise emissions	Electromagnetic emissions	Light emissions	Chemical pollution	Organic enrichment	Hypoxia	Introduction of individuals genetically different from local species	Dispersal of non-native species	Collisions	Obstruction to movement	Human activity
Buoys / Floating platforms	x		x		x	x			x			x						x	x		x	
TLP floating platforms			x		x	x												x	x		x	
Anchor lines - Steel	x		x		x	x				x		x						x	x		x	
Anchor lines - Synthetic fibres			x			x									x			x	x	x	x	
ROV inspection	x	x	x	x																	x	
Geophysical surveys	x		x							x		x			x							
Geotechnical surveys	x				x	x			x	x		x			x	x						
Magnetic surveys	x		x									x	x									
Depositing/pulling the anchor		x			x	x			x	x		x			x						x	
Drilling		x			x	x		x		x		x									x	
Installation of suction pile		x			x	x		x		x		x									x	
Hydraulic piling		x			x	x		x		x		x									x	
Scouring protection		x			x	x		x	x	x		x						x	x		x	
Fixed foundations			x		x	x		x	x	x		x			x			x	x	x	x	
Dredging		x			x	x	x	x	x	x		x			x		x				x	
Excavation		x			x	x	x		x	x		x			x						x	
Burying		x			x	x		x	x	x		x					x				x	
Cable protection		x			x	x		x	x	x		x						x	x		x	
Ballasting / De-ballasting		x	x	x														x	x			
Maritime traffic	x	x	x	x								x		x	x			x	x	x	x	x
Air traffic		x	x	x								x		x						x	x	x
Human intervention		x	x	x								x		x								x
Blade			x		x	x						x								x	x	
Nacelle			x		x	x						x	x							x	x	
Mast			x		x	x														x	x	
Cathodic protection			x		x										x							
Anti-corrosion coating			x		x										x							
Inter-array cable			x			x			x	x	x		x					x	x	x	x	
Buoyancy modules			x			x												x	x	x	x	
Bottom connector		x			x	x		x		x	x		x									
Day and night lighting			x			x						x		x						x	x	
De-burying				x	x	x		x	x	x		x						x	x		x	
De-protection				x		x				x	x										x	
De-construction				x	x	x	x	x	x	x		x					x				x	

Table 8: “activity - pressure” pairs established by the MSP-MED working group on activities (P, Prospecting; C, Construction; O, Operation; D, Decommissioning)

As for the “pressure – receptor” pairs, the results of the “activity – pressure” pairs presented in the previous **table should be treated with caution**. The pairs presented here are the result of the expertise and knowledge of a limited number of participants, which have a different perception of the potential interactions between offshore floating windfarms and marine ecosystems. In the context of the identification of the "activity – pressure" pairs, the production of a list leads to the loss of information such as pressure intensity, duration, frequency (etc.), essential for the prediction of potential interactions. For example, the change in turbidity is not comparable between the deposits of the anchoring systems, short in time and limited regarding to spatial extend, and the effect of anchor lines (chains) which remain during the entire life cycle of the offshore floating windfarms and have a much larger spatial footprint.

As for the identification of "pressure – receptor" pairs, the prospective approach carried out for MPS-MED makes the identification of "activity – pressure" pairs complex. Depending on the number of infrastructures, spatial coverage, duration, etc., some "activity – pressure" pairs are more or less relevant. For example, it can be considered that the presence of only one inter-array cable in the water column will have a rather limited impact on the modification of hydrodynamic conditions. On the other hand, for an offshore floating windfarm of several infrastructures, the multiplication of inter-array cables and anchor lines on a more or less reduced space could generate a modification of the hydrodynamic conditions on a local scale (increase of turbulence).

Furthermore, participants were unable to agree on the relevance (or not) of potential interactions between activities related to the development of offshore floating windfarms and the "changes of temperature" pressure. While the temperatures emitted by the cables seem low (Carlier & al., 2019; Taormina & al., 2020; *see part 3.1.3-d*) some participants are cautious on the impact of several cables on temperature variations, even if minimal, coupled with a shadow effect linked to the size of the infrastructure. In line with the prospective approach lead in MSP-MED and the precautionary principle, the potential interactions with the "changes of temperature" have been retained and are available in the table above.

The pollution inherent to some pressures: extraction of substrate, resuspension of sediments, will depend on the nature of the sediments and their contamination rate. The intensity of the pressure and the relevance of the "activity – pressure" pairs may vary according to the spatial extent of the offshore windfarms and their location. Chemical pressures linked to accidental pollution resulting from maritime and air traffic during work operations, maintenance, etc. are not considered here.

Noise emissions generated by the tensioning and movement of the chains were included in the "activity – pressure" matrix. Light emissions have been treated through the prism of infrastructure lighting and platform backlighting only. A dedicated activity allows the number of "activity – pressure" pairs to be reduced (e.g., the "*Buoys / Floating platforms*" -"*Light emissions*" pairs are removed because it is not the platform itself that will generate the "Light emissions" pressure, but the lighting installed on it). The number of "activities" – "Human activities" pairs have been reduced by focusing only on maritime and aerial traffic activities and human interventions. As offshore windfarms are an anthropic activity, all activities related to the development of the offshore floating windfarms could be associated with human activity pressure.

3.1.3 "pressure – receptor" pairs

As mentioned, the approach lead in the MSP-MED project is prospective and cannot benefits from important feedback at European scale regarding the technology concerned (offshore floating windfarms). Unless otherwise from **bibliographical reference**, the following elements show **potential interactions based on the experts' knowledge** of the species, their characteristics, and their needs, as well as on observations made for other anthropic activities likely to generate similar pressures to those caused by offshore floating windfarms (e.g., pressures generated by the aerial part are identical between fixed and floating windfarms). Within the limits of knowledge, the characterization of interactions proposed below can be relative to all the receptors, depending on the sensitivity, behavior, physical characteristics of individuals, etc. It should be noted that the work presented below reflects the **potential interactions** identified by a **limited number of experts** (those of the working group) in the context of a **prospective approach** in which **all possible scenarios are considered** (risk-based approach). A more in-depth study of the interactions must be carried out when the dimensions of the offshore floating windfarms projects are known.

a. Cetaceans and sea turtles

41 “pressure – receptor” pairs were identified by the “cetaceans and sea turtles” working group during the technical meetings which concern direct effects (in blue); indirect effects are also mentioned, for information, in grey in the table below (table 9).

	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)	x		x	x	x	x	x	x		x	x	x	x	x	x
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)	x		x	x	x	x	x	x		x	x	x	x	x	x
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)	x		x	x	x	x	x	x		x	x	x			x
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)	x		x	x	x	x	x	x		x	x	x			x
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)	x		x	x	x	x	x	x		x	x	x			x
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 9: “pressure – receptor” pairs established for “cetaceans and sea turtles” components by the MSP-MED working group

For each pressure, some elements of characterization of **potential interactions** (in the limits of the work carried out previously mentioned) are presented below:

Extraction of substrate

Extraction of substrate, particularly during the construction phase, may have directs effects on avoidance and, disturbance of behavior of some cetacean’s species related to their activity (feeding, resting, nesting etc.) all along their life cycle.

Changes in turbidity

The temporary (when installing the anchoring system of infrastructures) or continuous (movement of anchoring chains) increase of turbidity could have an indirect effect on the feeding behavior of some species of sea turtles by reducing the effectiveness of underwater vision.

Noise emission (acoustic and vibration)

The sensitivity of cetaceans and sea turtles could vary accordingly to the sources of emissions, frequencies, type of noise (continuous or impulsive), duration of exposure, etc. The direct effects linked to high and low frequency emissions during the construction phase of the farms (e.g. increase in maritime traffic, underwater exploration and cable laying activities, etc.) can consist in physical damage (hearing damage, etc.) and behavioral changes like: escapes, changes in abundance and distribution, increasing of swimming speed, changes in diving behavior, whistles frequency, number and duration of dives (Erbe & al., 2019), communication (singing behavior - Tusjii & al., 2018, frequency, etc.), foraging behavior (Blair & al., 2016), etc. These same effects may be observed in prey species, what could lead to an indirect impact on cetaceans and marine turtles, with consequences on their feeding effort and behavior. The increase in background noise (e.g. increase in maritime traffic or continuous movement of chains) can have an acoustic masking effect (inter-individual communication, prey/predator detection, etc.) (Pershon & al., 2020) with a consequent reduction or stop of vocalizations (Weilgart & al., 2007) and increased stress (physiological changes, immune system degradation). Finally, vibrations related to noise emissions must also be considered as direct effects such as avoidance of areas subject to noise, what is has been already observed in delphinids populations.

Light emissions

Light emissions can have an attractive effect on juvenile sea turtles and disrupt their orientation abilities or deviate their trajectories (exhaustion, dehydration, predation, death) (Thums & al., 2016).

Electromagnetic emissions

The risk of magnetic fields modification is considered probable for some sensitive species such as sea turtles which could be disoriented (orientation, navigation, migration). Electromagnetic emissions can have direct effects on the orientation of sea turtles, which are sensitive to terrestrial electromagnetism. With regard to cetaceans, the scientific community confirms the sensitivity of some cetaceans to electromagnetic fields but stresses the limited knowledge about their sensitivity level and the effect of these emissions on their behavior and biology.

Chemical pollution

Chemical pressures and, more particularly, the emission of metals and organic components can have direct and indirect effects on all receptors by contaminating the entire trophic chain. The *Common bottlenose dolphin* could be the most affected species by this contamination as it is the most likely to feed close to floating platforms.

Collision

The increase in maritime traffic due to the offshore floating windfarms development in a restricted area will necessarily increase the risk of collisions, particularly for species that regularly use the continental shelf (e.g., *Common bottlenose dolphin* or *Fin whale*). It is a high threat for turtle species whose risk of surface collision will be higher.

Human activities *(species disturbance)*

Increasing human activity will have a direct effect on species sensitive to human disturbance, with avoidance and/or bypassing of the area likely to affect species life cycles and survival rates. For about 20 years, new sea turtle nests have been regularly discovered in the north-western Mediterranean Sea (e.g. French and Spanish coasts) but it is still not possible to predict the nesting spots from one year to the next. Increased activity next to these breeding sites could have an impact on the distribution and concentration of breeding male and female individuals along the coast.

Obstruction to movement

Risk of obstruction and entanglement from underwater cables (anchor lines and power cables) appears to be low for cetaceans and turtles. If the pressure exists, it is still difficult to estimate how it will impact those species, even if the risk of entanglement and laceration and infection can be mentioned (Kropp & al., 2013; Taormina & al., 2018). For some species such as *Fin whale* or *Sperm whale*, the lack of agility due to its size may lead to a higher risk of entanglement (Benjamin & al., 2014).

Indirect effects

Changes of habitats or hydrodynamics conditions can have an impact in the distribution and availability of prey could have an indirect effect on the cetacean and sea turtle populations that feed on them. The consequences of changes in the food web are difficult to predict, especially for species that displays a large ecological plasticity. Species with a very specialized ecological niche would be more sensitive to changes in their feeding behavior linked to disturbances of the food web. These changes may impact sea turtle species and their distribution, which for juveniles and younger turtles varies accordingly to food availability. These changes of habitat can also be detrimental to species that migrate long distances to feed. The increase of turbidity can lead to a change in spatial distribution due to prey distribution (Todd & al., 2014).

For more details on the "pressure – receptor" pairs and the iterative process that led to the characterization of the potential interactions between "cetaceans and sea turtles" and the development of offshore floating windfarms in the Gulf of Lion, the detailed tables and technical meeting reports are available in the annexes (annex 7 for tables and annexes 3 to 6 for report).

b. Flying fauna

For the "flying fauna" working group, 141 "pressure – receptor" pairs were identified during the technical meetings and concern direct effects (in blue); indirect effects are also mentioned, for information, in grey in the table below (table 10).

	Loss of habitat	Changes of habitat	Changes in turbidity	Changes in hydrodynamic conditions	Noise emissions	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement
Migratory bats	x	x			x	x	x				x		x
Foraging bats	x	x			x	x	x				x		x
Passerines	x					x					x		x
Raptors	x	x				x					x		x
Anatidae & Rallidae	x	x				x					x	x	x
Shorebirds	x	x				x					x		x
Loons	x	x	x								x	x	x
Wader species		x									x		x
Herons and allies	x	x									x		x
Cormorants	x	x	x	x		x		x	x	x	x	x	x
Shearwaters	x	x	x	x		x		x	x	x	x	x	x
Gulls	x	x		x		x		x	x	x	x	x	x
Terns	x	x	x	x		x		x	x	x	x	x	x
Hydrobatidae	x	x	x	x		x		x	x	x	x	x	x
Razorbills	x	x		x		x		x	x	x	x	x	x
Puffins	x	x		x		x		x	x	x	x	x	x
Skua sp	x	x		x		x		x	x	x	x	x	x
Northern Gannet, Morus bassanus (Linnaeus, 1758)	x		x	x		x		x	x	x	x	x	x

Table 10:"pressure – receptor" pairs established for "flying fauna" components by the MSP-MED working group

Within the limits of the work carried out (previously mentioned) some elements of characterization of **potential interactions** are presented below for each pressure:

Loss of habitat

The loss of habitat affects all birds through avoidance of offshore floating windfarms, which can lead to an increase in foraging effort and impact the feeding and reproductive success. Passerines and some seabirds (shearwaters, gulls, terns or Northern Gannet) may be particularly sensitive to the loss of habitat (avoidance) (Mendel & al., 2019). Loss of habitats may lead to a change in species distribution (desertion or reduction of visiting - Mendel & al., 2019) or even a decrease on abundance (Dierschke & al., 2016; Welcker & Nehls., 2016) and an avoidance behaviour which can reduces the risk of collision (Skov & al., 2018).

Changes of habitat

For some species, such as ducks, a habituation phenomenon could also be observed (Nilsson., 2012), with positive (collision reduction) and negative (attraction) consequences. Reserve and reef effect related to changes of uses in offshore floating windfarms areas may lead to a local increase in biomass and may have an attractive effect on fish-eating seabirds. This could increase the risk of collision for diving species, such as cormorants, and species known to forage in the vicinity of anthropogenic infrastructures such as gulls or terns could be more impacted (Defingou & al., 2019).

Changes in turbidity

Turbidity can affect diving species such as loons or cormorants and surface-feeding species such as shearwaters, terns, hydrobatidae and Northern Gannet in their foraging success.

Changes in hydrodynamic conditions

In addition to indirect effects on prey distribution, changes in hydrodynamic conditions may have an impact on the foraging success of some species as terns or cormorants (Lieber & al., 2021).

Noise and electromagnetic emissions

Due to their characteristics and sensitivity, the impact of noise and electromagnetic emissions is suspected for bats, but there is still little knowledge on the subject.

Light emissions

Light emissions can have direct attraction effects on bats, some migratory birds and seabirds in offshore windfarms areas and indirect attraction effects on seabird prey. Indeed, light pollution from offshore windfarms can disrupt bird migration at sea and attract offshore shorebirds such as passerines (Blew & al., 2008), raptors, shearwaters and hydrobatidae species. Light emissions can also increase the risk of disorientation and collision (Defingou & al., 2019) and have an indirect effect by attracting prey with an appealing effect on birds (and some cetaceans) that experience their foraging success increased.

Chemical pollution, organic enrichment, and hypoxia

Species that spend a lot of time on surface such as cormorants, auks, and all diving species, may be impacted by accidental pollution and oil spills with different types of effects: loss of feather waterproofness, poisoning by direct ingestion of hydrocarbons, hypothermia, etc. Moreover, pollutant emissions into the environment can have an indirect effect on birds through contamination of the trophic chain. For this type of exposure, all seabird species are concerned.

Collision

The risk of collision varies according to flight height which can be specific to each species and weather conditions such as higher risk for nocturnal migratory species at sea flying below 200 meter or higher risk for gulls, loons and Anatidae due to their flight height (rotor level) (Defingou & al., 2019). The risk of collision for a given specie could change depending on the season or the period of its life cycle like (higher risk for raptors during migration for example). Collision can lead to mortality, injury, or barotrauma. The underwater risk collision with floating infrastructure for diving species can be also consider (Furness & al., 2013).

Obstruction to movement

The obstruction to movement is considered as a barrier effect which can have a negative effect on all bird populations and, more particularly, on migratory species at sea and some seabird's species such as gulls and terns. The barrier effect can have an impact on migration routes (i.e., increase migration distances and energy expenditure) (Defingou & al., 2019) or on local movements (increase distance to colonies and feeding areas). Cormorants, gulls, and razorbills species and to a lesser extent, terns and puffins are sensitive to the barrier effect.

Human activities *(species disturbance)*

Human activities are distinguished by type of activity as they can lead to different types of impact. Maritime activities related to the construction and maintenance of the floating infrastructure during the operational period can have different impacts on birds: loons, Anatidae and Rallidae will avoid maritime traffic zones, which can reduce functional habitat areas; shearwaters and gulls will tend to follow and fly over sailing vessels, which can increase the risk of collisions. The reserve effect of the offshore windfarms area may increase the presence of fishermen next to the windfarms with a consequently expansion of collision risk for seabird species, such as gulls and shearwaters, which tend to follow fishing vessels.

Indirect effects

Changes in abiotic conditions (turbidity, hydrographic conditions, temperature, etc.) can have effects on pelagic habitats and generate changes in the distribution of prey over in the long term and modify the feeding areas of some species of seabirds, particularly for in breeding birds (Lieber & al., 2021).

For more details about the "pressure – receptor" pairs and the iterative process that led to the characterization of the potential interactions of offshore floating windfarms in the Gulf of Lion and "flying fauna", the detailed tables and technical meeting reports are available in the annexes (annex 8 for tables and annexes 3 to 6 for report).

c. Benthic communities and habitats

151 “pressure – receptor” pairs were identified during the technical meetings for “benthic communities and habitats” working group, and concern direct effects (table 11).

	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Changes in temperature	Noise emissions	Light emissions	Electromagnetic emissions	Chemical pollution	Introduction of individuals genetically different from local species	Dispersal of non-native species
Biocenosis of supralittoral sands	x	x			x	x					x		
Biocenosis of mediolittoral sands	x	x			x	x					x		
Biocenosis of the mediolittoral detritic	x	x			x	x					x		
Biocenosis of mediolittoral rocks	x	x			x						x		
Biocenosis of superficial muddy sands of calm mode	x	x				x					x		
Biocenosis of infralittoral rocks	x	x			x						x		
Biocenosis of rough sands and fine gravels tossed by the waves	x	x			x	x					x		
Biocenosis of sands and gravels under the influence of bottom currents	x	x			x	x					x		
Biocenosis of the *P. oceanica* meadow	x	x	x	x	x	x					x		
Biocenosis of high-level fine sands	x	x			x	x					x		
Biocenosis of well calibrated fine sands	x	x			x	x					x		
Biocenosis of infralittoral algae	x	x			x	x					x		
Biocenosis of the *C. nodosa* meadow	x	x		x	x	x					x		
Biocenosis of the meadows with *Z. noltii* and *Z. marina*	x	x		x	x	x					x		
Perennial brown algae (ochrophytes, kelp, cystoseires)	x	x		x	x	x					x		
Biocenosis of coastal terrigenous muds	x	x				x					x		
Biocenosis of the offshore rock	x	x			x						x		
Biocenosis of coastal detritic	x	x			x	x					x		
Coralligenous biocenosis	x	x		x	x	x		x			x		
Biocenosis of muddy detritic bottoms	x	x				x					x		
Biocenosis of offshore detritic bottoms	x	x			x	x					x		
Biocenosis of bathyal muds	x	x				x					x		
Facies of soft mud with *F. quadrangularis* and *A. serresianus*	x	x		x		x					x		
Biocenosis of bathyal detrital sands with *G. vitreus*	x	x			x	x					x		
Biocenosis of bathyal rocks	x	x			x						x		
Underwater structures caused by gas emissions (pockmark)	x	x			x	x					x		
Hydraulic dunes	x	x			x	x					x		
Canyon heads	x	x			x	x					x		
Benthic species	x	x		x	x	x	x	x	x	x	x	x	x

Table 11: ”pressure – receptor” pairs established for “benthic communities and habitats” components by the MSP-MED working group

Some elements of characterization of **potential interactions** are presented below for each pressure (within the limits of the work carried out previously mentioned):

Loss of habitat

The loss of habitat is reflected in the coverage of habitats and concerns all habitats. These habitat losses can be associated with sediment reworking and could have a significant impact on less mobile species, seagrass beds and coralligenous biocenosis. This loss is limited to the cable/offshore windfarms footprint (Defingou & al., 2019) and will be dependent on substrate and foundation type (ICES., 2019). Sessile benthic communities associated with exposed rocks, gravels, coarse sands and muds are more sensitive than highly mobile clays and sands ecosystems to this coverage pressure (Defingou & al., 2019). The loss of habitat and associated benthic communities may impact on the invertebrate and/or benthic vertebrate populations and, consequently, the whole food-web.

Changes of habitat

Changes of habitat can be considered through the clogging and abrasion of the seabed and the creation of new habitats. Mainly due to the movement of anchor chains on the bottom, clogging and abrasion can lead to a long-term modification of the soft substrates (with or without particular facies) and have a significant impact on the diversity of benthic invertebrate/vertebrate populations. On the bottom, the creation of new habitats is an opportunity for the mobile demersal megafauna associated to hard bottoms (after 2 years, 100 times more hard-bottom species on foundations than on soft sediments) (Lüdeke., 2015). On floats, bio-colonization by different organisms will result in: (i) an increase in the complexity of the ecosystem and (ii) a possible modification of the granulometry of the bottoms by adding shell debris (e.g., mussel packs) which, in view of the planned operation period (25 years on average), could generate a very localized modification of the nature of the bottoms and therefore of the associated benthic communities.

Extraction of substrate

The extraction of substrate can lead to the destruction of some habitats/species, especially sensitive habitats such as *Posidonia sp.* meadows.

Material deposition

The impact of the material deposition depends on the duration and the extent of deposition. On soft substrate, the impact will be almost none for a small area, but it becomes less negligible as the surface area increases. If re-colonization by species can be rapid over a small area, the process is lengthier and more difficult if the impacted area is larger.

Changes in turbidity

Changes in turbidity concerns all habitats and depends on the nature and quantity of sediments that are resuspended. Muddy habitats are less sensitive to this type of pressure because they are characterized by a regular supply of fine particles. The impact on species will depend on their mobility and can be qualified as it is probably very localized at the scale of the offshore floating windfarms. The increase in turbidity may, however, be harmful to some benthic species, making them more vulnerable to predation or directly affecting their vital function by obstructing their feeding/filtration organs (ICES., 2019).

Changes in hydrodynamic conditions

The modification of hydrographic conditions and bottom geomorphology by the installation of the infrastructure, can lead to a modification of sediment dynamics and habitats which, by their features, retain sediments (Defingou & al., 2019) and can have an impact on benthic communities which can be disturbed by the alteration of sediment transport routes on the bottom. Changes in sedimentation patterns, particle size and nutrient content can lead to habitat fragmentation (ICES., 2019) and impact benthic communities.

Changes in temperature

Regarding physical pressures, temperature changes due to offshore floating windfarms can be considered negligible. The temperature increase on subtidal species affected by the connection zone is considered to be almost negligible in view of the seasonal temperature variations. The impact on deep-water species may be greater for some sessile species that are used to constant temperatures. The local increase in temperature linked to the cables could modify the local distribution of species at the limit of their thermal range (repulsion or attraction) such as the *Diadem urchin* in the Mediterranean Sea. The impact is localized around the cable and may vary according to the nature of the sediments (ICES., 2019). The chemical and physical properties of substrate can be modified by these temperature changes and could lead to a modification of the oxygen concentration profile which can have an influence on the development of microbial/bacterial communities and on the physiology of some benthic species (ICES., 2019).

Noise emissions

Feedback from the Scottish Sea shows that the acoustic impact of noise emissions on benthic communities is relatively low in comparison to the impact of particle movement. Sound vibrations can increase the attractiveness of floats and anchors for larvae and some vibration-sensitive species, such as the attractiveness of gorgonian facies, where the "noisiest" habitats seem to attract larvae. An increase in the colonization behavior of some species of bryozoan was observed (Defingou & al., 2019). Noise emissions may be the cause of malformation and/or mortality of the larvae of some species (crustaceans and lamellibranch) (Weilgart., 2018), but also could cause an increase in stress that may have consequences on the physiology and behavior of some species (ICES., 2019).

Light emissions

The impact of light emissions is minimal in relation to the depths of anchored, although it should be considered for benthic species whose nocturnal life cycle may be disrupted by the addition of night-time light emissions, even though little is known about the effects of the moon on the benthos. In combination with changes in light levels, the effect of shadowing can lead to a reduction in direct daylight and impact the development of photosynthetic organisms and algae. Although the effect of shadowing may be anecdotal for a few floating infrastructures, the effect can be considered significant for larger projects and will depends on the depth of deployment of the offshore floating windfarms.

Electromagnetic emissions

For some sedentary species, electromagnetic emissions can disrupt reproduction and modify immune and embryonic function. However, little is known about the behavioral and physiological effects on benthic organisms (ICES., 2019).

Chemical pollution

Chemical pollution of habitats can be observed by remobilization of polluted sediments and by direct contamination of species (accidental pollution) which will affect the whole food-web (ICES., 2019). The impact of various pollutants by type of biocenosis is not known, although the trend for pollutants to be adsorbed is stronger for fine sediments (muds and fine sands).

Introduction of individuals genetically different from local species & dispersal of non-native species

The settlement of infrastructures into the environment, regardless of the anthropogenic activity considered, represents an opportunity for species to colonize without competing with native populations (Tyrrel & Byers., 2007). The introduction of individuals genetically different from local species (ballast water, attraction of new fish populations) can lead to a modification in connectivity. Dispersal possibilities of invasive algae should be considered during the construction/decommissioning phases in order not to weaken ecosystems which, in the Mediterranean and depending on the location of offshore floating windfarms, are already weakened by some invasive algae species. The introduction of non-indigenous species (ballast systems, increase in maritime traffic) could increase ecosystems vulnerability. Although the sensitivity of the habitats in the Gulf of Lion is considered high for this type of pressure, the risk is considered low regarding (i) physical pressures, (ii) the connectivity of the habitats in the Gulf of Lion and, especially between the coastal and offshore habitats and (iii) the existing anthropic activity and associated pressures, particularly, the maritime traffic. While these biological pressures can lead to the destabilization of habitats, the effects on the ecosystem are highly dependent on the target species and the type of pathogens that will be introduced.

Indirect effects

The introduction of pathogens is added as an indirect pressure to the development of offshore floating windfarms and results from the introduction of individuals genetically different from local species and the modification of connectivity (new species bringing their pathogens).

For more details on the "pressure – receptor" pairs established for "benthic communities and habitats" and the iterative process that led to the characterization of the potential interactions, the detailed tables and technical meeting reports are available in the annexes (annex 9 for tables and annexes 3 to 6 for report).

d. Planktonic communities

The "planktonic communities" working group identified 8 "pressure – receptor" pairs during the technical meetings and concern direct effects (in blue in the table 12 below).

Methodological and prospective table derived from a risk-based approach. Cannot be applied to a specific site or defined project	Change of habitat	Changes in turbidity	Changes in hydrodynamic conditions	Change of temperature	Noise emissions	Light emissions	Chemical pollution	Introduction of individuals genetically different from local species
Planktonic communities	x	x	x	x	x	x	x	x

Table 12: "pressure – receptor" pairs established for "planktonic communities" components by the MSP-MED working group

Limited by the work carried out (mentioned previously), some elements of **potential interactions** characterizations are presented below:

Changes of habitats

For planktonic communities, the modifications associated to habitat changes are intrinsically linked to modifications in hydrodynamic conditions and turbidity (resuspension and mixing of sediments), even if the addition of anthropogenic infrastructures (floats, anchors, etc.) can provide new substrates and increase the surface area for the colonization of cnidarian polyps and some benthic species; this colonization may result in an increase in meroplanktonic phase populations such as polyps or hydromedusae.

Changes in turbidity

The local increase in turbidity can lead to a reduction in access to nutrients and lead to the emergence of some more competitive species such as diatoms. This emergence can lead to an unbalance ecosystem and have an impact on primary production. The increase in the suspended matter of the water column can also limit the access to light and thus limit phytoplankton growth, which could have repercussions on the entire food web and associated matter flows.

At a local scale, a modification of the community structure can be envisaged by a change in the dominant species. The increase in turbidity linked to the extraction of substrate or the resuspension of fine sediments by the movement of chains on the bottom, could limit the development of some species with a benthic larvae phase and favour the resuspension of cysts. Cysts correspond to the resting stage of some planktonic species and accumulate in the sediment awaiting a return to favourable conditions. As suggested by Belmonte & Rubino., (2019), some anthropogenic activities on the seabed (such as trawling) can lead to the resuspension of cysts and result in their germination or damage (Belmonte & Rubino., 2019).

Changes in hydrodynamic conditions

Hydrodynamic changes can affect the community structure and material flows within the food web. An increase in local agitation at the surface can lead to an increase in energy expenditure related to maintaining the water column and foraging. The physiological stress generated by this continuous surface turbulence can lead to a local reorganization of planktonic communities, regularly observed in the Gulf of Lion after storms. The presence of cables and anchor lines in the water column may, on a local scale, have an impact on stratification and on the transfer of nutrients that condition phytoplankton growth and, through a bottom-up effect, may impact the food web. The modification of hydrodynamic conditions can also favour the development of more generalist species with a wider range of tolerance to disturbances and contribute to a local change in planktonic communities and a decrease in the resilience of the ecosystem in the context of extreme events linked to the threshold effect. In the offshore floating windfarms area, the response of planktonic communities to these hydrodynamic disturbances can be very quick and have consequences on the whole food web (smaller planktonic resources or lower nutrient quality with visible effects on predator communities - e.g. results of Mona Lisa project[16]). Finally, the modification of hydrodynamic conditions could potentially contribute to the dilution of nutrients in the water column, which could have an impact in communities of detritus feeders. Even if the infrastructures are different, the impact of the modification of hydrodynamic conditions on the dynamics and structure of planktonic communities due to the development of offshore windfarms has been shown by Floeter & al., (2017).

Changes of temperature

Temperature variations in the immediate vicinity of the cables depend on the power of the cables and their protection system (on the bottom, buried, etc.). When they are on the bottom, temperature variations are low (< 0.11°C for an electrical power of 2MV) (Taormina & al., 2020), whereas when they are buried, a maximum rise of 2.5°C in the immediate vicinity of the cable (50 cm below the surface of the sediment and 50 cm from the cables) can be observed (for an electrical power of between 33 and 132 kV) (Carlier & al., 2019). In view of the natural temperature variations in the Gulf of Lion (6 to 7°C drop in water temperature in an event of strong wind that can be felt at a depth of up to 40 meters), local temperature changes due to the presence of the cables are considered secondary to the stakes related to changes in hydrodynamic conditions and turbidity for planktonic communities.

Noise emissions

The information available on the effects of noise emissions in planktonic communities (behavioural changes, sensory and physiological damages, larval malformations, etc.) is weak and mainly based on experimental approaches. An escape strategy for sensitive species could be considered depending on the type of emission (intensity, frequency, duration, etc.).

Light emissions

[16] https://wwz.ifremer.fr/Actualites-et-Agenda/Toutes-les-actualites/Baisse-de-taille-des-sardines-en-Mediterranee-le-role-de-l-alimentation-explique

Some planktonic species have a migratory daily cycle. These nychthemeral migrations are linked to their diurnal bathymetric level and concern all the species present in the water column (up to 250 meters deep) (Sardou & Andersen, 1993). Light emissions may influence the nychthemeral migrations of some species, with the main consequence of slowing down their ascent to the surface and increasing the risks of predation, even if this mainly concerns surface species which will, in fact, remain a little lower in the water column. The disturbances linked to these light emissions (backlighting of floats) may lead to a change in behaviour and physiological stress, which may reduce the efficiency of photosynthesis, the rate of reproduction and fecundity, feeding activity, etc.

Chemical pollution

Some information from the literature can be applied to the development of offshore floating windfarms, such as the effects of metal enrichment (iron and copper) in the water column (Floeter & al., 2017) or of chemical substances in some species: changes in reproduction rates (Jiang & al., 2010), physiological impacts, etc., with consequences along the whole food web.

Introduction of individuals genetically different from local species

The introduction and spread of species genetically different from native species and of non-native species is possible but not well documented. In the cases where infrastructure is produced and stored on site (in the Gulf of Lion), the introduction of species (genetically different and non-native) seems unlikely. On the other hand, the development of offshore windfarms may have an effect in connectivity by facilitating the expansion of species already present.

For deeper details on the “pressure – receptor” pairs and the iterative process that led to the characterization of the potential interactions between “planktonic communities” and the development of offshore floating windfarms in the Gulf of Lion, the detailed tables and technical meeting reports are available in the annexes (annex 10 for tables and annexes 3 to 6 for report).

e. Fish and cephalopods

185 “pressure – receptor” pairs were identified by the “fish and cephalopods” working group during the technical meetings and concern direct effects (in blue) (table 13).

Methodological and prospective table derived from a risk-based approach. Cannot be applied to a specific site or defined project	Loss of habitat	Change of habitat	Extraction of substrate	Changes in turbidity	Changes in hydrodynamic conditions	Changes of temperature	Noise emission (acoustic)	Noise emission (vibration)	Electromagnetic emissions	Light emissions	Chemical pollution	Organic enrichment	Hypoxia	Introduction of individuals genetically different from local	Dispersal of non-native species	Collision	Human activity	Obstruction to movement
Benthic soft substrate – eggs and larvae	x	x	x	x	x	x	x				x	x	x	x				
Benthic soft substrate – juveniles	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Benthic soft substrate – in transition	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Benthic soft substrate – adults	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Benthic hard substrate – eggs and larvae	x	x	x	x	x	x	x				x	x	x	x				
Benthic hard substrate – juveniles	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Benthic hard substrate – in transition	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x
Benthic hard substrate – adults	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pelagic – eggs and larvae	x	x		x	x	x	x				x	x	x	x				
Pelagic – juveniles	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Pelagic – in transition	x	x		x		x	x	x	x	x	x	x	x	x	x		x	x
Pelagic – adults	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 13: ”pressure – receptor” pairs established for “fishes and cephalopods” components by the MSP-MED working group

Within the limits of the work carried out (previously mentioned) some elements of characterization of **potential interactions** are presented below for each pressure:

Loss of habitat

Physical loss of habitats is a net, localised loss of functional habitat. Depending on the design of the floating infrastructure, the loss of habitat associated with a TLP model, held in place by tensioned chains, will be less than that of a semi-submersible barge/float model, held in place by anchored system. The regular pass of chains over the bottom during the operational period may limit the possibility of recolonization of the substrate, particularly for hard substrates which have a lower resilience than soft substrates. Depending on the location of the offshore windfarms, the loss of habitat may lead to the loss of functional habitats/areas (nesting, breeding, nurseries, feeding, etc.).

Changes of habitat

The addition of offshore floating infrastructure to the water surface will induce a change in habitat and can generate an attraction effect on some species. This attraction effect could have several consequences on community structure, migration routes, predation pressure, etc. Studies carried out in the Mediterranean on the "BoB buoy"[17] have shown an attraction effect on some coastal species such as *Gilthead*. Depending on the regulations that will be imposed within offshore floating windfarms, a reserve effect could potentially be observed with, once again, a risk of predators' attraction, modification of the communities' structure and connectivity by transferring fishing efforts to neighbouring populations or to the edge of the offshore windfarm. Finally, the alteration of connectivity through the destruction of functional habitat zones (breeding, feeding, reproduction, nursery, etc.) may lead to a reduction in the survival rate in the more or less long term, with mortality rates that may be high throughout the species' adaptation period (exploration of new, more favourable functional habitat zones). The change of habitat can also be materialized by the introduction of a new type of substrate into the environment which can have consequences on the recruitment rate and favour/limit the attachment of some eggs/larvae. All the consequences linked to these habitat changes can have an impact on the abundance of the population (Langhamer., 2012; Stenberg & al., 2015), the structure of the communities (Van hal & al., 2017) and induce a modification (complexification) of the trophic relations (Raoux & al., 2017).

Extraction of substrate

Depending on the type of habitat (hard or soft substrate), substrate extraction may lead to a punctual or permanent loss of egg attachment and eggs themselves, depending on the time of year. More broadly, substrate extraction can lead to a punctual or permanent loss of habitats and functional areas and lead some benthic and/or pelagic species to abandon a habitat of interest.

Changes in turbidity

A change in turbidity can lead to anoxia by reducing the oxygenation rate of eggs or clogging of gills, which can lead to suffocation (Wenger & al., 2017) or an increase in respiratory rate. The associated physiological stress can influence the growth and development of organisms and disrupt swimming ability (Wenger & al., 2017). By reducing visibility, increased turbidity can increase energy expenditure related to prey search and lead to a decrease in species survival rates. These changes in feeding behaviour may ultimately have consequences for trophic relationships (Kjelland & al., 2015). The presence of high turbidity areas can also change the behaviour of species which will tend to avoid the area and limit their movements. Increased particle load can lead to an increased risk of abrasion of the protective mucus of fish and favour the development of parasites and diseases making them more vulnerable to predators.

Changes in hydrodynamic conditions

The impact of offshore floating infrastructure on hydrodynamic conditions can affect some larvae and pelagic species that live at the surface between 0 and 4 metres depth, with less impact on benthic species (Schvartz., 2021). The modification of these surface currents can affect the transport and/or migration routes of larvae/juveniles and cause a decrease in their survival rate (increased energy expenditure, loss of food, etc.). Changes in hydrodynamic conditions can lead to an increase in the risk of predation and change the prey/predator ratios.

Changes of temperature

There is little information of the impact of power cables on fish and cephalopod communities. In absolute terms, a variation in temperature can generate a modification of attraction/repulsion behaviour depending on the species and could have an impact on the associated relationships. Depending on the species and temperature variations, these changes can lead to physiological stress with consequences for the respiratory rate, metabolic functioning, growth, reproduction, etc.

Noise emissions

Increased ambient noise can affect the masking of biologically important sounds and lead to changes in inter- and intra-specific interactions (prey/predator relationships - Popper & Hawkins., (2019), reproduction, etc.). This increase

[17] More information on BoB buoy: https://www.ecocean.fr/offshore-bob/

in noise level can also lead to physiological stress (Popper & al., 2019) and abandonment of the area. Depending on their nature (type, frequency, duration, intensity), noise emissions can also lead to physical and/or physiological injuries that have an impact on the species' hearing and survival rates.

Electromagnetic emissions

The impact of electromagnetic emissions on fish and cephalopod species is still poorly understood, although effects on the behaviour (attraction, avoidance, foraging, etc.), navigation and orientation capacity of some species can be envisaged. These behavioural changes may result in a modification of species distribution and community structure with consequences for specific prey/predator interactions.

Light emissions

Depending on the species, light emissions at night can generate physiological stress and behavioural changes (attraction, avoidance, etc.) with consequences for spatial distribution and population dynamics and the survival rate of species through attraction of visual predators (Keenan & al., 2017). During the day, the effect of shading can generate a phenomenon of attraction of predators and have an impact on the migratory routes of some species.

Chemical pollution

Chemical pressures could have direct and indirect effects on all receptors by contaminating the entire food web. Physiological changes induced by accidental pollution could have effects on larvae development, juvenile growth, adult reproduction and have consequences on reproduction rates, malformation, and mortality of individuals. Depending on the nature of the pollutants (toxicity, etc.) and the quantity emitted (punctual or continuous), chemical pollution can lead to a variation in biomass/abundance and modify the spatial distribution and dynamics of populations.

Organic enrichment and hypoxia

Organic enrichment and anoxia phenomena could have multiple consequences on benthic and pelagic species such as: increased physiological stress (growth, nutritive quality of prey, etc.), disruption of swimming capacities, behavioural modifications, etc., with consequences on mortality rates, spatial distribution of species and population dynamics.

Introduction of individuals genetically different from local species and dispersal of non-native species

Except for the early life stages (larvae and eggs), all life stages of fish and cephalopods can be impacted by the introduction of individuals genetically different from local species and the dispersal of non-native species and generate an increase in predation and a change in abundance/biomass and trophic relationships.

Collision

The chains movement in a restricted area will necessarily increase the risk of injuries and mortality, particularly for large species.

Human activities *(species disturbance)*

The increased of human activities will have a direct effect on species sensitive to human disturbance, with avoidance, escape, etc. and affect species life cycles and survival rates.

Obstruction to movement

The risk of obstruction mainly concerns species whose transition from the larvae to the juvenile stage (disruption of larval dispersal, for example) could be directly impacted by the presence of offshore floating infrastructures at sea, with a consequently changes in connectivity. This obstruction can also lead to the abandonment of a preferred habitat by some species.

For further details on the "pressure – receptor" pairs and the iterative process that led to the characterization of the potential interactions between "cetaceans and sea turtles" and the development of offshore floating windfarms in the

Gulf of Lion, the detailed tables and technical meeting reports are available in the annexes (annex 11 for tables and annexes 3 to 6 for report).

3.1.4 "Sensitivity", "Knowledge" and "Conservation status" assessment

The prioritization of the "activity – pressure - receptor" chains and the determination of final scores has not been carried out as initially planned though the MSP-MED case study. This step of the process was supposed to identify the highly sensitive interactions for which scientific knowledge is reasonable and interactions for which scientific knowledge is too low.

For the "*benthic communities and habitats*", "*cetaceans and marine turtles*" and, "*flying fauna*" working groups, the original method was simplified so that it could be implemented in a shorter technical meeting (1 hour) with a limited number of participants.

For the "*fish and cephalopods*" and "*planktonic communities*" working groups, the presentation of the scoring method could not be achieved as the 4th technical meetings were entirely dedicated to the definition of receptors and to the identification and characterization of potential interactions. **Results obtained during the technical meetings are presented in the following section only for information purposes, given limitations imposed by this type of exercise.**

a. Sensitivity

In response to the constraints of the technical meeting, the assessment of sensitivity has been simplified by using a colour code: green indicates that the sensitivity of the receptor to pressure is thought to be low by the participants, yellow medium, orange high and red major. According to the recommendation of the experts, the colour grey is added so that the experts can indicate that the sensitivity of the receptor to a pressure is not known. For the particular case of the "*benthic communities and habitats*" working group, a correspondence with the accurate evaluation defined by La Rivière & al. (2016) for the evaluation of physical pressures on benthic habitats was established in order to align the results. A correspondence between the original assessment grid and the simplified grid used in the framework of MSP-MED was defined in parallel.

Depending on the working groups and, despite the lack of overall knowledge, the different approaches (by group of species, species and habitats) allow each participant to assess the sensitivity according to their own knowledge of the biology, behaviour, characteristics and specificities of the various receptors. **At this step the assessment of sensitivity is even more difficult because of the approach is prospective**. The sensitivity of many receptors will depend on parameters that are not considered here, such as seasonality, biological rhythms, pressure intensity and frequency, etc.

These elements, as well as those provided by the experts during the technical meeting**, will have to be revised when a quantification of the effects is made possible by the acquisition of the necessary information** (surface area affected by the pressure, percentage of the habitat impacted, duration of exposure to the pressure, frequency, etc.). The notion of quantification is important because it allows experts to be more precise in their assessment of sensitivity and to estimate the degree of reaction of a habitat to a particular pressure according to its tolerance and resilience as well as the characteristics of the pressure (intensity, duration, frequency, etc.).

The table summarising all the preliminary results obtained for the sensitivity assessment within the three working groups is presented in annex 12.

b. Knowledge

Likewise, the sensitivity assessment, the knowledge assessment grid was simplified to a 4-level assessment grid: 1, the level of knowledge is considered low by the participants; 2, it is considered medium and 3 high. The level 0 is added flowing the recommendation of the participants to indicate a lack of knowledge. This addition allows to make the difference between interactions where participants indicate a lack of knowledge and those where participants do not wish or cannot give a score.

The knowledge assessment is based on the level of scientific knowledge (publications, research results, grey literature, etc.) and for the majority of participants the level of knowledge is considered to be the same for all phases of offshore floating windfarms development. This scoring exercise is even more difficult than the sensitivity scoring, and all the results is presented in annex 13.

c. Conservation status or "Ecological stake"

The "conservation status" score (1- 10), is named **"Ecological stake" (E)** in MSP-MED, were assigned according to two sub-criteria: IUCN status and the ecological issues identified in the French maritime spatial planning for the Mediterranean region. For species and habitats, the IUCN scores were defined according to the level of threat assigned by the IUCN for the "Europe" assessment area. The scores associated to the environmental issues identified in the Maritime Spatial Planning process were assigned by numerical transcription of the issue levels identified in the French MSP plan for the Mediterranean coastline for the areas concerning the MSP-MED project perimeter: continental shelf of the Gulf of Lion, south-western canyons of the Gulf of Lion and central and north-eastern canyons of the Gulf of Lion. For the particular case of the benthic habitats, the correspondence between the typology of the MSP-MED receptors and the French MSP plan for the Mediterranean coastline was carried out in collaboration with the "*benthic communities and habitats*" working group.

For each of these two sub-criteria, the final score corresponds to the highest (table 14). The detailed tables presenting all the results are available in annex 14.

Cetaceans and sea turtles	
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)	7
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)	7
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)	8
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)	5
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)	5
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)	5
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)	5
Flying fauna	
Migratory bats	2
Foraging bats	2
Passerines	2
Raptors	2
Anatidae & Rallidae	8
Shorebirds	2
Loons	2
Wader species	10
Herons and allies	8

Cormorants	10
Shearwaters	10
Gulls	10
Terns	10
Hydrobatidae	10
Razorbills	10
Puffins	10
Skua sp.	10
Northern Gannet, *Morus bassanus* (Linnaeus, 1758)	10
Benthic communities and habitats	
Biocenosis of supralittoral sands	10
Biocenosis of mediolittoral sands	10
Biocenosis of the mediolittoral detritic	10
Biocenosis of mediolittoral rocks	8
Biocenosis of superficial muddy sands of calm mode	10
Biocenosis of infralittoral rocks	8
Biocenosis of rough sands and fine gravels tossed by the waves	10
Biocenosis of sands and gravels under the influence of bottom currents	10
Biocenosis of the *Posidonia oceanica* meadows	10
Biocenosis of high-level fine sands	10
Biocenosis of well calibrated fine sands	10
Biocenosis of infralittoral algae	8
Biocenosis of the *Cymodocea nodosa* meadows	10
Biocenosis of the meadows with *Zostera noltii* and *Zostera marina*	10
Perennial brown algae (ochrophytes, kelp, cystoseires)	8
Biocenosis of coastal terrigenous muds	10
Biocenosis of the offshore rock	8
Biocenosis of coastal detritic	10
Coralligenous biocenosis	10
Biocenosis of offshore detritic bottoms	10
Biocenosis of bathyal muds	10
Facies of soft mud with *Funiculina quadrangularis* and *Aporrhais serresianus*	10
Biocenosis of bathyal detrital sands with *Gryphus vitreus*	10
Biocenosis of bathyal rocks	10
Underwater structures caused by gas emissions (pockmark)	10
Hydraulic dunes	8
Canyon heads	8
Benthic species	8

Table 14: Synthesis of ecological stakes allocated by the MSP-MED project. Based on Ministère de la transition écologique et solidaire., (2019); European commission., (2016); Bearzi & al., (2012); Panigada & al., (2012); Notarbartolo & al., (2012); Cañadas & al., (2012)a; Cañadas & al., (2012)b; Gaspari & al., (2012); Camiñas & al., (2020)

3.1.5 Draft of "activity – pressure – receptor" chains

The work carried out in collaboration with the scientific community has resulted in a very high number of "*activity – pressure - receptor"* chains (214 "activity – pressure" pairs & 526 "pressure – receptor" pairs in total). The high number of chains is partly the result of the *prospective approach* taken and the **absence of a precise and detailed study framework** (defined geographical area, technology used, surface area affected, etc.). It is also due to the **lack of prioritization, as this last step could not be carried out adequately** within the different working groups.

3.2 Limits

As already mentioned in the introduction of the "results" section, the main limits of the MSP-MED work are mainly due to the prospective approach made on the scale of the Gulf of Lion and the lack of knowledge.

The implementation of a prospective approach

The framework proposed at the scale of the Gulf of Lion for undefined projects (lack of spatiotemporal information - duration, pressure intensity, surface and volume impacted, scale of the windfarms, etc.) and covering all the technologies linked to offshore floating windfarms limits the results to a **high degree of uncertainty**. Within the theoretical and prospective approach conducted in MSP-MED, the large number of species and functional traits does not allow (i) to go into the **fine study of interaction risks** at a large scale and (ii) to carry out an **assessment of interaction risks relevant for the study of the effects of offshore floating windfarms on ecosystems**. The effect assessment requires the implementation of an operational approach. The prospective approach is a good solution to overcome the lack of experience with offshore floating windfarms and to provide expert knowledge (based on their individual knowledge and experience). The global approach makes possible to establish a knowledge basis and to put **forward hypotheses on the interactions and potential effects of offshore windfarms development** but does not allow going beyond the prospective exercise of identifying and characterizing the interactions. To compensate the bias linked to "expert opinion", a few bibliographical references relating to case studies or observations have been provided.

Despite the prospective approach, the MSP-MED work provides the basis for more concrete work. The broad spectrum of receptors can be reduced or adapted (deletion of habitats not concerned, addition of key species, etc.) during operational implementation. The same applies to the number of activities and pressures (deletion of some activities depending on the technologies implemented). A better distinction between what happens on the coast (connection) and what happens offshore (deployment area) will also be possible. Despite the difficulty of the prioritization exercise, the identification, characterization and expert assessment of the sensitivity of "pressure-receptor" pairs are exercises regularly carried out by the scientific community (e.g. Natura 2000 assessments). The methodological framework proposed in MPS-MED is therefore appropriate and consistent with what already exists.

Lack of knowledge

The study and assessment of the effects of an activity on marine ecosystems requires a good level of prior knowledge of the potentially impacted ecosystems and their functioning. Although some species in the Gulf of Lion are well described, there are still gaps in our knowledge of the complete life cycle of some species and the location of the functional areas (egg-laying area, feeding area, etc.) associated with them. These elements are important in the context of an assessment of the effects because the degradation of some functional areas without knowing the species' ability to carry over and the potential significant consequences on the populations structuration or on the ecosystems functioning. In the various working groups, the receptors were therefore determined within the limits of current knowledge and the individual knowledge/experience of the participants. In addition, for some working groups, the lack of knowledge on inter- and intra-species interactions or the role of some lesser-known species (not of commercial or heritage interest, for example) in the functioning of the ecosystem, or the consequences of changes in hydrodynamic conditions on species, made the definition of receptors difficult.

The ecological compartment approaches

While the ecological compartment approach seems appropriate for the study of interactions with marine megafauna (cetaceans, sea turtles, and seabirds) - despite the potential indirect effects of changes in the food web - it seems more difficult to implement for the other ecological compartments (pelagic and benthic habitats and communities), which remain in strong interaction/relation with (i) the oceanographic characteristics of the environment and (2) the other components of the food web. However, the different approaches undertaken by working groups allow to address each ecological compartment specificities and, in some cases, to also address common biodiversity. Species-based approaches generally focus on species of socio-economic interest (heritage species, commercial species, etc.) only, and are not representative of ecosystem functioning.

Methodological framework

In line with the species-based approaches described above, the establishment of a reduced list of species for the definition of receptors of interest restricts the analysis to species selected according to criteria (sensitive species, threatened species and, species of commercial interest) which may vary according to the objectives of the study and which generally focus on known species. This type of selection does not include little-known or little-considered species that are nevertheless essential to the functioning of marine ecosystems. While this preliminary inventory process seems suitable for the marine megafauna (mainly cetaceans and sea turtles), it can quickly turn complex for other ecological compartments given the number of species and the inter- and intraspecific relationships that govern the food web. Furthermore, this type of inventory is limited to known species within the area of interest and does not include terrestrial or migratory species which may also be impacted by offshore windfarms development and not be consider in the study of potential effects. Involving experts earlier in the process of defining receptors seems more appropriate for defining a list of receptors rather than studying, *posteriori*, a reduced and non-exhaustive list of receptors from the impact studies.

The prospective approach conducted in this MSP-MED task allows to identify pressures for which there is little or no knowledge about potential interactions with the marine ecosystem in the context of offshore floating windfarms development. The occurrence of some pressures is also difficult to assess (e.g., turbidity on deep-sea habitats). Some pressures may have short-term effects, while others may have an impact on marine ecosystems if they persist over time. This distinction must be considered in the case of offshore floating windfarms (which are expected to operate for 25 to 30 years) but is not possible with the method implemented. A prospective rating of the probability of occurrence could provide additional information.

Finally, the definitions of pressures may also vary from one working group to another. In MSP-MED the definition associated with each pressure has not been modified to maintain a common methodological framework between the different working groups. However, this has led to the definition of sub-categories of pressure in order to specify the type of pressure considered by the participants (e.g. acoustic pressure and vibration pressure for noise emissions, which do not have the same impact on marine fauna).

4 Perspectives

4.1 Methodological framework

The prospective approach implemented in MSP-MED imposes the consideration of a wide spectrum of receptors which may, depending on the working groups, be very broad and seem irrelevant. The definition of one or more scenarios according to the study area, the number of infrastructures, etc., even if they are theoretical, can allow a better definition of the receptors. This is especially true for habitats where area-based approaches are more relevant for determining the relevant receptors. For example, in the case of MSP-MED and regarding to the cross-border objectives, 4 scenarios can be proposed to "operationalize" the method implemented by limiting it to area 3 of the **commercial offshore floating windfarms** projects located close to the French-Spanish border:

Area 3	Area 3	Area 3	Area 3
Barge/Semi-submersible	Barge/Semi-submersible	TLP	TLP
Small commercial offshore windfarms (20 wind-turbines)	Medium commercial offshore windfarms (40 wind-turbines)	Small commercial offshore windfarms (20 wind-turbines)	Medium commercial offshore windfarms (40 wind-turbines)

Table 15: Example of a possible concrete scenario for a more operational implementation of the method used in MSP-MED

In addition to the scenarios, various types of risk-based approach would provide information on the potential effects of interactions between human activities and marine ecosystems. Without mentioning the species to be considered, the approach proposed by Ruitton & al., (2020) is based on a sensitivity grid which, according to the main biological traits and characteristics of the habitats and/or species (ingenious species, photophilic species, etc.) and allows to identify the species and/or habitats that will be more or less sensitive to a pressure. This approach allows a wider range of species as well to be considered and it is based on their biological characteristics and not on their regulatory or protection status. The work of La Rivière & al., (2016) also proposes a method for assessing the risks of anthropogenic activities and it is based on tables for evaluating the sensitivity of habitats according to their resistance and resilience.

A complementary approach to the definition of receptors can also be carried out to assess interactions based on the principles of the “*avoidance-reduction-compensation*” sequence to prior the projects. The definition of receptors would allow the identification of habitats for which the risk of interaction is low and thus guide projects (e.g., directing landing works towards soft substrates or fine sands). Such approach should guide decisions and could be used in the context of maritime spatial planning to define areas suitable for the development of some uses, including offshore floating windfarms.

In addition to the 5 ecological compartments studied here, the consideration of interactions between *"infrastructure"* and *“marine environment”* may be interesting, in particular for hydrodynamic conditions. The pressure "modification of hydrodynamic conditions" can be removed and be considered through a dedicated working group. This proposal is the result of discussions in the “benthic communities and habitats”, “fish and cephalopods” and “planktonic communities” working groups and it is the result of the strong relationship (or even dependence) of some marine organisms with the hydrodynamic conditions. However, the potential impacts of offshore windfarms on the abiotic environment and their effects on fauna and flora are still poorly studied and the specific case of the impact of floating infrastructures on hydrodynamics has not been addressed (Defingou & al., 2019). The main risks of changes in hydrodynamic conditions identified during the MSP-MED project (changes in surface currents and turbulence, changes in turbidity and sediment dynamics, destabilization of clines, etc.) and the effects of offshore fixed windfarms observed could serve as a basis for the creation of a dedicated working group bringing together scientists from different fields: oceanography, modelling, physics, etc. This work on the potential effects of offshore windfarms on hydrodynamic conditions, carried out prior to the identification of receptors, can facilitate, or orient the definition of more relevant receptors.

4.2 Recommendations

The set of recommendations proposed below is the result of the exchanges within the different working groups. These recommendations are the result of the needs identified during the work conducted in the MSP-Med project or directly result of the list of recommendations transmitted by the participants in the 4th technical meeting. These recommendations are addressed to the authorities responsible of the implementation of MSP and for developers to improve the consideration of marine ecosystems in future offshore windfarm projects. Only the general recommendations are mentioned below (specific recommendations for each working group are available in annex 15).

Improving ecological knowledge

- Encouraging the implementation of standardized monitoring protocols at a European scale. Such cooperation will make it possible to increase knowledge with homogeneous and comparable data at the scale of the Gulf of Lion and the Mediterranean Sea;
- Providing the necessary means (technical, financial, human, etc.) for the exploitation of existing data - mainly resulting from cetacean and seabird monitoring - for which the processing and analysis could not be carried out exhaustively due to the lack of means;
- In partnership with the scientific community (and the coordinators of campaigns and national observation services in particular), improving the monitoring of hydrological (salinity, temperature, etc.), physico-chemical (turbidity, dissolved oxygen, pH, etc.) and biological (fluorescence) parameters to better understand the local functioning of the ecosystems and to monitor their responses to the pressures generated by offshore floating windfarms. This cooperation could take the form of (i) the instrumentation of new sites next to offshore windfarms according to the protocols set up and tested by the existing national observation services[18] and (ii) the addition of complementary equipment in existing instrumented sites[19] to mutualize collect and monitoring efforts;
- Improving monitoring protocols (i.e. duration and frequency) so that the sampling effort is sufficient and relevant to assess long-term changes in species distribution and density within the Gulf of Lion;
- Improving knowledge of the life cycle and movements/migrations of species at different spatial (e.g. horizontal, vertical) and temporal (e.g. daily, seasonal, annual) scales in order to better identify the connections between the different areas of the Gulf of Lion, and between the benthic and pelagic compartments, which are closely linked in their functioning;
- Improving knowledge in the identification of functional species/habitats.

Improving knowledge of environmental conditions

- Modelling currents and hydrodynamics conditions in the area in order to (i) produce scenarios for the evolution of currents (locally and at the scale of the Gulf of Lion) according to the types of infrastructures and their location, and (ii) to estimate the repercussions of the hydrodynamic modifications due to the transport of passive organisms or life stages (plankton, including eggs, larvae) in order to choose the infrastructure designs.

[18] Gathered in the ILICO research infrastructure (national observation services COAST-HF, MOOSE, etc.): https://www.ir-ilico.fr/
[19] MESURHO station of COAST-HF network, MOLA station of MOOSE network, etc.

Developing relevant monitoring for the study of interactions and experimenting technologies to benefit from feedback

- Waiting for the results and feedback from the pilot offshore windfarms before deploying commercial offshore windfarms, in order to know the main impacts and determine the best "pressure-receptor" pairs to be monitored. This feedback will also help to select the least impacting technology regarding ecosystems and to identify the possibilities of eco-design of floats in favour of indigenous biodiversity;
- Based on the feedback from the pilot offshore windfarms, quantifying the effects (volume, surface area impacted, etc.) to allow the scientific community to make relevant and operational recommendations.
- Equipping the pilot offshore windfarms areas with the tools needed to benefit from solid feedback on the best monitoring methods. From this experience, equipping this area with precise and adapted tools to identify interactions and study their effects (short and long term) at the scale of species, communities and ecosystem;
- Developing systematic sampling protocols on board of all vessels involved in the development and maintenance of offshore windfarms to be performed by qualified observers. Direct observations will provide information on the behaviour and density of species in the area and will document collisions and entanglements with existing infrastructure and equipment;
- Implementing monitoring programs for monitoring all species frequenting this area. In particular, the distribution and abundance of cetaceans and sea turtles can be monitored by visual and acoustic methods (e.g., fixed devices), and the distribution of seabirds during the day and night can be monitored by fixed radars at sea. These programs should be implemented both, in the area of offshore windfarms and in adjacent 'control' areas;
- Extending monitoring to contaminants that may have an impact on the food web and its functioning, so as not to be limited to the prism of human health. Dedicated monitoring of chemical pollution within the pilot offshore windfarms would make it possible to identify the different types of pollutants emitted into the marine environment - in particular from sacrificial anodes - and to implement specific monitoring for distinguish punctual and chronic pollution;
- Improving knowledge of the reef effect in order to assess the attraction/repulsion effect on various species, including the species that constitute the food resources of top-predators (cetaceans, marine turtles, etc.);
- Implementing adapted monitoring to the duration of the life cycle of species and the renewal/recovery time of populations. Three-year impact studies do not make it possible to predict the effects on the entire life cycle of a species and on trophic levels. In order to study the indirect effects on the whole food-web, even longer monitoring times (> 10 years) should be envisaged;
- In this sense, project developers (pilot or commercial offshore windfarms) should be encouraged to implement multi-annual contracts to monitor the impacts of infrastructures on communities over the long term. The implementation of this type of long-term cooperation agreement offers the guarantee of relevant and comparable monitoring over time (protocol, experts mobilized, constant sampling effort, operators mobilized for analyses, etc.). Several contracts of this type already exist for some industrial projects and should be applied to offshore windfarms;

- Using the pilot offshore windfarms to study their effects on hydrodynamics conditions and currents by setting up ADCP[20] directly in the area of the offshore windfarms and outside, focusing on the east and west areas that correspond to the direction of the prevailing winds (in the Gulf of Lion);
- Prioritizing the acquisition of knowledge on the study of interactions and effects of offshore windfarms at a local scale, with an emphasis on monitoring material flows, changes in hydrodynamic conditions and potential changes in light (natural light and attenuation; light generated by the structures themselves).

Improving the consideration of interaction risks and effects

- According to stakeholders, defining a common protocol to harmonise the monitoring carried out in impact studies and sharing the results by making them public, accessible and interoperable;
- Improving knowledge of the pressures generated by all human activities in order to consider their cumulative effects on ecosystems, and integrate these cumulative effects into impact risk assessments. The synergistic effect of pressures on species is poorly known and should be allowed for studying and assessing interactions;
- Integrating the study of oceanographic conditions and their evolution in the analysis of the potential effects of offshore windfarms on ecosystems;
- Allowing the differences in resilience between habitats and communities on hard substrates (very long and limited recovery) and soft substrates (greater and faster recovery) during the area's selection;
- Identifying, by ecological compartment, the species for which there is no alternative in the event of habitat destruction, to preserve their functional areas (particularly egg-laying and larval dispersal areas) by directing the definition of the areas for offshore windfarms towards areas of lesser functional importance or better represented. This identification and location work would allow the determination of the possible existence and extent of ecologically redundant areas (same functionalities) at the Gulf of Lion scale. Their protection (total or partial) will ensure the sustainability of the species affected;
- Considering the impacts of offshore windfarms beyond the ecosystem according to the potential indirect effects on society and other economic activities in the impacted area (in particular fishing, tourism and maritime transport);
- Giving priority to study the functional impact of offshore windfarms development in order to understand (i) how the installation of one (or more) wind-turbine(s) will impact a species and its environment and (ii) how these impacts will affect the whole food-web;
- Considering the size of the projects (number of infrastructures, impacted surface, etc.). The observations made at the scale of the pilot offshore windfarms cannot be extrapolated to a larger dimension. If the degradation of a habitat over a small area can be considered acceptable depending on its characteristics and the duration and frequency of the pressure, it may be considered unfavourable if the entire area of this habitat is impacted;
- Identifying the sources of chemical emissions resulting from the development of offshore windfarms in order to know the types and nature of the pollutants that will potentially be emitted into the water column in order to study, in a second phase, their effects on the different ecological compartments;
- Encouraging cross-border cooperation in the study of long-term effects, particularly for projects located on the border of the Gulf of Lion, in order to mutualise monitoring and data. This cooperation would make it possible to monitor and study the effects of offshore windfarms at a large scale (western Mediterranean);

[20] ADCP: Acoustic Doppler Current Meters are used to determine the speed of currents

- Considering potential effects at the appropriate geographic scale for each species, population, parameter or type of monitoring. The national scale is often too small to provide information on the spatio-temporal distribution of highly mobile species;
- In this sense, encouraging cross-border cooperation at a Mediterranean scale by including European and North African countries in order to obtain a global vision of the migratory routes and distribution of species (among fish, cetaceans, birds, etc.);
- Encouraging the continuation of the cross-border cooperation initiated within the framework of the MSFD in order to harmonize monitoring and to facilitate data exchange;
- Encouraging the implementation of standardized protocols on a cross-border scale and the use of common tools (models, satellite images) in order to carry out large-scale comparative studies.

Reducing potential impacts

- Developing and testing eco-design methods to limit the environmental impact of infrastructures;
- Encouraging the development of alternative mooring techniques and technologies that have little or no impact on the seabed (particularly dredging). Float designs that limit the number of chains, such as TLP designs, could reduce the level of impact of dredging on the seabed and limit the area of destruction of substrates (soft or hard);
- Defining, in consultation with scientific experts, a maximum surface area acceptable for the degradation of the seabed by all human activities carried out in the Gulf of Lion and integrate it into maritime spatial planning documents to reconcile all activities generating destruction (punctual or permanent) of the seabed. Reducing the surface area of degradation will ensure the functionality of habitats at a large scale and thus limit the risks of collapse of ecosystems dependent on soft substrate habitats. According to the experts, agreements with other activities that cause seabed degradation should be reached so as not to increase the degradation surface of soft substrates;
- Maintaining a functional network in the installation scheme of offshore windfarms to ensure that a minimum of habitats or migration routes are maintained in the vicinity of the areas, ensuring rapid recolonization of the substrates after the work and guaranteeing a minimum of functionality in these habitats;
- Ensuring that the size of offshore floating infrastructures and the distance between them do not impact the natural light of the water column so that the natural functioning and productivity of the euphotic zone is preserved;
- Considering the biological cycles and rhythms of species during the installation, maintenance and decommissioning work (particularly for avifauna: wintering period, migration, etc.);
- Excluding potential offshore windfarms development areas from "major" migration routes;
- Setting up offshore windfarms as far as possible from the coast (for birds) and functional areas (feeding, breeding, etc.);
- Testing and improving scaring methods to reduce collision rates (specially for cetaceans, sea turtles and seabirds);
- Considering all the alternatives to the development of offshore windfarms that could have less impact on biodiversity and marine ecosystems. This initiative would enable the different marine renewable energy

technologies to be put into perspective, despite their different stages of development, and to choose the most suitable technology to limit the impact on biodiversity;

- Identifying and assessing the ecosystem services (direct and indirect, etc.) of the concerned coastal zones concerned to better guide the choice of areas for the deployment of offshore windfarms.

Raising awareness among stakeholders, citizens and decision makers

- Raising awareness among stakeholders and citizens about the risks of interactions between offshore windfarms activities and ecosystems, such as the risks of habitat loss and population displacement;
- Advocating a reduction in energy consumption at different scales (European, national, regional and, individual) by inducing new laws (national and European) but also encouraging a change in individual behaviour.

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Sitography:

- Website of PGL project: https://www.provencegrandlarge.fr
- Website of EFGL project: https://info-efgl.fr
- Website of EOS public debate: https://eos.debatpublic.fr

Annexes

Annex 1

Detailed list of activities defined in the context of the MSP-MED project by the different working groups involved. The list concern all phases of offshore floating windfarms life cycle (Prospecting; Construction; Operation; Decommissioning).

	Phases of floating offshore windfarms life cycle			
Activities	Prospecting	Construction	Operation	Decommissioning
Buoys / Floating platforms (barge and semi-submersible)	*LIDAR buoys; Scope buoys*		*LIDAR buoys; Scope buoys*	
TLP floating platforms			*Floating infrastructure*	
Anchor lines - Steel	*LIDAR buoys; Scope buoys*		*Anchoring of floating infrastructure*	
Anchor lines - Synthetic fibres (nylon, polyester)			*Anchoring of floating infrastructure*	
ROV inspection (umbilical + module)	*Site survey*	*Site inspection / Monitoring*	*Site inspection / Monitoring*	*Site monitoring*
Geophysical surveys	*Site survey*		*Site inspection / Monitoring*	
Geotechnical surveys	*Site survey*			
Magnetic surveys	*Site survey*		*Site inspection / Monitoring*	
Depositing and pulling the anchor (burial anchor)		*Anchoring (burial anchor) of floating infrastructure*		
Drilling (for hard substrate - suction pile, driven pile)		*Drilling for hard substrate (suction pile, drilled pile) - Floating and fixed infrastructures (offshore electrical substation)*		
Installation of suction pile and associated tensions-leg		*Anchoring (burial anchor) of floating infrastructure*		
Hydraulic piling (driven pile)		*Installation of fixed infrastructures (offshore electrical substation)*		
Scouring protection		*Protection of fixed infrastructures (offshore electrical substation)*		
Fixed foundations			*Foundation of fixed infrastructures (offshore electrical substation)*	
Dredging		*Ground preparation*		
Excavation		*Ground preparation*		
Burying		*Burying of cables*		
Cable protection (Concrete mats, Riprap, Protective shells)		*Protection of cables*		
Midarch water			*Offshore floating electrical substation) (R&D in progress)*	
Ballasting / De-ballasting of floating		*Stabilisation of*	*Stabilisation of floating*	*Stabilisation of*

platforms		*floating infrastructure*	*infrastructure*	*floating infrastructure*
Maritime traffic	*Vessels (work, transport, surveillance, etc.)*	*Vessels (work, transport, surveillance, etc.)*	*Vessels (service, transport, surveillance, etc.)*	*Vessels (work, transport, surveillance, etc.)*
Air traffic		*Site inspection / Monitoring*	*Site inspection / Monitoring / Service*	*Site monitoring*
Human intervention (divers, infrastructure maintenance, etc.)		*Site inspection / Monitoring*	*Site inspection / Monitoring*	*Site monitoring*
Blade			*Wind-turbines*	
Nacelle			*Wind-turbines*	
Mast			*Wind-turbines*	
Cathodic protection			*Floating and fixed infrastructures (offshore electrical substation)*	
Anti-corrosion coating			*Floating and fixed infrastructures (offshore electrical substation)*	
Inter-array cable			*Inter-array cable*	
Buoyancy modules			*Inter-array cable*	
Bottom connector (TDP, Touch Down Point)		*Protection of cables*		
Day and night lighting (lights and infrastructure back-lighting)			*Floating (platforms and buoys) and fixed infrastructures (offshore electrical substation)*	
De-burying				*Removal of cables*
De-protection				*Removal of protection system*
De-construction				*Floating and fixed infrastructures (offshore electrical substation)*

Annex 2

Detailed list of receptors defined in the context of the MSP-MED project by the different working groups involved.

This table results from the work carried out by the 5 MSP-MED working groups and the following bibliography for the lists of associated benthic species (based on the selection criteria proposed during the technical meetings): Baraud L., (2020); Conseil de l'Europe., (1979); De Rock P., & al., (2021); Goñi R., (2014); IUCN., (2016); Kersting D., & al., (2019); Michez N., & al., (2014); UNEP., & al., (1976).

Receptors			
Cetaceans and marine turtles			
	Species approach		
	Cetaceans		Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)
			Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)
			Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)
			Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)
			Long-finned pilot whale, *Globicephala melas* (Traill, 1809)
			Risso's dolphin, *Grampus griseus* (Cuvier, 1812)
	Marine turtles		Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)
Flying fauna			
	Group of species approach		
	Groups of species		*Associated species*
	Migratory bats		
	Foraging bats		
	Passerines		
	Raptors		Osprey, *Pandion haliaetus* (Linnaeus, 1758)
			European Honey-buzzard, *Pernis apivorus* (Linnaeus, 1758)
			Western Marsh-harrier, *Circus aeruginosus* (Linnaeus, 1758)
			Montagu's Harrier, *Circus pygargus* (Linnaeus, 1758)
			Eurasian Hobby, *Falco subbuteo* (Linnaeus, 1758)
			Lesser Kestrel, *Falco naumanni* (Fleischer, 1818)
	Anatidae & Rallidae		
	Shorebirds		
	Loons		
	Wader species		Black-tailed Godwit, *Limosa limosa* (Linnaeus, 1758)
	Herons & allies		Purple heron, *Ardea purpurea* (Linnaeus, 1766)
			Squacco heron, *Ardeola ralloides* (Scopoli, 1769)
			Little bittern, *Ixobrychus minutus* (Linnaeus, 1766)
			Grey heron, *Ardea cinerea* (Linnaeus, 1758)
			Great bittern, *Botaurus stellaris* (Linnaeus, 1758)
			Little egret, *Egretta garzetta* (Linnaeus, 1766)
			Cattle egret, *Bubulcus ibis* (Linnaeus, 1758)
	Seabirds	Cormorants	Desmarest Shag, *Phalacrocorax aristotelis subsp. Desmarestii* (Payraudeau, 1826)
			Great Cormorant, *Phalacrocorax carbo* (Linnaeus, 1758)
		Shearwaters	Scopoli's Shearwater, *Calonectris diomedea* (Scopoli, 1769)
			Balearic Shearwater, *Puffinus mauretanicus* (Lowe, 1921)
			Yelkouan Shearwater, *Puffinus yelkouan* (Acerbi, 1827)
		Gulls	Audouin's Gull, *Larus audouinii* (Payraudeau, 1826)
			Mediterranean Gull, *Larus melanocephalus* (Temminck, 1820)
			Little Gull, *Hydrocoleus minutus* (Pallas, 1776)
			Yellow-legged Gull, *Larus michahellis* (JF Naumann, 1840)

		Slender-billed Gull, *Larus genei* (Breme, 1839)
		Lesser Black-backed Gull, *Larus fuscus* (Linnaeus, 1758)
	Terns	Black-legged Kittiwake, *Rissa tridactyla* (Linnaeus, 1758)
		Black tern, *Chlidonias niger* (Linnaeus, 1758)
		Sandwich tern, *Thalasseus sandvicensis* (Latham, 1787)
		Common tern, *Sterna hirundo* (Linnaeus, 1758)
		Little tern, *Sternula albifrons* (Pallas, 1764)
	Hydrobatidae	Storm petrel, Hydrobates pelagicus melitensis (Schembri, 1843)
	Razorbills	
	Puffins	
	Skua sp.	
		Northern Gannet, *Morus bassanus* (Linnaeus, 1758)

Benthic communities and habitats

Habitats approach		
Habitats		
Connection area	Biocenosis of supralittoral sands	
	Biocenosis of mediolittoral sands	
	Biocenosis of the mediolittoral detritic	
	Biocenosis of mediolittoral rocks	
	Biocenosis of superficial muddy sands of calm mode	
	Biocenosis of infralittoral rocks	
	Biocenosis of rough sands and fine gravels tossed by the waves	
	Biocenosis of sands and gravels under the influence of bottom currents	
	Biocenosis of the *Posidonia oceanica* meadow	
	Biocenosis of high-level fine sands	
	Biocenosis of well calibrated fine sands	
	Biocenosis of infralittoral algae	
	Biocenosis of the *Cymodocea nodosa* meadow	
	Biocenosis of the meadows with *Zostera noltii* and *Zostera marina*	
	Perennial brown algae (ochrophytes, kelp, cystoseires)	
Cable and anchoring	Biocenosis of coastal terrigenous muds	
	Biocenosis of the offshore rock	
	Biocenosis of coastal detritic	
	Coralligenous biocenosis	
	Biocenosis of muddy detritic bottoms	
	Biocenosis of offshore detritic bottoms	
Area of influence	Biocenosis of bathyal muds	
	Facies of soft mud with *Funiculina quadrangularis* and *Aporrhais serresianus*	
	Biocenosis of bathyal detrital sands with *Gryphus vitreus*	
	Biocenosis of bathyal rocks	
	Underwater structures caused by gas emissions (pockmark)	
	Hydraulic dunes	
	Canyon heads	
	Benthic species	*Associated species*
		White coral, *Isidella elongata* (Esper, 1788)
		Red coral, *Corallium rubrum* (Linnaeus, 1758)
		Tall sea-pen, *Funiculina quadrangularis* (Pallas, 1766)
		European date mussel, *Lithophaga lithophaga* (Linnaeus, 1758)

			Noble penshell, *Pinna nobilis* (Linnaeus, 1758)
			Rude penshell, *Pinna rudis* (Linnaeus, 1758)
			Mediterranea slipper lobster, *Scyllarides latus* (Latreille, 1803)
			Nepture grass, *Posidonia oceanica* (Delile, 1813)
			Yellow cave-sponge, *Aplysina cavernicola* (Vacelet, 1959)
			Yellow tube-sponge, *Aplysina aerophoba* (Nardo, 1833)
			Cushion star, *Asterina pancerii* (Gasco, 1876)
			Short-snouted seahorse, *Hippocampus hippocampus* (Linnaeus, 1758)
			Long-snouted seahorse, *Hippocampus guttulatus* (Cuvier, 1829)
			Stony sea urchin, *Paracentrotus lividus* (Lamarck, 1816)
			Sendler seagrass, *Cymodocea nodosa* (Ucria) Asch.
			Narrow-leaved eelgrass, *Zostera marina* (Linnaeus, 1753)
			Dwarf eelgrass, *Zostera noltei* (Hornemann, 1832)
			Diadem urchin, *Centrostephanus longispinus* (Philippi, 1845)
			Common antlers sponge, *Axinella polypoides* (Schmidt, 1862)
			Bushy crust coral, *Savalia savaglia* (Bertoloni, 1819)
			Elephant's ear sponge, *Spongia (spongia) agaricina* (Pallas, 1766)
			Lithophyllum byssoides (Lamarck) Foslie, 1900
			Dendropoma cristatum (Biondi, 1859)
			Knobbed triton, *Charonia lampas* (Linnaeus, 1758)
			Wandering triton, *Ranella olearium* (Linnaeus, 1758)
			Royall red prawn, *Aristaeomorpha foliacea* (Risso, 1827)
			Giant sponge, *Geodia cydonium* (Linnaeus, 1767)
			Black sponge, *Sarcotragus foetidus* (Schmidt, 1862)
			Pear cowrie, *Zonaria pyrum* (Gmelin, 1791)
			Spiny lobster, *Palinurus elephas* (JC Fabricius, 1787)
			Maine lobster, *Homarus gammarus* (Linnaeus, 1758)
			Thorn-crab spider crabe, *Maja squinado* (Herbst, 1788)
			True scampi, *Nephrops norvegicus* (Linnaeus, 1758)
			Deep-water rose shrimp, *Parapenaeus longirostris* (H. Lucas, 1846)
			Spottail mantis squilid, *Squilla mantis* (Linnaeus, 1758)
			Pillow coral, *Cladocora caespitosa* (Linnaeus, 1767)
			Mediterranea sea-fingers, *Alcyonium palmatum* (Pallas, 1766)
			Phosphorescent sea-pen, *Pennatula phosphorea* (Linnaeus, 1758)
			Dark-red sea-pen, *Pennatula rubra* (Ellis, 1764)
			Gray sea-pen, *Pteroeides griseum* (Bohadsch, 1761)
			Yellow sea-pen, *Veretillum cynomorium* (Pallas, 1766)
			Pheasant-tail hydroid, *Lytocarpia myriophyllum* (Linnaeus, 1758)
			Ophidiaster ophidianus (Lamarck, 1816)
			Leptometra spp. (AH Clark, 1908)
			Comb penshell, *Atrina pectinata* (Linnaeus, 1767)
Pelagic habitats			
	Planktonic communities		
		Communities approach	
	Fishes and cephalopods		
		Ecological and ethological approach	
		Benthic soft substrate – Eggs and larvae	
		Benthic soft substrate – Larvae	
		Benthic soft substrate – In transition	
		Benthic soft substrate – Adults	

Benthic hard substrate – Eggs and larvae
Benthic hard substrate – Larvae
Benthic hard substrate – In transition
Benthic hard substrate – Adults
Pelagic – Eggs and larvae
Pelagic – Larvae
Pelagic – In transition
Pelagic – Adults

Annex 3

Synthesis of “Cetaceans and marine turtles” reports

Report of the first Technical Meeting 15th of June, 2021

In line with the importance of conducting a coordinated and coherent transboundary Maritime Spatial Planning process, the Gulf of Lion case study of the MSPMED[21] project has several objectives:

- Build and promote a global view of ecological stakes in the Gulf of Lion, especially related to cetaceans, seabirds and deep habitats;
- Provide knowledge about interactions between Mediterranean ecosystems and maritime uses, with a specific focus on windfarm development in the Gulf of Lion area.

For this purpose, the OFB[22] , FEM[23] and IEO[24] team, in close collaboration with scientific experts, aim at producing a knowledge synthesis about ecological stakes and their interactions with activities related to windfarm development, through technical meetings.

Objectives of technical meetings

Technical meetings are aimed at (1) boosting knowledge and methodology sharing so as to complete an updated view of ecological stakes and their sensitivity in the Gulf of Lion (from Barcelona to Marseille), (2) providing information on potential interactions between windfarms and ecosystems in the study area, (3) highlighting important knowledge gaps to be bridged, (4) comparing evaluation processes in Spain and France in order to facilitate a common understanding and (5) encouraging cross-border cooperation to address ecological stakes, especially regarding mobile species such as cetaceans, sea turtles and seabirds.
Among many topics of interest, technical meetings will address:

- Existing datasets in the study area;
- The characterization of interactions between Mediterranean ecosystems and windfarm development;
- Assessment of differences in evaluation of issues/stakes;
- Knowledge and data gaps, and perspectives ways to bridge them;
- Ecological stakes spatialization.

This document reports the exchanges held during the first technical meeting dedicated to “Cetaceans and sea turtles”, the 15th of June 2021.

<u>Technical meeting 1: complement the knowledge synthesis</u>

This first meeting has been dedicated to (1) the identification of existing data and knowledge gaps regarding cetaceans and turtles encountered in the Gulf of Lion, and (2) the initiation of the work to be conducted on interactions between ecological stakes and offshore windfarms, following the program below:

Introduction
Presentation of the MSP-MED project and objectives of meeting 1; introduction to/of experts (20’)
Session 1: Build a global view of existing knowledge in the Gulf of Lion
a. Presentation of preliminary work: existing datasets (20’)
b. Knowledge gaps selection: from pre-identified knowledge gaps, a ranking exercise will help to prioritize those to address during the session (25’)
Virtual Coffee Break (15’)
c. Discussion: contribution of on-going research/projects to bridging knowledge gaps, design of complementary programs and methodological perspectives (45’)
Virtual Coffee Break (15’)
Session 2: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion
d. Presentation of the methodology; and presentation of technologies and activities related to floating windfarm projects in

[21] MSPMED project, 2020-2022, https://mspmed.eu
[22] Office Français de la Biodiversité, https://ofb.gouv.fr/
[23] France Energies Marines, https://www.france-energies-marines.org/
[24] Instituto Español de Oceanografía, http://www.ieo.es/

Mediterranean and potential pressures (30’)
e. Open discussion on the relevance of pre-identified ecological receptors (50’)
Conclusion and future work (20’)

Participants:

Name	Institution
Neil Allonce*	Office français de la biodiversité (OFB)
Camille Assali*	Office français de la biodiversité (OFB)
Sybill Henry*	France Énergies Marines (FEM)
Morgane Lejart*	France Énergies Marines (FEM)
Mónica Campillos Llanos*	Instituto Español de Oceanografía (IEO)
Cristina Cervera Núñez*	Instituto Español de Oceanografía (IEO)
José Carlos Báez	Instituto Español de Oceanografía (IEO)
Manuel Bou	Instituto Español de Oceanografía (IEO)
Txema Brotons	Asociación Tursiops
Carla Álvarez Chicote	SUBMON
Léa David	EcoOcean Institute
Lucía Di Iorio	CHORUS Institute
Alexandra Gigou	Office français de la biodiversité (OFB)
Marc Girondot	U. Paris Saclay
Hélène Labach	MIRACETI
Helena Moreno	MITERD
Toni Raga	Universitat de València
José Antonio Vázquez	Instituto Español de Oceanografía (IEO)

**Organisers (MSPMED team*

Session 1: Build a global view of existing knowledge in the Gulf of Lion

a. Presentation of preliminary work: existing datasets

Participants have been presented the preliminary overview of datasets/campaigns/programs documenting cetaceans and sea turtles, partly or entirely covering the Gulf of Lion[25].
The number of at-sea surveys (from boat or plane) increased during the last decade, concomitantly with the increasing need for cetacean and sea turtle data (e.g. MSFD implementation).

b. Pinpoint data and knowledge gaps

Through a brainstorm exercise[26], participants contributed to three questions related to the at-sea distribution of cetaceans and sea turtles. Questions and synthetized results are presented in section c. below. Raw results are reported in Table 2.
Participants could answer by selecting four categories referring to knowledge level: (1) Incomplete/Poor, (2) Spatially incomplete / temporally incomplete, (3) Satisfying/Complete, (4) Other, and complement their choice by writing comments.
For the three questions, only the categories “(1) Incomplete/Poor” and “(2) Spatially incomplete/Temporally incomplete” received contributions.

c. Perspectives: bridge knowledge gaps

After having identified main knowledge gaps regarding the distribution of cetaceans and sea turtles in the Gulf of Lion, a discussion was conducted so as to characterize these gaps in details (e.g. spatially, temporally, distinctly between different data types, technological or methodological limitations).
In the following paragraphs, results of the brainstorming session and subsequent discussion are synthetized in two main topics: (1) cetacean & sea turtle distribution, and functional areas in the Gulf of Lion, (2) predictability of the habitat use by these species.

[25] Detailed information about identified datasets, completed with experts’ contributions during the meeting, can be found in the following table: https://lite.framacalc.org/9nyb-mspmed_identified_data_cetaceans_seaturtles
[26] Used tool: http://digistorm.app

At-sea distribution and functional areas

For both components (cetacean species and sea turtle species found in the Gulf of Lion), the knowledge levels associated with their at-sea distribution and functional areas (and especially through life stages) have confirmed either poor or incomplete knowledge.

This knowledge level referred either to a larger scale consideration (e.g. distribution area of those species) or to our specific Gulf of Lion case study. Globally, the monitoring effort that is larger in coastal areas and in summer suggests a poorest knowledge in offshore areas and during non-summer months. Moreover, experts highlighted both the need to obtain data from unsampled areas and the lack of fine scale temporal and spatial data. In the study area, more and more large-scale information is acquired, in addition with local studies, but a gap exists between these two scales and this would require a combination of existing datasets or results.

Furthermore, knowledge levels have been qualified relatively to the considered species. In link with the spatial and temporal distribution of the standardized monitoring effort (aerial or boat-based surveys, commonly conducting line-transect or strip-transect protocols), the distribution of coastal cetacean species is more easily described than the distribution of deep-divers or more cryptic species (e.g. Cuvier's beaked whale). In addition to a limited effort in offshore areas, the limited time span of boat-based and aerial surveys may not inform the diversity of behaviors and habitat uses, such as suggested by opportunistic observations of fin whales and common bottlenose dolphins in coastal waters during summer in the Natural Marine Park of the Gulf of Lion (MPA).

Despite the significant effort conducted in the Gulf of Lion area, photo-identification data and analysis have not yet achieved a satisfying knowledge about cetacean's functional areas.

However, photo-identification and genetics of common bottlenose dolphin showed either resident or transient individuals in the study area[27]. In the northern part of the Spanish jurisdictional waters, just in the frontier with French waters, experts mentioned a lot of common bottlenose dolphin re-sightings, which highlighted the important variation of group structure. Contrarily to the resident population of the Balearic Islands, common bottlenose dolphin of the Gulf of Lion may use a large area of the north-western basin of the Mediterranean Sea. The structure, residency or spatial plasticity of populations in the study area, as well as their movements at the transboundary scale, can have consequences on their consideration into planning processes, e.g. when planning the settlement of offshore windfarms.

If stranding events are well monitored, no baseline information exists about the at-sea distribution of sea turtles in the Gulf of Lion. Indeed, despite a significant effort at sea, very few observations have been acquired in the Gulf of Lion. On the contrary, Spanish experts mentioned an important number of boat-based observations in the Spanish waters (census, species identification).

Data from tracked (GPS, Argos, etc.) individuals from French coasts or waters can be considered as biased (females or by-caught individuals only), and non-representative of the population(s). No data exists from male or through life stages, and very few data was acquired from juveniles, especially in the Gulf of Lion area. However, more and more nesting events occur in the study area and must be considered when addressing the distribution of sea turtle functional zones.

Predictability of cetacean and sea turtle distributions

Experts stressed the incomplete knowledge about predictability of cetacean and sea turtle distributions, both at the Gulf of Lion scale than at a larger scale.

Despite the increasing need for habitat modelling, and especially in the context of offshore windfarm development, such analysis is limited by (1) a lack of homogeneous data, (2) an inappropriate quality of environmental data, (3) the environment dynamics.

Considering the first parameter, experts mentioned the usual analysis of a single observation dataset in habitat modelling studies. However, an increasing effort is currently made in order to combine different observation data sources to build habitat models from.

The second parameter refers to a lack of appropriate environmental data, including deep oceanography and dynamics, which sets the environmental conditions faced by deep-diving cetacean species. Moreover, complementary variables such as resource distribution and availability, as well as the distribution of human activities (influencing megafauna distribution) may be critical to consider when predicting the cetacean atsea distribution. As an example, the behavior of Common bottlenose dolphin during non-trawling days (week-ends) is quite unknown. Finally, experts mentioned the very limited use of ecosystem-based approaches to

[27] Final report of GDEGeM project, 2013-2015, https://www.gdegem.org/sites/gdegem.org/files/documentation/gis3m_gdegem_rapport_technique_final.pdf

predict the distribution of megafauna species and interactions between them (until now, such analysis have been limited to spatial co-occurrence studies), despite appropriate data exists (ASI[28], SAMM[29] surveys, etc.).
The last parameter suggests that predictive models must deal with a changing environment (e.g. global warming) and thus be frequently updated. This is critical to be considered for sea turtles, which recent nesting events in the French Mediterranean coasts indicate dynamic distributions of functional areas.

Session 2: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion

a. Presentation of the methodology and presentation of technologies and activities related to floating windfarm projects in Mediterranean

The proposed method for provide knowledge and assess the interactions between marine ecosystems and windfarm development was presented to the participants. Developed by the Ministry in charge of the environment since 2018 this method results of a reflection on the environmental integration of marine renewable energies. In the context of MSPMED project the objective is to implement the first steps of impact qualification and assess the existing interactions between the activities related to the development and operation of floating windfarms, the pressures they generate and the ecological receptors[30].
Preliminary work was conducted to identify activities, pressures and receptors. Based on the impact studies of the pilot windfarm projects in the Mediterranean, these lists were submitted for discussion by experts. In parallel with the work carried out in the "cetaceans and marine turtles" technical meeting, professionals from the marine renewable energy sector were also consulted to assess the lists of activities. The list of pressures includes the pressures identified for the MSFD and may be discussed during the second technical meeting.
The first list of receptors submitted to the experts' opinion summarize the species censuses realised in the impact studies of floating windfarm projects in the Mediterranean and on additional bibliography (occurrence data, protection status, etc.) and includes more than 20 species of cetaceans and marine turtles.

b. Open discussion on the relevance of pre-identified ecological receptors

27 species (21 cetaceans and 6 marines turtles) were identified during the preliminary step as susceptible to be impacted by the development of floating windfarms in the Gulf of Lion. The objective of the technical meeting was to identify ways for reduce the number of receptors by focusing on the most relevant species or groups of species to study in the context.
To facilitate the technical meeting and the discussions, a virtual post-its session[31] focused on two main questions was organised: the proposed list of species is relevant? (experts were asked to add or remove species); What criteria can be used for selecting the most relevant species/groups of species?
Experts are invited to express their opinions and/or vote for define the most relevant groups of species for the evaluation. The main elements of the discussions are grouped under different topics presented below.

Define a relevant list of receptors
Several species considered irrelevant by the experts were deleted (e.g. Hawksbill sea turtle and some species of baleen whales) because they are not present or are very rare in the Mediterranean basin. To experts, the main species that could interact with floating windfarms are the common bottlenose dolphin (*Tursiops truncatus*) and the loggerhead sea turtle (*Caretta caretta*). They are frequently present on the continental shelf area throughout the year. Fin whales (*Balaenoptera physalus*) may also be relevant given their abundance in the Gulf of Lion. In addition to these three major species, a shortlist of 15 species (12 cetaceans and 3 marine turtles) was identified during a voting session.

Cetaceans					**Marine turtles**	
Common bottlenose dolphin	*Tursiops truncatus*	Sperm whale	*Physeter macrocephalus*		Loggerhead sea turtles	*Caretta caretta*
Fin whale	*Balaenoptera physalus*	Cuvier's beaked whale	*Zipihus cavirostris*		Green sea turtles	*Chelonia mydas*

[28] ACCOBAMS Survey Initiative, 2018, https://accobams.org/main-activites/accobams-survey-initiative-2/accobams-survey-initiative/
[29] Suivi Aérien de la Mégafaune Marine, https://www.observatoire-pelagis.cnrs.fr/pelagis-2/les-programmes/samm/
[30] Species, habitats or groups of living organisms susceptible to be endure a pressure from human activity
[31] MURAL tool: https://www.mural.co/

Risso's dolphin	*Grampus griseus*	Striped dolphin	*Stenella coeruleoalba*		Leatherback sea turtles	*Dermochelys coriacea*
Short-beaked common dolphin	*Delphinus delphis*	Long-finned pilot whale	*Globicephala melas*			
Minke whale	*Balaenoptera acutorostrata*	Killer whale	*Orcinus orca*			
Harbour porpoise	*Phocoena phocoena*	Rough-toothed dolphin	*Steno bredanensis*			

Cumulative effect and long-term vision

To experts, due to the number of pressures that may have a real impact on the area where the windfarms are implemented, a global vision of the interactions is necessary. An iterative process of analysis of cumulative pressures must be carried out for all pressures and not only those generated by the development of offshore windfarms. The study of cumulative pressures at the scale of a receptor is also not relevant. It must be considered at the scale of species populations and, to be realistic, consider all pressures on all functional areas of the species' life cycle.

The consideration of pressures must integrate the analysis of long-term and large-scale effects. This spatio-temporal notion is important, especially as the pressures generated will vary in nature and intensity between the different steps of the project. It is therefore necessary to consider the different phases of windfarm development.

Identified pressures

Noise and acoustic pressures

To experts, all species can be impacted by acoustic pressures. Their sensitivity may vary according to the frequency, the type of noise generated (continuous or impulsive) and the duration of exposure. Among cetaceans, deep divers such as the Sperm whale or Cuvier's beaked whale are two species that regularly frequent the continental shelf area and may be more sensitive to noise and acoustic pressure. Beyond the direct pressure on individuals, the indirect effects of noise must be considered. The impact of noise on fish populations may also reduce the availability of prey and affect the diet of cetaceans. Sensitivity to noise is not the same between cetaceans and fish. By indirect effects, cetaceans and some predators may be impacted by types of pressures to which they are not directly sensitive.

Disturbance

If noise can have a significant impact on the temporary disappearance of certain species in the impacted area, the level of human activity associated with the noise emission must be also considered.

Ecosystem change

Without commenting on the positive or negative effects of these effects on individuals and populations, the risk of habitat modification is highlighted by the experts. The addition of offshore infrastructures may generate a temporary aggregation of fish that could be beneficial for the diet of some cetaceans. The evolution of practices in the windfarm area could lead to a modification of fishing activities and generate a modification of the structure of populations and communities of species in the long term. The modification of habitats and ecosystems associated with the life cycle of species could have a long-term impact on cetacean species populations.

Entanglement and collision

The risk of entanglement of species is also mentioned, although it is considered low due to the size of the dynamic cables. On the other hand, the risk of modification of magnetic fields by emission of electric fields is considered probable for certain sensitive species such as turtles which could be disoriented by these anthropogenic pressures. Increasing risk of collision due to the maritime traffic for construction and maintenance operations, for certain species (sperm whales and fin whales), is also mentioned.

Implementing acquisition programmes: improving knowledge & monitoring interactions

To experts, the assessment of interactions between marine megafauna and floating windfarms at sea cannot be carried out effectively without the implementation of data acquisition and knowledge improvement programmes. If the implementation of such programmes is not foreseen for the MSPMED project, it is important to note that the work carried out constitutes a preliminary basis for the qualification of the impacts and pressures. The gaps identified may be the subject of a subsequent research and development programme. A harmonisation of environmental monitoring should be implemented to improve knowledge of interactions.

Conclusion and outlook

All elements provided by the experts during this first session were included in this report.

Scheduled for **14 September 2021 from 9:00 to 12:00**, the second technical meeting will focus on the reflections initiated during session 2 "Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion" on interactions between pressures and ecological receptors.

A synthesis of these comments will be made during the summer and submitted to the experts for validation during the second technical meeting in order to determine a list of receptors considered to be the most relevant for assessing their interactions with the development of floating windfarms in Mediterranean.

After validation, the objective of this second technical meeting will be to continue the discussions on the pressures and the receptors previously selected and validated. Based on the pressures established by the MSFD, the list of potential pressures will be presented and discussed during the session.

Report of the second Technical Meeting 14th of September, 2021

This document reports the exchanges held during the second technical meeting dedicated to "**Cetaceans and sea turtles**", the **14th of September 2021**. For more information on the MSPMED project and on the objectives of these technical meetings, please refer to the first technical report.

<u>Technical meeting 2: Identify and characterize the potential interactions between pressures and ecological receptors</u>

This second meeting has been dedicated to the identification and characterization of potential interactions between the marine ecosystem components -and particularly cetaceans and sea turtles- with offshore floating windfarms, following the programme below:

Introduction
Introduction to/of experts & reminders of the objectives of technical meetings (15')
Identification and characterisation of potential interactions
a. Validation of preliminary works (15')
b. Completion and discussion on potential interactions (70')
Conclusion
Future work and perspectives (5')

Participants:

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**Organisers (MSPMED team*

The approach implemented for the MSPMED project to gather knowledge about potential interactions between Mediterranean marine ecosystems and the development of offshore floating windfarms is adapted from a method used for assessing the cumulative impacts of offshore windfarm projects, developed by the French Ministry in charge of the environment since 2018. Within the Gulf of Lion case study, the first steps of this assessment method are implemented and adapted to characterize potential interactions. The almost non-existent feedback on the impacts generated by floating infrastructures on marine ecosystems requires the implementation of a prospective approach based on expert judgement, through technical meetings.

The aim of these technical meetings is to describe risks of potential interactions in a comprehensive way. Many interactions are already identified and documented by the scientific community, but related studies are generally based on experience from fixed offshore windfarms in the North Sea for marine species, and from onshore windfarms for birds and chiropterans. While some identified risks of interactions between fixed offshore windfarms and marine ecosystems can be applied to floating offshore windfarms (increase in maritime traffic, modification of habitats, etc.), specificities of floating windfarms (ballast system, chain anchoring, etc.) would need further reflection. The prospective approach carried out within the MSPMED case study allows to identify the potential interactions of marine ecosystems with floating infrastructures of which there is no feedback and precise scientific knowledge yet. By applying the precautionary principle, the objective of these technical meetings is also to highlight needs of vigilance and awareness considering, for example, sensitive species or species whose behaviour or functional areas (reproduction, migration, preferential use of certain habitats, etc.) are partly unknown.

The first technical meeting enabled to define a set of ecological receptors[32]. The objective of this second meeting was to identify all the potential interactions between receptors and pressures, and to characterize them (direct or indirect effect, short- or long-term effect, etc.). Within the prospective approach that is implemented here, experts have been encouraged to indicate any suggestion/hypothesis about risks of interaction, even if knowledge is still limited.

Next paragraphs report exchanges and results of the second technical meetings focussing on cetaceans and sea turtles in the Gulf of Lion area.

a. Validation of preliminary work

Based on the discussions conducted during the first meeting, 5 receptors have been submitted to expert for validation: Common bottlenose dolphin (*Tursiops truncatus*), Fin whale (*Balaenoptera physalus*), Loggerhead sea turtle (*Caretta caretta*), Sperm whale (*Physeter macrocephalus*) and Cuvier's beaked whale (*Ziphius caviostris*).

This list has been completed during the meeting by an addition of two globicephalidae species (Risso's dolphin, *Grampus griseus* and Long-finned pilot whale, *Globicephala melas*). These species preferentially use the continental slope, but there is little data on their behaviour. Studies and monitoring projects dedicated to Risso's dolphin are currently underway both in France and in Spain (e.g. data acquisitions of Grampus project by MIRACETI, Proyecto Grampus by SUBMON - mentioned during the first technical meeting). In addition, in the context of the current (July-October) French public debate about offshore floating windfarm projects in the Gulf of Lion, these two species have been considered in the bibliographical study and linked to a moderate risk for "collision" and "acoustic disturbance" pressures. In order to maintain coherence between the different approaches conducted in the Gulf of Lion in relation with the development of offshore floating windfarms, these two species have been added to the present list of receptors.

The relevance of considering Sperm whales and Cuvier's beaked whales with regards to the depths of the offshore floating infrastructures has also been discussed during the meeting. Indeed, while the electrical stations will be located rather close to the coast (10 to 20 metres deep), the floating infrastructures will be deployed at depths estimated to range between 60 and 120 metres. Sperm whales and Cuvier's beaked whales mainly use deep waters at depths greater than 800 metres, so it may not be relevant to consider them in the process of interactions identification. However, as sound propagation is very difficult to assess as a function of sound emission level and bathymetry, these two receptors have been conserved. Interactions have been distinguished into the direct and indirect effects of sound emissions, in order to include impacts related to increased background noise and vibrations.

7 receptors are therefore finally considered in this MSPMED task: 6 cetacean species (Common bottlenose dolphin, *Tursiops truncatus*; Fin whale, *Balaenoptera physalus*; Sperm whale, *Physeter macrocephalus*; Cuvier's beaked whale, *Ziphius caviostris*; Long-finned pilot whale, *Globicephala melas*; Risso's dolphin, *Grampus griseus*) and 1 marine turtle species (Loggerhead sea turtle, *Caretta caretta*).

b. Completion of potential interactions and discussion

[32] Species, habitats or groups of living organisms likely to be subject to pressure from human activity

Once validated, these 7 receptors have been submitted to a list of pressures. The list of pressures is based on the MSFD list and has been adapted to the context of offshore floating windfarm development, and some pressures had been identified before the meeting from bibliography. Within this list, noise emissions are subdivided into two pressures in order to distinguish acoustic pressure from vibratory pressure. Direct effects (e.g. masking of communication signals, etc.) and indirect effects (e.g. increase in background noise, disturbance, etc.) are also distinguished for all pressures.

As requested by the experts, the different phases of windfarm operation (construction, operation, and decommissioning) are considered to characterize the different types of pressures. During this second meeting, the exercise has been limited to linking pressures and receptors and collecting justifications/background for illustrating these associations.

• Physical losses and damages

The pressures related to **physical losses and damages** relate to the physical modifications of the marine habitat. All receptors seem likely to be impacted by **habitat modification** generated by the introduction of an anthropogenic infrastructure and new conditions of use in a restricted area. Changes in the distribution and availability of pelagic species (prey) could have an indirect effect on the cetacean and sea turtle populations that feed on them. The consequences of changes in the food web are difficult to predict, especially for the Common bottlenose dolphin - whose preferred habitat is the continental shelf (area where floating infrastructures are deployed) - that displays a large ecological plasticity. Less present on the continental shelf, the Fin whale and Sperm whale however have a very specialised ecological niche and would be more sensitive to changes in their feeding behaviour linked to disturbances of the food web. As for cetaceans, these changes may impact sea turtle species (i.e. Loggerhead sea turtle) and their distribution, which for juveniles and younger turtles varies accordingly to food availability. These habitat changes can also be detrimental to species that migrate long distances to feed. **Extraction of substrate**, particularly during the construction phase, may have indirect effects of avoidance by cetacean and sea turtle populations, and disturbance of their behaviour related to their activity (feeding, resting, nesting etc.) all along their life cycle. The **material deposition** and **changes in hydrographic conditions** may also have an indirect effect on all receptors by modifying habitat and prey distribution. The temporary (when installing the anchoring system of infrastructures) or continuous (movement of anchoring chains) increase of **turbidity** could have an indirect effect on the feeding behaviour of some species such as the Common bottlenose dolphin or the Loggerhead sea turtle by reducing the effectiveness of underwater vision. **Noise emissions** must be considered at each stage of the windfarm operation, from the construction phase to the decommissioning phase, as the effects on cetaceans and turtles vary accordingly to the sources of emissions, frequencies, type of noise, duration of exposure, etc. The direct effects linked to high and low frequency emissions during the construction phase of the farms (increase in maritime traffic, underwater exploration and cable laying activities, etc.) can consist in physical damage (hearing damage, etc.) and flight behaviour for all receptors, even if the species whose preferred habitat is located on the continental shelf would be the most affected one. These same effects may be observed in prey species, what could lead to an indirect impact on cetaceans and marine turtles, with consequences on their feeding effort and behaviour. During the operational phase, the increase in background noise due to maintenance operations (increase in maritime traffic) and the continuous movement of chains on the bottom and in the water-column are also considered to have direct effects (masking of communication signals, avoidance, etc.) and indirect effects (feeding behaviour, etc.). Finally, vibrations related to noise emissions must also be considered during the construction and operation phases, with direct effects such as avoidance of areas subject to noise, what is already observed on delphinids populations. Finally, although deep-sea diving species do not appear to be directly impacted as they mainly do not frequent the continental shelf area, noise emissions from the development of floating windfarms would be an additional acoustic pressure and contribute to underwater noise which can have a significant impact on species living further at sea. **Electromagnetic emissions** can have direct effects on the orientation of sea turtles, which are sensitive to terrestrial electromagnetism. With regard to cetaceans, the scientific community confirms the sensitivity of certain cetaceans to electromagnetic fields, but stresses the limited knowledge about their sensitivity level and the effect of these emissions on their behaviour and biology. Finally, **light emissions** can have an indirect effect on cetaceans by attracting prey and their predators. For the same reason, light emissions can have an attractive effect on juvenile sea turtles.

• Chemical pressures

Chemical pressures and more particularly the emission of **synthetic and non-synthetic components** (metals and organic components) can have indirect effects on all receptors by contaminating the entire food web. The Common bottlenose dolphin could be the most affected species by this contamination as it is the most likely to feed close to floating platforms. It is the same for the pressures of **hypoxia** and **organic enrichment** of the environment, which could have indirect effects on cetaceans and marine turtles, with a probably higher risk in the case of floating windfarms due to the bio-colonisation of floats and could have significant effects on the local modification of pelagic ecosystems.

• **Biological pressures**

Finally, **biological pressures** include pressures that will have a direct impact on the biology of species and their physical integrity. The highest risk of interaction for all receptors is the **collision risk**. The increase in maritime traffic during the construction/decommissioning and operation (maintenance) phases in a restricted area will necessarily increase the risk of collisions, particularly for species that regularly use the continental shelf, such as the Common bottlenose dolphin and the Fin whale. The same is true for turtle species whose risk of surface collision will be higher. Increased **human activity** will have a direct effect on species sensitive to human disturbance, with avoidance and/or bypassing of the area likely to affect species life cycle and survival rates. For about 20 years, new sea turtle nests have been regularly discovered in the north-western Mediterranean Sea (e.g. French and Spanish coasts) but it is still not possible to predict the nesting spots from one year to the next. Increased activity next to these breeding sites could have an impact on the distribution and concentration of breeding male and female individuals along the coast. The risk of obstruction and entanglement from underwater cables (anchor lines and power cables) appears to be low for cetaceans and turtles. If the pressure exists, it is still difficult to estimate how it will impact those species.

Conclusion and outlook

All elements provided by the experts during this second session have been included in this report and are still available on the workspace on line. It is regularly checked by the MSPMED team and all the contributions will be taken up for the technical meeting 3. This workspace can be amended by experts until the **15th of October 2021**.

Scheduled for the **22nd of October 2021 from 10:00 to 12:00**, the third technical meeting will build on the reflections initiated during the two first technical meetings in order to achieve a global – transboundary view of ecological stakes in the Gulf of Lion.

During the fourth and last technical meeting, pressures will be linked to the activities generated by the development of floating windfarms in order to identify and discuss chains of activities > pressures > receptors.

Report of the third Technical Meeting 22nd of October, 2021

This document reports the exchanges of the third technical meeting dedicated to "Cetaceans and sea turtles", on the 22nd of October 2021. For more information about the MSPMED project and the objectives of these technical meetings, please refer to the first and second technical reports.

Technical meeting 3: Build a transboundary view of ecological stakes related to cetaceans and sea turtles

The third technical meeting was dedicated to the consideration of ecological parameters within public policies, in the context of the MSPMED transboundary case study "Planning the offshore Gulf of Lion" (sessions 1 and 2). The last part of the technical meeting (session 3) was focused on the presentation of the last step of the methodological framework conducted so far to characterize interactions between ecosystems and pressures linked to offshore floating windfarm development. The meeting was conducted following the program below:

Introduction (15')
Introduction of experts and presentation of the objectives of technical meetings
Session 1: Focus on criteria informing public policies (30')
Selection of topics to be addressed during the meeting.
Session 2: Focus on knowledge transfer to decision makers (40')
Discussion about (a) the knowledge level associated to the selected topics, and (b) the consideration of these topics into public policies.
Session 3: Characterization of interactions with a ranking method (20')
Presentation of the last step of the methodological framework addressing the characterization of interactions between ecological receptors and pressures.
Conclusion and objectives of technical meeting 4 (10')

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**Organisers (MSPMED team*

Introduction

The global objective of sessions 1 and 2 was to discuss the consideration of ecological stakes within public policies and to share experience between France and Spain in order to help improving the coherence of Maritime Spatial Planning (MSP) at the transboundary scale.

From (i) background information collected in literature (evaluation reports, existing datasets, current projects, scientific articles, etc.), and (ii) the results of the first technical meeting of June 2021 (identification of knowledge gaps about cetacean and sea turtle distributions, their predictability, and functional areas), exchanges were conducted so as to answer two general questions:

- How could we better inform ecological stakes at the transboundary scale?
- How should we transfer appropriately this information to decision makers of the MSP process?

To address those questions, discussions were divided into two steps: the first session was focused on topics collectively selected from a list of criteria (see Session 1: focus on criteria informing public policies), and a second session was dedicated to highlighting limitations and perspectives to facilitate knowledge sharing, especially with competent authorities (see Session 2: focus on knowledge transfer to decision makers) and at a transboundary scale.

Session 1: focus on criteria informing public policies

In order to focus on key topics to be addressed in our transboundary exchanges, the experts were proposed a list of criteria, selected from current public policies such as the descriptor 1 "Biodiversity is maintained" of the Good Environmental Status targeted by the Marine Strategy Framework Directive (MSFD), as well as from criteria commonly used to inform Marine Protected Area (MPA) designation.

Experts were firstly asked to vote for 5 out of 10 the topics to be addressed during the meeting, considering two decision rules:

- Is the criterion relevant for informing public policies (especially MSP) in the study area?
- Is the criterion relevant to be addressed at the transboundary scale?

Secondly, experts were asked to associate a level of knowledge (high/sufficient, medium/incomplete, low/insufficient) to these topics, either relative to the baseline data (e.g. abundance) or to the evaluation method for the criterion (e.g. threshold).

The results of this voting session are reported below.

Process	Criteria		Number of votes	Vote to associate a knowledge level		
				High	Medium	Low
MPA designation	Uniqueness	The area contains unique or rare ecosystems, or rare or endemic species.	3	2	2	0
	Representativeness	The area has highly representative ecological processes, or community or habitat types or other natural characteristics.	4	0	3	0
	Diversity	The area has a high diversity of species, communities, habitats or ecosystems.	3	1	2	0
	Naturalness	The area has a high degree of naturalness as a result of the lack or low level of human-induced	0	0	0	0

		disturbance and degradation				
	Critical habitats	The area hosts habitats where any impact represents a high potential risk for endangered, threatened or endemic species.[33]	5	2	0	1
MSFD – Good Environmental Status evaluation	D1C1	The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long- term viability is ensured.	3	0	0	3
	D1C2	The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.	4	0	3	0
	D1C3	The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.	3	0	1	1
	D1C4	The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions.	2	0	1	0
	D1C5	The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.	3	1	0	1

The three selected topics obtained 5 or 4 votes (rated by 7 experts), and were respectively associated to a high or low level of knowledge ("The area hosts habitats where any impact represents a high potential risk for endangered, threatened or endemic species"), and a medium knowledge level (criteria "The area has highly representative ecological processes, or community or habitat types or other natural characteristics." and "The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured."). The poorest knowledge score was obtained for the criterion "The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured." (3 votes).

Session 2: focus on knowledge transfer to decision makers

Session 2 was dedicated to (i) experience sharing about the current limitations related to selected topics, (ii) perspectives to overcome those difficulties, and (iii) information transfer to decision makers of MSP.

Topic 1: The area hosts habitats where any impact represents a high potential risk for endangered, threatened or endemic species.

Experts were asked to comment about necessary data, method or strategy to inform this criterion.

Parameters such as relative abundance, functional areas, resident/transient status of individuals as well as their spatio-temporal distribution were cited as important input to be considered.

Firstly, experts suggested that **habitat models** shall be developed for each species in the area. However, data is limiting this analytical effort, especially for deep-diving species in cetaceans and for sea turtles. For the latter, satellite tracking was suggested as the best way to obtain relevant information (when combined with environmental data[34]) for habitat modelling.

Secondly, **spatial and temporal scales** appeared as key parameters to be defined for this criterion. Both distribution and abundance of species have to be informed at the marine sub-region level (e.g. MSFD reporting units), before assessing the importance of a smaller target area (in our case: the Gulf of Lion) and its **representativity** for species. Habitat models may allow to extrapolate from individual tracks to population, but need to be interpreted cautiously. Indeed, as mentioned during the first

[33] Adapted from the SPAMI criteria « Presence of habitats that are critical to endangered, threatened or endemic species." in order to integrate the "risk" approach in subsequent discussion.

[34] Copernicus services have been mentioned as an example: https://www.copernicus.eu/en

technical meeting held in June, individual tracks may not be representative of a population, e.g. in the case of telemetry data of sea turtles from by-catch events, or nesting females in the Gulf of Lion area.
Large-scale survey data (e.g. ASI[35] 2018) does not allow to describe species distribution at the local scale (i.e. at the scale of the Gulf of Lion). If southern Balearic waters are known to be critical for sea turtles, the Gulf of Lion area must not be neglected with regards to the number of by-caught individuals, tracked individuals, recent nesting events[36], etc. However, at the Gulf of Lion' scale, precise information on spatio-temporal distribution of sea turtles is still lacking; while recent data from Ifremer/CESTMed may provide valuable information. For cetaceans and sea turtles, **connectivity** between functional areas is still to be understood. For cetacean species displaying migratory patterns, an important gap remains in the **seasonal variability** of their distribution, as large-scale surveys are often conducted during summer months.
Thirdly, experts highlighted perspectives to improve the global knowledge at the transboundary scale: from data collection to the evaluation processes, cooperation and coordination has to be strengthen (e.g. sharing questions, building projects together, standardizing and coordinating monitoring surveys, using standardized analysis and combining existing data and methods).
Finally, these exchanges underlined the importance of considering cetacean and sea turtle species within any maritime planning process in the area. Information exchanges at the **transboundary scale** shall also contribute to the **investigation of cumulative risks and impacts** in space and time.

Topic 2: The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.

Parameters to be assessed in order to inform this criterion are (i) population abundance and (ii) impacts of anthropogenic pressures on abundance.
Experts emphasized the need to **conduct long-term surveys** in order to inform trends in populations abundance but also trends in pressures and their impacts. As an example, aerial surveys seem to be the best method to assess sea turtle density, although confidence intervals are usually rather large. Complementarily, telemetry data is also necessary to estimate the time individuals spend at the sea surface, corresponding to individuals' "availability" – linked to detection probability- at the surface during aerial or boat-based surveys.
Moreover, experts stressed again the need to assess the **seasonal and interannual variability** of distributions and thus local-scale abundance. This could be addressed with additional and shared data acquisitions[37] (e.g. during non-summer months, at fine spatial scale). A lot of datasets already exist[38] in the Gulf of Lion area and can inform population abundance; however, the major limitation of their analysis remains the diverse scales of data acquisitions. According to experts' opinion, if sharing is interesting, conducting surveys and studies together may be more productive.
With regards to anthropogenic pressures and MSP, **existing designations** should be appropriately considered. In that sense, experts mentioned the Fishing Restricted Area (FRA) of the General Fisheries Commission of the Mediterranean (GFCM) adopted in the eastern Gulf of Lion. With the aim of minimizing conflicts between stakeholders and pressures on ecosystems, including cetacean and sea turtle species, the planning of additional human activities such as offshore windfarms shall be avoided in the existing FRA.

Topic 3: The area has highly representative ecological processes, or community or habitat types or other natural characteristics.

The Gulf of Lion is already recognized as an important area for the Common bottlenose dolphin – *Tursiops truncatus* (Shelf of the Gulf of Lion Important Marine Mammal Area[39], and N2000 site[40]).
As an additional information, results from the GDEGeM project[41] were provided to experts. These results show the density of Common bottlenose dolphin from four different groups (social units). Social units were defined through photo-ID analysis[42] (recaptures of individuals often found in association), and distribute themselves differently within the Gulf of Lion area. Some

[35] ACCOBAMS Survey Initiative: https://accobams.org/wp-content/uploads/2021/04/ASI-Med-Report.pdf
[36] Experts mentioned that the number of nesting events is increasing in the whole western Mediterranean, but that eggs may either be unviable or produce only males (low temperature).
[37] The marine mammal group of IEO (Spain) and researchers from La Rochelle University (France) collaborate to share data collection methods and coordinate MSFD monitoring programs.
[38] Experts mentioned data from Proyecto Mediterráneo, SUBMON association, MEDIAS campaigns, for the Spanish side.
[39] Shelf of the Gulf of Lion IMMA : https://www.marinemammalhabitat.org/portfolio-item/shelf-gulf-of-lion/
[40] FR9102018 - Grands dauphins du golfe du Lion : https://inpn.mnhn.fr/site/natura2000/FR9102018
[41] GDEGeM project reports: https://www.gdegem.org/rapports
[42] Data is searchable in: http://intercet.it/

individuals move over the whole area ("transient" individuals) while others usually stay in specific areas ("resident" individuals). This information seems difficult to integrate into maritime planning process. Indeed, human at-sea activities may impact differently distinct social groups (depending on the co-occurrence of cetaceans and activities), but at the Gulf of Lion' scale, which encompasses the home ranges of Common bottlenose dolphin social groups, any pressure could have an effect on all groups.
Moreover, in the specific context of offshore windfarm development in the Gulf of Lion area, the effect on species is still mostly unknown. As an example, the Common bottlenose dolphin could be disturbed by the increasing maritime traffic and the activities conducted during the construction phase, while it may also be attracted by fish aggregation during the functioning phase. Extrapolation from other offshore windfarm projects is not easy in this Mediterranean case as -(i) technologies (fixed vs floating windfarms), (ii) species in the cetacean community, and (iii) species' reactions to pressures- are different.

How to share this information with MSP competent authorities?
As a concluding question, experts were asked to provide recommendations/ideas about the best way(s) to transfer this knowledge and associated limitations to competent authorities.
Several recommendations emerged:

- Make results easily available. Make abundance and distribution maps of the sensitive species available through the official GIS servers, such as https://sig.mapama.gob.es/geoportal/ in Spain and https://www.geoportail.gouv.fr/carte in France.
- Conduct collaborative, transboundary, and synthetic work, based on experts' knowledge (robust science), provide synthetic information to decision makers (e.g. IMMA[43], IMTA[44], CCH[45]), conduct workshop gathering scientists and decision makers from different member states (e.g. PSSA[46]).
- Ensure stakeholders engagement. See recommendations in UNESCO-IOC/European Commission. 2021. MSPglobal International Guide on Marine/Maritime Spatial Planning. Paris, UNESCO. (IOC Manuals and Guides no 89).

Session 3: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in the Gulf of Lion.
For this task, the objective of this third technical meeting was to synthesize the results previously collected in the context of the MSP-MED project and to present the SKE ranking method (Sensitivity, Knowledge, Ecological stake).
Presentation of the ranking method
The third technical meeting aimed at presenting the ranking method (last step of our collective work). Adapted from the method proposed by the working group on the cumulative effects of offshore windfarms (Brignon & al., 2020), the classification of potential interactions is based on three scores: sensitivity, knowledge and ecological stake. This classification will allow to highlight the level of knowledge on potential interactions and distinguish them according to the different steps of development of offshore floating windfarms (survey & prospection, construction & decommissioning, operation).
These three scores consist in a rating process from 1 to 10 and reflect:

- The SENSITIVITY of a receptor to a pressure;
- The level of scientific KNOWLEDGE about the interaction according to the importance of the scientific corpus, the degree of knowledge or controversy, etc.;
- The level of ECOLOGICAL STAKE of a receptor. The sensitivity and knowledge scores are based on experts' opinion (see below). The score of ecological stakes is adapted by numerical transcription of experts' assessments already carried out in the context of MSP and the allocation of conservation status by the IUCN.

Sensitivity
The score from 1 to 10 indicates the level of sensitivity of a receptor to a pressure. For example, a score of 10 stands a major sensitivity of the receptor to the pressure. A "+" corresponds to the statement "no opinion". This symbol allows to indicate that a

[43] Important Marine Mammal Areas: https://www.marinemammalhabitat.org/
[44] Important Marine Turtle Areas: https://www.iucn-mtsg.org/imtas
[45] Critical Cetacean Habitats: https://accobams.org/conservations-action/protected-areas/
[46] Particularly Sensitive Sea Areas: https://www.imo.org/en/OurWork/Environment/Pages/PSSAs.aspx

sensitivity of the receptor to the pressure may exist but that it is not possible to assign a sensitivity score due to a lack of scientific knowledge.

Knowledge

The score from 1 to 10 indicates the level of knowledge associated to the effect of a pressure on a receptor. It reflects the state of current knowledge according to the importance of the scientific corpus, etc. For example, a score of 10 will reflect a good knowledge of the effect of a pressure on a receptor, whereas a score of 1 will reflect a hypothetic effect.

Ecological stakes

The score of ecological stakes is already completed and available to the expert (sheet "stakes"). Scores from 1 to 10 are established according to two sub-criteria: the IUCN status and the environmental issue identified in maritime spatial planning process. Only the highest score is conserved. For "cetaceans and sea turtles", the IUCN scores are assigned according to the level of threat indicated on the IUCN website[47] for the assessment scope "Mediterranean". The scores associated to the environmental stakes identified in the maritime spatial planning process are attributed by numerical transcription of the levels of stakes identified in the French strategic document of the Mediterranean coastline for the areas concerned by the perimeter of the MSPMED project: continental shelf of Gulf of Lion, southwestern canyons of Gulf of Lion and central and north-eastern canyons of Gulf of Lion.

The attribution of these three scores (S, K and E) will allow the ranking of potential interactions in order to identify, for example:

- Potential interactions for which it is possible to implement actions quickly because the sensitivity and the level of ecological stake are both high and there is a good scientific knowledge associated to this interaction (high S*K*E score);
- Knowledge gasp about potential interactions for which the sensitivity of the receptor is high (high S/K score);
- Knowledge gaps about the level of sensitivity of a receptor to a pressure ("+").

In order to carry out this ranking method, the experts are invited to complete the "sensitivity" and "knowledge" sheets of the attached Excel document before the 17 of November, just before the fourth and final technical meeting.

Conclusion and outlooks

A synthesis of all the experts' contributions will be produced before the fourth technical meeting. The objective of this last technical meeting will be to discuss the final results and the methodology. It will also present the preliminary results obtained for the other ecological components under study and contextualize these results in the transboundary context of the Gulf of Lion and the MSP-MED project. Based on the results of the ranking process, a discussion will also be conducted in order to address the knowledge gaps about windfarm-ecosystems interactions in the Mediterranean Sea, and to build recommendations either on the improvement of this first iterative and prospective exercise of identification of interaction risks for offshore floating windfarms or to improve monitoring of the ecosystem in future offshore floating windfarms areas.

Report of the final technical Meeting 18nd of November, 2021

This document reports the exchanges of the fourth and final technical meeting dedicated to "**Cetaceans and sea turtles**", on the **18th of November 2021**. For more information about the MSPMED project and the objectives of these technical meetings, please refer to the previous technical reports.

Technical meeting 4: Build recommendations to improve monitoring of the ecosystem in future offshore floating windfarms

The fourth technical meeting has been dedicated to producing a set of recommendations for a better consideration of potential risks of interaction between marine ecosystems and the development of floating offshore windfarms through the creation of an observatory. The meeting was conducted following the program below:

Introduction (15')
Introduction of experts

[47] IUCN Red List of Threatened Species

Session 1: Classify the potential interactions with SKE method (60’)	
Scoring sensitivity and knowledge	
Session 2: Contextualize knowledge gaps to offshore floating windfarms scale (20‘)	
Discussion on the needed monitoring effort and its scale	
Session 3: Recommendations to authorities (20‘)	
Recommendations and comments on methodology	
Conclusion	
Perspectives & MSPMED final conference (5’)	

Participants:

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**Organisers (MSPMED team*

Session 1: Classify the potential interactions with SKE method

The few contributions received before the technical meeting did not allow to establish the SKE scores that are necessary to prioritising interactions. The scoring exercise was proposed during the technical meeting in order to highlight the priorities and to initiate a discussion about the monitoring effort to conduct in order to inform the effects of offshore floating windfarms on cetaceans and marine turtles. In order to facilitate the scoring exercise and the exchanges, the scoring protocol proposed in the methodological note (transmitted just after the third technical meeting 3) was simplified.
The sensitivity was assessed using a 4-level colour code:

- Grey - the sensitivity of the receptor to the pressure is not known;
- Green - the sensitivity of the receptor to the pressure is considered as low by the experts;
- Yellow - the sensitivity of the receptor to the pressure is considered as medium by the experts;
- Orange - the sensitivity of the receptor to the pressure is considered as high by the experts.

Based on the discussions about the possible differences in sensitivity of ecological receptors during the different phases of the development of offshore floating windfarms (cf. the second technical meeting report), sensitivity assessment is required for the two main phases: construction (and decommissioning) and operation. According to experts, the sensitivity scores will nevertheless be the same for both phases related to some identified pressures (material deposition for example). Due to the low number of votes and the high variation in sensitivity assessment for some pressure-ecological receptor pairs, only the raw, unaveraged results are presented.
For some experts, sensitivity is intrinsic to each species and will no vary from one phase to another. If this is true in most cases, there are some differences in the nature of pressure during the difference phases. This is the case for noise emissions (impulsive noise in the construction phase vs. increase in ambient noise in the operation phase), chemical pollution (hydrocarbon pollution in the construction phase vs. increase in dissolved metal concentrations in the operation phase) or human activity (increase in maritime traffic in the construction phase vs. increase in ship speed in the operation phase). All the activities linked to a specific step allow to distinguish between the different types of pressure. Such activities are indicated in the sensitivity assessment table and in the Excel summary file sent to all the experts following technical meeting 3.
Knowledge of the interactions between ecological receptors and pressures is assessed through a smaller number of levels ranging from 0 to 3 where 0 corresponds to an absence of knowledge, and scores from 1 to 3 indicate a level of knowledge ranging from low to high.

Similarly to the sensitivity assessment, due to the low number of votes obtained during the technical meeting, only the raw, un-averaged results are presented.

According to the experts, the exercise of rating knowledge at the species level is more difficult to carry out than scoring the sensitivity. Some experts prefer to score at the level of the "cetacean" and "marine turtle" groups, or at the level of one particular species based on their personal knowledge and experience.

Furthermore, the knowledge assessment is based on the level of scientific knowledge (publications, research results, grey literature, etc.) of the interaction. However, despite this lack of knowledge, the experts are able to provide an estimation of sensitivity based on their knowledge of the ecology and biology of the species. In contrast to the sensitivity assessment exercise, for this second rating exercise, the level of knowledge is identical for all phases of the development of the offshore floating windfarms (construction/decommissioning and operation).

Session 2: Contextualize knowledge gaps to offshore floating windfarms scale

This second part aimed at identifying the parameters and types of monitoring to be implemented in order to (i) reduce the lack of knowledge about the effects of offshore floating windfarms on ecosystems, (ii) propose measures to limit the effects of already known interactions, and (iii) consider the effects at the ecosystem scale.

Based on the results of the scoring, several monitoring proposals were put forward by the experts in order to overcome the lack of knowledge about the effects of offshore floating windfarms on cetaceans and marine turtles by developing visual observation campaigns. These proposals are presented as recommendations in the third section.

To estimate the effects at the ecosystem level, the experts suggest considering the effects of offshore floating windfarms on some fish species whose abundance and distribution may be correlated with the distribution of some species of cetaceans and marine turtles. Tuna could be a good monitoring indicator to consider the effects on fisheries. This species is often found in rich areas and can be considered like a good indicator of the ecosystem and the pressures on pelagic species. A change in the spatial distribution of tuna could reflect a change in the behaviour of other species. It could also be a good indicator because tuna monitoring by aerial survey is possible, allowing the counting of individuals at the surface which can provide indications of distribution and abundance. The standardised tuna monitoring protocols developed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) could be applied[48] at the offshore windfarms level in order to monitor their effects on the populations of tunas in the Gulf of Lion.

According to the experts, knowledge about the potential consequences of the reef effect on ecosystems needs to be improved in order to consider the movement and habitat use of species before and after the installation of floating infrastructures at sea.

Session 3: Recommendations to authorities and developers

The recommendations provided by experts during the technical meeting mainly concern the consideration of relevant spatial scale and parameters in order to have a holistic view of the effects of offshore floating windfarms. It is therefore important to develop monitoring of all ecosystem components within the perimeter of future projects in order to monitor, scientifically document and evaluate the effects on marine ecosystem and to integrate these results into a more global approach studying cumulative effects.

These recommendations can be divided into the following broad categories:

Monitoring and improving knowledge within the OFW and their areas of influence

- Develop systematic sampling protocols from all vessels that will intervene in the development and maintenance of floating windfarms area in order to acquire observation data with monitoring instruments and qualified observers. Visual observations provide information on the behaviour and concentration of species in the area and will allow to document collisions and entanglement with infrastructure and equipment.
- Establish programmes to monitor the distribution and abundance of cetaceans and sea turtles in the area of influence of offshore floating windfarms using visual and acoustic methods (e.g. anchored devices).
- Encourage observation within the offshore windfarm area with dedicated monitoring adapted to all the species frequenting the area.
- Implement protocols to compare the distribution of species, and more particularly the Common bottlenose dolphin, between the implementation area and the area of influence. Photo-identification of fins of individuals

[48] Example of protocol implemented by ICCAT: https://www.iccat.int/GBYP/Docs/Aerial_Survey_Phase_9_Protocol.pdf

regularly visiting the offshore windfarms area could provide interesting information on the distribution of individuals and their use of the site.

- Use tuna as a monitoring indicator to consider the effects of offshore floating windfarms on fisheries by adapting standard ICCAT protocols to the scale of the windfarms and the Gulf of Lion.
- Implement hydrodynamic monitoring at the scale of the windfarm and its area of influence in order to better understand the distribution of cetacean and marine turtle species.

Improving ecological knowledge

- Improve knowledge of the reef effect in order to evaluate the resulting attraction or avoidance effect for the various pelagic species, the food resource of cetaceans and marine turtles.

Experimentation

- Conduct experiment on demonstration sites with adapted monitoring tools. Improve consideration of the risks
- Integrate into the assessment of effects, the notions of cumulative effects with other pressures such as maritime traffic, by-catches, etc.
- Consider the effects at the ecosystem scale and not only at the scale of each compartment or species. The species of interest are selected according to a set of criteria which may not be adapted for assessing the effects of offshore floating windfarms.
- Consider effects at the appropriate geographical scale for each species, parameter or type of monitoring. The national scale is often too small for some highly mobile species and to inform the spatio-temporal distribution of species.
- Integrate the study of oceanographic conditions and their evolution in the analysis of the effects of offshore floating windfarms on ecosystems.

This last technical meeting also provided first feedbacks on the method implemented in the MSPMED project to improve the knowledge of interactions between marine ecosystems and the development of offshore floating windfarms in the Gulf of Lion. The transboundary approach to marine megafauna has allowed a sharing of knowledge and experience between French and Spanish experts. The prospective approach carried out within the project has also initiated discussions about the floating offshore windfarm technology for which there is very little feedback at an international scale, despite the fact that there are still many unknowns about the technologies that will eventually be deployed in the Gulf of Lion. Finally, as offshore floating windfarm development projects are still in their early steps of implementation or consideration, all the recommendations made by the experts to better consider the potential effects of offshore windfarms can be transmitted to the competent authorities and developers upstream of the projects.

The main difficulty with this prospective exercise was to link the lack of information about the size of the infrastructure to be deployed (type of floats, type and power of wind turbines, number of anchors) and the location of the parks (location within the Gulf of Lion, distance from the coast, spatial extent, etc.). Some experts also regretted the lack of a holistic view of the ecosystem in the approach conducted through distinctly ecosystem components, which does not allow to integrate and understand the effects of an offshore floating windfarm on the whole ecosystem.

Conclusion and outlooks

All the results collected within the 5 ecosystem compartments (cetaceans and marine turtles, birds and chiropterans, planktonic communities, fish and cephalopods, benthic habitats) will be compared and synthesised in order to provide an ecosystemic vision of the expert contributions.

The study report presenting all expert contributions for all ecosystem components will be presented to the Spanish and French competent authorities of MSP in a restitution workshop in January 2022. In particular, the knowledge gaps identified and the experts' recommendations will be presented.

Annex 4

Synthesis of "Flying fauna" reports

Report of the first Technical Meeting 16th of June, 2021

In line with the importance of conducting a coordinated and coherent transboundary Maritime Spatial Planning process, the Gulf of Lion case study of the MSPMED project has several objectives:

- Build and promote a global view of ecological stakes in the Gulf of Lion, especially related to cetaceans, seabirds and deep habitats;
- Provide knowledge about interactions between Mediterranean ecosystems and maritime uses and activities, with a specific focus on windfarm development in the Gulf of Lion area.

For this purpose, the OFB[49] , FEM[50] and IEO[51] team, in close collaboration with scientific experts, aim at producing a knowledge synthesis about ecological stakes and their interactions with activities related to windfarm development, through technical meetings.

Objectives of technical meetings

Technical meetings are aimed at (1) boosting knowledge and methodology sharing so as **to complete an updated view of ecological stakes and their sensitivity** in the **Gulf of Lion** (from Barcelona to Marseille), (2) providing information on potential **interactions between windfarms and ecosystems** in the study area, (3) **highlighting important knowledge gaps** to be bridged, (4) **comparing evaluation processes in Spain and France** in order to facilitate a common understanding and (5) **encouraging cross-border cooperation** to address ecological stakes, especially regarding mobile species such as cetaceans, sea turtles and seabirds.

Among many topics of interest, technical meetings will address:

- Existing datasets in the study area;
- The characterization of interactions between Mediterranean ecosystems and windfarm development;
- Assessment of differences in evaluation of issues/stakes;
- Knowledge and data gaps, and perspectives ways to bridge them;
- Ecological stakes spatialization.

This document reports the exchanges held during the first technical meeting dedicated to "Seabirds, birds and bats of the Gulf of Lion", on 16th of June 2021.

Technical meeting 1: complement the knowledge synthesis

This first meeting has been dedicated to (1) the **identification of existing data and knowledge gaps** regarding seabirds encountered in the Gulf of Lion, and (2) the initiation of the work to be conducted on **interactions between ecological stakes and offshore windfarms**, following the program below:

Introduction
Presentation of the MSP-MED project and objectives of meeting 1; introduction to/of experts (20')
Session 1: Build a global view of existing knowledge in the Gulf of Lion
a. Presentation of preliminary work: existing datasets (20')
b. Knowledge gaps selection: from pre-identified knowledge gaps, a ranking exercise will help to prioritize those to address during the session (25')
Virtual Coffee Break (15')
c. Discussion: contribution of on-going research/projects to bridging knowledge gaps, design of complementary programs and methodological perspectives (45')
Virtual Coffee Break (15')
Session 2: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion
d. Presentation of the methodology; and presentation of technologies and activities related to floating windfarm projects in

[49] Office Français de la Biodiversité, https://ofb.gouv.fr/
[50] France Energies Marines, https://www.france-energies-marines.org/
[51] Instituto Español de Oceanografía, http://www.ieo.es/

Mediterranean and potential pressures (30’)
e. Open discussion on the relevance of pre-identified ecological receptors (50’)
Conclusion and future work (20’)

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Session 1: Build a global view of existing knowledge in the Gulf of Lion

a. Presentation of preliminary work: existing datasets

Participants presented the preliminary overview of datasets/campaigns/programs documenting seabirds, partly or entirely covering the Gulf of Lion. In the study area, 34 and 28 boat-based surveys have been censed in June and July respectively, while less than 10 were identified during each of the other months, from 1993 and 2020 (these results have to be considered as minimal). On the contrary, aerial surveys have been conducted less frequently, with at least one survey per each month, up to 5 in January and February (first aerial survey considered - 2011). Globally, when merging boat-based and aerial survey yearly distribution, spring (especially April) and autumn (especially October) months have been less informed than summer and winter months.

In order to comment more specifically the spatial redundancy of datasets, complementary information has to be collected (transects and precise time span) so as to calculate and represent the cumulative linear effort in the study area.

b. Pinpoint data and knowledge gaps

Through a brainstorm exercise[52], participants contributed to five topics related to different potential knowledge gaps about seabirds in the Gulf of Lion. Participants could answer by selecting each of the five categories referring to (1) seabird at-sea distribution, (2) functional areas in the Gulf of Lion, (3) predictability of seabird distribution, (4) seabird abundance and trends, (5) other, and complement their choice by writing comments on the associated knowledge level or specific gaps. Contribution were collected and organized in a mind ap for a subsequent discussion with experts.

Topics and synthetized results are presented in section below.

c. Perspectives: bridge knowledge gaps

After identifying main knowledge gaps regarding the distribution of seabirds in the Gulf of Lion, a discussion was conducted to characterize these gaps in detail (e.g. spatially, temporally, distinctly between different data types, technological or methodological limitations).

[52] Used tool: http://digistorm.app

In the following paragraphs, results of the brainstorming session and subsequent discussion are synthetized in five main topics: (1) seabird distribution, (2) seabird functional areas in the Gulf of Lion, (3) predictability of their habitat use, (4) seabird abundance and trends, (5) seabird sensitivity to anthropogenic pressures. Due to time limitation, the last topic could not be discussed in detailed and will be studied further during next meetings.

At-sea distribution of seabirds

While many individuals have been, or are equipped[53],[54] (GPS, GLS, ARGOS, etc.) and many boat-based or aerial surveys have been conducted in the study area, seabird at-sea distribution has been characterized as partially known. Indeed, experts mentioned (1) a progress to be made about the standardization of at-sea survey protocols to complete a global view of seabirds' distribution in the area, in addition to (2) the limited available data further offshore the continental shelf and during non-summer months.

Moreover, data is still lacking for small species (e.g. storm-petrel) or wintering ones. For the latter, data is rather obtained at low resolution (GLS) or from the coast (ring re-sightings), thus poorly inform on the individual and local-scale behaviors of wintering species in the Gulf of Lion and all along their migratory route.

Globally, 3D distribution (i.e. including flight altitudes) is unknown for seabirds, except for Scopolis shearwater (on-going research at the CEFE-CNRS). Moreover, their nocturnal behavior at sea is unknown (except for tracked individuals).

Functional areas of seabirds in the Gulf of Lion

To experts, many gaps remain about functional areas of seabirds in the Gulf of Lion, except for some well-informed species such as the Scopolis shearwater. However, current technology (as long as colonies' location is known) and existing data may be sufficient to bridge those knowledge gaps. Firstly, equipment at colonies allows to track either juveniles or breeding adults. Secondly, a lot of data has been acquired in recent years (gulls, shearwaters, terns) and could be analyzed to estimate "densities of at-sea behaviors" (foraging areas, flight corridors, etc.). Fine-scale tracking of seabirds is possible and shall be used in MSP processes. The main limitation remains in the cost of tracking devices.

Predictability of seabird at-sea distribution

The predictability of seabird distribution has been commented on several aspects: environmental factors, co-occurrence with other top-predators, attendance of maritime activities and infrastructure.

Firstly, experts mentioned the lack or unavailability of fine-scale environmental data that could be used to inform the relationship between environmental conditions and at-sea distribution of seabirds. Moreover, wind patterns (intensity, distribution, etc.) have been qualified as a key factor to be studied. Indeed, as for migratory species, wind patterns can influence the space used by seabirds and especially their flight altitude, which is critical to be considered in the context of windfarm development. To date, flight altitude of seabirds found in the Gulf of Lion has been rather rarely addressed in research, except recently with the development of energetic models for the Scopolis shearwater[55]. To address the relationship between wind patterns and seabird 3D distribution, fine-scale (high-frequency) data is required and thus may represent an important limiting factor.

Secondly, experts underlined the influence of human maritime activities and infrastructures on seabird distribution. As an example, at-sea distribution of seabirds (e.g. gulls and shearwaters) is known to be influenced by trawling activities (attendance behaviour, e.g. in the western Gulf of Lion), and might be an interesting explanatory variable to be considered in predictive models. Moreover, several species are known to attend floating infrastructures (resting sites) and tuna farms (e.g. gulls, gannets, terns, shags, … feed either on waste, feeding resource of tuna, or surrounding fish).

Thirdly, experts commented on the co-occurrence of top-predators in the study area. If seabirds' distribution is more commonly studied in relation with prey distribution, from fieldwork experience, seabirds are known to associate with surface-feeding tuna, but not with cetacean species that adopt other foraging strategies (e.g. the Common bottlenose dolphin consumes demersal resources).

Seabird abundance and trends

At-sea abundance and trends of seabirds in the Gulf of Lion area may be difficult to obtain as few baseline data exists. Moreover, abundance variations at colonies are insufficiently explained, and monitoring may not be sufficiently compared and combined between colonies so as to describe the variability of site use.

[53] INTEMARES, 2018-2024, https://intemares.es/prensa/actualidad/estudiamos-movimientos-pardela-balear-para-reforzar-proteccion
[54] Data acquisition in the context of pilot and commercial windfarm development, A. Gigou, pers. com.
[55] ORNIT-EOF project, 2019-2021, https://www.france-energies-marines.org/en/projects/ornit-eof/

Demographic models are needed to evaluate the potential impact of windfarms on populations (e.g. collision, disturbance or habitat loss/modification). Such methodologies already exist, but the main limitation relies in getting both (1) data of spatial distribution of birds and (2) data informing the population demographics and trends, i.e. to combine information at the individual and population scales.
Similarly, an important information to be considered would be the origin of seabirds observed at sea, e.g. through connectivity models, to estimate if pressures would impact one or several colonies, what would have different demographic implications.

Sensitivity of seabird species
This very large topic could not be addressed in the remaining time; however, here is reporting some related comments. Sensitivity can be addressed through different criteria, and to different kinds of pressures (by-catch, collision, disturbance, etc.). The classification of species regarding their sensitivity to pressures is still to be conducted, and especially in the context of offshore windfarm development. In this precise case, very few is known about the avoidance behavior of seabirds towards wind turbines at fine-scale. Seabirds' sensitivity to these new obstacles could be linked to their maneuverability under the different weather conditions they encounter.
The sensibility to windfarm-related pressures will be studied and discussed further during next meetings.

Session 2: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion

a. Presentation of the methodology and presentation of technologies and activities related to floating windfarm projects in Mediterranean

The proposed method for provide knowledge and assess the interactions between marine ecosystems and windfarm development was presented to the participants. Developed by the Ministry in charge of the environment since 2018 this method results of a reflection on the environmental integration of marine renewable energies. In the context of MSPMED project, the objective is to implement the first steps of impact qualification and assess the existing interactions between the activities related to the development and operation of floating windfarms, the pressures they generate and the ecological receptors[56].
Preliminary work was conducted to identify activities, pressures and receptors. Based on the impact studies of the pilot windfarms projects in the Mediterranean, these lists were submitted for discussion by experts. In parallel with the work carried out in the "birds, seabirds and chiropterans" technical meeting, professionals from the marine renewable energy sector were also consulted to assess the lists of activities.
The list of pressures includes the pressures identified for the MSFD and may be discussed during the second technical meeting. The first list of receptors submitted to the experts' opinion summarize the species censuses realized in the impact studies of floating windfarm projects in the Mediterranean and on additional bibliography (occurrence data, protection status, etc.) and includes more than 230 species of birds, seabirds and bats.

b. Open discussion on the relevance of pre-identified ecological receptors

239 species (139 birds, 77 seabirds and 23 bats) were identified during the preliminary step as susceptible to be impacted by the development of floating windfarms in the Gulf of Lion. Due to the number of species, it is not possible to study and assess the interactions with floating windfarms for each of them. The objective of the technical meeting was to identify ways for reduce the number of receptors by focusing on the most relevant species or groups of species.
To facilitate the technical meeting, a reduced list of 83 species (2 birds, 59 seabirds and 22 bats) was discussed in a virtual post-its session[57] focused on two main questions: the proposed list is it relevant (add or removal of species)? What criteria can be used for selecting the most relevant species/groups of species?
Experts were invited to express their opinions and/or vote for define the most relevant groups of species for the evaluation. The main elements of the discussions were grouped under different topics presented below.

Main difficulty: the lack of knowledge

[56] Species, habitats or groups of living organisms susceptible to be endure a pressure from human activity
[57] MURAL tool: https://www.mural.co/

To experts, the identification of relevant receptors is difficult due to the lack of knowledge of the species that cross and frequent the Gulf of Lion. The evaluation of interactions between avifauna and floating windfarms at sea cannot be carried out effectively without the implementation of data acquisition and knowledge improvement programs. Although the implementation of such programs is not foreseen for the MSPMED project, it is important to note that the work conducted constitutes a preliminary basis for the qualification of the impacts and pressures. The gaps identified may be the subject of a subsequent research and development program.

Implementing acquisition programs: improving knowledge & monitoring interactions

The distance to the coast (15 to 20 km on average) can be considered small for many migratory bird and bat species. They can regularly visit the windfarm area and there is no (or little) monitoring. The identification of a relevant and precise list of species requires improved knowledge of many components: frequentation of the area (day or night, seasonal or permanent, etc.), occurrence, behavior (attraction effect, flight altitude, etc.), study of functional areas (hunting area, resting area, etc.). In this sense, the experts proposed to prioritize the acquisition of knowledge for wintering species in the Gulf of Lion for which there is a lack of data and considering the temporality of the species.

In the context of climate change, the improvement of knowledge will have to cover all species of birds and chiropterans in order to anticipate possible changes in migration routes and behavior (use of space at sea, etc.). Multi-species assessment using radars posted from the coast or on board can be a first step for implement this monitoring.

Particular case of bats

Unlike onshore windfarms, few studies and bibliographical data exist to qualify the interactions between chiropterans and offshore windfarms. The behavior of bats at sea it is not widely known, and significant work is needed to improve knowledge in order to identify the species that frequent the coast and define the issues. Complementary monitoring will be carried out for chiropterans in order to improve knowledge through the deployment of ultrasound detectors and/or thermal cameras.

Define a relevant list of receptors

Several species considered irrelevant by the experts were deleted (i.e. Northern fulmar, Bulwer's petrel, Magnificent frigate birds, Palla's gull, etc.) as they do not occur in the Gulf of Lion area. The occurrence of several species was also questioned by some experts (i.e. *Miniopterus schreibersii, Tadarida teniotis, Pipistrellus pygmareus*, etc.) and modified, as this component could be used as a criterion for selecting relevant receptors. Several species will have to be integrated such as terrestrial and migratory species at sea (swallow, black swift, Eleonora’s falcon, etc.) as well as species accustomed to spending time away from the coast at night (herons, egrets).

In view of the decline of some terrestrial bird species, offshore windfarms represent a significant additional constraint to the maintenance of their populations. In order to identify the terrestrial species to be considered for the MSPMED project, it is proposed to take work of prioritization of species carried out for the MIGRALION[58] project (France) and to takes reports of studies identifying the migratory terrestrial bird species (Spain), by focusing in particular on baggage programs.

Depending on the number of species selected, two groups of land birds could be defined to assess the interactions: diurnal land birds vs. nocturnal land birds.

Possible ways of grouping

In order to reduce the number of receptors, several groupings were mentioned by the experts. To compensate the lack of knowledge inherent in the species, the study of existing interactions between floating windfarms and chiropterans could initially focus on two key groups: foraging species and migratory species.

Grouping species would make it possible to implement an initial assessment of interactions by focusing on only a few representative species of this group. The selection can be realized according to various criteria: conservation status, level of knowledge of the species (behavior, geographical distribution, etc.). The experts proposed that herons and egrets be grouped together in the "Ardeidae" family. Considering the taxon rather than the species and grouping together the 8 species of herons

[58] MIGRALION: Characterization of the use of the Gulf of Lion by terrestrial and marine avifauna using complementary methods. MIGRALION is a project of the French Office of Biodiversity (OFB) and will be implemented from 2021. It will provide knowledge on the spatio-temporal distribution of terrestrial and marine avifauna and chiropterans on the scale of the Gulf of Lion in order to improve the implementation of public policies for the preservation of these species and their natural habitats.

and egrets that frequent the Gulf of Lion. It is also proposed that “Raptors” be represented by the most threatened species such as the Honey Buzzard (*Pernis apivorus*) or the Eleonora's Falcon (*Falco eleonorae*).
To experts, the most harmful impact on birds is the risk of collision with the blades. The definition of receptors must therefore consider species whose behavior and flight height make them more sensitive than others to this pressure. However, the literature on the study of flight altitudes is poor and needs to be improved, especially on the maneuverability of birds changes according to climatic and oceanic conditions.
The possibility of grouping species with a critical conservation status at the species level and to focusing on the family level for other lower priority species was also mentioned. This method of selection would make it possible to have particular attention to the most sensitive species for which few data exists and for which knowledge acquisition programs are currently underway.

Conclusion and outlook
Many additional elements were transmitted after the technical meeting and included in this report. All the elements provided by the experts during this first session will be completed during the summer to be presented during the second workshop.
Scheduled for **21 September 2021 from 9:00 to 12:00**, this second technical meeting will focus on the reflections initiated during session 2 "Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in Gulf of Lion".

Report of the second Technical Meeting 21st of September, 2021

This document reports the exchanges held during the second technical meeting dedicated to “**Birds, seabirds and bats**”, the **21st of September 2021**. For more information on the MSPMED project and on the objective of these technical meetings, please refer to the first technical report.

<u>Technical meeting 2: Identify and characterize the potentials interactions between pressures and ecological receptors</u>

This second meeting has been dedicated to the identification and characterization of potentials interactions between marine ecosystem components -and particularly birds, seabirds and chiropterans- with offshore floating windfarms, following the program below:

Introduction
Introduction to/of experts & reminders of the objectives of technical meetings (15’)
Identification and characterisation of potential interactions
a. Validation of preliminary works (15’)
b. Completion and discussion on potential interactions (70’)
Conclusion
Future work and perspectives (5’)

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The approach implemented for the MSPMED project to gather knowledge about potential interactions between Mediterranean marine ecosystems and the development of offshore floating windfarms is adapted from a method for assessing the cumulative impacts of offshore windfarm projects, developed by the French Ministry in charge of the environment since 2018. Within the Gulf of Lion case study, the first steps of this assessment method are implemented and adapted to characterize potential interactions. The almost non-existent feedback on the impacts generated by floating infrastructures on marine ecosystems requires the implementation of a prospective approach based on expert judgement, through technical meetings.

The aim of these technical meetings is to describe risks of potential interactions in a comprehensive way. Many interactions are already identified and documented by the scientific community, but related studies are generally based on experience from fixed offshore windfarms in the North Sea for marine species, and from onshore windfarms for birds and chiropterans. While some identified risks of interactions between fixed offshore windfarms and marine ecosystems can be applied to floating offshore windfarms (increase in maritime traffic, modification of habitats, etc.), specificities of floating windfarms (ballast system, chain anchoring, etc.) would need further reflection. The prospective approach carried out within the MSPMED case study allows to identify the potential interactions of marine ecosystems with floating infrastructures for which there is no feedback and precise scientific knowledge yet. By applying the precautionary principle, the objective of these technical meetings is also to highlight needs of vigilance and awareness considering, for example, sensitive species or species whose behavior or functional areas (reproduction, migration, preferential use of certain habitats, etc.) are partly unknown.

The first technical meeting enabled to define a set of ecological receptors[59]. The objective of this second meeting was to identify all the potential interactions between receptors and pressures, and to characterize them (direct effect, indirect effect, short- or long-term effect, etc.). Within the prospective approach that is implemented here, experts have been encouraged to indicate any suggestion/hypothesis about risks of interaction, even if knowledge is still limited.

Next paragraphs report exchanges and results of the second technical meetings focusing on birds, seabirds and bats in the Gulf of Lion area.

a. Validation of preliminary work

Based on the discussions conducted during the first meeting, many receptors (species and groups of species) have been submitted to expert for validation: 13 groups of species (migratory bats, foraging bats, passerines, raptors, anatidae & rallidae, shorebirds, loons, herons & egrets, cormorants, shearwaters, gulls, terns and hydrobatidae) and 24 species.

Two approaches have been proposed by the experts to define the receptors. A functional group approach has firstly been proposed according to two criteria: 1/ Distinguish diving birds (shearwaters, cormorants, loons, etc.) and non-diving birds (gulls, etc.); 2/ Distinguish species according to the MSFD groups: grazing birds, wading birds, surface-feeding birds, pelagic-feeding birds, benthic-feeding birds. However, according to the experts, the approach by functional group is not the most appropriate one to consider in the context of windfarms because of all the effects that a windfarm can generate on avifauna. Diving species, for example, would move in the same way as non-diving species within a windfarm, although they might be impacted differently by other types of pressures. A second approach by groups of species with similar physical and behavioural characteristics is proposed (auks, gulls, etc.). Within these different groups of species, several species can be considered individually even if it seems complicated to define representative species - because all species have different characteristics. These species may be selected according to existing pressures, their sensitivity and their conservation and protection status (Bonn and Bern Conventions, etc.). If the "species group" level allows to identify the main risks of interactions with floating windfarms, the "species" level allows to conduct a more detailed analysis of certain behaviors and characteristics. Following the discussions initiated during the first workshop, **an approach by groups of species with a few species selected according to their conservation and protection priority is retained**.

The exchanges related to each species group are summarized below:

[59] Species, habitats or groups of living organisms likely to be subject to pressure from human activity

- Raptors. During migration, the Mediterranean Sea can be crossed by several species of harriers and falcons that may be vulnerable to windfarms like Osprey, *Pandion haliaetus* (breeding in Corsica and the Balearic Islands), European Honey buzzard, *Pernis apivorus* (present at sea during strong winds), Western Marsh harrier, *Circus aeruginosus*, Montagu's Harrier, *Circus pygargus*, Eurasian Hobby, *Falco subbuteo* and Lesser Kestrel, *Falco naumanni* (migratory falcons).
- Loons. The knowledge is low about this species group. Their presence in the Mediterranean Sea is anecdotal and their wintering areas are rather located in the North Atlantic (Cantabrian Sea, Atlantic and North Sea). Their migratory routes are unknown, although the scientific community knows that loons do not cross the Strait of Gibraltar. In application of the precautionary principle, the species group is retained regarding to the prospective approach carried out in the framework of MSPMED.
- Wader species. As loons, the behavior of this species group is not well known in the Mediterranean Sea and this group is added at the request of experts. Within this group, the Black-tailed Godwit (*Limosa limosa*) is added and others may be included in the list depending on their protection status in the conventions (redshanks, dunlins, ringed plovers, avocets, etc.).
- Herons and allies. The original group "herons and egrets" is expanded and renamed "herons and allies" to include spoonbills, ibises, cranes and flamingos with mention of some species: Purple heron, *Ardea purpurea*; Squacco heron, *Ardeola ralloides*; Little bittern, *Ixobrychus minutus*; Great bittern, *Botaurus stellaris*; Little egret, *Egretta garzetta*; Grey heron, *Ardea cinerea* and Cattle egret, *Bubulcus ibis*; added in view of the numbers of individuals breeding along the Mediterranean coast.
- Within seabirds, Cormorants, Gulls and Hydrobatidae did not receive any particular comments. Within the Shearwaters, the name of one species is updated (Scopoli's shearwater, *Calonectris diomedea*) and within the Terns, the Little tern (*Sternula albifrons*) is added to the list. Two groups are also added: Skuas and Auks, the latter being potentially affected by habitat modification and loss, and in particular Razorbills. Atlantic puffins likely use the Gulf of Lion during the wintering period. According to experts, shearwaters deserve special attention because at night and in strong winds they can fly at higher altitudes and collide with blades (e.g. collision observation in the Canary Islands). Shearwaters may also be particularly sensitive to oil pollution from floating windfarms. Details of the species associated to each group are available in the summary table at the end of this section.
- The Migratory bats, Foraging bats, Passerines, Anatidae & Rallidae, and Shorebirds groups did not receive any particular comments, as the Northern Gannet species, which is considered to be a receptor on its own regarding to the species' specificities.

50 receptors are therefore finally considered in this MSPMED task: 18 groups of species associated to 32 species selected regarding to their respective characteristics and protection status.

Migratory bats	
Foraging bats	
Passerines	
Raptors	Osprey, *Pandion haliaetus*
	European Honey-buzzard, *Pernis apivorus*
	Western Marsh-harrier, *Circus aeruginosus*
	Montagu's Harrier, *Circus pygargus*
	Eurasian Hobby, *Falco subbuteo*
	Lesser Kestrel, *Falco naumanni*
Anatidae & Rallidae	
Shorebirds	
Loons	
Wader species (redshanks, dulins, ringed plovers, avocets, etc.)	Black-tailed Godwit, Limosa limosa
Herons & allies	Purple heron, *Ardea purpurea*
	Squacco heron, *Ardeola ralloides*
	Little bittern, *Ixobrychus minutus*
	Grey heron, *Ardea cinerea*
	Great bittern, *Botaurus stellaris*
	Little egret, *Egretta garzetta*

		Cattle egret, *Bubulcus ibis*
Seabirds	Cormorants	Desmarest shag, *Phalacrocorax aristotelis desmarestii*
		Great cormorant, *Phalacrocorax carbo*
	Shearwaters	Scopoli's shearwater, *Calonectris diomedea*
		Balearic shearwater, *Puffinus mauretanicus*
		Yelkouan shearwater, *Puffinus yelkouan*
	Gulls	Audouin's gull, *Larus audouinii*
		Mediterranean gull, *Larus melanocephalus*
		Little gull, *Hydrocoleus minutus*
		Yellow-legged gull, *Larus michahellis*
		Slender-billed gull, *Larus genei*
		Lesser Black-backed gull, *Larus fuscus*
		Black-legged Kittiwake, *Rissa tridactyla*
	Terns	Black tern, *Chlidonias niger*
		Sandwich tern, *Thalasseus sandvicensis*
		Common tern, *Sterna hirundo*
		Little tern, *Sternula albifrons*
	Hydrobatidae	Storm petrel, *Hydrobates pelagicus melitensis*
	Auks	Razorbills
		Puffins
	Skua sp.	
	Sulidae	Northern Gannet, *Morus bassanus*

b. Completion and discussion of potential interactions

Once validated, these 18 species groups have been submitted to a list of pressures. For this first step of identification and characterization of risks of potential interactions, the "group of species" level is sufficient. Details on certain species were provided in comments by the experts and the "species" level will be useful for providing details on interactions during the third technical meeting. As requested by the experts, the different phases of windfarms operation (construction, operation, decommissioning) are considered in order to characterize the different types of pressure. During this second technical meeting, the exercise has been limited to linking pressures and receptors and collecting justifications/background for illustrating these associations.

The list of pressures is based on the MSFD list and has been adapted to the context of offshore floating windfarms development, and some pressures had been identified before the meeting from bibliography. Direct (e.g. avoidance) and indirect effects (e.g. diet modification) are distinguished for all pressures and more details on the effects of their pressures are also mentioned.

The exchanges and information provided by the experts during and after the meeting are still available on the online workspace, and results are reported hereafter:

Physical losses and damages

The pressures related to **physical losses and damages** refer to the physical modifications of the marine habitat. **Loss of habitat** affects all birds through avoidance of windfarms, which can lead to an increase in foraging effort and impact the feeding and reproductive success. Passerines and some seabirds (shearwaters, gulls, terns and Northern gannet) may be particularly sensitive to this loss of habitat and some species such as loons are known to be repelled by windfarms and shipping traffic (Mendel & al., 2019). At the local scale, **changes of habitat** generated by floating infrastructures are multiple. In the long term, the floats can lead to a reef effect as well as a "FAD"[60] effect. The resulting modification of pelagic communities may have an indirect effect on the seabird populations that feed on them. The reserve effect related to changes of uses in windfarm areas may lead to a local increase in biomass and may have an attractive effect on fish-eating seabirds. Diving species, such as cormorants, and species known to forage in the vicinity of anthropogenic infrastructures such as gulls (Herring gulls and Brown gulls) or terns could be more impacted (Venermen & al., 2015). These floating infrastructures can also represent an obstacle for diving species and thus increase the collision risk for these species which could be attracted by the local increase in biomass. For some species, such as ducks, a habituation phenomenon can also be observed (Nilsson, 2011) with positive (collision reduction) and negative (attraction) consequences. Knowledge is poor about the possible effects of **extraction of substrate** on bird populations, although indirectly all

[60] Fish Aggregation Device

seabirds may be impacted by changes in prey behavior. In the context of floating windfarms, **material deposition** refers to the addition of a floating infrastructure in the marine environment. Depending on the design of the floating infrastructures and their immersion volume (between 8 and 20 meters depending on the model), this material deposition can have an impact on the foraging of diving species. Changes in **abiotic conditions** (turbidity, hydrographic conditions, temperature, etc.) can have effects on pelagic habitats and generate changes in the distribution of prey over the long term and modify the feeding areas of certain species of seabirds, particularly breeding seabirds and cormorants (Lieber & al., 2021). **Turbidity** can affect diving species such as loons, cormorants and surface-feeding species such as shearwaters, terns, hydrobatidae and Northern Gannet in their foraging success. **Light emissions** can have direct attraction effects on bats, some migratory birds and seabirds in windfarms areas and indirect attraction effects on seabird prey. Indeed, light pollution from windfarms can disrupt bird migration at sea and attract offshore shorebirds such as passerines (Blew & al., 2008), raptors, shorebirds, shearwaters and hydrobatidae species. Light emissions can also have an indirect effect by attracting prey with an attractiveness effect on birds (and some cetaceans) that increases their foraging success.

Chemical pressures

The identification of potential interactions with **chemical pressures** is complex regarding the pressures list. If offshore oil platforms can provide elements for identifying the sources of pressures, the levels of pollution and possible sources of contamination are difficult to estimate in the context of offshore windfarm development. An approach by type of exposure to the various pollutants is considered to be more relevant for birds and chiropterans. Firstly, pollutants emissions into the environment can have an indirect effect on birds through contamination of the food web. For this type of exposure, all seabird species are concerned. Secondly, species that spend a lot of time on surface such as cormorants, auks and all diving species, may be impacted by accidental pollution and oil spills. The possible direct effects on these species are various: loss of feather waterproofness, poisoning by direct ingestion of hydrocarbons, hypothermia, etc. The direct and indirect effects of chemical pressures will depend on the potential pollution created by the activity of windfarms in operation (oil leaks, accidents due to increased maritime traffic, etc.). Specific plans for intervention and prevention of chemical pollution (oils, spills, etc.) must be carried out before the installation of windfarms to limit the impact on marine ecosystems and more particularly on birds in the event of an "oil spill".

Biological pressures

Finally, **biological pressures** include pressures that will have a direct impact on the biology of species and their physical integrity. The risk of **collision** is the major risk for all bird species. The barrier effect resulting from the **obstruction to movement** can have effects on all bird populations and more particularly on migratory species at sea and certain species of seabirds such as gulls and terns. **Human activities** are distinguished by type of activity as they can lead to different types of impact. Maritime activities related to the construction and maintenance of floating infrastructure during the operational period can have different impacts on birds: loons, anatidae and rallidae such as the Common scoter will avoid maritime traffic zones, which can reduce functional habitat areas; shearwaters and gulls will tend to follow and fly over vessels in activity, which can increase the risk of collisions The reserve effect of the windfarms area may increase the presence of fishermen next to the windfarms with an increased risk of collision for seabird species, such as gulls, which tend to follow fishing vessels.

c. Points of vigilance raised during meeting

The prospective approach conducted in this MSPMED task allows to identify pressures for which there is little or no knowledge about potential interactions with the marine ecosystem in the context of windfarm development. Some pressures may have short-term effects, while others may have an impact on marine ecosystems if they persist over time. This distinction must be considered in the case of floating windfarms, which are expected to operate for 25 to 30 years. As mentioned above, pollution risk prevention plans must be planned before the construction of the windfarms in order to prevent the risk of accidental pollution. In order to improve knowledge and better anticipate the potential impacts of floating infrastructure on birds and chiropterans, further work is needed to define relevant methods for assessing flight heights.

d. Additional information

The development of floating windfarms is recent and few case studies have been documented in France and Europe (cf. Hywind Scotland,[61] SEM-REV[62]). These technologies are designed to fit with bathymetric constraints for depths greater than 50 meters on average (up to 200 m) (Bon & al., 2021).

Three main categories of floating infrastructure exist (Defingou & al., 2019):

- **Semi-submersible platforms and barges**: The float is stabilized at the water surface by its shape (case of the barge) or by a set of submerged volumes (case of the semi-submersible platform). These infrastructures are often heavy and large to ensure the stability of the float. A system of anchor lines is used to keep the float in position (Defingou & al., 2019).
- **Tension leg platform (TLP)**: The float is held below the surface of the water by an anchoring device that pulls the float towards the bottom and ensures its stability (Defingou & al., 2019). The vertical anchoring system allows the infrastructure to be held in place but is subject to high physical stresses due to the pre-tension of the lines and the drift force (Bon & al., 2021).
- **Single point anchor reservoir (SPAR)**: Often cylindrical, the float is immersed in a large depth of water and stabilized by its weight (lower part of the float is weighted). A simple anchor line is used to hold the structure in place (Defingou & al., 2019). This type of infrastructure is only possible in depths greater than 100 meters (Bon & al., 2021).

Pilot and commercial windfarm projects in France

Since 2015, France is committed in a program for the development of floating offshore windfarms through the energy transition law for green growth and initiated the development of pilot windfarms. Three pilot windfarm projects have been proposed in the Gulf of Lion and two commercial windfarm projects are currently under public debate (July-October 2021).

		EOLMED pilot windfarm	EFGL pilot windfarm	PGL pilot windfarm	Windfarm project
Area		8.15 km²	6.17 km²	Unknown	Between 50 and 100 km²
Depth		60 m	70 m	Between 95 and 100 m	Between 60 and 120 m
Distance from the coast		18 km	16 km	17 km	Approx. 50 km
Number of turbines		4	3	3	Between 20 and 40
FLOATS	Type	Barges	Semi-submersible platforms	TLP	Unknown
	Size (aprox.)	43 x 43 m (L x l)	95 x 80 m (L x l)	80 x 80 (L x l)	Unknown
	Height	8 m underwater and 16 m emerged	10 m underwater and 14 m emerged	25 m underwater and 15 m emerged	Unknown
ANCHORING	Number of lines	8 lines/floats	3 lines/floats	3 lines/floats	Unknown
	Anchor dimensions	600 m toward the coast + 1430 m toward the sea	600 m	Not applicable	Unknown
WIND-TURBINES	Diameter	145 m			
	Height of the mast	100 m			
	Total height	180 m (mast + blades)			
	Blade length	70 – 75 m			

Table 1: Synthesis of information from: Bon & al., 2021; Débat public., 2021; EFGL., 2018; EOLMED., 2018; Projects websites of EFGL (https://info-efgl.fr) and PGL projects (https://www.provencegrandlarge.fr)

Conclusion and outlook

All elements provided by the experts during this second meeting have been included in this report and are still available on the workspace on line. It is regularly checked by the MSPMED team and all the contributions will be considered to prepare the technical meeting 3. This workspace can be amended by experts until the **15th of October 2021**.

Scheduled for the **21st of October 2021 from 3:00 to 5:00 p.m.**, the third technical meeting will build on the reflections initiated during the two first technical meetings in order to achieve a global – transboundary-view of ecological stakes in the Gulf of Lion. During the fourth and last technical meeting, pressures will be linked to the activities generated by the development of floating windfarms to identify and discuss chains of activities > pressures > receptors.

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Report of the third Technical Meeting 21st of October, 2021

This document reports the exchanges held during the third technical meeting dedicated to "**Birds, seabirds and bats**", on the **21st of October 2021**. For more information about the MSPMED project and the objectives of these technical meetings, please refer to the first and second technical reports.

Technical meeting 3: Build a transboundary view of ecological stakes related to seabirds

The third technical meeting was dedicated to the consideration of ecological parameters within public policies, in the context of the MSPMED transboundary case study "Planning the offshore Gulf of Lion" (sessions 1 and 2). The last part of the technical meeting (session 3) was focused on the presentation of the last step of the methodological framework conducted so far to characterize interactions between ecosystems and pressures linked to offshore floating windfarm development. The meeting was conducted following the program below:

Introduction (15')
Introduction of experts and presentation of the objectives of technical meetings
Session 1: Focus on criteria informing public policies (30')
Selection of topics to be addressed during the meeting.
Session 2: Focus on knowledge transfer to decision makers (40')
Discussion about (a) the knowledge level associated to the selected topics, and (b) the consideration of these topics into public policies.

Session 3: Characterization of interactions with a ranking method (20')
Presentation of the last step of the methodological framework addressing the characterization of interactions between ecological receptors and pressures.
Conclusion and objectives of technical meeting 4 (10')

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Introduction

The global objective of sessions 1 and 2 was to discuss the consideration of ecological stakes within public policies and to share experience between France and Spain in order to help to improve the coherence of Maritime Spatial Planning (MSP) at the transboundary scale.

Based on (i) the background information collected in literature (evaluation reports, existing datasets, current projects, scientific articles, etc.), and (ii) the results of the first technical meeting held in June 2021 (identification of knowledge gaps about seabird at-sea distribution, its predictability, functional areas and abundance assessments), exchanges were conducted to answer two general questions:

- How could we better inform ecological stakes at the transboundary scale?
- How should we transfer appropriately this information to decision makers of the MSP process?

To address those questions, discussions were divided into two steps: the first session was focused on topics collectively selected from a list of criteria (see Session 1: focus on criteria informing public policies), and the second session was dedicated to highlighting limitations and perspectives to facilitate knowledge sharing, especially with competent authorities (see Session 2: focus on knowledge transfer to decision makers) and at a transboundary scale.

Session 1: focus on criteria informing public policies

In order to focus on key topics to be addressed in our transboundary exchanges, the experts were proposed a list of criteria, selected from current public policies such as the descriptor 1 "Biodiversity is maintained" of the Good Environmental Status targeted by the Marine Strategy Framework Directive (MSFD), as well as from criteria commonly used to inform Marine Protected Area (MPA) designation.

Experts were firstly asked to vote for 5 out of 10 the topics to be addressed during the meeting, considering two decision rules:

- Is the criterion relevant for informing public policies (especially MSP) in the study area?
- Is the criterion relevant to be addressed at the transboundary scale? Secondly, experts were asked to associate a level of knowledge (high/sufficient, medium/incomplete, low/insufficient) to these topics, either relative to the baseline data (e.g. abundance) or to the evaluation method for the criterion (e.g. threshold).

The results of this voting session are reported below.

Process	Criteria		Number of votes	Vote to associate a knowledge level		
				High	Medium	Low
MPA designation	Uniqueness	The area contains unique or rare ecosystems, or rare or endemic species.	5	4	1	0
	Representativeness	The area has highly representative ecological processes, or community or habitat types or other natural characteristics.	3	1	1	0
	Diversity	The area has a high diversity of species, communities, habitats or ecosystems.	3	2	0	0
	Naturalness	The area has a high degree of naturalness as a result of the lack or low level of human-induced disturbance and degradation.	1	0	0	0
	Critical habitats	Presence of habitats that are critical to endangered, threatened or endemic species	7	4	0	0
MSFD – Good Environmental Status evaluation	D1C1	The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long- term viability is ensured.	1	1	0	1
	D1C2	The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.	3	0	2	0
	D1C3	The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.	1	1	0	1
	D1C4	The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions.	2	1	2	0
	D1C5	The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.	4	1	1	1

The three selected topics obtained 7, 5 and 4 votes (rated by 8 experts), and were respectively associated to a high level of knowledge ("Presence of habitats that are critical to endangered, threatened or endemic species"), a high/medium knowledge ("The area contains unique or rare ecosystems, or rare or endemic species."), and disparate knowledge level ("The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species").

Session 2: focus on knowledge transfer to decision makers

Session 2 was then dedicated to (i) experience sharing about the current limitations related to selected topics, (ii) perspectives to overcome those difficulties, and (iii) information transfer to decision makers of the MSP.

Topic 1: The area hosts habitats that are critical to endangered, threatened or endemic species.
According to experts' opinion, the assessment of this criterion relates to **abundance and demographics** of seabird species in the north-western Mediterranean Sea.
From both France and Spanish experience, abundance and demographic assessments are not limited by the methodology (either regarding data collection or the subsequent evaluation process). Data is acquired through a standardized protocol at the Macaronesia scale, and this standardized effort could be enlarged to Balearic Islands, Mediterranean French waters and western Italian waters at least.

However, such evaluation is still **limited by data** itself. Experts mention that assessments are limited either by demographic parameters estimates (e.g. Audouin's gull - *Ichthyaetus audouinii*, Common tern - *Sterna hirundo*) or by population estimates (e.g. Scopoli's shearwater - *Calonectris diomedea*, Balearic shearwater - *Puffinus mauretanicus*). In addition, species distribution is not completely known in the area since colonies are undescribed, even for species receiving special attention such as the Balearic shearwater. For those cases, additional monitoring effort shall be conducted.

For unknown reasons, colonies sites and habitat use can **vary over space** from one year to another (e.g. Audouin's gull, Sandwich tern - *Thalasseus sandvicensis*) at the transboundary scale. While this information is transmitted by ornithologists/scientists' networks, **an official data sharing network is needed** at least at the north-western Mediterranean scale (e.g. data from census of colonies).

Within the MSFD process, evaluation relies on the selection of representative species for each kind of habitat (e.g. continental shelf/productive areas, pelagic habitats, seamounts, etc.). In Spain, pilot colonies are monitored and results are extrapolated to the whole population. The Good Environmental Status assessment thus relies on the best associations of indicator species and pilot colonies. However, as mentioned during the first technical meeting held in June, evaluation thresholds are not definable without **baseline values**, which are still difficult to assess in both Spain and France.

Topic 2: The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.

As the experts pointed out, this topic corresponds to a **secondary** MSFD criterion. Habitat extent and condition are not the most relevant descriptors to assess the Good Environmental States for seabirds, as their at-sea distribution and breeding success are rather linked to the feeding resource (prey distribution and availability). In that sense, demographics and abundance of breeding adults are more relevant (primary criteria) for describing seabird population states. For example, adult survival rate is especially important for tubenoses, whereas productivity is a key parameter for charadriiformes populations. However, it is still difficult to assess if some species breed in the study area (e.g. Storm petrel - *Hydrobates pelagicus*).

Moreover, this topic questions the current level of knowledge about habitat use through life stages in seabirds. For example, juveniles are almost exclusively monitored from at-sea surveys, and functional needs of seabirds through life stages may not be known for each species. Experts thus mention that **behavioral data** (e.g. activity, flight direction, etc.) should be collected simultaneously with identification and counting's. This is actually done in the Gulf of Lion's continental shelf area[63] in boat-based surveys. Moreover, experts mention seabird species **associated with at-sea human activities**, such as storm petrels concentrating around fish farms and foraging in their vicinity, or shearwaters attending fishing vessels. The different activities can turn the habitat either suitable or unsuitable for foraging individuals, and potentially benefit specific life stages (e.g. juvenile northern gannets on fish farms).

However, life stages and behavioral data still have to be analyzed at the Gulf of Lion's scale. Firstly, behavioral data could be analyzed so as to **understand rough patterns**, i.e. circadian activity and among life stages, in order to better inform seabird habitat use. Secondly, when the relationship between at-sea activities and seabird distribution is known, at-sea activities could be used as **predictors in habitat modelling**, and weighted dependently of other predictors (environmental factors). Experts highlight that literature already exists about seabird distribution modelling in relation to fish farms and fishing vessels distribution.

Finally, experts underline that a lot of information still needs to be collected through **analysis which combine telemetry data and at-sea surveys**, and could be used as an input for habitat models.

Topic 3: The area contains unique or rare ecosystems, or rare or endemic species

This "Uniqueness" criterion is abundantly informed by literature. Among seabird species, experts cited the Balearic shearwater (*Puffinus mauretanicus*), the Mediterranean shag (*Phalacrocorax aristotelis*) and the storm petrel (*Hydrobates pelagicus*) to be considered in that topic, in addition to several other ecological components such as Posidonia meadows.

[Additional] Topic 4: The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions.

This topic refers to the assessment of an "optimal use of habitat" by seabirds. According to experts, this criterion is closely related to others, while others are easier to assess (see above). As mentioned before (topic 1), important distributional variations can occur over time. Consequently, this criterion is not useful e.g. for terns and gulls because of the variability of colonies locations

[63] Boat-based surveys conducted by EcoOcéan Institut.

which does not seem to affect the species breeding success. Finally, this criterion would be even more difficult to address because of still undiscovered seabird colonies within the study area and at a broader scale (Balearic Islands).

How to share this information with MSP competent authorities?
As a concluding question, experts were asked to provide recommendations/ideas about the best way(s) to transfer this knowledge and associated limitations to competent authorities.
Several recommendations emerged:

- **Open data**. A lot of ecological data exists and, even when data is public, the access is still very difficult. A specific online database could be built to collect all data producers' contributions. Standardize data acquisition protocols. As previously mentioned by experts, data still miss homogeneity and effort shall be carried out to improve protocol standardization (frequency, sample size, collected information) at an extended spatial scale/within public policies.
- **Standardize data analysis methods and discussion**. Producing relevant analysis requires a significant effort, which is insufficiently considered in evaluation/expertise processes. Analysis should be standardized and discussion of data/methods limitations should be closely associated with results. Confidence/uncertainty descriptors should be emphasized.
- **Increase exploratory analysis**. As many different and complementary data types exist, experts underline the need of additional analysis effort and exploratory work to combine data sources[64].
- **Communicate synthetic information**. Effort has to be continued in order to communicate scientific information through concept diagrams, synthetic documents and appropriate artwork. In the specific context of MSFD evaluation, a simple tool aimed at comparing the obtained results and the thresholds established to define the GES would be very informative/understandable. More generally, information is easier to be communicated through official frameworks and initiatives (e.g. similarly to Cetaceans Critical Habitats – ACCOBAMS).

Session 3: Provide knowledge about interactions between Mediterranean ecosystems and windfarm development in the Gulf of Lion.

For this task, the objective of this third technical meeting was to synthesize the results previously collected in the context of the MSP-MED project and to present the SKE ranking method (Sensitivity, Knowledge, Ecological stake).

Presentation of the ranking method
The third technical meeting aimed at presenting the ranking method (last step of our collective work). Adapted from the method proposed by the working group on the cumulative effects of offshore windfarms (Brignon & al., 2020), the classification of potential interactions is based on three scores: sensitivity, knowledge and ecological stake. This classification will allow to highlight the level of knowledge on potential interactions and distinguish them according to the different steps of development of offshore floating windfarms (survey & prospection, construction & decommissioning, operation). These three scores consist in a rating process from 1 to 10 and reflect:

- The SENSITIVITY of a receptor to a pressure;
- The level of scientific KNOWLEDGE about the interaction according to the importance of the scientific corpus, the degree of knowledge or controversy, etc.;
- The level of ECOLOGICAL STAKE of a receptor.

The sensitivity and knowledge scores are based on experts' opinion (see below). The score of ecological stakes is adapted by numerical transcription of experts' assessments already carried out in the context of MSP and the allocation of conservation status by the IUCN.

Sensitivity
The score from 1 to 10 indicates the level of sensitivity of a receptor to a pressure. For example, a score of 10 stands a major sensitivity of the receptor to the pressure. A "+" corresponds to the statement "no opinion". This symbol allows to indicate that a

[64] See for example: https://seo.org/wp-content/uploads/2012/06/lg_140_ibamarina_primer_inventario_oto%C3%B1o2009.pdf

sensitivity of the receptor to the pressure may exist but that it is not possible to assign a sensitivity score due to a lack of scientific knowledge.

Knowledge

The score from 1 to 10 indicates the level of knowledge associated to the effect of a pressure on a receptor. It reflects the state of current knowledge according to the importance of the scientific corpus, etc. For example, a score of 10 will reflect a good knowledge of the effect of a pressure on a receptor, whereas a score of 1 will reflect a hypothetic effect.

Ecological stake

The score of ecological stakes is already completed and available to the expert (sheet "stakes"). Scores from 1 to 10 are established according to two sub-criteria: the IUCN status and the environmental issue identified in maritime spatial planning process. Only the highest score is conserved. For "**birds, seabirds and bats**", the IUCN scores are assigned according to the level of threat indicated on the IUCN website[65] for the assessment scope "Europe". The scores associated to the environmental stakes identified in the maritime spatial planning process are attributed by numerical transcription of the levels of stakes identified in the French strategic document of the Mediterranean coastline for the areas concerned by the perimeter of the MSPMED project: continental shelf of Gulf of Lion, southwestern canyons of Gulf of Lion and central and north-eastern canyons of Gulf of Lion.

The attribution of these three scores (S, K and E) will allow the ranking of potential interactions in order to identify for example:

- Potential interactions for which it is possible to implement actions quickly because the sensitivity and the level of ecological stake are both high and there is a good scientific knowledge associated to this interaction (high S*K*E score);
- Knowledge gaps about potential interactions for which the sensitivity of the receptor is high (high S/K score);
- Knowledge gaps about the level of sensitivity of a receptor to a pressure ("+").

In order to carry out this ranking method, the experts are invited to complete the "sensitivity" and "knowledge" sheets of the attached Excel document before the 22nd of November, just before the fourth and final technical meeting.

Conclusion and outlooks

A synthesis of all the expert contributions will be produced before the fourth technical meeting. The objective of this last technical meeting will be to discuss the **final results and the methodology**. It will also present the preliminary results obtained for the other ecological components under study and contextualize these results in the transboundary context of the Gulf of Lion and the MSP-MED project. Based on the results of the ranking process, a discussion will also be conducted in order to **address the knowledge gaps** about windfarm-ecosystems interactions in the Mediterranean Sea, and to **build recommendations either on the improvement of this first iterative and prospective exercise** of identification of interaction risks for offshore floating windfarms or to improve monitoring of the ecosystem in future offshore floating windfarms areas.

Report of the final Technical Meeting 23rd of October, 2021

This document reports the exchanges of the fourth and final technical meeting dedicated to "**Birds, seabirds and bats**", on the **23rd of November 2021**. For more information about the MSPMED project and the objectives of these technical meetings, please refer to the previous technical reports.

Technical meeting 4: Build recommendations to improve monitoring of the ecosystem in future offshore floating windfarms

The fourth technical meeting has been dedicated to producing a set of recommendations for a better consideration of potential risks of interaction between marine ecosystems and the development of floating offshore windfarms through the creation of an observatory. The meeting was conducted following the program below:

Introduction (15')
Introduction of experts

[65] https://www.iucnredlist.org/

Session 1: Classify the potential interactions with SKE method (60’)	
Scoring sensitivity and knowledge	
Session 2: Contextualize knowledge gaps to offshore floating windfarms scale (20‘)	
Discussion on the needed monitoring effort and its scale	
Session 3: Recommendations to authorities (20‘)	
Recommendations and comments on methodology	
Conclusion	
Perspectives & MSPMED final conference (5’)	

Participants:

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Jacob Gonzales Solis-Bou	Universidad de Barcelona (UB)
Julie Marmet *(post-technical meeting inputs)*	Office français de la biodiversité (OFB)
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**Organisers (MSPMED team*

Session 1: Classify the potential interactions with SKE method

The few contributions received before the technical meeting did not allow to establish the SKE scores that are necessary to prioritizing interactions. The scoring exercise was proposed during the technical meeting in order to highlight the priorities and to initiate a discussion about the monitoring effort to conduct in order to inform the effects of offshore floating windfarms on birds, seabirds and bats. In order to facilitate the scoring exercise and the exchanges, the scoring protocol proposed in the methodological note (transmitted just after the third technical meeting 3) was simplified.
The sensitivity was assessed using a 4-level color code:
• Grey - the sensitivity of the receptor to the pressure is not known;
• Green - the sensitivity of the receptor to the pressure is considered as low by the experts;
• Yellow - the sensitivity of the receptor to the pressure is considered as medium by the experts;
• Orange - the sensitivity of the receptor to the pressure is considered as high by the experts.
Based on the discussions about the possible differences in sensitivity of ecological receptors during the different phases of the development of offshore floating windfarms (cf. the second technical meeting report), sensitivity assessment is required for the two main phases: construction (and decommissioning – orange table) and operation (green table).
Due to the low number of votes and the high variation in sensitivity assessment for some pressure ecological receptor pairs, only the raw, unaveraged results are presented here.
As specified in the technical meeting by some experts, the sensitivity rating corresponds to “experts’ opinion”. The approach by group of species allows each expert to evaluate the sensitivity according to his/her own knowledge about the biology and behavior of some close species belonging to the same group. The scoring exercise is carried out for the species that are present in the Gulf of Lion as part of the prospective process conducted in the MSPMED project. According to the experts, the exercise is complex as the sensitivity of many species (or groups of species) depends on the period (wintering, migration, etc.). Different species will be impacted by the development of the offshore floating windfarms (OFW), depending of the timing and duration of the development phases (construction, operation, decommissioning).

Previously not detailed in the pressure table, barotrauma is added for migratory bats with a high level of sensitivity and knowledge.

Knowledge of the interactions between ecological receptors and pressures is assessed through a smaller number of levels ranging from 0 to 3, where 0 corresponds to an absence of knowledge, and scores from 1 to 3 indicate a level of knowledge ranging from low to high. Similarly, to the sensitivity assessment, due to the low number of votes obtained during the technical meeting, only the raw, un-averaged results are presented here.

The knowledge assessment is based on the level of scientific knowledge (publications, research results, grey literature, etc.) of the interaction. However, despite some lacks of knowledge about specific interactions, the experts were able to provide an estimation of sensitivity based on their own knowledge of the ecology and biology of the species.

The method used for defining the ecological stakes was also reminded during the technical meeting. Scores from 1 to 10 were established according to two sub-criteria: the IUCN status and the environmental stake identified in the maritime spatial planning process (French EEZ, including the Gulf of Lion). Only the highest score was conserved. For "birds, seabirds and bats", the IUCN scores were assigned according to the level of threat indicated on the IUCN website[66] for the assessment scope “Europe”. The scores associated to the environmental stakes identified in the maritime spatial planning process were attributed by numerical transcription of the stake’s levels (5) identified in the French strategic document of the Mediterranean coastline for the areas concerned by the perimeter of the MSPMED project: continental shelf of the Gulf of Lion, southwestern canyons of the Gulf of Lion and central and north-eastern canyons of the Gulf of Lion.

Session 2: Contextualize knowledge gaps to offshore floating windfarms’ scale

This second part aimed at identifying the parameters and types of monitoring to be implemented in order to overcome the lack of knowledge about the effects of OFW on ecosystems. Based on the results of the scoring exercises, several monitoring proposals were made by the experts relatively to seabirds, birds and bats. These proposals are presented as recommendations in the third section.

Before improving knowledge about the effects of OFW on bird and seabird populations, it is necessary to increase knowledge of flight altitudes, behavior and migratory flows of common species in the Gulf of Lion. The effects of climatic and environmental conditions (e.g. wind patterns and their variations) on birds and their behavior also need to be improved. Based on the results of the scoring exercises, several gaps of knowledge regarding the sensitivity of species to some pressures were identified. This is the case, for example, with noise emissions, changes in hydrodynamic conditions, increase in turbidity and organic enrichment.

The risk of collision is the major risk identified by the experts. However, the reason and frequency of collisions is not well known. Improving our knowledge about the factors that influence the probability of collisions is complex because it can vary from one species to another and factors themselves are probably multiple: weather conditions, period of the year, type of lighting, etc. In order to assess the risk of collision, improving knowledge about the effect of (i) wind conditions on flight altitudes and (ii) natural light emissions (moon, stars, etc.) at night on behavior is needed. But equipping infrastructure with lighting could attract some bird species and increase the collision risk. A better understanding of the effects of lighting on all the species frequenting the area of interest could help scientists to propose relevant recommendations adapted to each site by testing different wavelengths or lighting conditions, for example. Some references on attraction phenomena related to wavelength and intensity variations were provided by the experts in the technical meeting[67] and will need to be further investigated to be applicable to all seabird species. Still related to the behavior of the species, it is necessary to improve the understanding of the reason of collisions in order to know if they are a consequence of the movements of the blades and/or the addition of a static structure.

Many types of monitoring are proposed by experts to bridge the lack of knowledge. Visual observations from boat-based transects, for example, are known to provide information about the distribution of species within the Gulf of Lion. Biologging, which has already been implemented as part of the MIGRALION project, allows to improve knowledge about flight altitudes and distribution of some species. According to the experts, radar monitoring is the best solution for merging the monitoring of bird flows a and the monitoring of environmental conditions, at the Gulf of Lion’ scale. This monitoring should be carried out on land and at sea, with a major interest in equipping pilot farms or floating infrastructures with fixed radars at sea. These two types of

[66] https://www.iucnredlist.org/

[67] Rebke, M., Dierschke, V., Weiner, C. N., Aumüller, R., Hill, K., & Hill, R. (2019). Attraction of nocturnally migrating birds to artificial light: The influence of colour, intensity and blinking mode under different cloud cover conditions. Biological Conservation, 233, 220-227 & Migratory birds react strongest to white and red light (long wavelength); little to green light (shorter wavelength); and blue. From Poot, H., Ens, B. J., de Vries, H., Donners, M. A., Wernand, M. R., & Marquenie, J. M. (2008). Green light for nocturnally migrating birds. Ecology and Society, 13(2).

monitoring are complementary, in particular for the estimation of the flight altitude, which will be more representative from a fixed radar at sea, which, unlike on-board radars, may be less dependent on the sea state. Acoustics and infrared thermal camera monitoring are also proposed as well as telemetry and altimetry to monitor the flight altitude and the behavior of individuals. Often carried out on breeding (sea)birds, it is also proposed to extend GPS monitoring to migratory birds in order to better understand their movements within the Gulf of Lion and their distribution. These GPS tracking devices could improve the understanding of potential impacts on seabird populations whose breeding sites are located in the vicinity of windfarms (particularly for short-range foraging species).

Session 3: Recommendations for authorities

The recommendations provided by experts during the technical meeting can be divided into the following broad categories:

Improving ecological knowledge

- Extending GPS monitoring to migratory species to improve knowledge of their movements and distribution within the Gulf of Lion.
- Improving monitoring protocols so that the sampling effort is sufficient and relevant for assessing changes in distribution and density (length and frequency of monitoring).
- Improving efforts to deploy radars on land and at sea to improve knowledge of the distribution of birds at sea during the day and at night, with an emphasis on the deployment of fixed radars at sea (pilot farms).
- Developing acoustic monitoring protocols at land and sea for better know the distribution and behavior of bats at sea. GPS monitoring could be also proposed for some chiropteran species for better understand their distribution.
- Implementing monitoring and research programs to improve knowledge of bats in the Gulf of Lion for better understand their distribution, their functional areas, their migratory routes, etc.
- Extending the French MIGRALION program to the Spanish coast (Girona and Balearic Islands) by deploying radars to increase knowledge about migratory bird flows within the Gulf of Lion.

Improving knowledge of environmental conditions

- Improving knowledge of the impact of environmental and meteorological conditions on birds and bats by deploying fixed radar monitoring on land and at sea

Experiment on sites to benefit from feedback

- Equipping pilot farms and floating infrastructures at sea with measurement and monitoring tools to (i) improve knowledge about their effects on bird and bat populations during the day at night, and under various weather conditions, (ii) benefit from solid feedback to identify the best monitoring methods. More specifically, monitoring mortality induced by existing offshore windfarms with robust protocols and developing methods if it does not exist for good collision monitoring.
- Testing of different ranges of intensities and wavelengths to study the effect of light emissions on birds' and bats' behavior and adapting the lighting of floating infrastructures according to these results.
- Improving knowledge of causes of collisions recorded on OFW in order to determine whether they result from the movement of the blades or from the static structure so as to propose relevant and adapted mitigation measures to reduce the risk of collision (reduction of the rotation speed or even stopping the wind turbines).
- Regulating the monitoring protocols carried out by developers in order to harmonize them and increasing the spatial extent and frequency of the campaigns. Harmonizing monitoring and increasing the sampling effort would provide data that is relevant from the biology of the species and comparable on a national -to an international- scale.
- Increasing knowledge about the potential effects of OFW on migratory seabirds (in particular Scopoli's shearwaters).
- Developing and implementing specific monitoring for increase knowledge about the potential effects of OFW on chiropteran's species.

Improving consideration of interaction risks and effect risks

- Considering cumulative effects of windfarms at the individual and population levels.
- Defining protocols and monitoring the levels of bird mortality on all the offshore windfarms sites in the Gulf of Lion and nationally in order to have homogeneous and comparable data.

Carrying out a large-scale study

- Conducting a methodological study at a European scale to develop research programs that implement standardized bird monitoring protocols. Such a cooperation will allow to increase knowledge by the means of homogeneous and comparable data at the scales of the Gulf of Lion and the whole Mediterranean Sea.
- In that sense, encouraging cross-border cooperation on the Mediterranean scale by including European and North African countries in order to have a global vision of the migration routes and distribution of species.

Reducing potential impacts

- Waiting for a better knowledge of effects, through feedback from pilot farms before deploying larger OFW.
- Considering the biological cycles and rhythms of the species when defining work schedules (wintering period, migration period, etc.).
- Excluding major migration routes from OFW areas.
- Implementing OFW as far as possible from the coast and functional habitats (colonies, wintering sites, etc.).

Raising awareness among stakeholders and citizens

- Raising awareness among the general public of all the potential risks of interactions between OFW and birds, such as the risks of habitat loss and population displacement, so as not to focus solely on the risk of collision.

This last technical meeting also provided first feedbacks on the method implemented in the MSPMED project to improve the knowledge of interactions between marine ecosystems and the development of offshore floating windfarms in the Gulf of Lion. The transboundary approach to marine megafauna has allowed a sharing of knowledge and experience between French and Spanish experts. The prospective approach carried out within the project has also initiated discussions about the floating offshore windfarm technology for which there is very little feedback at an international scale, despite the fact that there are still many unknowns about the technologies that will eventually be deployed in the Gulf of Lion. Some experts regret the small number of experts involved in the project and mention that a lot of information and personal experience is therefore not considered. It was also proposed to modify the sensitivity scoring method in order to allow the experts to distinguish between "pressure-receptor" pairs for which there is no sensitivity and those for which the experts do not wish to express an opinion.

Conclusion and outlooks

All the results collected within the 5 ecosystem compartments (cetaceans and marine turtles, birds and chiropterans, planktonic communities, fish and cephalopods, benthic habitats) will be compared and synthesized in order to provide an ecosystemic vision of the expert contributions.

The study report presenting all expert contributions for all ecosystem components will be presented to the Spanish and French competent authorities of MSP in a restitution workshop in January 2022. In particular, the knowledge gaps identified and the experts' recommendations will be presented.

Annex 5

Synthesis of "Benthic communities and habitats" reports *(in French only)*

Compte-rendu du premier atelier du 29 Juin 2021

Contexte

Le projet MSP-MED Co-financé par la Direction Générale des Affaires Maritimes et des pêches (DG MARE) de l'Union Européenne et le Fonds Européen pour les affaires maritimes et la pêche (FEAMP), MSPMED vise à (i) soutenir les Etats-membres et (ii) promouvoir la coopération transfrontalière dans la mise en œuvre de la planification de l'espace maritime (PEM). Initié en 2020, le projet MSP-MED réunit 10 partenaires[68] issus de 6 pays méditerranéens (Espagne, France, Italie, Slovénie, Grèce, Malte). En accord avec l'importance de mener un processus coordonné et cohérent de planification de l'espace maritime transfrontalier, l'Office Français pour la Biodiversité (OFB) mène une étude de cas sur le Golfe du Lion afin de répondre à deux objectifs principaux :

- Construire et promouvoir une vision globale des enjeux écologiques du Golfe du Lion ;
- Fournir des connaissances sur les interactions entre les écosystèmes méditerranéens et les usages maritimes, avec un accent particulier sur le développement des parcs éoliens dans la zone du Golfe du Lion.

C'est dans le cadre de ce second objectif que France Énergies Marines[69] (FEM), institut pour la transition énergétique dédié aux énergies marines renouvelables, est mandaté par l'OFB pour définir les interactions potentielles entre les écosystèmes méditerranéens et l'implantation de parcs éoliens flottants. Ateliers MSP-MED Initiée en avril 2021, l'identification des interactions entre les écosystèmes marins et le développement des parcs éoliens flottants en mer repose sur les travaux menés par le Ministère en charge de l'environnement depuis 2018. L'objectif des ateliers est de mettre en œuvre les premières étapes de qualification des impacts et d'identifier les interactions potentielles entre les activités liées au développement des parcs éoliens flottants, les pressions qu'elles génèrent et les récepteurs[70] de l'environnement marin. Pour réaliser cette évaluation plusieurs ateliers réunissant des experts scientifiques seront réalisés entre juin et décembre 2021. Ce document rend compte des échanges qui ont eu lieu lors du premier atelier dédié aux « habitats benthiques » organisé le 29 juin 2021.

Atelier 1

Ce premier atelier a été consacré à la présentation du projet et à l'identification des récepteurs à prendre en compte pour décrire les interactions potentielles entre les enjeux écologiques et les parcs éoliens flottants en Méditerranée.

Participants :

Nom	Organisme
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Morgane Lejart*	France Énergies Marines (FEM)
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Lucía Di Iorio	Institut CHORUS
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Noémie Michez	Office français de la biodiversité (OFB)
Sandrine Ruitton	Institut Méditerranéen d'Océanologie (M.I.O) - EMBIO

**Organisateurs (équipe MSPMED)*

Compte-rendu de séance

a. Présentation de la méthode et des technologies et activités liées aux projets d'éoliennes flottantes en Méditerranée

La méthodologie proposée pour identifier les interactions entre les écosystèmes marins et le développement des parcs éoliens flottants en mer a été présentée aux participants. Développés par le Ministère en charge de l'environnement depuis 2018, ces travaux résultent d'une réflexion menée autour de l'intégration environnementale des énergies marines renouvelables. Pour cela, des travaux préliminaires d'identification des activités, des pressions et des récepteurs ont été menés. Basées sur les études d'impacts des projets de fermes pilotes en Méditerranée, les listes obtenues sont ensuite soumises à discussion d'experts. En

[68] CORILA (http://www.corila.it/), Université de Venise (http://www.iuav.it/), ISMAR (http://www.ismar.cnr.it/), SHOM (https://www.shom.fr/), Université de Thessaly (http://old.uth.gr/en/), OFB (https://ofb.gouv.fr/), Ministère Grecque de l'environnement et de l'énergie (https://ypen.gov.gr/), Planning authority of Malte (https://www.pa.org.mt/), RRC Koper (https://www.rrc-kp.si/en/), IEO (http://www.ieo.es/es/)

[69] France Énergies Marines, https://www.france-energies-marines.org/

[70] Espèces, habitats ou regroupement d'organismes vivants susceptibles de subir une pression générée par une activité anthropique

parallèle des travaux menés dans le cadre de l'atelier « habitats benthiques », des professionnels du secteur des énergies marines renouvelables sont également consultés pour évaluer les listes d'activités et de pressions. La première liste de récepteurs synthétise les recensements d'espèces réalisés dans le cadre des études d'impact des projets éoliens flottants en Méditerranée et regroupe plus de 400 espèces d'invertébrés et 40 habitats d'intérêt communautaire. La liste des pressions reprend les pressions identifiées dans le cadre de la DCSMM et pourra faire l'objet de discussions lors du second atelier. Enfin, les technologies flottantes prévues pour la mise en service des fermes pilotes en Méditerranée sont également présentées aux experts afin de contextualiser la démarche.

b. Discussion sur la pertinence des récepteurs à prendre en compte

425 espèces d'invertébrés (173 polychètes, 133 crustacés, 86 mollusques et 15 échinodermes) et 42 habitats ont été identifiés au cours de la phase préliminaire comme susceptibles d'être impactés par le développement de l'éolien flottant dans le golfe du Lion. Au vu du grand nombre d'espèces, l'étude et l'identification des interactions avec l'éolien flottant pour chacune d'entre elles n'est pas envisagée dans le cadre des présents travaux. L'objectif de l'atelier était donc d'identifier les pistes de réduction du nombre de récepteurs, par regroupement ou suppression, en se focalisant sur les habitats, les espèces ou les groupes les plus pertinents à étudier au regard du contexte exposé.

Pour faciliter les discussions, une liste réduite de 16 habitats[71] et de 22 espèces[72] a été soumise à discussion au cours d'un atelier post-it virtuel8 articulé autour de deux questions principales : La liste proposée est-elle pertinente (besoin d'ajout ou de suppression d'espèces) ? Sur quels critères pouvons sélectionner les récepteurs les plus pertinents ?

Pour chaque post-it, les experts ont été invités à s'exprimer et/ou à voter pour définir les regroupements d'espèces les plus pertinents pour l'étude à mener. Les principaux éléments issus des discussions sont regroupés selon différents thèmes présentés ci-après.

Principales difficultés de l'exercice

L'éolien flottant étant encore peu développé en France et à l'international, la principale difficulté de l'exercice demandé repose sur le manque de retour d'expérience concernant l'éolien flottant et ses impacts sur l'environnement. S'il existe une bonne connaissance des habitats et de leurs descriptions (espèces associées, etc.), leurs rôles fonctionnels au sein de l'écosystème est encore peu connu. Or, selon les experts, c'est justement l'étude de l'impact fonctionnel du développement de l'éolien en mer qui est intéressant afin de comprendre : (i) comment l'implantation d'une (ou plusieurs) éolienne(s) va impacter une espèce et son environnement et (ii) comment ces impacts vont se répercuter sur l'ensemble de la chaine trophique. Une approche écosystémique doit être privilégiée pour l'étude des interactions existantes.

Une autre difficulté évoquée au cours de l'atelier est l'absence d'informations précises sur le dimensionnement et l'implantation des parcs. Si la dégradation d'un habitat sur une petite surface peut être jugée acceptable en fonction de ses caractéristiques, de la durée et de la fréquence de la pression, elle pourra être jugée défavorablement si l'ensemble de la surface de cet habitat est impacté. L'évaluation des impacts doit donc tenir compte du dimensionnement des projets.

Selon les experts, la définition de récepteurs pertinents pour réaliser une évaluation précise des interactions doit tenir compte de la spatialisation des habitats afin de pouvoir écarter les habitats et les espèces qui ne sont pas directement concernées par ce risque d'interaction. La démarche plus générale proposée dans le cadre du projet MSP-MED rend cette définition plus complexe et moins restrictive. Cette difficulté peut être illustrée par l'exemple du coralligène. La probabilité que des travaux soient menés sur les zones de développement du coralligène étant très faible, le coralligène ne devrait pas ou peu être soumis à des pressions liées au développement de l'éolien flottant en Méditerranée. Or, au vu de la démarche générale menée dans le cadre du projet MSP-MED et de la sensibilité de cet habitat à différentes pressions, il demeure pertinent d'inclure le coralligène dans la liste des récepteurs à prendre en compte pour l'étude des interactions.

La possible redistribution de certaines espèces de poissons benthiques détritivores sensibles aux pressions exercées par les travaux doit également être intégrée dans l'évaluation des impacts. Cette redistribution peut avoir un impact non négligeable sur l'équilibre des communautés et sur le fonctionnement de l'écosystème. L'implantation d'éoliennes en mer doit donc prendre en compte et éviter les zones où des espèces à longue durée de vie, rares et fixées sont largement représentées.

[71] Critère de sélection : habitats benthiques d'intérêt pris en compte dans le plan de gestion du Parc Naturel Marin du Golfe du Lion

[72] Critère de sélection : espèces à prendre prioritairement en compte selon le plan de gestion du Parc Naturel Marin du Golfe du Lion (au regard de plusieurs critères : valeur patrimoniale, suivi existant, données disponibles, espèces clés à forte valeur écologique au sein des différents habitats, espèce à forte valeur économique) + espèces bentho-démersales dominantes des fonds marins du Golfe du Lion

Sur proposition des experts, une approche complémentaire à la définition des récepteurs pourrait également être menée pour évaluer les interactions en se basant sur les principes de la séquence ERC (éviter-réduire-compenser). La définition des récepteurs permettrait d'identifier les habitats pour lesquels le risque d'interaction est faible et ainsi orienter les projets vers certains habitats comme, par exemple, l'orientation des travaux d'atterrage sur des substrats meubles ou de sable fin. Une telle approche pourrait orienter les décisions et être utilisée dans le cadre de la planification de l'espace maritime pour définir les zones propices au développement de certains usages, dont l'éolien flottant, et sera proposée comme recommandation dans le volet "critique de la méthode" du projet MSPMED (atelier 4).

Définir une liste pertinente de récepteurs

L'approche proposée par les experts pour la définition des récepteurs est une approche par habitat couplé à des espèces ou regroupements d'espèces d'intérêt permettant d'intégrer certains faciès particuliers (e.g. faciès à funicules).

Plusieurs critères de sélection sont proposés pour établir une liste de récepteurs "espèces" plus pertinente que celle proposée en séance qui, si elles sont caractéristiques d'une communauté, ne représentent pas un intérêt particulier en tant que récepteur (e.g. *Owenia fusiformis, Moerella donacina*, etc.). La liste des récepteurs doit donc intégrer les espèces protégées en mer par les différentes conventions internationales (Berne et Barcelone) et les espèces dont le statut UICN est jugé défavorable (CR, EN, NT, VU). Les espèces "ingénieures" doivent également être intégrées à cette liste (eg. Gorgone, Coralligène).

La sensibilité des espèces à certaines pressions est également proposée comme critère de sélection supplémentaire pour identifier les espèces (et les habitats) déjà fragilisés par des pressions anthropiques (pêche, pollution, etc.) et qui pourraient présenter une sensibilité plus forte à l'ajout d'une nouvelle pression.

Quelques regroupements d'espèces (*Echinocardium sp*) et ajouts d'espèces supplémentaires (*Pinna rudis*, Posidonies, etc.) sont également proposés par les experts. Le récepteur "algues brunes pérennes" incluant différentes espèces de laminaires, ochrophyta et cystoseires, est ajouté afin de prendre en compte un groupe d'espèces actuellement en forte régression sur le littoral méditerranéen. L'ajout d'espèces commerciales ciblées par la pêche est également proposé pour les espèces benthiques, l'ichtyofaune (poissons, raies, requins) étant prise en compte dans le cadre d'un autre atelier. Par ailleurs, au regard de l'approche très générale menée dans le cadre de MSP-MED, l'ensemble des habitats méditerranéens doivent être considéré selon les experts, pour lesquels, seule une approche surfacique précise permet de déterminer des récepteurs pertinents. La sélection des espèces peut donc également reposer sur leur répartition spatiale et sur la superficie de leur habitat.

La prise en compte de l'ensemble des habitats impose l'ajout d'habitats spécifiques : roches du large et roches bathyales, dunes hydrauliques, têtes de canyons, pockmarks, faciès à Funicules, herbiers de Posidonies, de Cymodocées et à Zostère, coralligène, roches infralittorales, détritique côtier, etc. Des regroupements sont cependant proposés pour réduire le nombre de récepteurs (e.g. Fusion de "biocénose de roches infralittorales à algues photophiles" et "biocénose des algues infralittorales). Au regard des pressions exercées, il est également proposé de considérer les habitats au sein de deux groupes distincts : "habitats de la zone d'implantation" et "habitats de la zone de raccordement".

Pressions identifiées

Modification de l'habitat

L'implantation d'éoliennes en mer va générer une modification des habitats à différentes échelles :

- L'ajout d'un substrat dur en mer, couplé à une modification des usages (restriction de la pêche et de la plaisance) pourrait générer un effet récif.
- La biocolonisation des flotteurs par différents organismes aura pour conséquence : (i) une complexification de l'écosystème par les organismes qui colonisent le flotteur et (ii) une possible modification de la granulométrie des fonds par ajout de débris coquilliers (e.g. paquets de moules) résultants de cette biocolonisation qui, au regard de la durée d'exploitation prévue (25 ans en moyenne) pourrait générer une modification très localisée de la nature des fonds et donc des communautés benthiques associées.
- Le radage des chaines qui peut modifier de grandes surfaces de substrats sur l'ensemble de la durée d'exploitation du parc. Les experts remarquent que la modification à long terme de grandes surfaces de substrats meubles, même si ces derniers ne présentent pas de faciès particuliers, peut impacter la diversité des populations de vertébrés et d'invertébrés benthiques associés et dont dépendent d'autres espèces de la chaine trophique, impactant ainsi l'ensemble de la communauté.

Bruit

Si le bruit émis par les éoliennes flottantes est peu connu, il existe, selon les experts, une bonne connaissance du bruit des chaines (hautes fréquentes, assez localisé, faible sensibilité des espèces de poissons et d'invertébrés). Les retours d'expériences portant sur le bruit des infrastructures éoliennes en mer d'Ecosse montrent que le bruit en phase d'exploitation est relativement faible et que l'impact majeur sur les communautés d'invertébrés et poissons résulte du mouvement des particules. Les espèces sensibles au bruit émis par le frottement des chaines sur le fond comme la squille, le homard ou la langouste pourront être intégrés à la liste des récepteurs. Les bivalves, réagissant au bruit impulsionnel, pourront être considérés plus particulièrement pour les phases de construction et de démantèlement.

ENI

Selon les experts, la possibilité de dispersion d'algues invasives doit être prise en considération lors des phases de construction et de démantèlement afin de ne pas fragiliser des écosystèmes qui, en Méditerranée et en fonction de la localisation des futurs parcs éoliens, sont déjà fragilisés par la présence de certaines espèces d'algues invasives.

Variation de la luminosité

La question de l'impact de la diminution de la lumière sous les flotteurs pour les espèces benthiques ayant un cycle circadien a également été évoqué par les experts comme interaction potentielle.

c. Informations complémentaires post-atelier

Sur demande des experts, quelques éléments complémentaires relatifs à la taille et au dimensionnement des flotteurs sont apportés ici.

La dimension des flotteurs varie en fonction de la technologie mise en œuvre et de la taille des éoliennes qu'ils supportent. Si la technologie envisagée pour les parcs commerciaux prévus en Méditerranée n'est pas encore connue (débat publique en cours), les caractéristiques des flotteurs qui seront déployés au sein des trois fermes pilotes peuvent fournir des éléments de réponse. Dans le cas de la barge flottante type IDEOL déployée pour la ferme pilote "EolMed", les dimensions du flotteur sont estimées à 43 m de longueur x 43 m de largeur pour une hauteur d'environ 24 m (16 émergés et 8 immergés). Le flotteur type "Windfloat" déployé pour la ferme pilote "Eoliennes Flottantes du Golfe du Lion" est de plus grande envergure avec des dimensions estimés à 90 m de longueur x 80 m de largeur pour une longueur entre les colonnes d'environ 70 m. La hauteur totale du flotteur est d'environ 25 m dont 10 à 15 m de tirant d'eau (variable grâce au système de ballaste). Enfin, les dimensions du modèle TLP déployés pour la ferme pilote "Provence Grand Large" sont estimés à 85 m de longueur x 85 m de largeur environ pour une hauteur de flotteur estimé à 40 m (15 m émergés et 25 m immergés).

Le déploiement de 3 infrastructures de ce type sont envisagés au sein des trois projets de fermes pilotes en Méditerranée. Pour les projets de parcs commerciaux, le nombre d'infrastructures n'est pas encore défini. Dans le cadre du débat public actuellement en cours, les deux projets de parcs éoliens flottants de 250 MW chacun et leur extension (500 MW) pourrait déployer une centaine d'éolienne au total en Méditerranée (données issues du débat EOS, Partageons nos questions sur le milieu marin du golfe du Lion du 05/07/2021)[73].

d. Conclusion et perspectives

Dans le cadre du projet MSPMED, l'objectif n'est pas d'évaluer les impacts mais d'identifier les récepteurs (habitats, espèces ou groupes d'espèces) qu'il serait intéressant de prendre en compte pour évaluer les impacts en s'intéressant aux interactions potentielles entre les pressions générées par l'éolien flottant et les récepteurs écologiques. Seules les premières étapes d'identification des interactions potentielles sont mises en œuvre au travers des 4 ateliers d'experts organisés de juin à décembre 2021. L'évaluation plus précise de l'impact cumulé des parcs éoliens en mer par une approche surfacique pourra être menée sur la base des résultats du projet MSP-MED dans le cadre, par exemple, de projets de recherche et de développement.

Prévu le 17 septembre 2021 de 10h00 à 12h00, l'objectif du second atelier sera d'initier les discussions sur l'identification des interactions existantes entre les pressions et les récepteurs précédemment sélectionnés et validés. Le croisement des pressions et des récepteurs pré-identifiés lors du premier atelier permettra d'identifier les récepteurs les plus sensibles aux pressions (remise en suspension, changement d'habitats, etc.). Basée sur les pressions identifiées dans le cadre de la DCSMM, la liste des pressions pourra être discutée lors du second atelier pour focaliser les réflexions sur les pressions ayant un impact sur les habitats et communautés benthiques.

[73] Rediffusion du débat sur le site du débat public : https://eos.debatpublic.fr/

Reposant sur l'ensemble des suggestions faites en atelier, la liste des récepteurs à prendre en compte pour réaliser une définition préliminaire des interactions en Méditerranée sera complétée et mise à jour au cours de l'été. Elle sera de nouveau soumise à avis d'experts à la rentrée, en amont des discussions qui seront menées au cours du second atelier.

Compte-rendu du deuxième atelier du 17 Septembre 2021

Ce document synthétise les échanges qui ont eu lieu lors du deuxième atelier MSPMED dédié aux habitats benthiques, le 17 septembre 2021. Pour plus d'informations sur le projet MSPMED et les objectifs de ces ateliers, se référer au premier compte-rendu de séance.

<u>Atelier 2 : Identifier et caractériser les risques d'interactions potentielles entre les pressions et les récepteurs</u>

Ce second atelier a été consacré à l'identification et à la caractérisation des risques d'interactions potentielles entre les écosystèmes marins – et plus particulièrement les habitats benthiques - et le développement de l'éolien flottant dans le golfe du Lion, selon l'ordre du jour suivant :

- Introduction
- Rappels des objectifs de l'atelier (15')
- Identification et caractérisation des interactions potentielles : validation des travaux préliminaires (15') + discussion sur les interactions potentielles (70')
- Conclusion Perspectives et travaux à venir (5')

<u>Participants :</u>

Nom	Organisme
Camille Assali*	Office français de la biodiversité (OFB)
Sybill Henry*	France Énergies Marines (FEM)
Noémie Michez	Office français de la biodiversité (OFB)
Sandrine Ruitton	Institut Méditerranéen d'Océanologie (M.I.O) - EMBIO

**Organisateurs (équipe MSPMED)*

L'approche mise en œuvre dans le cadre du projet MSP-MED pour recueillir des éléments de connaissances sur les interactions entre les écosystèmes méditerranéens et les activités relatives au développement des parcs éoliens flottants est adaptée d'une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer, développée par le Ministère en charge de l'environnement depuis 2018. Le retour d'expérience quasi-inexistant des impacts des infrastructures flottantes sur les écosystèmes marins impose la mise en œuvre d'une démarche prospective à dire d'experts. Pour cela, seules les premières étapes de cette méthode d'évaluation sont mises en œuvre et déclinées pour réaliser une caractérisation des interactions potentielles.

L'objectif de ces ateliers est de déterminer le plus exhaustivement possible les risques d'interactions potentiels. De nombreuses interactions sont d'ores-et-déjà connues et documentées par la communauté scientifique. Ces études sont généralement issues du retour d'expérience de l'éolien posé en mer en Manche Mer du nord pour les espèces marines auxquels s'ajoutent ceux de l'éolien terrestre pour les oiseaux et les chiroptères. Si certains risques d'interactions entre l'éolien **posé** en mer et les écosystèmes marins peuvent être déclinés à l'éolien **flottant** (augmentation du trafic maritime, modification des habitats, etc.), il existe certaines spécificités de l'éolien **flottant** (système de ballast, flotteurs, ancrage par chaine, etc.) pour lesquelles une réflexion est nécessaire. La démarche prospective menée dans le cadre de MSP-MED permet ainsi d'identifier les interactions potentielles entre les écosystèmes marins et les infrastructures flottantes pour lesquelles nous n'avons pas encore de retours d'expériences et de connaissances scientifiques précises. Par application du principe de précaution, l'objectif de ces ateliers est d'apporter un ensemble d'éléments de réflexion sur les interactions potentielles en apportant un point de vigilance pour certaines espèces sensibles ou dont les comportements (reproduction, migration, fréquentation préférentielle de certains habitats, etc.) ne sont pas ou peu connus.

Le premier atelier a permis de définir un ensemble de récepteurs écologiques[74]. L'objectif de ce deuxième atelier était d'identifier l'ensemble des risques d'interaction potentielles et de les caractériser (effet direct, effet indirect, à plus ou moins long terme, etc.). La démarche étant prospective, les hypothèses ou les risques d'interactions pour lesquels il n'y a pas encore de connaissances sont tout autant pris en compte. Un exercice de qualification des interactions sera réalisé au cours de l'atelier 3

[74] Espèces, habitats ou groupes d'organismes vivants susceptibles d'être soumis à la pression de l'activité humaine

selon trois critères : la connaissance, l'enjeu, et la sensibilité (fonction de ce que l'on connait de la capacité de résistance et de résilience des récepteurs). La notation sera faite à dire d'experts et permettra d'alimenter les discussions qui seront menées au cours du quatrième et dernier atelier.

a. Validation des travaux préliminaires

Issue des discussions du premier atelier, l'approche par habitat avec quelques espèces complémentaires est confirmée. Cette approche pourra être mise en œuvre en deux temps : un premier temps dédié aux interactions existantes entre les pressions issues de l'éolien flottant et les écosystèmes benthiques, et un second dédié aux espèces d'intérêt auxquelles une attention particulière doit être portée, notamment lors de la mise en œuvre opérationnelle. Les habitats bathyaux sont conservés même si à la profondeur envisagée pour le développement de l'éolien flottant dans le Golfe du Lion (entre 60 et 120 mètres selon les informations issues du débat public en méditerranée[75]), il est peu probable que ces derniers soient directement impactés. En effet, l'aire d'influence des éoliennes flottantes a peu de chance d'impacter le domaine bathyal, mais au regard de la démarche prospective menée dans le cadre de MSPMED et, par application du principe de précaution, les habitats bathyaux sont conservés, notamment parce que l'aire d'influence des infrastructures flottantes n'est pas encore connue. En accord avec les discussions du premier atelier, la définition de la liste des récepteurs écologiques se veut la plus exhaustive possible et pourra être réduite lorsque les projets d'éolien flottant seront opérationnels.

Les discussions relatives à chaque type d'habitat sont synthétisées ci-après :

- Les habitats des zones médiolittorales et certains habitats du supra- et du circa-littoral sont ajoutés car potentiellement impactés par le raccordement (câble et atterrage) ;
- Le regroupement des herbiers proposé en atelier n'est pas retenu car les habitats de Cymodocées, Posidonies et Zostères sont des habitats aux dynamiques différentes devant être considérés comme des récepteurs écologiques à part entière ;
- Le regroupement de certains habitats dans des catégories plus larges, comme les biocénoses rocheuses infralittorales ou les biocénoses sableuses infralittorales, est proposé et certaines typologies d'habitats sont supprimées (bancs de sable à faible couverture permanente, etc.) ;
- Les structures géomorphologiques (pockmarks, dunes hydrauliques et têtes de canyons) sont conservées au regard de l'intérêt patrimonial qu'elles présentent dans le document stratégique de façade Méditerranée (DSF)[76] mais sont distinguées des habitats benthiques ;
- Si le mélange des typologies d'habitat n'est pas gênant pour l'étude des interactions potentielles – les différents niveaux (habitats, sous-habitats, etc.) permettent de prendre en compte certains habitats de manière plus précise – il est nécessaire d'avoir une nomenclature harmonisée et intelligible au plus grand nombre et d'autant plus au regard du contexte transfrontalier du projet MSP-MED. Si la typologie EUNIS est mentionnée, elle n'est pas retenue afin de considérer la typologie HABREF des habitats méditerranéens qui sera plus pertinent à l'échelle du territoire. L'équivalent EUNIS pourra être utilisé comme correspondance pour une diffusion des résultats à l'échelle européenne.

En plus des habitats, une liste de 46 espèces basée sur les discussions du premier atelier est proposé. Si ce nombre est élevé, la présence de chacune de ces espèces dans cette liste se justifie au regard de leur statut de protection, leur sensibilité, etc.

Si coupler les deux approches (par habitats et par espèces) peut paraitre redondant -certaines espèces de la liste étant caractéristiques de certains habitats- la prise en compte des espèces est importante pour considérer certaines pressions, comme les émissions sonores et lumineuses par exemple, et être plus précis dans l'évaluation du degré d'interaction, l'approche par espèce pouvant faire ressortir une sensibilité particulière. Par exemple, la sensibilité d'un habitat vaseux pourra être évaluée différemment s'il présente ou non des espèces érigées. De plus, la prise en compte de ces quelques espèces et la vigilance qui leur est apportée permettent, par effet parapluie, de prendre en compte l'ensemble de la communauté qui leur est associée. Les regroupements d'espèces sont supprimés pour ne conserver que les espèces d'intérêt et les différents noms d'espèces seront mis à jour et actualisés pour le prochain atelier.

b. Discussion sur la pertinence des récepteurs à prendre en compte

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[75] https://eos.debatpublic.fr/

[76] http://www.dirm.mediterranee.developpement-durable.gouv.fr/le-document-strategique-de-facade-mediterranee-r335.html

Comme demandé par les experts au cours du premier atelier, les différentes phases de fonctionnement d'un parc (construction, exploitation, démantèlement) seront prises en compte pour caractériser les différents types de pression. La liste des pressions proposée repose sur la liste DCSMM et fut adaptée au contexte du développement de l'éolien flottant en mer. Parmi les risques d'interactions potentielles, certaines pressions ont été identifiées en amont de l'atelier grâce à la bibliographie existante, notamment sur l'éolien posé en mer. Les effets directs (destruction, etc.) et indirects (modification de la chaine alimentaire, etc.) sont également distingués pour l'ensemble des pressions.
Les pressions peuvent avoir des niveaux d'impact différents qui seront fonction de la sensibilité des habitats (résistance et résilience), de leur durée et de leur emprise spatiale. Certaines pressions non listées par la DCSMM ou supprimées de la liste initiale ont été ajoutées en atelier (ombre portée, introduction de pathogènes, extraction d'espèces, etc.) et d'autres sont renommées afin de faire la distinction entre "pression" et "impact" (perte d'habitat devient recouvrement d'habitat, etc.).
Les échanges et les éléments d'informations apportés par les experts au cours de l'atelier et a posteriori sont toujours disponibles sur l'espace de travail en ligne et sont rapportés ci-après.

Pertes et dommages physiques

Les pressions liées aux **pertes et dommages physiques** concernent les modifications physiques de l'habitat marin. La pression de **recouvrement** concerne l'ensemble des habitats quels que soient leurs caractéristiques. Les indices de sensibilité qui seront attribués au cours du troisième atelier permettront de faire la distinction entre les différents degrés d'impact. Il est en de même pour la pression de **colmatage** qui concerne l'ensemble des habitats et dont la sensibilité sera fonction des capacités de résistance et de résilience de chacun. L'effet de ragage des chaines d'ancrage peut entrainer une modification à long terme des substrats meubles (avec ou sans faciès particuliers) avec un impact non négligeable sur la diversité des populations d'invertébrés et de vertébrés benthiques. À long terme, ces modifications peuvent avoir des effets indirects sur la chaine trophique. L'**extraction de matériaux** peut, en phase de travaux (préparation des tranchées, excavation des granulats), entrainer une destruction de certains habitats/espèces. L'impact du **dépôt de matériel** sera fonction de la durée et de l'emprise des matériaux déposés. Sur substrat meuble, l'impact sera quasi-nul pour une faible emprise mais deviendra de moins en moins négligeable proportionnellement à l'augmentation de la surface concernée. Si la recolonisation par les espèces peut être rapide sur une petite surface, ce processus sera d'autant plus long et difficile que la surface impactée sera grande. L'ensemble des espèces benthiques pourra être impacté par ce type de pressions et sera fonction de la mobilité des espèces avec des degrés de sensibilité probablement élevés et variables pour les espèces érigées, sessiles et les algues. La **modification de la charge en particules** résulte majoritairement des phases de travaux (installation du matériel, ancrage des flotteurs, etc.) et d'exploitation (ragage des chaines). L'augmentation locale de la turbidité concerne l'ensemble des habitats et sera fonction de la nature et de la quantité des sédiments qui seront remis en suspension. Les habitats vaseux par exemple, seront moins sensibles à ce type de pression car ils sont caractéristiques d'un apport régulier en particules fines. L'impact sur les espèces sera fonction de leur mobilité et peut être nuancé car probablement très localisé à l'échelle des parcs éoliens. L'impact des infrastructures flottantes sur les **conditions hydrodynamiques** semble limité et très localisé à l'échelle des parcs éoliens, avec des impacts sur les courants de fond qui peuvent modifier la connectivité entre les habitats à petite échelle par effets indirects. De plus, l'ajout d'une infrastructure flottante type flotteur en surface (cf. paragraphe d.) peut générer un obstacle qui sera source de vibration dans l'eau ayant pour effet d'attirer certaines espèces. Cet effet DCP (dispositif concentrateur de poisson) pourra générer une modification de la chaine trophique et une augmentation de la matière organique directement liée à l'augmentation de l'activité trophique. La **modification de la température** générée par l'éolien flottant semble négligeable au regard des autres pressions physiques évoquées, même si une augmentation locale de la température à proximité immédiate des câbles peut avoir un effet sur certaines espèces (environ +2.5°C sur 50 cm selon SPECIES[77]). L'impact de l'augmentation de température sur les espèces infralittorales concernées par la zone de raccordement est jugée quasi-nul au regard des variations saisonnières de température qu'elles subissent. L'impact sur les espèces d'eaux profondes en revanche est jugé non négligeable en particulier pour les espèces sessiles comme *Isidella* et les gorgones qui sont habituées à des températures d'eaux constantes (environ 13°C). L'augmentation locale de la température à proximité des câbles peut également avoir un impact non négligeable sur les espèces déjà situées en limite d'aire de répartition thermique comme l'Oursin diadème. De fait, l'augmentation locale de la température liée aux câbles pourrait ainsi modifier la répartition locale des espèces en limite d'aire de répartition par effet répulsif ou attractif en fonction du preferundum thermique des espèces marines. Les **émissions sonores** peuvent générer des vibrations dans la colonne d'eau qui pourront impacter

[77] Projet SPECIES : https://www.france-energies-marines.org/projets/species/

certaines espèces sensibles (crustacés, bivalves, poissons, etc.) en phase de travaux (augmentation du trafic maritime, etc.) et d'exploitation (augmentation du bruit de fond). L'augmentation du niveau de bruit ambiant peut également renforcer l'effet DCP : les vibrations sonores peuvent augmenter l'attractivité des flotteurs et des ancrages pour les larves et espèces sensibles aux vibrations comme cela peut s'observer sur certains faciès à gorgonaires, où les habitats les plus "bruyants" semblent attirer le plus de larves. L'impact des **émissions de lumière** est jugé minime au regard des profondeurs d'ancrage des infrastructures, même s'il doit être pris en considération pour les espèces benthiques dont le cycle biologique nycthéméral peut être perturbé par l'ajout d'émissions lumineuses nocturnes, bien que les effets de la lune sur le benthos soient peu connus. En revanche, l'émission de lumière la nuit va renforcer l'effet DCP par effet d'attraction de certaines espèces pélagiques et de leurs prédateurs. Pour en limiter les effets, l'éclairage des infrastructures flottantes ne devra donc pas être dirigé vers la colonne d'eau. Associé aux modifications de la luminosité, l'**effet d'ombre portée** peut générer une diminution de la lumière naturelle directe en journée et impacter le développement des organismes photosynthétiques et des algues dont on retrouve certaines espèces à 60 mètres de profondeur (habitats du coralligène et habitats du détritique côtier par exemple). Si l'effet de l'ombre portée peut être anecdotique pour quelques infrastructures flottantes éparses, l'effet peut être considéré comme non négligeable pour les projets de plus grandes envergures.

Pressions biologiques

Les **pressions biologiques** regroupent les pressions qui vont avoir un impact direct sur la biologie des espèces et leur intégrité physique. L'**introduction d'espèces non indigènes** (ENI), notamment via les systèmes de ballast servant à l'équilibrage des flotteurs et via l'augmentation du trafic maritime (construction et maintenance des infrastructures flottantes) peut accentuer la fragilité des écosystèmes sous pression. En parallèle, il faut prendre en considération l'arrivée d'**individus génétiquement différents**, issus de population éloignées qui pourraient être connectées par l'installation d'infrastructures flottantes. En lien avec la modification de la connectivité et l'attractivité des parcs (effet DCP), l'**introduction de pathogènes** est ajoutée comme pression indirecte du développement de l'éolien flottant. L'**extraction d'espèces** est mentionnée comme pression indirecte également car fonction de la réglementation et des usages qui seront autorisés, ou non, au sein des parcs. Les réglementations au sein des futurs parcs éoliens, notamment pour la pêche, ne sont pas encore connues.

Pressions chimiques

Enfin, la nomenclature proposée en atelier pour les **pressions chimiques** ne correspond pas aux typologies généralement utilisées pour l'étude des interactions entre les polluants chimiques et les espèces/habitats, avec une préférence pour la segmentation des pressions chimiques en deux catégories : éléments traces et composés organiques incluant des organo-métaux. Par manque de temps, les pressions chimiques n'ont pas fait l'objet de discussions en atelier et seront complétées d'ici au prochain atelier par des recherches bibliographiques portant sur l'éolien posé.

c. Points de vigilance et recommandations émis en atelier

La démarche prospective menée dans le cadre de MSP-MED permet d'identifier les pressions pour lesquelles il n'existe pas ou peu de connaissance sur les impacts qu'elles génèrent. Certaines pressions peuvent avoir des effets à court terme alors que d'autres pourront avoir un impact sur les écosystèmes marins si elles perdurent dans le temps. Cette distinction doit être prise en compte dans le cas des parcs éoliens flottants dont la durée d'exploitation est prévue pour 25 à 30 ans.

Les effets du réchauffement climatique pourront accentuer certains effets des parcs éoliens comme l'attractivité de certains prédateurs qui fréquentent de plus en plus la zone du golfe du Lion et dont le regroupement d'espèces lié à l'effet DCP généré par les parcs pourrait encourager la fréquentation à plus long terme.

Sans informations sur les technologies et les zones précises d'implantation des éoliennes flottantes, l'approche menée dans le cadre de MSP-MED est une approche par le risque avec une identification des risques d'interactions potentiels. Les récepteurs sont définis de façon assez globale et l'ensemble des interactions potentielles, même celles potentiellement négligeables, sont prises en compte par principe de précaution. Plusieurs perspectives aux travaux MSP-MED sont proposées pour compléter et approfondir l'analyse des risques entreprise ici. Sans citer les espèces à prendre en compte, l'approche proposée par Ruitton & al., (2020) repose sur une grille de sensibilité qui, en fonction des grands traits biologiques et des caractéristiques des habitats et/ou des espèces (espèces ingénieures, espèces photophiles, etc.) permet d'identifier les espèces et/ou les habitats qui seront plus ou moins sensibles à une pression. Cette approche permet de prendre en considération un panel plus large d'espèces et repose sur leurs caractéristiques biologiques et non leur statut réglementaire. Les travaux de La Rivière & al., (2016) proposent également une méthode d'évaluation des risques des activités anthropiques et reposent sur des tableaux d'évaluation de la sensibilité des habitats selon leur résistance et leur résilience. Si ce niveau d'analyse des risques n'est pas mené dans le cadre du projet MSPMED, ce type d'approche permet de rendre la démarche opérationnelle.

d. Informations complémentaires

Le développement des éoliennes flottantes est relativement récent et peu d'études de cas ont été documentées en France et en Europe (cf. Hywind Scotland[78], SEM-REV[79]). Ces technologies sont dimensionnées pour répondre aux contraintes bathymétriques pour des profondeurs supérieures à 50 mètres en moyenne (jusqu'à 200 mètres) (Bon & al., 2021). On recense trois grandes catégories d'infrastructures flottantes (Defingou & al., 2019) :

- Les **plateformes semi-submersibles et les barges** : Le flotteur est stabilisé à la surface de l'eau par sa forme (cas de la barge) ou par un ensemble de volumes immergés (cas de la plateforme semi-submersible). Ces infrastructures sont souvent lourdes et de grandes tailles pour assurer la stabilité du flotteur avec un faible tirant d'eau. Un système de lignes d'ancrage permet de maintenir l'ensemble en position (Defingou & al., 2019).
- Les **plateformes à jambes tendues** (aussi appelée "tension leg platform" ou TLP) : Le flotteur est maintenu sous la surface de l'eau par un dispositif d'ancrage qui le tire vers le fond et assure sa stabilité (Defingou & al., 2019). Le système d'ancrage vertical permet un maintien de l'infrastructure sur site mais est soumis à de fortes contraintes physiques due à la pré-tension des lignes et à l'effort de dérive (Bon & al., 2021).
- Les **"bouées crayons"** (communément appelé "single point anchor reservoir" ou SPAR) : Souvent cylindrique, le flotteur est immergé sur une large hauteur d'eau et stabilisé par son poids (partie basse du flotteur lestée). Une ligne d'ancrage simple est utilisée pour maintenir la structure en place (Defingou & al., 2019). Ce type d'infrastructure n'est envisageable que dans des profondeurs supérieures à 100 mètres (Bon & al., 2021).

Conclusion et perspectives

Tous les éléments fournis par les experts lors de ce second atelier ont été inclus dans ce compte-rendu et sont toujours disponibles sur l'espace de travail en ligne. Prévue le 26 octobre 2021 de 10h00 à 12h00, le troisième atelier permettra de caractériser avec plus de détails les risques d'interactions potentiels entre les activités liées au développement des parcs éoliens flottants et les récepteurs écologiques, au regard de trois critères : la connaissance, les enjeux et la sensibilité. Les experts seront invités à réaliser ce processus de notation, dont les résultats alimenteront les discussions qui seront menées lors du quatrième et dernier atelier.

Compte-rendu du troisième atelier du 26 Octobre 2021

Le troisième atelier du 26 Octobre 2021 avait pour objectif de synthétiser les éléments précédemment recueillis dans le cadre du projet MSPMED et de présenter la méthode de hiérarchisation SCE (Sensibilité, Connaissance, Enjeu) à conduire d'ici le quatrième et dernier atelier.

Atelier 3 : Hiérarchiser les risques d'interactions potentiels entre les pressions et les récepteurs écologiques

Pour rappel, le projet MSP-MED vise à recueillir des éléments de connaissances sur les interactions entre les écosystèmes méditerranéens et les activités relatives au développement des parcs éoliens flottants. Si de nombreuses interactions sont d'ores-et-déjà connues et documentées par la communauté scientifique, ces études sont généralement issues du retour d'expérience de l'éolien posé en mer en Manche Mer du nord (espèces marines) et de l'éolien terrestre (oiseaux et chiroptères). Si certains risques d'interactions entre l'éolien posé en mer et les écosystèmes marins peuvent être déclinés à l'éolien flottant (augmentation du trafic maritime, modification des habitats, etc.), il existe certaines spécificités de l'éolien flottant (système de ballast, flotteurs, ancrage par chaine, etc.) pour lesquelles une réflexion est nécessaire.

La démarche prospective menée dans le cadre du projet MSP-MED permet d'identifier et de caractériser les **risques d'interactions potentiels entre les écosystèmes marins et les infrastructures flottantes** pour lesquelles nous n'avons pas encore de retours d'expériences et de connaissances scientifiques précises. La méthode proposée pour identifier et caractériser ces interactions potentielles repose sur une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer, développée par le Ministère en charge de l'environnement depuis 2018 (Brignon & al., 2020). Seules les premières étapes de cette méthode d'évaluation sont mises en œuvre et déclinées au travers de 4 ateliers d'experts.

[78] http://marine.gov.scot/datafiles/lot/hywind/Environmental_Statement/Environmental_Statement.pdf
[79] https://sem-rev.ec-nantes.fr/

Atelier 1 : Définir une liste de récepteurs écologiques (29 Juin)
Atelier 2 : Identifier et caractériser les risques d'interactions potentiels (17 Septembre)
Atelier 3 : Hiérarchiser les risques d'interactions potentiels (26 Octobre)
Atelier 4 : Commenter les résultats & identifier les lacunes : critique de la méthode et points de vigilance (2 Décembre)

Synthèse des résultats

Atelier 1

Le premier atelier a permis de définir un ensemble de récepteurs écologiques selon une approche par habitat couplée à plusieurs espèces d'intérêt complémentaires. Sur demande des experts, la typologie des récepteurs écologiques a été harmonisée en se référant au référentiel des "*Typologie des biocénoses benthiques de Méditerranée*" (Michez & al., 2014). Les discussions ont ainsi permis d'aboutir à une liste de 28 récepteurs. Trois catégories ont été proposées pour distinguer les pressions inhérentes aux activités de raccordement et d'exploitation des parcs : "raccordement", "câble, ancrage des flotteurs et zone du parc" et "aire d'influence". Suite aux discussions, un pool d'espèces a également été établi selon un ensemble de critères proposés en atelier : espèces protégées et menacées, espèces mentionnées dans les conventions de Berne et de Barcelone et espèces halieutiques sensibles. Les espèces dont l'aire de répartition est extérieure aux limites du Golfe du Lion ou considérées comme éteintes dans la région par l'INPN n'ont pas été retenues. Les noms scientifiques de chaque espèce ont été mis à jour via WoRMS et les noms vernaculaires en anglais ont été retenus par défaut au regard du contexte européen du projet MSP-MED.

Atelier 2

Le deuxième atelier a permis d'identifier les risques d'interaction potentiels entre les écosystèmes méditerranéens et le développement des parcs éoliens flottants. La démarche étant prospective, les discussions se voulaient les plus exhaustives possible, en incluant les hypothèses et les risques d'interactions pour lesquels peu de connaissances sont disponibles à ce jour. Des éléments de caractérisation de ces interactions portant notamment sur les effets indirects à plus ou moins long terme ont également été mentionnés au cours de l'atelier et ont été complétés par des informations issues de la bibliographie portant sur la connaissance des interactions entre les écosystèmes marins et le développement de l'éolien offshore.

Présentation de la méthode de hiérarchisation (atelier 3)

Le troisième atelier avait pour objectif de présenter la méthode de hiérarchisation à mettre en œuvre pour finaliser la démarche MSP-MED. Dérivée de la méthode proposée par le groupe de travail sur les effets cumulés des projets éoliens en mer (Brignon & al., 2020), la hiérarchisation des risques d'interactions repose sur trois scores : sensibilité, connaissance et enjeu écologique. Cette hiérarchisation permettra d'indiquer le niveau de connaissance des risques d'interactions et de les distinguer en fonction des différentes étapes de développement d'un parc éolien flottant (pré-travaux, construction/démantèlement, exploitation).
Ces trois scores résultent d'une note de 1 à 10 et reflètent :

- La SENSIBILITE d'un récepteur à une pression ;
- Le niveau de CONNAISSANCE scientifique de l'interaction fonction de l'importance du corpus scientifique, du degré de connaissance ou de controverse, etc. ;
- Le niveau d'ENJEU écologique d'un récepteur au sein de l'écosystème marin. L'attribution des scores de sensibilité et de connaissance est réalisée à dire d'experts. Le score d'enjeu est issu d'une retranscription numérique des évaluations d'experts déjà réalisés dans le cadre de la planification de l'espace maritime et de l'attribution des statuts de conservation par l'IUCN.

Pour le cas particulier de l'atelier "habitats benthiques", les scores de "sensibilité" et de "connaissance" ont été préremplis sur la base du *rapport d'évaluation de la sensibilité des habitats benthiques de Méditerranée* aux pressions physiques (La Rivière & al., 2016). L'équivalence entre les critères de notation de la méthode MSPMED et des critères d'évaluation utilisée dans le rapport sont présentés ci-après :

Sensibilité

Critères MSP-MED		Critères d'évaluation selon La Rivière & al., 2016	
10	Majeure	TH	Très haute
8	Forte	H	Haute
6	Moyenne	M	Modérée

4	Faible	F	Faible
2	Très faible	TF	Très faible
+	Ne se prononce pas		

Un score de 2 à 10 (ou de TF à TH) indique le niveau de sensibilité d'un récepteur à une pression. Par exemple, pour un score de 10 (TF), la sensibilité d'un récepteur à une pression sera considérée comme majeure/très haute. Les mentions NA (non applicable) et V (variable) proposées par La Rivière & al., (2016) sont conservées en l'état.
Suite aux discussions de l'atelier 3, un critère non numérique « + » est ajouté afin de correspondre à la mention "ne se prononce pas". Cet ajout permet d'indiquer qu'il existe une sensibilité entre un récepteur et une pression mais pour laquelle il n'est pas possible d'attribuer un score de sensibilité par manque de connaissance scientifique.

Connaissance
Un score de 1 à 10 indique le niveau de connaissance de l'**effet** d'une pression sur un récepteur. Il reflète l'état des connaissances actuelles en fonction de l'importance du corpus scientifique. Par exemple, une note de 10 traduira une bonne connaissance de l'interaction existante entre une pression et un récepteur, alors qu'une note de 1 pourra traduire une hypothèse.
Suite aux discussions de l'atelier 3, la graduation initiale à 6 niveaux (10 ; 8 ; 6 ; 4 ; 2 et 1) proposée selon Brignon & al., (2020) est réduite à 3 niveaux (10 ; 5 et 1) pour correspondre aux scores de connaissance attribués par La Rivière & al., (2016).

Critères MSP-MED	Critères d'évaluation selon La Rivière & al., 2016	
10	H	Haut
5	M	Moyen
1	F	Faible

Enjeu écologique
Le score d'enjeu écologique est également prérempli et mis à la disposition des membres du groupe d'experts pour avis et observations. Les scores de 1 à 10 sont attribués selon deux sous-critères : le statut UICN et l'enjeu environnemental attribué dans le cadre de planification de l'espace maritime via le Document Stratégique de Façade (DSF). Le score le plus élevé est ensuite retenu comme score final.
Dans le cas de l'atelier "habitats benthiques", les scores UICN ont été attribués selon : la liste rouge des habitats benthiques de Méditerranée[80], la liste rouge des anthozoaires de Méditerranée[81] et le site internet de l'UICN en considérant les « *assessment scope* » suivants : « *mediterranean* » et par défaut « global » (les statuts pris en compte à l'échelle « globale » sont mentionnés par un astérisque dans le document joint). Les habitats menacés identifiés par l'IUCN se réfèrent à la typologie EUNIS. Une équivalence entre la typologie utilisée pour MSPMED (Michez & al., 2014) et la typologie EUNIS a donc été utilisée pour attribuer les scores associés aux habitats benthiques via HabRef[82]. Les scores inhérents aux enjeux environnementaux identifiés dans le cadre de la planification de l'espace maritime ont été attribués par retranscription numérique des niveaux d'enjeux identifiés dans le document stratégique de façade Méditerranée pour les zones d'enjeux correspondant au périmètre d'étude de MSPMED : Plateau continental du Golfe du Lion, Canyons du Golfe du Lion (sud-ouest), Canyons du Golfe du Lion (centre et Nord-Est). L'équivalence entre la typologie figurant dans les DSF et les récepteurs écologiques utilisés dans MSPMED a été réalisé au cours de l'atelier 3.

Récepteurs écologiques MSP-MED	Habitats à enjeux mentionnés dans le DSF associés
Biocénose des sables supralittoraux	Habitats sédimentaires
Biocénose des sables médiolittoraux	Habitats sédimentaires
Biocénose du détritique médiolittoral	Habitats sédimentaires
Biocénose des roches médiolittorales	Habitats rocheux
Biocénose des sables vaseux superficiels de mode calme	Habitats sédimentaires
Biocénose des roches infralittorales	Habitats rocheux
Biocénose des sables grossiers et fins graviers brassés par les vagues	Habitats sédimentaires
Biocénose des sables et graviers sous influence des courants de fond	Habitats sédimentaires

[80] European commission., (2016): European Red List of Habitats. Part 1 - Marine habitats, p52.
[81] International union for the Conservation of Nature and Natural Resources., (2016): The IUCN red list of anthozoans in the Mediterranean, p2
[82] https://inpn.mnhn.fr/telechargement/referentiels/habitats

Biocénose de l'herbier à *Posidonia oceanica*	Habitats biogéniques
Biocénose des sables fins de haut niveau	Habitats sédimentaires
Biocénose des sables fins bien calibrés	Habitats sédimentaires
Biocénoses des algues infralittorales	Habitats rocheux
Biocénose de l'herbier à *Cymodocea nodosa*	Habitats sédimentaires
Biocénose des herbiers à *Zostera noltii* et *Zostera marina*	Habitats sédimentaires
Algues brunes pérennes (ochrophytes, laminaires, cystoseires)	Habitats rocheux
Biocénose des vases terrigènes côtières	Habitats sédimentaires
Biocénose de la roche du large	Habitats rocheux
Biocénose du détritique côtier	Habitats sédimentaires
Biocénose coralligène	Habitats biogéniques
Biocénose des fonds détritiques envasés	Habitats sédimentaires
Biocénose des fonds détritiques du large	Habitats sédimentaires
Biocénose des vases bathyales	Habitats profonds
Faciès de vase molle à *Funiculina quadrangularis* et *Aporrhais serresianus*	Habitats profonds
Biocénose des sables détritiques bathyaux à *Gryphus vitreus*	Habitats profonds
Biocénose des roches bathyales	Habitats profonds
Structures sous-marines causées par des émissions de gaz (pockmark)	Structures géomorphologiques particulières
Dunes hydrauliques	Dunes hydrauliques
Têtes de canyons	Structures géomorphologiques particulières

Tableau 1 : Equivalence entre les récepteurs écologiques MSPMED et les habitats à enjeux mentionnés dans le Document Stratégique de Façade Méditerranée

L'attribution de ces trois scores (S, C et E) permettra de réaliser une classification des risques d'interaction afin d'identifier notamment :

- Les risques d'interaction pour lesquels il est possible de mettre en œuvre des actions rapidement car la sensibilité et le niveau d'enjeu écologique sont fort et qu'il existe une bonne connaissance scientifique de ce risque d'interaction (score S x C x E élevé)
- Les lacunes de connaissance des risques d'interaction pour lesquels la sensibilité d'un récepteur est élevée (score S/C élevé)
- Les lacunes de connaissance du niveau de sensibilité d'un récepteur à une pression (« + »).

Conclusion et perspectives (atelier 4)

Une synthèse de l'ensemble des contributions d'experts sera réalisée en amont de l'atelier 4 afin d'être soumise à discussion. L'objectif de ce dernier atelier sera de commenter les résultats finaux et de discuter de la méthode mise en œuvre. Il s'agira également de présenter les résultats préliminaires obtenus pour les autres compartiments écologiques et de replacer ces résultats dans le contexte transfrontalier du Golfe du Lion et du projet MSP-MED. Sur la base des résultats issus de la classification des risques d'interactions, une discussion sera également menée sur les lacunes de connaissance des interactions entre les écosystèmes marins et le développement de l'éolien flottant en Méditerranée ainsi que sur les recommandations émises par les experts suite à ce premier exercice itératif et prospectif d'identification des risques d'interaction.

Compte-rendu du quatrième atelier du 2 Décembre 2021

Le quatrième et dernier atelier avait pour objectif de (i) prioriser les possibilités d'actions et/ou de suivis au regard des niveaux de sensibilité, de connaissance et d'enjeux écologiques identifiés par les experts ; et de (ii) proposer un ensemble de recommandations afin que les interactions et les effet potentiels du développement des parcs éoliens flottants sur les écosystèmes méditerranéens – et plus particulièrement les habitats benthiques – soit mieux pris en compte par les autorités compétentes (planification de l'espace maritime) et développeurs.

Il s'est tenu le 2 Décembre 2021 de 14h00 à 16h00 selon l'ordre du jour suivant :

- Introduction
- Rappels des objectifs de l'atelier (5')
- Classer les interactions potentielles selon la méthode SCE (90') : Attribution des scores de « sensibilité » et de « connaissance »
- Discussion ouverte (20') : Identification des lacunes et définition des recommandations à destination des autorités compétentes

- Conclusion Perspectives et restitution des travaux MSP-MED (5')

Participants :

Nom	Organisme
Camille Assali*	Office français de la biodiversité (OFB)
Sybill Henry*	France Énergies Marines (FEM)
Céline Labrune	Organisme Observatoire Océanologique de Banyuls (OOB) - LECOB
Noémie Michez	Office français de la biodiversité (OFB)

**Organisateurs (équipe MSPMED)*

Atelier 4 : Proposer des recommandations pour améliorer le suivi au sein des parcs éoliens flottants ainsi que de leurs effets sur les écosystèmes

Pour rappel, la démarche prospective menée dans le cadre du projet MSPMED permet d'identifier et de caractériser les interactions potentielles entre les écosystèmes marins et les infrastructures flottantes pour lesquelles nous n'avons pas encore de retours d'expériences et de connaissances scientifiques précises. La méthode proposée pour identifier et caractériser ces interactions potentielles repose sur une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer, développée par le Ministère en charge de l'environnement depuis 2018 (Brignon & al., 2020)[83]. Seules les premières étapes de cette méthode d'évaluation ont été mises en œuvre et déclinées au travers de 4 ateliers d'experts (se référer aux précédents comptes-rendus d'atelier pour plus d'informations sur le projet, la méthode et la synthèse des échanges).

Classer les interactions potentielles selon la méthode SCE

L'absence de contributions aux tableaux transmis suite à l'atelier 3 n'a pas permis d'établir les scores SCE (Sensibilité, Connaissance, Enjeux écologiques – se rapporter à la note méthodologique de l'atelier 3) nécessaires à la classification des interactions potentielles. L'exercice de notation a donc été proposé en atelier afin de pouvoir faire émerger les priorités d'actions et initier une réflexion sur les moyens à mettre en œuvre pour suivre les effets des parcs éoliens flottants sur les habitats benthiques. Pour les besoins de l'atelier et afin de faciliter l'exercice de notation et les discussions, le système de notation initialement proposé a été simplifié.

Il a ainsi été proposé aux participants d'évaluer la sensibilité au travers un code couleur à 5 niveaux : Gris (la sensibilité du récepteur à la pression **n'est pas connue**), Vert (la sensibilité du récepteur à la pression est jugée **faible** par les experts), Jaune (**moyenne**), Orange (**forte**) et Rouge (**majeure**).

Faisant suite aux discussions de l'atelier 2 portant sur les possibles différences de sensibilité des récepteurs écologiques en fonction des phases de travaux, l'évaluation de la sensibilité est requise pour les deux principales étapes de vie d'un parc éolien flottant : la construction/démantèlement et l'exploitation.

Au cours des réflexions, les experts ont évoqué la difficulté de l'exercice et le besoin impératif de fixer un cadre méthodologique précis pour évaluer la sensibilité. La démarche prospective menée dans le cadre de MSPMED ne permet pas d'avoir des informations spatiotemporelles précises (durée, amplitude ou fréquence de la pression, surface et volume impactés, échelle des parcs – ferme pilote (3 à 4 machines) ou parc commercial (> 20), etc.) et ne permet donc pas de produire une évaluation de sensibilité qui soit pertinente pour étudier les effets des parcs éoliens flottants sur les écosystèmes. L'approche globale permet de poser une base de connaissance et d'émettre des hypothèses sur les interactions et leurs effets potentiels sur les différents compartiments de l'écosystème, mais ne permet pas d'aller au-delà de l'exercice prospectif d'identification et de caractérisation, à dire d'experts. De plus, certains éléments relatifs à l'estimation de la sensibilité des habitats aux pressions physiques sont extraits d'une étude (La Rivière & al., 2016) qui présente elle-même ses propres limites[84].

Ces éléments, tout comme ceux apportés par les experts au cours de l'atelier, devront donc être **impérativement révisés** lorsqu'une quantification des effets sera rendue possible par l'acquisition des informations nécessaires (surface concernée par la pression, pourcentage de l'habitat impacté, durée d'exposition à la pression, fréquence, etc.). La notion de quantification est importante car elle permet aux experts d'être plus précis dans leur évaluation de la sensibilité et d'estimer le degré de réaction d'un habitat à une pression particulière en fonction de sa tolérance et de sa résilience ainsi que des caractéristiques de la pression (intensité, durée, fréquence, etc.).

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[83] Brignon J.M., (coord) Nexer M., Lejart M., Thiebaud L., Michel S., Quentric A., (2020) Recommandations pour l'évaluation des impacts cumulés de projets de parcs éoliens en mer. GT ECUME (coord. INERIS), 33p

[84] La sensibilité y est notamment évaluée en considérant un seul événement de pression à une échelle spatiale qui permet la résilience éventuelle de l'habitat

Par ailleurs, pour de nombreuses pressions identifiées, il n'est pas possible de distinguer la part des effets liés au développement des parcs éoliens flottants de ceux liés aux autres activités anthropiques. La prise en compte des effets cumulés est donc indispensable pour réaliser une évaluation des impacts de l'éolien flottant sur les écosystèmes. De plus, certaines pressions sont étroitement liées et selon les experts, il est difficile, par exemple, de distinguer les effets de l'enrichissement organique de celui des contaminations chimiques liées à la remise en suspension des sédiments.

Concernant la pression "pollution chimique", l'évaluation de la sensibilité est d'autant plus complexe que l'impact des différents polluants par type de biocénose n'est pas connu, même si la tendance à l'adsorption des polluants est plus forte pour les sédiments fins (vases et sables fins). Concernant l'introduction/propagation de pathogènes, d'espèces génétiquement différentes des espèces locales, ou d'espèces non indigènes, la sensibilité des habitats dans leur globalité est estimée majeure mais avec un risque faible au regard de (i) la connectivité des habitats au sein du Golfe du Lion et en particulier entre les habitats côtiers et les habitats du large et (ii) l'activité anthropique déjà effective et source de pressions, notamment le trafic maritime. Si ces pressions biologiques peuvent conduire à une déstabilisation des habitats, les effets sur l'écosystème sont fortement dépendants des espèces cibles et du type de pathogènes qui sera introduit.

Une augmentation de la connectivité générale du Golfe du Lion est probable sous réserve que les conditions environnementales du large rencontrées au sein des parcs éoliens permettent à des espèces côtières de prospérer. Le risque est également jugé faible pour l'introduction/propagation d'espèces génétiquement différentes à l'échelle du Golfe du Lion, et ce d'autant plus en l'état actuel des connaissances relatives au suivi génétique des populations d'invertébrés (à l'exception peut-être de quelques espèces d'intérêt commercial).

L'évaluation des niveaux de connaissance de ces interactions n'a pas été réalisée en atelier.

Discussion ouverte

Critique de la méthode

Au regard des difficultés rencontrés au cours des ateliers, les experts considèrent que la méthode mise en œuvre avec une approche par habitats est adaptée à l'approche théorique et prospective menée dans le cadre du projet MSP-MED. L'identification, la caractérisation et l'évaluation à dire d'experts de la sensibilité des couples « pressions - récepteurs écologiques » sont des exercices régulièrement menés par la communauté scientifique (cas des évaluations Natura 2000, etc.). Le cadre méthodologique est donc adapté et cohérent avec ce qui existe déjà. L'approche par habitat permet de considérer leur fonctionnalité et d'intégrer la biodiversité commune aux réflexions alors que les approches par espèces s'intéressent généralement aux espèces d'intérêt socio-économique (espèces patrimoniales, commerciales, etc.) uniquement.

En revanche, si les premiers résultats obtenus dans le cadre de MSP-MED pourront être réutilisés (identification des récepteurs écologiques & identification et caractérisation des interactions potentielles), il sera **impératif** de reprendre le cadre conceptuel défini pour l'adapter à une échelle plus locale. Le cadre proposé à l'échelle du Golfe du Lion pour des projets non définis et portant sur l'ensemble des technologies liées à l'éolien flottant est trop prospectif et théorique pour que les évaluations de la sensibilité de chacune des interactions proposées soit représentatives. Une meilleure connaissance du contexte (type de pressions, secteur géographique, type et surface d'habitats impactés, etc.) permettra de réduire le nombre de couples « pressions - récepteurs écologiques » et d'aboutir à une matrice plus fine et plus précise.

A cela s'ajoute le manque de retours d'expérience portant sur les effets des parcs éoliens flottants sur les écosystèmes et le biais associé à l'approche à dire d'experts, dépendante des connaissances et expériences individuelles. Dans le cadre du projet MSP-MED, ce biais est d'autant plus important que le cadre méthodologique proposé est large.

Lacunes de connaissance et recommandations

Concernant les lacunes de connaissances identifiées au cours des discussions, les experts reconnaissent qu'il n'est pas possible d'acquérir des connaissances sur tous les habitats et toutes les espèces benthiques. En considérant le compartiment benthique dans son ensemble, le manque de connaissance générale est trop important. Dans le contexte de développement des parcs éoliens flottants, l'acquisition de connaissance doit dont prioritairement porter sur l'étude des interactions et des effets de ces infrastructures flottantes à l'échelle locale, en mettant l'accent sur les pressions majeures identifiées pour les habitats benthiques, à savoir les **pressions physiques** liées à : l'**abrasion des fonds marins**, la **remise en suspension** et le **recouvrement d'habitat**. Face à ce constat, plusieurs propositions portant principalement sur (i) l'importance de bénéficier d'un retour d'expérience (fermes pilotes) et (ii) de pouvoir développer des suivis pertinents et adaptés sur ces sites d'essai ont été émises sous forme de recommandations :

Améliorer les connaissances des conditions environnementales

- Modéliser la courantologie des zones d'implantation des fermes afin de produire des scénarios d'évolution des courants en fonction des types d'infrastructures et de leur localisation.

Expérimenter les technologies pour bénéficier d'un retour d'expérience

- Attendre les résultats et le retour d'expérience des fermes pilotes avant de déployer des parcs commerciaux afin de connaitre les principaux impacts et déterminer les couples « pressions – récepteurs écologiques » qu'il est pertinent de suivre.
- Sur la base des retours d'expérience des fermes pilotes, quantifier les effets (volume, surface impactée, etc.) pour permettre à la communauté scientifique d'émettre des recommandations opérationnelles et pertinentes.
- Développer et mettre en œuvre des suivis adaptés à l'étude des interactions et des effets des infrastructures flottantes et de leurs systèmes d'ancrage sur les fonds (abrasion, remise en suspension, recouvrement) à une échelle spatiotemporelle pertinente.

Améliorer la prise en compte des risques d'interactions et des risques d'effet

- Approfondir l'approche menée dans le cadre du projet MSPMED quand les informations relatives au dimensionnement et à la localisation des parcs (type de flotteur, emprise totale, etc.) seront connues afin de faire une évaluation de la sensibilité plus pertinente et plus représentative.
- Améliorer la connaissance des écosystèmes et des pressions générées par l'ensemble des activités anthropiques afin d'en considérer les effets cumulés.
- Définir, en concertation avec les experts, une surface maximale acceptable de dégradation des fonds pour l'ensemble des activités à l'échelle du Golfe du Lion et l'intégrer aux documents de planification de l'espace maritime afin de concilier les activités générant une destruction des fonds marins et la préservation de leurs fonctionnalités pour l'ensemble du réseau trophique.

Perspectives

L'ensemble des résultats collectés au sein des 5 compartiments écologiques étudiés vont être synthétisés afin de fournir une vision écosystémique des contributions d'experts. Le rapport final intégrant l'ensemble des contributions sera présenté aux autorités compétentes de la planification de l'espace maritime au sein d'un atelier de restitution en janvier 2022. Les lacunes de connaissances identifiées et les recommandations d'experts y seront particulièrement soulignées.

Ces recommandations seront transmises aux autorités compétentes afin d'améliorer la connaissance et de mieux intégrer la prise en compte des effets des parcs éoliens flottants sur l'écosystème afin de les suivre, les documenter et les limiter. Toutes les contributions sont importantes et permettront (i) d'étayer le rapport final portant sur l'amélioration de la connaissance des risques d'interaction entre les écosystèmes marins et le développement de l'éolien flottant dans le golfe du lion et de (ii) proposer une note de recommandation pertinente aux autorités compétentes en France dans le cadre des projets de développement des parcs commerciaux, et en Espagne pour nourrir les réflexions liées à la planification maritime des EMR.

Annex 6

Synthesis of "Pelagic communities and habitats" (eg: "fishes and cephalopods" & "planktonic communities") reports *(in French only)*

Compte-rendu du premier atelier du 28 Juin 2021

Contexte

Le projet MSP-MED Co-financé par la Direction Générale des Affaires Maritimes et des pêches (DG MARE) de l'Union Européenne et le Fonds Européen pour les affaires maritimes et la pêche (FEAMP), MSPMED vise à (i) soutenir les Etats-membres et (ii) promouvoir la coopération transfrontalière dans la mise en œuvre de la planification de l'espace maritime (PEM). Initié en 2020, le projet MSPMED réunit 10 partenaires[85] issus de 6 pays méditerranéens (Espagne, France, Italie, Slovénie, Grèce, Malte). En accord avec l'importance de mener un processus coordonné et cohérent de planification de l'espace maritime transfrontalier, l'Office Français pour la Biodiversité (OFB) mène une étude de cas sur le Golfe du Lion afin de répondre à deux objectifs principaux :

- Construire et promouvoir une vision globale des enjeux écologiques du Golfe du Lion ;
- Fournir des connaissances sur les interactions entre les écosystèmes méditerranéens et les usages maritimes, avec un accent particulier sur le développement des parcs éoliens dans la zone du Golfe du Lion.

C'est dans le cadre de ce second objectif que France Énergies Marines[86] (FEM), institut pour la transition énergétique dédié aux énergies marines renouvelables, est mandaté par l'OFB pour définir les interactions potentielles entre les écosystèmes méditerranéens et l'implantation de parcs éoliens flottants. Ateliers MSP-MED Initiée en avril 2021, l'évaluation des interactions entre les écosystèmes marins et le développement des parcs éoliens flottants en mer repose sur les travaux menés par le Ministère en charge de l'environnement depuis 2018. L'objectif des ateliers est de mettre en œuvre les premières étapes de qualification des impacts et d'identifier les interactions potentielles entre les activités liées au développement des parcs éoliens flottants, les pressions qu'elles génèrent et les récepteurs[87] de l'environnement marin. Pour réaliser cette évaluation, plusieurs ateliers réunissant des experts scientifiques seront réalisés entre juin et décembre 2021. Ce document rend compte des échanges qui ont eu lieu lors du premier atelier dédié aux « habitats pélagiques » organisé le 28 juin 2021.

Atelier 1

Ce premier atelier a été consacré à la présentation du projet et à l'identification des récepteurs à prendre en compte pour décrire les interactions potentielles entre les enjeux écologiques et les parcs éoliens flottants en Méditerranée.

Participants :

Nom	Organisme
Neil Alloncle*	Office français de la biodiversité (OFB)
Sybill Henry*	France Énergies Marines (FEM)
Maëlle Nexer*	France Énergies Marines (FEM)
Daniela Banaru	Institut Méditerranéen d'Océanologie (M.I.O)
Eric Goberville	Sorbonne Université – Laboratoire BOREA
Anne Goffart	Université de Liège
Delphine Thibault	Institut Méditerranéen d'Océanologie (M.I.O)
Dorothée Vincent	Office français de la biodiversité (OFB)

**Organisateurs (équipe MSPMED)*

Compte-rendu de séance

a. Présentation de la méthode et des technologies et activités liées aux projets d'éoliennes flottantes en Méditerranée

La méthodologie proposée pour identifier les interactions entre les écosystèmes marins et le développement des parcs éoliens flottants en mer a été présentée aux participants. Développés par le Ministère en charge de l'environnement depuis 2018, ces travaux résultent d'une réflexion menée autour de l'intégration environnementale des énergies marines renouvelables.

[85] CORILA (http://www.corila.it/), Université de Venise (http://www.iuav.it/), ISMAR (http://www.ismar.cnr.it/), SHOM (https://www.shom.fr/), Université de Thessaly (http://old.uth.gr/en/), OFB (https://ofb.gouv.fr/), Ministère Grecque de l'environnement et de l'énergie (https://ypen.gov.gr/), Planning authority of Malte (https://www.pa.org.mt/), RRC Koper (https://www.rrc-kp.si/en/), IEO (http://www.ieo.es/es/)

[86] France Énergies Marines, https://www.france-energies-marines.org/

[87] Espèces, habitats ou regroupement d'organismes vivants susceptibles de subir une pression générée par une activité anthropique

Pour cela, des travaux préliminaires d'identification des activités, des pressions et des récepteurs ont été menés. Basées sur les études d'impacts des projets de fermes pilotes en Méditerranée, les listes obtenues sont ensuite soumises à discussion d'experts. En parallèle des travaux menés dans le cadre de l'atelier « habitats pélagiques », des professionnels du secteur des énergies marines renouvelables sont également consultés pour évaluer les listes d'activités et de pressions. La première liste de récepteurs synthétise les espèces identifiées et/ou décrites par les études environnementales des études d'impact des projets de fermes pilotes en Méditerranée. La liste des pressions reprend les pressions identifiées dans le cadre de la DCSMM et pourra faire l'objet de discussions lors du second atelier. Enfin, les technologies flottantes prévues pour la mise en service des fermes pilotes en Méditerranée sont également présentées aux experts afin de contextualiser la démarche.

b. Discussion sur la pertinence des récepteurs à prendre en compte dans le cadre de l'évaluation

Plus de 240 espèces de poissons, élasmobranches et céphalopodes ont été recensées au sein du golfe du Lion. Au vu du nombre d'espèces et de la connaissance potentiellement partielle de leurs caractéristiques biologiques et écologiques, l'étude et l'évaluation des interactions avec l'éolien flottant pour chacune d'entre elles n'est pas envisagée dans le cadre des présents travaux. L'objectif de ce premier atelier était donc d'identifier les pistes de réduction du nombre de récepteurs, par regroupement ou suppression, en se focalisant sur les habitats, les espèces ou les groupes les plus pertinents à étudier au regard du contexte exposé.

Les principaux éléments issus des discussions sont regroupés selon différents thèmes présentés ci-après.

Difficulté de l'exercice et critique de la méthode

Selon les experts, si des travaux de sélection de récepteurs pertinents peuvent être réalisés pour l'ichtyofaune au regard de la structure des communautés de poissons, l'exercice est beaucoup plus complexe pour les communautés de zoo et de phytoplancton qui sont à la base du réseau trophique et dont les interactions avec les différentes composantes de l'écosystème sont trop importantes, et impose la mise en œuvre d'une approche intégrée. L'approche proposée par compartiment écologique ne semble donc pas pertinente pour les experts qui privilégieraient une approche écosystémique. Selon les experts, si l'approche par compartiments écologiques est appropriée pour l'étude des interactions avec la mégafaune marine mobile, ce n'est pas le cas de la composante planctonique qui demeure en forte interaction/relation avec (i) les caractéristiques océanographiques du milieu et (2) les autres composantes du réseau trophique.

Ainsi, la définition de récepteurs pertinents par les experts requiert un questionnement préliminaire sur l'hydrodynamisme, la courantologie et la distribution des communautés planctoniques au sein du Golfe du Lion. Selon les experts, c'est au travers de l'étude des impacts sur l'hydrodynamisme et la courantologie que des récepteurs pourront être définis, en traitant les communautés qui seraient en conséquence impactées par l'implantation d'infrastructures flottantes en mer.

Le dimensionnement des infrastructures et des projets (fermes pilotes ou parcs commerciaux) doit également être considéré, le nombre de structures pouvant conditionner les différents impacts sur les caractéristiques de l'écosystème. Cependant, les estimations faites pour quelques infrastructures (cas des fermes pilotes) ne sont pas transférables à un nombre plus élevé d'infrastructures du même type.

Il ressort des discussions qu'une approche intégrative comprenant l'ensemble des composantes du réseau trophique et des forçages environnementaux doit être mise en œuvre et que les modifications potentielles de l'hydrodynamisme induites par l'implantation d'infrastructures flottantes sont à prendre en compte dans les modèles pour déterminer les communautés ou les espèces qui seront les plus soumises aux pressions générées par le développement de l'éolien.

A noter que les besoins de mettre en œuvre une approche écosystémique et de développer des modèles pour mieux comprendre les impacts du développent de l'éolien en mer sur les écosystèmes ont également été identifiés par les experts mobilisés lors de la première mise en œuvre de la méthode utilisée dans le cadre de MSP-MED, relative au développement de l'éolien posé en Manche. Si la modélisation fait effectivement partie des objectifs de la méthode proposée, le travail mis en œuvre dans le cadre de MSP-MED ne concerne que les premières étapes d'identification des interactions potentielles. Par ailleurs, des travaux portant sur le développement d'une approche multi-modèles permettant de prévoir les impacts des parcs éoliens en mer sur les écosystèmes est actuellement en cours de développement au sein de FEM via le projet WINDSERV[88].

Liste de récepteurs

[88] Fiche projet WINDSERV : https://www.france-energies-marines.org/projets/windserv/

Concernant le compartiment planctonique, la liste des récepteurs présentés en atelier correspond, selon les experts, aux genres phytoplanctoniques les plus représentés et les plus identifiables. La définition des récepteurs à l'échelle de l'espèce ou du genre (comme cela a été proposé) n'est pas pertinente pour étudier les interactions avec une liste de pressions. Il serait plus intéressant de considérer les communautés phytoplanctoniques dans leur ensemble. Le besoin d'associer les experts en amont de la démarche de définition des récepteurs est également mentionné pour que les experts puissent proposer directement les récepteurs qui leur semblent pertinents plutôt que d'étudier, a posteriori, une liste réduite et non exhaustive issue des études d'impacts. Les indicateurs définis dans le cadre de la DCSMM ainsi que les espèces et groupes d'espèces retenus pour l'atteinte et le maintien du bon état écologique (BEE) pourront être repris pour définir une première liste de récepteurs. Quelques récepteurs sont cependant proposés pour être pris en compte dans le cadre des travaux MSP-MED (méroplancton - organisme temporaire du plancton, zooplancton – en séparant les espèces sentinelles au sens environnemental et les espèces importantes en termes trophiques, polypes de cnidaires, etc.).

Concernant l'ichtyofaune, le nombre d'espèces potentiellement impactées par le développement de l'éolien en mer est trop important au regard de la diversité d'espèces du Golfe du Lion. L'exercice de définition des récepteurs est d'autant plus complexe que les espèces des compartiments benthiques et pélagiques sont fortement liées d'un point de vue fonctionnel et que le développement de l'éolien en mer s'ajoute à des pressions anthropiques (comme la pêche) qui influencent/modifient déjà ces interactions. L'ajout de quelques espèces à intégrer à la liste de récepteurs est proposé en séance (*Eledone cirrhosa, Eledone moschata, Sepietta oweniana, Sprattus sprattus*, etc.) et quelques références sont transmises pour établir une nouvelle liste plus pertinente (INDISEAS[89] et MERMEX[90]).

Critères de sélection proposés

Plusieurs critères sont proposés par les experts pour définir une liste de récepteurs : la structure des communautés, le spectre de tailles, la démographie des populations, l'indice de biodiversité, l'abondance, la biomasse, le niveau trophique moyen de l'écosystème, les espèces vulnérables, etc. Tous s'accordent en revanche sur le besoin d'informations complémentaires au regard des forçages physiques exercés sur les communautés phytoplanctoniques : hydrodynamisme, courantologie, nature des fonds et des sédiments, évolution temporelle et saisonnière des courants, etc.

L'étude des séries temporelles à long terme est également proposée et permettrait de mettre en avant des tendances qui pourraient être utilisées pour proposer un meilleur ciblage des récepteurs.

Pressions identifiées

Certains experts s'interrogent tout de même sur l'impact réel de l'implantation d'infrastructures flottantes sur les populations de phytoplancton. Des doutes sont émis concernant ce compartiment écologique, même si le développement de l'éolien flottant en mer fournira de nouveaux substrats fournissant une superficie d'accroche intéressante pour certaines espèces de polypes de cnidaires par exemple. Le risque d'effet réserve lié aux modifications des usages dans une région fortement exploitée par la pêche peut également générer des impacts sur la répartition de l'effort de pêche sur d'autres territoires et être à l'origine d'une modification de la distribution et de la structure des communautés de poissons.

c. Informations complémentaires post-atelier

Sur demande des experts, quelques éléments complémentaires relatifs à la taille et au dimensionnement des flotteurs sont apportés ici.

La dimension des flotteurs varie en fonction de la technologie mise en œuvre et de la taille des éoliennes qu'ils supportent. Si la technologie envisagée pour les parcs commerciaux prévus en Méditerranée n'est pas encore connue (débat public en cours), les caractéristiques des flotteurs qui seront déployés au sein des trois fermes pilotes peuvent fournir des éléments de réponse. Dans le cas de la barge flottante type IDEOL déployée pour la ferme pilote "EolMed", les dimensions du flotteur sont estimées à 43 m de longueur x 43 m de largeur pour une hauteur d'environ 24 m (16 émergés et 8 immergés). Le flotteur type "Windfloat" déployé pour la ferme pilote "Eoliennes Flottantes du Golfe du Lion" est de plus grande envergure avec des dimensions estimés à 90 m de longueur x 80 m de largeur pour une longueur entre les colonnes d'environ 70 m. La hauteur totale du flotteur est d'environ 25 m dont 10 à 15 m de tirant d'eau (variable grâce au système de ballast). Enfin, les dimensions du modèle TLP déployés pour la ferme

[89] https://www.euromarinenetwork.eu/activities/indiseas-2020-next-frontier-ebfm-and-ecosystem-indicators
[90] https://mermex.mio.univ-amu.fr/

pilote “Provence Grand Large” sont estimées à 85 m de longueur x 85 m de largeur environ pour une hauteur de flotteur estimée à 40 m (15 m émergés et 25 m immergés).

Le déploiement de ces 3 types d’infrastructures est envisagé pour les trois projets de fermes pilotes en Méditerranée (3 éoliennes/sites). Pour les projets de parcs commerciaux, le nombre d’infrastructures n’est pas encore défini. Dans le cadre du débat public actuellement en cours, les deux projets de parcs éoliens flottants de 250 MW chacun et leur extension (500 MW) pourraient déployer une centaine d’éoliennes au total en Méditerranée (données issues du débat EOS, Partageons nos questions sur le milieu marin du golfe du Lion du 05/07/2021). En moyenne, les éoliennes sont distantes d’environ 1 à 1.5 km les unes des autres.

d. Conclusion et perspectives

Pour rappel, l’objectif du projet MSP-MED n’est pas d’évaluer les impacts et les risques de l’éolien flottant en Méditerranée mais d’identifier et de définir les interactions potentielles du développement de cette activité avec les écosystèmes. Seuls les effets directs sont pris en compte afin d’apporter des connaissances sur les interactions. La méthode proposée est structurée selon plusieurs étapes dont la première consiste à définir une liste de récepteurs pouvant entrer en interaction avec les parcs éoliens flottants et qui serait pertinents à prendre en compte pour réaliser une évaluation des impacts.

Dans la cadre du projet MSP-MED, seules les premières étapes de qualification des interactions existantes (effets directs) seront réalisées au travers de 4 ateliers d’experts organisés de juin à décembre 2021.

L’objectif du second atelier sera d’initier les discussions sur l’identification des interactions existantes entre les pressions et les récepteurs précédemment sélectionnés et validés. Basée sur les pressions identifiées dans le cadre de la DCSMM, la liste des pressions pourra être discutée lors du second atelier afin de focaliser les réflexions sur les pressions ayant un impact sur les communautés pélagiques.

Reposant sur l’ensemble des suggestions faites en atelier, la **liste des récepteurs** à prendre en compte pour réaliser une évaluation préliminaire des interactions en Méditerranée sera complétée et mise à jour au cours de l’été. Elle sera de nouveau soumise à avis d’experts à la rentrée, en amont des discussions qui seront menées au cours du second atelier.

Comme demandé par les experts lors du premier atelier, des éléments complémentaires portant sur l’hydrodynamisme actuel du golfe du Lion, la courantologie et la nature des fonds et des sédiments seront transmis en amont du second atelier. Le retour d’expérience relatif au développement de l’éolien flottant étant très faible, des experts hydrodynamiciens seront sollicités d’ici le prochain atelier afin d’obtenir des informations préliminaires sur d’éventuelles modifications de l’hydrodynamisme résultant de l’implantation d’une ou plusieurs éoliennes flottantes.

En complément du présent compte-rendu de séance et des annexes, un extrait de la note méthodologique sur laquelle repose les travaux menés dans le cadre du projet MSP-MED est transmis pour information aux experts.

Compte-rendu du deuxième atelier du 20 Octobre 2021

Ce document synthétise les échanges qui ont eu lieu lors du deuxième atelier MSPMED dédié aux habitats pélagiques et plus particulièrement aux poissons & céphalopodes, le 20 octobre 2021. Pour plus d’informations sur le projet MSPMED et les objectifs de ces ateliers, se référer au premier compte rendu de séance.

Atelier 2 : Définir une liste de récepteurs et identifier les risques potentiels d’interactions

Ce second atelier a été consacré à la définition des récepteurs écologiques d’intérêt pour l’identification des risques potentiels d’interactions entre les écosystèmes marins – et plus particulièrement les poissons et les céphalopodes - et le développement de l’éolien flottant dans le golfe du Lion, selon l’ordre du jour suivant :

- Introduction
- Discussions et collecte d’informations auprès des experts : Définition des critères pour établir une liste de récepteurs écologiques (40’) et initiation des travaux sur l’identification des risques potentiels d’interaction (30’)
- Conclusion et travaux à venir (5’)

Participants :

Nom	Organisme
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L'approche mise en œuvre dans le cadre du projet MSP-MED pour recueillir des éléments de connaissances sur les interactions entre les écosystèmes méditerranéens et le développement des parcs éoliens flottants est adaptée d'une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer, développée par le Ministère en charge de l'environnement depuis 2018 (Brignon & al., 2020)[91]. Le retour d'expérience quasi-inexistant des impacts générés par les infrastructures flottantes sur les écosystèmes marins impose la mise en œuvre d'une démarche prospective à dires d'experts.

De nombreuses interactions sont d'ores-et-déjà bien connues et documentées par la communauté scientifique. Ces études sont généralement issues des retours d'expérience de l'éolien posé en mer en Manche Mer du nord pour les espèces marines, auxquels s'ajoutent ceux de l'éolien terrestre pour les oiseaux et les chiroptères. Si certains risques d'interactions entre l'éolien posé en mer et les écosystèmes marins peuvent être déclinés à l'éolien flottant (augmentation du trafic maritime, modification de l'habitat, etc.), il existe des spécificités inhérentes à l'éolien flottant (système de ballast, flotteurs, ancrage par chaine, etc.) pour lesquelles une réflexion est nécessaire. La démarche prospective menée dans le cadre de MSP-MED permet ainsi d'identifier les risques potentiels d'interactions entre les écosystèmes marins et les infrastructures flottantes, d'identifier les lacunes de connaissance, et d'émettre des recommandations pour les analyses de risques et les évaluations des interactions qui seront réalisées lors de l'opérationnalisation des projets de parcs éoliens flottants dans le golfe du Lion.

Le premier atelier n'a pas permis de définir une liste de récepteurs écologiques[92] et les discussions ont majoritairement portées sur les limites de la méthode mise en œuvre. Il a cependant permis de mettre en avant les spécificités des différentes composantes du pelagos et le besoin de traiter indépendamment la composante planctonique. La compartimentation initialement proposée (pelagos incluant les poissons, les céphalopodes et le plancton) a donc été modifiée pour constituer deux ateliers : un premier dédié au compartiment planctonique et un second dédié aux poissons et aux céphalopodes. Les invertébrés benthiques sont pris en compte au sein d'un atelier spécifique dédié au "benthos".

L'objectif de ce second atelier était de poursuivre les réflexions pour définir une liste de récepteurs écologiques et d'initier les discussions sur les risques potentiels d'interactions – identification et caractérisation (effet direct, effet indirect, à plus ou moins long terme, etc.). La démarche étant prospective, les hypothèses émises au regard des risques d'interactions pour lesquels il n'y a pas encore de connaissances ont elles aussi été retenues. Un exercice de qualification des risques potentiels d'interactions sera présenté lors de l'atelier 3 selon trois critères : la connaissance, l'enjeu, et la sensibilité. La notation sera faite à dire d'experts et permettra d'alimenter les discussions qui seront menées au cours du quatrième et dernier atelier.

Définition des récepteurs

Basée sur les travaux menés au sein des autres ateliers et au regard de l'approche prospective menée dans le cadre de MSP-MED, une approche plus large dans la définition des récepteurs écologiques est proposée.

En accord avec les participant.e.s, le pool d'espèce initialement proposé est supprimé. À ce stade de la démarche, la définition d'une liste d'espèces n'est pas pertinente. Une telle liste pourra être réalisée lorsque la zone d'implantation des parcs éoliens flottants sera connue. La collecte d'informations précises sur l'abondance, la répartition, les taux de fréquentation des espèces, les voies de migrations, etc., croisées à des données spatiales (emprises des parcs), permettra de réaliser une évaluation des risques d'interactions pertinente. De plus, l'établissement d'une liste d'espèces réduite restreint l'analyse à des espèces sélectionnées selon des critères (espèces sensibles, espèces menacées, espèces d'intérêt commerciales) qui peuvent varier en fonction des objectifs de l'étude et qui se focalisent généralement sur les espèces connues. En effet, une telle sélection n'intègre généralement pas certaines espèces peu connues, ou peu considérées, et pourtant essentielles au fonctionnement des écosystèmes marins.

La définition des récepteurs écologiques proposée en atelier repose donc sur une approche plus générale reposant sur l'écologie et l'éthologie des espèces. Cette approche permet de définir des grands groupes fonctionnels au sein desquels les espèces d'intérêt pourront être réparties lorsque les zones d'implantation des parcs éoliens seront connues. Les récepteurs écologiques

[91] Brignon J.M., (coord.) Nexer M., Lejart M., Thiebaud L., Michel S., Quentric A., (2020) Recommandations pour l'évaluation des impacts cumulés de projets de parcs éoliens en mer. GT ECUME (coord. INERIS), 33p

[92] Espèces, habitats ou regroupement d'organismes vivants susceptibles de subir une pression générée par une activité anthropique

sont donc définis sur la base des trois grands groupes retenus pour l'atelier "pelagos" (poissons osseux, élasmobranches et céphalopodes) couplés à un ensemble de traits fonctionnels[93] présenté ci-après :

- **Cycle de vie** : Adulte ; Juvénile ; Larvaire (permet de considérer les risques potentiels d'interaction en fonction de l'étape du cycle de vie concerné par le développement des parcs éoliens)
- **Mode de vie** : Benthique ; Démersal ; Pélagique / Migrateur ; Sédentaire / Amphihalin
- **Régime alimentaire** : Herbivore ; Carnivore ; Omnivore
- **Mode de reproduction** : Avec dispersion larvaire ; Sans dispersion larvaire (permet de faire la différence entre les espèces qui se reproduisent dans des zones de nurseries à proximités des zones fréquentées par les individus adultes, de celles qui ont des zones de ponte disjointes des zones fréquentées par les adultes – sur le fond ou dans la colonne d'eau) pour les poissons osseux. Ovipare ; Vivipare placentaire ; Vivipare aplacentaire pour les élasmobranches.
- **Fréquentation de l'espace côtier** : Très côtier – 0 à 50/60 mètres ; Plateau continental – 50/60 à 200 mètres ; Au-delà du plateau continental – Plus de 200 mètres *(permet de prendre en compte les espèces qui fréquentent occasionnellement le plateau continental comme les grands prédateurs et les élasmobranches. La délimitation de la zone côtière à 50 mètres résulte de la nette différence observable dans les populations de petits pélagiques côtiers au-delà de 50 mètres)*.

Les espèces fourrages sont également mentionnées et permettent de considérer le rôle trophique de certaines espèces. Pour les céphalopodes, les espèces les plus susceptibles d'être impactées par le développement des parcs éoliens flottants sont les Eledones et les Calmars qui fréquentent essentiellement la zone du plateau continental dans le Golfe du Lion.

Définir une liste de récepteurs écologiques en combinant l'ensemble des traits fonctionnels mentionnés (exemple : Poissons osseux de la zone côtière – Juvénile d'espèce benthique herbivore migratrice avec dispersion larvaire) conduirait à un nombre de récepteurs écologiques plus élevé que le nombre d'espèces recensées dans le golfe du Lion (450 espèces environ). Afin d'identifier les risques potentiels d'interaction, il est proposé de se limiter à la production d'une grille d'interaction entre les pressions identifiées et les grands traits biologiques/caractéristiques des espèces.

Discussions sur les risques potentiels d'interactions

Les échanges et les éléments d'informations apportés par les experts au cours de l'atelier sont toujours disponibles sur l'espace de travail en ligne. L'identification des risques potentiels d'interaction seront au cœur des discussions du troisième atelier et les quelques risques d'ores-et-déjà été identifiés sont présentés ci-après :

Les **émissions sonores** peuvent générer des vibrations dans la colonne d'eau qui pourront impacter la faune pélagique lors des phases de travaux (augmentation du trafic maritime, etc.) et d'exploitation (augmentation du bruit de fond). En fonction du type, de la fréquence, de la durée et de l'intensité des émissions sonores, les impacts sur la faune pélagique pourront porter sur la vessie natatoire ou/et l'audition. L'impact des infrastructures flottantes sur les **conditions hydrodynamiques** pourra avoir une incidence sur les larves pélagiques vivant essentiellement en surface entre 0 et 4 mètres. La modification des courants de surface pourra être répercutée sur les voies de transport des larves et être à l'origine d'une diminution de leur taux de survie (augmentation de la dépense énergetique, etc.). De plus, l'ajout d'une infrastructure flottante à la surface de l'eau peut générer à la fois un obstacle au mouvement et une source de vibration dans l'eau ayant pour effet d'attirer certaines espèces. L'**effet DCP** pourra induire une modification de la structure des communautés de certaines espèces, des voies de migration, ou augmenter la pression de prédation. L'observation à long terme d'un **effet récif** sur les flotteurs est également à prévoir comme en atteste les résultats des études menées en Manche dans le cadre du projet ABIOP+ (qui ont mis en évidence le développement d'espèces de moules et d'ulves sur les infrastructures posées) ou des études menées en Méditerranée sur la bouée BOB (qui ont montré un effet d'attraction au large de certaines espèces précédemment marquées en zone côtière – sar, sériole, dorade, loup par exemple). En fonction des réglementations qui seront imposées au sein des parcs éoliens flottants, un **effet réserve** pourra potentiellement être observé avec, à nouveau, un risque d'attraction des prédateurs, de modification de la structure des communautés et de la connectivité par report des efforts de pêche sur des populations voisines ou en bordure de parc. Enfin, la **modification de la connectivité** par destruction des zones d'habitats fonctionnels (abris, reproduction, nurserie, alimentation, etc.) pourra générer une baisse du taux de survie à plus ou moins long terme avec des taux de mortalité pouvant être élevés pendant toute la période d'adaptation des espèces (exploration de nouvelles zones d'habitats fonctionnels plus favorables).

Difficultés de l'exercice

[93] Caractéristiques morphologique, physiologique, phénologique ou comportementale propre à un organisme

La principale difficulté évoquée par les experts pour réaliser l'exercice d'identification des risques potentiels d'interaction résulte de la démarche prospective. Le site d'implantation, l'emprise finale des parcs ou les zones concernées ne sont pas connues et ne permettent pas de fournir des éléments précis sur les risques d'interaction et la biologie spécifique des espèces. Seuls des éléments d'informations généraux sur l'écologie des poissons peuvent être proposés par les experts pour réaliser une démarche prospective d'identification des risques potentiels. Une identification exhaustive de ces risques n'est également pas réalisable à ce stade car trop dépendantes des relations interspécifiques et des *preferendum* de chaque espèce.

Afin de réaliser une évaluation des risques d'interaction pertinente, une large collecte d'information sur l'écologie et la répartition des espèces fréquentant la zone d'intérêt est recommandée par les experts. Une analyse cartographique superposant des données écologiques (cartes d'abondance, répartition, biomasse, routes de migration) et de planification spatiale (emprise des parcs, etc.) fournira une évaluation plus précise des risques d'interaction. L'analyse des données cartographiques permettra également d'exclure les zones fonctionnelles (zone de ponte, de recrutement, etc.) des projets de parcs éoliens. Si ces zones fonctionnelles sont bien connues pour certaines espèces, notamment les espèces halieutiques exploitées dans le golfe du Lion, il existe encore des lacunes de connaissances pour certaines espèces peu connues mais pouvant avoir un rôle essentiel dans le fonctionnement de l'écosystème.

Si les compartiments benthiques et pélagiques sont traités dans deux groupes de travail disjoints dans le cadre du projet MSP-MED, il est rappelé que les deux compartiments sont étroitement liés. Si certaines activités liées au développement de l'éolien flottant, comme le ragage des chaines sur le fond, n'impacteront pas directement les espèces de poissons et de céphalopodes vivant dans la colonne d'eau, de nombreuses espèces pélagiques dépendent de la préservation des fonds marins pour se nourrir, se reproduire, etc. De nombreuses zones fonctionnelles (abris des juvéniles, frayères, nourriceries, etc.) sont également dépendantes de l'intégrité des fonds et, selon les experts, la planification de l'espace maritime et le développement de nouvelles activités en mer devraient prendre en considération une surface d'implantation maximale à ne pas dégrader afin de préserver les espèces qui dépendent de la qualité des habitats benthiques et limiter les impacts sur l'ensemble de la chaine trophique.

Conclusion et perspectives

Prévu le 9 novembre 2021 de 14h00 à 16h00, le troisième atelier permettra de poursuivre les travaux d'identification et de caractérisation des risques potentiels d'interactions.

Compte-rendu du troisième atelier du 9 Novembre 2021

Le troisième atelier du 9 Novembre 2021 avait pour objectif de poursuivre les discussions sur l'identification des risques d'interactions potentiels.

Atelier 3 : Identifier et caractériser les risques potentiels d'interactions

Ce troisième atelier a été consacré à la poursuite de l'identification et de la caractérisation des risques d'interactions entre les écosystèmes marins – et plus particulièrement **les poissons et les céphalopodes** - et le développement de l'éolien flottant dans le golfe du Lion, selon l'ordre du jour suivant :

- Introduction
- Discussions et collecte d'informations auprès des experts : Validation des critères pour établir une liste de récepteurs écologiques (50') et poursuite des travaux sur l'identification et la caractérisation des risques potentiels d'interaction (60')
- Conclusion

Participants :

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Daniela Banaru	Institut Méditerranéen d'Océanologie (M.I.O)
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**Organisateurs (équipe MSPMED)*

Si de nombreuses interactions sont d'ores-et-déjà connues et documentées par la communauté scientifique, ces études sont généralement issues du retour d'expérience de l'éolien posé en mer en Manche Mer du nord (espèces marines) et de l'éolien terrestre (oiseaux et chiroptères). Si certains risques d'interactions entre l'éolien posé en mer et les écosystèmes marins peuvent être déclinés à l'éolien flottant (augmentation du trafic maritime, modification des habitats, etc.), il existe certaines spécificités de l'éolien flottant (système de ballast, flotteurs, ancrage par chaine, etc.) pour lesquelles une réflexion est nécessaire.

La démarche prospective menée dans le cadre du projet MSPMED permet d'identifier et de caractériser les risques d'interactions potentiels entre les écosystèmes marins et les infrastructures flottantes pour lesquelles nous n'avons pas encore de retours d'expériences et de connaissances scientifiques précises. La méthode proposée pour identifier et caractériser ces interactions potentielles repose sur une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer, développée par le Ministère en charge de l'environnement depuis 2018 (Brignon & al., 2020[94]). Seules les premières étapes de cette méthode d'évaluation sont mises en œuvre et déclinées au travers de 4 ateliers d'experts (se référer aux précédents comptes-rendus d'atelier pour plus d'informations sur le projet, la méthode et la synthèse des échanges).

Validation des récepteurs écologiques

La première partie de l'atelier a permis de poursuivre les discussions sur la définition des récepteurs écologiques à prendre en compte pour l'étude des risques d'interactions.

La prise en compte de l'ensemble des traits fonctionnels ("poissons osseux de la zone côtière – Juvénile d'espèce benthique herbivore migratrice avec dispersion larvaire" par exemple) aboutirait à des matrices trop complexes et trop importantes dans le cadre de l'étude de cas du projet MSP-MED. Une réflexion a alors été menée en atelier pour regrouper ces grands traits fonctionnels afin de généraliser la méthode et considérer l'ensemble des espèces potentiellement impactées. Pour l'étude des effets des pressions sur les poissons, élasmobranches et céphalopodes, il apparait essentiel de considérer le lieu de vie des espèces et leurs besoins. Ainsi, la distribution verticale des espèces dans la colonne d'eau permet de considérer l'ensemble des espèces - qu'elles soient migratrices, amphihalines, carnivores, etc.

Dérivée de l'approche utilisée par les experts mobilisés pour l'élaboration du « Référentiel pour la prise en compte des activités d'énergies marines renouvelables dans la préservation de l'environnement marin », une approche par écophase est alors proposée en atelier. Une écophase correspond à une étape de développement d'une espèce pendant laquelle elle occupe un habitat particulier. En fonction des espèces, cette écophase peut concerner quelques stades ou l'ensemble du cycle de vie. Les trois écophases retenues sont : **écophase benthique sur substrat rocheux, écophase benthique sur substrat meuble** et **écophase pélagique**. Les espèces démersales (qui fréquentent alternativement le benthos et le pélagos pour se nourrir et/ou se déplacer) sont prises en compte en couplant les résultats obtenus pour les écophases benthiques (rocheux et/ou meubles) et pélagiques.

Afin d'être plus précis dans l'étude des risques d'interaction, une approche à deux niveaux couplant "écophase" (niveau 1) et "stade du cycle de vie des espèces" (niveau 2) est proposée. Sur la base des traits fonctionnels précédemment identifiés au cours de l'atelier 2, les différents stades de vie retenus dans le cadre de MSPMED sont les suivants : **œufs et larves** ; **juvéniles** ; **adultes** (la distinction entre les juvéniles et les adultes est maintenue car pour une même espèce les habitats préférentiels peuvent tout de même être différents) et **en transition**. Le stade "en transition" est ajouté car il permet de prendre en compte les différentes phases de migration et de transformation des individus et d'intégrer les périodes du cycle de vie pendant lesquelles ils peuvent changer d'habitat fonctionnel. Il peut s'agir des étapes de transition d'un stade à un autre (de juvénile à adulte par exemple) ou de transition au sein d'une même phase (migration des adultes vers les zones de ponte par exemple).

Le temps de dispersion des larves est également mentionné en atelier mais n'est pas retenu comme pouvant contribuer à la définition de récepteurs écologiques à part entière, même si cette différence (temps de dispersion long vs temps de dispersion court) pourra être rappelée lors de la caractérisation des risques d'interactions. Ces temps de dispersion sont, en effet, importants à prendre en compte puisqu'ils permettent de mettre en avant la sensibilité des larves à temps de dispersion long qui vont subir une série de métamorphoses. L'approche par mode d'alimentation évoqué lors de la définition des traits fonctionnels d'intérêt pourra être réalisée ultérieurement, lors de la mise en œuvre opérationnelle de l'étude des risques d'interactions. L'approche simplifiée par **écophase couplée à la prise en compte du stade de vie** permet de prendre en compte l'ensemble des espèces et correspond au cadre prospectif fixé par MSP-MED.

Identification et caractérisation des risques d'interaction

[94] Brignon J.M., (coord.) Nexer M., Lejart M., Thiebaud L., Michel S., Quentric A., (2020) Recommandations pour l'évaluation des impacts cumulés de projets de parcs éoliens en mer. GT ECUME (coord. INERIS), 33p.

La seconde partie de l'atelier fut majoritairement dédiée à la poursuite des travaux d'identification et de caractérisation des risques d'interactions.
La perte d'habitat physique correspond à une perte nette et localisée d'habitats fonctionnels. En fonction des designs retenus pour le développement des infrastructures flottantes, la perte nette d'habitat associé à un modèle dit TLP (flotteur maintenu par des chaines tendues via des piles à succion) sera moins importante que celle d'un modèle de barge ou de flotteur semi-submersible (flotteur maintenu par des chaines ancrées) puisque la recolonisation ne sera pas possible sur un substrat régulièrement soumis au ragage des chaines. Par écophase et en fonction du cycle de vie, plusieurs risques d'interaction ont été identifiés en atelier :

Ecophase benthique sur substrat meuble	
Œufs et larves	Mortalité et perte d'habitats (zone de nidification, de développement des larves)
Juvéniles	Perte de proies (modification du benthos) et perte d'habitats fonctionnels (zones d'abris et de protection par les structures 3D des habitats – ex : forêts algales)
Adultes	Perte d'habitats fonctionnels et perte de proies (modification du benthos)
En transition	Interruption des routes migratoires
Ecophase benthique sur substrat meuble	
Œufs et larves	Mortalité et perte d'habitats (zone nidification, développement des larves).
Juvéniles	Perte de proies (modification du benthos), perte d'habitats fonctionnels (zones d'abris et de protection par les structures 3D des habitats – ex : coralligènes/bryozoaires et structures bio-construites).
Adultes	Perte d'habitats fonctionnels et perte de proies (modification du benthos).
En transition	Interruption des routes migratoires.
Ecophase pélagique	
Œufs et larves	Perturbation des migrations par ombrage, perte de productivité et perte locale d'habitat (en surface).
En transition	Perturbation des migrations nycthémérales.

A noter que pour les substrats meubles, la résilience est plus importante que pour les substrats durs (6 mois en moyenne).
L'**obstacle au mouvement** est également régulièrement mentionné et est classé dans les pressions biologiques avec un risque notable pour le stade "transition" et en particulier pour le passage du stade larvaire à juvénile (plus que pour celui du stade juvénile à adulte).
L'**effet d'ombrage** est également ajouté comme pression avec pour conséquence des phénomènes d'attraction des prédateurs et de modification des routes migratoires.
À noter que les effets d'une même pression pourront avoir des conséquences très différentes sur une même espèce en fonction de son stade de vie, mais aussi en fonction de ses capacités de reproduction. S'il existe peu d'information pour faire la distinction entre les mâles et les femelles dans l'étude des risques d'interaction, une perte d'alimentation ou une augmentation (même ponctuelle) du stress physiologique aura un impact différent sur les mâles et les femelles en fonction de la durée, de l'intensité et du type de pression. Par exemple, un mâle sous-alimenté sera en mesure de se reproduire alors que cela ne sera pas le cas d'une femelle. La prise en compte de différents degrés d'interaction doit permettre de distinguer les effets sur les individus mâles de ceux portant sur les individus femelles.

Points de vigilance et recommandations des experts
L'impact des chaines : favoriser le développement de modèles qui limitent le nombre de chaines comme le TLP limiterait les effets du ragage (équivalent d'une action localisée et permanente de chalutage). En fonction des surfaces qui seront réellement concernées par ce phénomène de ragage, le potentiel effet « positif » des restrictions d'usages (effet réserve) lié au développement des parcs éoliens flottants pourrait être remis en question. Si beaucoup d'effets du développement des parcs éoliens ne sont pas connus, ce n'est pas le cas des effets du dragage avec des temps de récupération des écosystèmes qui sont connus des scientifiques. Les effets du ragage ne sont pas spécifiques à l'éolien et la capitalisation des connaissances sur le sujet est possible pour donner une estimation des impacts sur l'écosystème.
La luminosité : au regard de la taille de flotteurs, les experts appellent à la vigilance dans l'espacement des infrastructures les unes par rapport aux autres et dans le choix de la zone d'implantation afin d'éviter les zones d'alimentation des larves. De par leurs tailles, les flotteurs peuvent avoir un impact non négligeable sur le fonctionnement de la zone euphotique de surface et perturber le développement des larves et de la vie planctonique mais aussi perturber la thermocline de surface dont la profondeur varie en fonction de la zone du golfe du lion et de la période de l'année. Quelle que soit la zone d'implantation choisie, il est primordial que

la lumière puisse passer de façon à ce que (i) la zone euphotique puisse continuer de fonctionner normalement et (ii) la productivité du golfe du Lion ne soit pas modifiée.
Enfin, dans le cadre de l'approche théorique et prospective menée dans MSPMED, le nombre élevé d'espèces et de traits fonctionnels ne permet pas d'aller dans l'étude fine des risques d'interaction à grande échelle, d'autant plus avec une approche segmentée par « composante écologique ». Si l'approche semble pertinente pour les compartiments "oiseaux" et "cétacés" -bien qu'il y ait des effets indirects sur ces composantes par les potentielles modifications du réseau trophique-, elle l'est bien moins pour les compartiments "pélagique" et "benthique" qui sont très étroitement liés. L'étude des relations trophiques permet d'avoir une approche beaucoup plus large et d'étudier les effets cumulés directs et indirects d'une espèce sur les autres, et différencie les espèces qui survivraient ou qui ne seraient pas impactées par le développement de l'éolien flottant en mer de leur source de nourriture qui pourrait être plus impactée. Le modèle "ecopath"[95] permet de mettre en œuvre une approche écosystémique plus pertinente pour évaluer les effets d'une activité sur l'écosystème.

Perspectives pour l'atelier 4

Prévu le 23 novembre 2021 de 10h00 à 12h00, le quatrième et dernier atelier permettra de poursuivre l'identification et la caractérisation des risques d'interactions.
L'objectif de ce dernier atelier sera également d'échanger sur les lacunes de connaissance identifiées au cours des discussions et de proposer des recommandations pour améliorer la prise en compte des risques d'interactions dans le cadre du développement de l'éolien flottant dans le golfe du Lion suite à ce premier exercice itératif et prospectif.

Compte-rendu du quatrième atelier du 23 Novembre 2021

Le quatrième et dernier atelier avait pour objectif de (i) poursuivre les discussions sur l'identification et la caractérisation des risques potentiels d'interaction entre les écosystèmes marins – et plus particulièrement les poissons et les céphalopodes - et le développement des parcs éoliens flottants et de (ii) proposer un ensemble de recommandations afin de mieux considérer ces risques d'interaction dans le développement des parcs éoliens flottants (par les autorités compétentes de la planification de l'espace maritime et développeurs).
Il s'est tenu le 23 novembre 2021 de 10h00 à 12h30 selon l'ordre du jour suivant :

- Introduction
- Identifier et caractériser les risques d'interaction potentiels (70') : Poursuite des discussions et des travaux conduits lors de l'atelier 3 (temps individuel de remplissage des tableaux)
- Discussion ouverte (60') : Identification des lacunes et définition des mesures de recommandations à destination des autorités compétentes
- Conclusion

Participants :

Nom	Organisme
Neil Alloncle*	Office français de la biodiversité (OFB)
Sybill Henry*	France Énergies Marines (FEM)
Daniela Banaru	Institut Méditerranéen d'Océanologie (M.I.O)
Lydie Couturier	France Énergies Marines (FEM)
Audrey Darnaude	CNRS, UMR MARBEC
Marion Verdoit-Jarraya	Université de Perpignan via Domitia – CEFREM, UMR 5110 (CNRS-UPVD)

**Organisateurs (équipe MSPMED)*

Atelier 4 : Caractériser les risques potentiels d'interactions et proposer des mesures de recommandations

Pour mémoire, la démarche prospective menée dans le cadre du projet MSPMED permet d'identifier et de caractériser les risques d'interactions potentiels entre les écosystèmes marins et les infrastructures flottantes pour lesquelles nous n'avons pas encore de retours d'expériences et de connaissances scientifiques précises. La méthode proposée pour identifier et caractériser ces interactions potentielles repose sur une méthode d'évaluation des impacts cumulés des projets de parcs éoliens en mer,

[95] https://ecopath.org/

développée par le Ministère en charge de l'environnement depuis 2018 (Brignon & al., 2020)[96]. Seules les premières étapes de cette méthode d'évaluation ont été mises en œuvre et déclinées au travers de 4 ateliers d'experts (se référer aux précédents comptes-rendus d'atelier pour plus d'informations sur le projet, la méthode et la synthèse des échanges).

Identification et caractérisation des risques d'interaction

La première partie de l'atelier fut consacrée à la poursuite de l'identification et de la caractérisation des risques d'interactions potentiels. Chaque expert a pu bénéficier d'un temps de remplissage individuel du tableau « pressions » / « récepteurs écologiques » validé au cours de l'atelier 3.

A noter que les experts considèrent que l'exercice prospectif demandé dans le cadre du projet MSP-MED est difficile. Selon eux, il serait nécessaire de réitérer l'approche en incluant des experts de tous les compartiments de l'écosystème afin d'être plus précis et plus descriptif dans l'identification et la caractérisation des interactions. Le manque de connaissance de la localisation des projets et des types de technologies qui seront déployées limite les résultats de cette étude à un haut degré d'incertitude. L'ensemble des hypothèses relatives aux risques d'interaction formulées à dire d'experts devront être complétés par une bibliographie portant sur les interactions pressions-récepteurs en fonction des différents stades de vie afin d'être plus précis dans la caractérisation et ce, même si les éléments de connaissances scientifiques à disposition ne sont pas spécifiques aux effets de l'éolien flottant dans le golfe du Lion. Selon les experts, il est certain que le déploiement d'infrastructures flottantes en mer va avoir un impact sur le fonctionnement et la nature des écosystèmes marins. Le manque de retour d'expérience concernant les technologies flottantes rend difficile l'identification des effets directs sur les espèces et sur l'ensemble de la chaine trophique et interroge sur les effets indirects et sur leurs conséquences à long terme.

Identification des lacunes de connaissances

Les réflexions sur la caractérisation des interactions ont permis aux experts d'identifier des lacunes de connaissance. Plusieurs propositions d'amélioration des connaissances et des suivis ont été proposées et sont exposées sous forme de recommandations en troisième partie.

Selon les experts, l'étude et l'évaluation des effets d'une activité sur les écosystèmes marins requiert un bon niveau de connaissance préalable des écosystèmes potentiellement impactés et de leur fonctionnement. Si certaines espèces du golfe du Lion sont bien décrites, des lacunes de connaissances persistent sur le cycle de vie complet de certaines espèces et sur la localisation des zones fonctionnelles (zone de ponte, zone de croissance, etc.) qui leurs sont associées. La dégradation de certaines zones de ponte sans connaitre la capacité de report des espèces pourrait avoir des conséquences non négligeables sur le taux de reproduction et la structure de la population toute entière. L'amélioration des connaissances de l'impact des infrastructures flottantes sur les courants est également importante afin de déterminer la conséquence sur le transport et le recrutement des espèces (ex : stade larvaire).

Les courants ont un rôle majeur dans la dispersion des larves. Cette connectivité implique que les moyens mis en œuvre pour réaliser des suivis soient menés en coopération avec les pays transfrontaliers. En effet, l'impact sur la capacité de dispersion des larves dans la partie française du Golfe du Lion pourra avoir un impact sur les stocks et les pêcheries espagnoles. L'amélioration des connaissances sur les zones de dispersion des larves est donc importante à l'échelle transfrontalière d'autant plus que la période de dispersion des larves est une période critique du développement de certaines espèces. Les connaissances des communautés de poissons et de céphalopodes et de leurs structures, devront être améliorées afin de mieux comprendre les interactions existantes entre les compartiments de l'écosystème et ainsi mieux anticiper les potentiels effets d'une nouvelle activité. Selon les experts, les connaissances actuelles sur les effets (émissions de bruit, émissions électromagnétiques, etc.) portent majoritairement sur quelques espèces. Par ailleurs, il existe un manque de connaissance général sur les interactions inter-espèces et sur le rôle de certaines espèces moins connues (n'ayant pas d'intérêt commercial ou patrimonial par exemple) dans le fonctionnement de l'écosystème.

Enfin, les experts identifient également un manque de connaissance des effets cumulés des activités liées au développement des parcs éoliens flottants mais aussi à l'ajout d'une activité dans un écosystème déjà fortement anthropisé. L'effet synergique des pressions sur les espèces est mal connu et devrait être pris en considération pour l'étude et l'évaluation des interactions.

[96] Brignon J.M., (coord) Nexer M., Lejart M., Thiebaud L., Michel S., Quentric A., (2020) Recommandations pour l'évaluation des impacts cumulés de projets de parcs éoliens en mer. GT ECUME (coord. INERIS), 33p.

Recommandations des experts

Plusieurs points de vigilance avaient déjà été mis en avant par les experts au cours de l'atelier 3. Les mesures de recommandations associées portant sur (i) la réduction de l'impact des chaines sur le fond et (ii) de la modification de la luminosité de la colonne d'eau, ont donc été reportées ci-après. L'ensemble des recommandations émises dans le cadre du projet MSPMED pour le groupe « Habitats pélagiques – Poissons & Céphalopodes » peuvent être réparties au sein des 7 grandes catégories suivantes :

Améliorer les connaissances écologiques

- Améliorer la connaissance des communautés de poissons et de céphalopodes et de leur structure afin de mieux comprendre les interactions existantes entre les différentes composantes de l'écosystème et la répercussion des effets des parcs éoliens flottants sur l'ensemble du réseau trophique.
- Améliorer les connaissances du cycle de vie des espèces benthiques et pélagiques afin de mieux comprendre les interactions existantes entre ces deux compartiments écologiques étroitement liés dans leur fonctionnement.
- Améliorer les connaissances dans l'identification des espèces fonctionnelles ayant un rôle important dans le fonctionnement de l'écosystème (herbivores stricts, espèces fourrage, top prédateurs, espèces d'importance halieutique, élasmobranches, etc.). L'approche menée dans le cadre du projet MSP-MED pourra être approfondie afin de les identifier et réaliser une évaluation des impacts pertinente.

Améliorer les connaissances des conditions environnementales

- Modéliser la courantologie des zones d'implantation des fermes afin de produire des scénarios d'évolution des courants en fonction des types d'infrastructures et de leur localisation. Utiliser des outils de modélisation pour définir quels seront les impacts des infrastructures sur l'hydrodynamisme local et de ses répercussions sur l'hydrodynamisme du golfe du lion afin de choisir des designs d'infrastructure adapté.

Expérimenter les technologies pour bénéficier d'un retour d'expérience

- Attendre les résultats et le retour d'expérience des fermes pilotes avant de déployer des parcs commerciaux afin de sélectionner la technologie la moins impactante au regard des écosystèmes.
- Equiper les sites pilotes avec des outils de suivi précis et adaptés pour suivre les effets (à court et long terme) des infrastructures flottantes à l'échelle des individus et des communautés.
- Développer et programmer des protocoles de suivis adaptés aux communautés pélagiques (poissons, élasmobranches, céphalopodes) sur les sites des fermes pilotes.

Développer des suivis pertinents pour l'étude des interactions

- Privilégier une approche écosystémique pour l'étude des effets en utilisant des logiciels de modélisation des écosystèmes. Le modèle existant Ecopath with Ecosim (EwE) peut être utilisé pour comprendre et évaluer les impacts des parcs éoliens flottants sur les écosystèmes marins. Les résultats du projet WINDSERV[97] à l'horizon 2023 pourront nourrir ces modèles et la discussion au travers d'une approche multi-modèles d'indicateurs de services.
- Mettre en œuvre des suivis adaptés au rythme biologique des espèces. Pour être pertinents, les suivis mis en œuvre pour étudier l'effet des infrastructures doivent être réalisés sur une période d'au moins 5 ans correspondant aux principales étapes de développement et de maturité sexuelle de certaines espèces (pour la sole par exemple la maturité sexuelle n'est atteinte qu'à partir de 3 ans). Les études d'impact à 3 ans ne permettent pas de prédire les effets sur le cycle de vie complet d'une espèce et sur les niveaux trophiques. Pour correspondre au cycle de développement (passage du stade œufs/larvaires au stade adulte et en âge de se reproduire) de la plupart des espèces de poissons, la durée des suivis doit être au moins de 5 ans. Pour étudier les effets indirects sur l'ensemble de la chaine alimentaire, les suivis doivent donc être plus longs, soit compris entre 8 et 10 ans.

Améliorer la prise en compte des risques d'interactions et des risques d'effet

- Considérer les différents niveaux de résilience entre les habitats de substrats durs et les habitats de substrats meubles lors du choix des zones retenues pour le déploiement des parcs.

[97] Projet WINDSERV : https://www.france-energies-marines.org/projets/windserv/

- Améliorer la connaissance des écosystèmes et des pressions générées par l'ensemble des activités anthropiques afin de considérer les effets cumulés.
- Identifier, par compartiment écologique, les espèces pour lesquelles il n'existe pas d'alternative possible en cas de destruction d'habitats afin de préserver les zones fonctionnelles (zones de ponte et de dispersion larvaire) et orienter la définition des zones d'implantation des parcs éoliens offshore vers des zones de moindre importance fonctionnelle ou davantage représentées. Ce travail d'identification et de localisation permettra de déterminer l'existence de zones de réplicas (mêmes fonctionnalités) à l'échelle du Golfe de Lion et de s'assurer de la pérennité des espèces impactées.
- Considérer les impacts de l'éolien flottant au-delà de l'écosystème en s'intéressant aux potentiels effets indirects sur la société.

Mener une réflexion à large échelle

- Encourager la coopération transfrontalière dans l'étude des effets à long terme et en particulier pour les projets situés en bordure du Golfe du Lion afin de mutualiser les suivis et les données. Ces coopérations permettraient de suivre et d'étudier les effets des parcs éoliens flottants à grande échelle (Ouest de la Méditerranée).
- Considérer les effets potentiels à l'échelle géographique appropriée correspondant à la distribution spatiale des populations. Pour des espèces très mobiles (voire migratrices), l'échelle des parcs ou du Golfe du Lion n'est pas adaptée pour l'étude des effets.

Réduire les impacts potentiels

- Développer et tester des méthodes d'éco-conception pour limiter l'impact des infrastructures sur l'environnement et encourager au développement de techniques d'ancrage alternatives dont les impacts sur le milieu marin sont limités et avérés.
- Privilégier les technologies dont l'impact sur le fond marin et en particulier le ragage sera limité voire nul. Des modèles de flotteurs limitant le nombre de chaines comme les modèles TLP pourraient réduire le niveau d'impact du ragage sur le fond et limiter la surface de destruction des substrats meubles. Le ragage est considéré par les experts comme l'équivalent d'une action localisée et permanente de chalutage en termes d'impact sur les fonds de substrats meubles.
- Considérer l'ensemble des alternatives au développement de l'éolien flottant offshore (houlomoteur, etc.) pouvant être moins impactant pour la biodiversité et les écosystèmes marins. Cette initiative permettrait de mettre en perspective les différentes technologies d'énergies marines renouvelables malgré leurs différents stades de développement et ainsi choisir la technologie la plus adaptée pour limiter les impacts sur la biodiversité.
- Identifier et évaluer les services écosystémiques des zones côtières afin de mieux guider les réflexions dans le choix des zones de déploiement des parcs éoliens offshores.
- Pour veiller à ce que les habitats dégradés bénéficient d'une possibilité de recolonisation, plusieurs recommandations spécifiques sont émises par les experts :
    - En concertation avec les experts, définir une surface maximale acceptable de dégradation des fonds pour l'ensemble des activités à l'échelle du Golfe du Lion et l'intégrer aux documents de planification de l'espace maritime afin de concilier les activités générant une destruction des fonds marins. La réduction de la surface de dégradation permettra d'assurer la fonctionnalité des habitats à large échelle et ainsi limiter les risques d'effondrement des écosystèmes dépendant des habitats de substrats meubles. Selon les experts, des accords avec les autres activités sources de dégradations des fonds devront être trouvés afin de ne pas augmenter la surface de dégradation actuelle des substrats meubles.
    - Conserver un maillage fonctionnel dans le schéma d'installation des éoliennes flottantes afin de veiller à ce que les habitats dégradés soient entourés d'habitats non dégradés assurant une recolonisation rapide des substrats post-travaux et garantissant un minimum de fonctionnalité à ces habitats.
    - Veiller à ce que la taille des infrastructures flottantes et la distance entre elles n'impacte pas la luminosité naturelle de la colonne d'eau de façon à ce que le fonctionnement et la productivité naturelle de la zone euphotique soient préservés.

Perspectives

L'ensemble des résultats collectés au sein des 5 compartiments de l'écosystème étudiés (cétacés et tortues marines, oiseaux et chiroptères, communautés planctoniques, poissons et céphalopodes, habitats benthiques du plateau continental) vont être comparés et synthétisés afin de fournir une vision écosystémique des contributions d'experts.

Le rapport final intégrant l'ensemble des contributions pour toutes les composantes de l'écosystème sera présenté aux autorités compétentes de la planification de l'espace maritime (PEM) au sein d'un atelier de restitution en janvier 2022. Les lacunes de connaissances identifiées et les recommandations d'experts y seront particulièrement soulignées.

En conclusion des travaux MSPMED, les experts sont invités à compléter la liste des recommandations établies lors de l'atelier 4 avant le 10 décembre prochain. Ces recommandations seront transmises aux autorités compétentes afin d'améliorer la connaissance et de mieux intégrer la prise en compte des effets des parcs éoliens flottants sur l'écosystème afin de les suivre, les documenter et les limiter.

Toutes les contributions sont importantes et permettront (i) d'étayer le rapport final portant sur l'amélioration de la connaissance des risques d'interaction entre les écosystèmes marins et le développement de l'éolien flottant dans le golfe du Lion et de (ii) proposer une note de recommandation pertinente aux autorités compétentes en France dans le cadre des projets de développement des parcs commerciaux, et en Espagne pour nourrir les réflexions liées à la planification maritime des EMR.

Annex 7

Synthesis of “pressure – receptor” matrix for “Cetaceans and sea turtles”

This table results from the work carried out by the “Cetaceans and sea turtle” MSP-MED working groups (*see illustration below*) and additional bibliography (Kropp RK., (2013); Taormina B., & al., (2018); Blair HB., & al., (2016); Erbe C., & al., (2019); Persohn C., & al., (2020); Todd VLG., & al., (2014); Tusjii K., & al., (2018); Weilgart LS., (2007); Defingou M., & al., (2019); Thums M., (2016); Benjamins S., (2014)). **This methodological and prospective table derived from a risk-based approach and cannot be applied to a specific site or a defined project**.

	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electro-magnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement
CETACEANS	Aggregation/ Concentration of fish due to changes of uses, Changes in community and population structure, Changes of attendance rate (to abandonment) [Defingou., 2019]	Avoidance, Disturbance (feeding, resting, nesting, etc.)	Aggregation/ Concentration of fish due to the addition of substrate (floating structure, etc.), Changes in the distribution and availability of preys	Changes in spatial distribution due to prey distribution [Todd., 2014]	Changes in the distribution and availability of prey, Changes of habitats and associated food web	Physical damages (auditory system), Changes in the distribution and availability of prey, Behavioural changes, Increased stress, Changes in communication (social interactions, group cohesion, cultural transmission, etc.), Disruption of environmental recognition (coastal noise, prey and predator detection), Decrease/stop of vocalizations [Weilgart & al., 2007], Acoustic masking (inter-individual communication, prey/predator detection, Lombard effects) [Pershon., 2020]		Attractive effects on preys and predators		Changes in community and population structure	Changes of habitats and associated food web, Changes in the distribution and availability of preys	Changes of habitats and associated food web, Changes in the distribution and availability of preys			Entangle-ment, Laceration and infection [Kropp & al., 2013 ; Taormina & al., 2018]
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)	x	Avoidance, Disturbance (feeding, resting, nesting, etc.)	Changes of habitats and associated food web, Changes in community and prey population	Reduce the effectiveness of underwater vision	x	Behavioural changes (change in direction, escape, increase in swimming speed, change in diving behaviour, whistle frequency, number and duration of dives) [Erbe., 2019]	Avoidance effect of vibro-compaction	x		High risk (feed under the platforms)	x	x	Injury and mortality, Less sensitive as agile and faster species	Avoidance, Bypassing of the area (impact life cycle & survival rate)	x
Fin whale, *Balaenoptera physalus*	Mediterranean population particularly		x	x	x	Behavioural changes (change in direction, escape, increase in swimming speed, change in diving behaviour, whistle		x		x	x	x	Injury and mortality, High risk due to large	Avoidance, Bypassing of the area (impact life	Low capacity for cable detection and agility

(Linnaeus, 1758)	specialized and less resilient					frequency, number and duration of dives), Decrease/stop of vocalizations [Defingou., 2019]							species with reduced mobility	cycle & survival rate)	[Benjamin & al., 2014]
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)	Specific ecology on the continental shelf and canyons. More sensitive to changes, Specific ecology and low adaptive capacity		x	x	x	High sensitivity to underwater noise, Additional disturbance, Behavioural changes (change in direction, escape, increase in swimming speed, change in diving behaviour, whistle frequency, number and duration of dives), Decrease/stop of vocalizations [Defingou., 2019]		x		x	x	x	Injury and mortality, High risk due to large species with reduced mobility	Avoidance, Bypassing of the area (impact life cycle & survival rate)	Low agility due to its size [Benjamin & al., 2014]
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)	x		x	x	x	High sensitivity to underwater noise	x	x		x	x	x			x
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)	Specific ecology and low adaptive capacity		x	x	x	x	x	x		x	x	x			x
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)	x		x	x	x	x	x	x		x	x	x			x
Sea turtles	Changes in the distribution and availability of prey, Changes of habitats and associated food web	Avoidance, Disturbance (feeding, resting, nesting, etc.)	Changes of habitats and associated food web	Changes of the feeding behaviour, Reduce the effectivenes s of underwater vision	Changes in the distribution and availability of prey, Changes of habitats and associated food web	Physical damages (loss of sensitivity, injury), Reducing of hearing sensitivity, Avoidance, Acoustic masking, Increased stress, [Defingou., 2019], Behavioural change (increasing swimming speed, changing speed travel, cessation of search activities, changes in breathing patterns, etc.) [Blair & al., 2016. Tusjii & al., 2018]		Disruption of orientation capacity (exhaustion, dehydration, predation), Deviation of hatching trajectory and disorientatio n (death, exhaustion, dehydration, predation) [Thums & al., 2016]	Disorientati on	Changes in community and population structure	Changes of habitats and associated food web, Changes in the distribution and availability of preys	Changes of habitats and associated food web, Changes in the distribution and availability of preys	Injury and mortality, High risk at the surface	Avoidance, Bypassing of the area (impact life cycle & survival rate)	Entanglement, Low capacity for cable detection and agility [Benjamin & al., 2014]

Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)	Modify the distribution and availability of food for young and juveniles, Impact for species that migrate long distances to feed	x	x	x	x	Acoustic masking (communication signals), Changes of the feeding behaviour	Attractive effects on juveniles, Attractive effects on feeding resources	Disorientation (orientation, navigation, migration)	x	x	x	High risk at the surface	Disturbance, Modification of distribution of breeding male/female	x

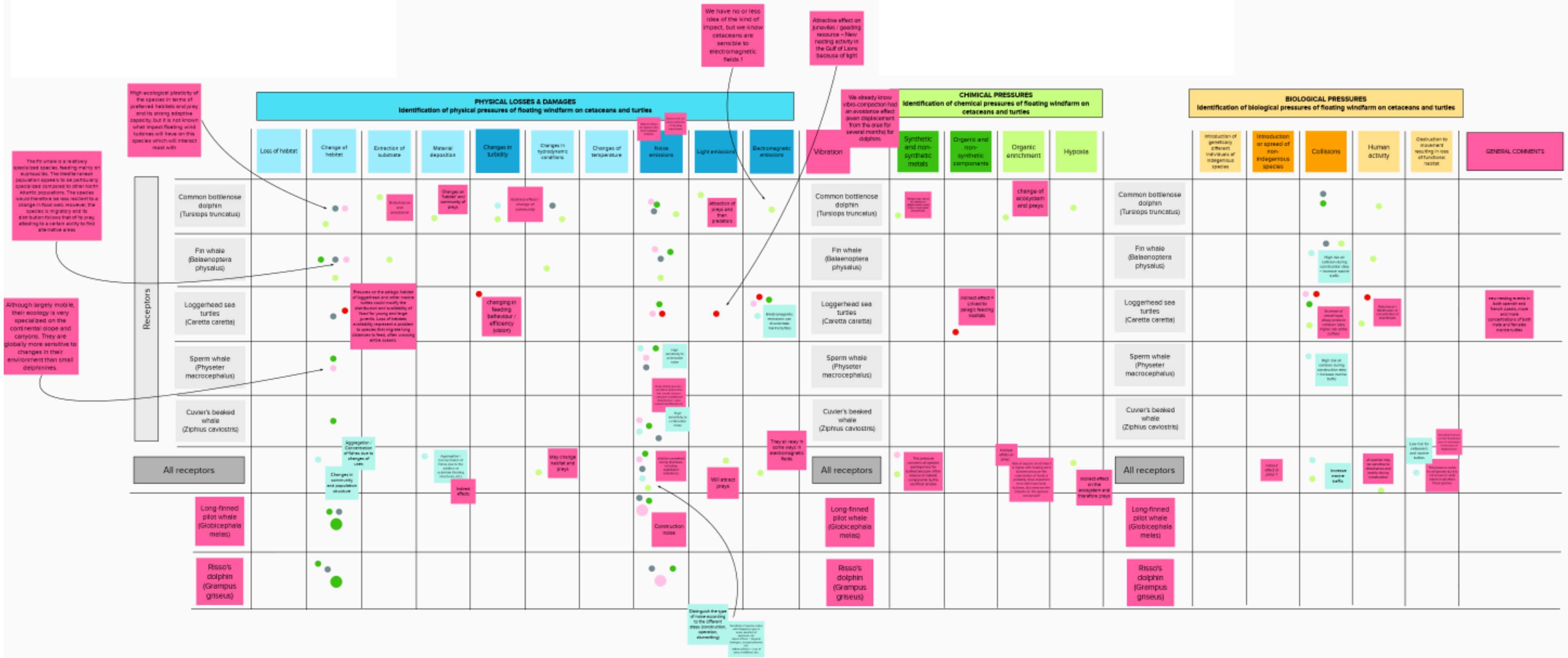

Illustration 1: Screenshot of the online workspace provided (on MURAL) to identify the pressure-receptor pairs with the "Cetaceans and sea turtles" working group

Annex 8

Synthesis of “pressure – receptor” matrix for “Flying fauna”

This table results from the work carried out by the “Flying fauna” MSP-MED working groups (*see illustration below*) and additional bibliography (Blew J., & al., (2008); Lieber L., & al., (2021); Mendel B., & al., (2019); Nilsson., (2012); Vanermen N., & al., (2015); Nilsson L., & Green M., (2011); Dierschke V., & al.? (2016); Furness RW., & al., (2013); Skov H., & al., (2018); Welcker J., & al., (2016)). **This methodological and prospective table derived from a risk-based approach and cannot be applied to a specific site or a defined project**.

	Loss of habitat	Changes of habitat	Changes in turbidity	Changes in hydrodynamic conditions	Noise emissions	Light emissions	Electro-magnetic emissions	Chemical pollution	Organic enrichment & Hypoxia	Collision	Human activity	Obstruction to movement
Migratory bats	Avoidance of windfarm (increase foraging effort and impact the feeding and reproductive success)	Avoidance of windfarm			Possible impact on bats	Direct attraction effects	Unknow for bats			Direct effects		Species sensitive to the barrier effect
Foraging bats	Avoidance of windfarm (increase foraging effort and impact the feeding and reproductive success)	Avoidance of windfarm. Possible attraction if platform attract the insects			Possible impact on bats	Direct attraction effects	Unknow for bats			Direct effects		Species sensitive to the barrier effect
FLYING FAUNA	Avoidance of windfarm (increase foraging effort and impact the feeding and reproductive success). Avoidance. Change in bird abundance (noise and visual disturbance) due to vertical structures, Significant changes in species distribution (desertion or reduction of visiting) [Mendel & al., 2019].	Modification of pelagic communities (indirect effect). Aversion leading to change the spatial distribution. Temporary aggregation effect, Reserve effect, Perch effect, Disturbance, increase frequentation of mobile pelagic species that use the structure (feeding, orientation, protection, etc.). Attraction effect by adding an artificial resting or feeding area [Dierschke & al., 2016].				Indirect effect by attracting prey. Potential attraction by light emission. Increases risk of disorientation, exhaustion, collision and predation				Immediate mortality and injury, Barotrauma (depending on flight and blade characteristics and heights)		Modification of flight path. Increased energy expenditure. Avoidance of the functional area (feeding, breeding, resting).
Passerines	Species particularly sensitive to the loss of habitat (avoidance) [Mendel & al., 2019]					x				x		x
Raptors	x	Possible attraction effect [Defingou., 2019]				x				High risk during migration period but low risk for the area		x

										concerned [Defingou., 2019]		
Anatidae & Rallidae	x	Habituation phenomenon can be observed [Nilsson., 2011]				Species very sensitive to light emissions				High risk because of flight height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species [Furness & al., 2013]	Reduce functional habitat due to maritime traffic	Species very sensitive to the barrier effect
Shorebirds	x	x				Light pollution can disrupt bird migration at sea [Blew & al., 2008]				x		x
Loons	Decrease of abundance (even desertion) [Vanermen & al., 2015 ; Dierschke & al., 2016 ; Welcker & Nehls., 2016]	x	Turbidity can affect diving species in their foraging success							High risk because of flight height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species [Furness & al., 2013]	Reduce functional habitat due to maritime traffic	Species very sensitive to the barrier effect
Wader species		x								x		x
Herons & allies	x	x								x		x
SEABIRDS	Avoidance behaviour that reduces the risk of collision [Defingou., 2019]	Modification of communities that favour the development of a specific marine fauna. Movement of vertical structures can lead to desertion of sensitive species. Modification of the behaviour and location of seabirds.		Effects on pelagic habitats (changes in the distribution of prey, modify the feeding areas). Impact more breeding seabirds [Lieber & al., 2021]		Direct attraction effects. Increase risk of disorientation and collision [Defingou., 2019]		Oil spill at sea may affect physical integrity.	Indirect effect (contamination of the food web).	Varies according to flight height. Specific to each species and weather conditions [Defingou., 2019]	Disturbance due to increased air and sea traffic. Risk depending on the species considered (agility, weather conditions, manoeuvrability, etc.) [Defingou., 2019]. Significant increase in the relative abundance of fish [Defingou., 2019]. Disturbance due to increased shipping traffic. Food attractiveness through boat tracking	Increase energy expenditure. Barrier effect on local movements (increase distance to colonies and feeding areas). Barrier effect on migration routes
Cormorants	x	Specie known to forage in the vicinity of anthropogenic infrastructure [Vanermen & al., 2015]. Attraction by resting effect	Turbidity can affect diving species in their foraging success	More impacted by changes of pelagic habitats [Lieber & al., 2021]		x		Sensitive species to accidental pollution and oil spills (loss of waterproofness, poisoning,	x	High risk because of flight height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species	x	Species very sensitive to the barrier effect

								etc.). Species sensitive to chemical pollution at sea.		[Furness & al., 2013]		
Shearwaters	Species particularly sensitive to the loss of habitat (avoidance) [Mendel & al., 2019]	x	Turbidity can affect surface-feeding species in their foraging success	x		Species very sensitive to light emissions		x	x	x	Increase risk of collision (fly over vessels in activity)	x
Gulls	Species particularly sensitive to the loss of habitat (avoidance) [Mendel & al., 2019]	Specie known to forage in the vicinity of anthropogenic infrastructure [Vanermen & al., 2015]. Attraction by resting effect		x		x		Species sensitive to chemical pollution at sea.	x	High risk because of flight height at rotor level.	Increase risk of collision (fly over vessels in activity). Increase risk of collision (increase the presence of fishermen)	x
Terns	Species particularly sensitive to the loss of habitat (avoidance) [Mendel & al., 2019]	Specie known to forage in the vicinity of anthropogenic infrastructure [Vanermen & al., 2015]. Attraction by resting effect	Turbidity can affect surface-feeding species in their foraging success	More impacted by changes of pelagic habitats [Lieber & al., 2021]		x		Species sensitive to chemical pollution at sea.	x	x	x	x
Hydrobatidae	x	x	Turbidity can affect surface-feeding species in their foraging success	X		x		Species sensitive to chemical pollution at sea.	x	x	x	x
Razorbills	x	x		X		Species very sensitive to light emissions		Sensitive species to accidental pollution and oil spills (loss of waterproofness, poisoning, etc.).	x	High risk because of flight height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species [Furness & al., 2013]	x	x
Puffins	x	x		X		x		Sensitive species to accidental pollution and oil spills (loss of waterproofness, poisoning, etc.).	x	High risk because of flight height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species [Furness & al., 2013]	x	x
Skua sp.	x	x		X		x		x	x	x	x	x
Northern Gannet, *Morus bassanus*	Species particularly sensitive to the loss of		Turbidity can affect surface-	x		x		Species sensitive to	x	High risk because of flight	x	x

(Linnaeus, 1758)	habitat (avoidance) [Mendel & al., 2019]. Decrease of abundance (even desertion) [Vanermen & al., 2015 ; Dierschke & al., 2016 ; Welcker & Nehls., 2016]		feeding species in their foraging success					chemical pollution at sea.		height at rotor level [Defingou., 2019]. Risk of underwater collision for diving species [Furness & al., 2013]		

Illustration 2: Screenshot of the online workspace provided (on MURAL) to identify the pressure-receptor pairs with the “Flying fauna” working group

Annex 9

Synthesis of “pressure – receptor” matrix for “Benthic communities and habitats”

This table results from the work carried out by the “Benthic communities and habitats” MSP-MED working groups (*see illustration below*) and additional bibliography (Coolen JW., & al., (2016); Defingou M., & al., (2019); Weilgart L., (2018); ICES., (2019); Langhamer O., & al., (2009); Tyrrell MC., & Byers JE., (2007); Lüdeke J., (2015); Schvartz T., (2021)). **This methodological and prospective table derived from a risk-based approach and cannot be applied to a specific site or a defined project**.

	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Change in temperature	Noise emissions	Light emissions	Electro-magnetic emissions	Chemical pollution	Introduction of individuals genetically different from local species	Dispersal of non-native species
HABITATS	Long-term modification of soft substrates with/without specific facies; Loss of habitat du to sediment remobilisation for less mobile species. Loss of habitat and associated communities [Schvartz., 2021]. Negligible short-term effect on soft substrate and long-term increase in benthos [Lüdeke., 2015]. Loss of habitat limited to the park/cable area; Impact depending on substrate and foundation type [Defingou., 2019]. Loss of critical habitat depending on its ecosystem role [ICES.,	Concerns all habitats (destruction and/or modification of the substrate); Long-term modification of soft substrates with/without facies (chain movement); Abrasion of bottom seabed [Schvartz., 2021]. Possible reversible effect (recolonisation in the long-term depending on the intensity of the impact, the structure of the seabed and the associated benthic communities) [Defingou., 2019]. Movement of chains could conduct to scouring of the seabed and damage benthic habitats around the anchorage point [ICES., 2019]. Reef effect by adding organic matter and increasing trophic activity; Addition of an obstacle in the water can creating a vibration that attracts some species; Indirect effect induced by modification of the water column and associated food web. Extension of the distribution of some mobile species; Positive/neutral effect with colonisation of indigenous species (ecological niches)	Cables in *Posidonia* meadows	Almost no impact on soft substrates (depends on the type of soft substrate); Direct loss of vegetation (reduction of growth density, biomass, etc.). Impact localised to the area of the cables [Defingou., 2019]	Depends on the duration of deposition and the surface area, Muds less sensitive to resuspension of fine particles. Increase in turbidity [Taormina, 2018]. Disturbance of shallow sediments (works and positioning of anchors) ; Affects marine vegetation (Posidonia meadows and sandy substrates - slow recovery) [Defingou., 2019]. Remobilisation of sediments; Accumulation of sediment on the seabed; Sedimentation and turbidity depending on hydrological	Limited and localised impact; Modification of bottom currents; Modification of connectivity and flow (indirect effect and biological pressure). Modification of sediment dynamics by destruction of seagrass beds that retain sediment [Defingou., 2019]. Changes in sedimentation patterns, particle size and nutrient content that can lead to habitat fragmentation [ICES., 2019]		Noise which can play a role in the functioning of habitats (Coralligenous biocenosis) and vibrations which can increase the attractiveness of some species.			Accumulation of pollutants in sediments		

	2019].	or negative effect with colonisation of invasive species [Defingou., 2019]. Increase in available colonisation area [ICES., 2019]. Colonisation by planktonic larvae/migration from nearby artificial structures/natural reefs [Langhamer, 2009].			conditions, particle size, type and duration of deployment ; Benthic communities can recover on soft substrates more easily than hard substrates [ICES., 2019].								
SPECIES	Impacts the diversity of benthic invertebrate/vertebrate populations and the food web; Loss of habitat du to sediment remobilisation for less mobile species; Sensitive species are mainly *Cymodocea* meadows and coralligenous biocenosis. Change in species composition and increase in vegetation; Negligible short-term effect on soft substrate and long-term increase in benthos [Lüdeke., 2015]. Loss of sessile benthic communities associated to exposed rocks, gravels, coarse sands, and	Impact on the diversity of benthic invertebrate/vertebrate populations and the food web; Possible reversible effect (recolonisation in the long-term depending on the intensity of the impact, the structure of the seabed and the associated benthic communities) [Defingou., 2019]. Creation of new habitats for mobile demersal megafauna associated with hard substrate (after 2 years, 100 times more hard substrates species on foundations than on soft substrates); Foundation can be used as a breeding area [Lüdeke., 2015]. Increased habitat complexity and altered ecosystem functioning [Coolen, 2018].		Impact of all species (depends to their mobility). Increase in endobenthic; Increase richness in the impact area [Lüdeke., 2015]	Injury to sedentary benthic organisms; Increased turbidity detrimental to some benthic species made more vulnerable to predation; Mortality due to obstruction of feeding/filtration organs of filter feeders (mussel beds, seagrass beds and reefs) [Defingou., 2019]. Smothering of benthic communities; Alteration of filter feeding efficiency in invertebrates [ICES., 2019]	Modification of connectivity and flow (indirect effect and biological pressure). Benthic communities impacted by changing bottom sediment transport pathways [Defingou., 2019]	Low and very localised impact; Mainly affects cold water species, deep sessile species (Isidella and gorgonians) and species at the limit of their distrbution range (infralittoral species less sensitive due to the summer temperature variations) ; Cable maybe attract some species ; Impact on benthic invertebrates. Crabs that seem to be attracted by cables [Defingou., 2019]. Variable heat transmission depending on the nature of the sediments (cohesive sediments that emit more heat than coarse sediments);	Risk of malformation of crustacean larvae and mortality of larvae [Weilgart, 2018]. Positive effect in some bryozoan species with increased colonisation behaviour [Defingou., 2019]. Impact physiology and behaviour of some crab species (increased stress levels) that can lead to an increase of risk of predation; Increased oxygen consumption [ICES., 2019].	Impact on the nycthemeral cycle of some species; Low impact on benthos but not negligible for some species whose life cycle is influenced by the moon/light (crustaceans/bivalves). Decrease in natural light can limits the development of photosynthetic organisms and coral reefs; Significant impact on photosynthetic species/habitats (coraligenous, coastal detritus, algae)	Disrupts reproduction of some sedentary species. Species-specific effects in benthic invertebrates (crustaceans, bivalve molluscs, sea urchins, benthic fish, etc.) ; Modification of the immune and embryonic functioning of some species ; Behavioural and physiological effects on benthic organisms (studies needed to assess thresholds) [ICES., 2019]	Accumulation of pollutants in sediments and contamination of the food web; Impact on benthic communities through sediment remobilisation. Contamination of planktonic species (accidental pollution, etc.) can affects the trophic web; Change in the benthic food web; Source of bioaccumulation of pollutants in sedimentary organisms [ICES., 2019]	Introduction of individuals genetically different from local species and modification of connectivity (ballast water + fish population previously disconnected from the area) bringing their pathogens and modifying existing populations. Colonisation opportunity in competition with native population [Tyrrel., 2007]. Addition of hard substrate in soft sediments can offer new niches for species and lead to a secondary dispersal [ICES., 2019]	Dispersal of non-native species that may weaken ecosystems already under pressure. Infrastructure may act as a springboard for the establishment of new populations of non-native species [ICES., 2019]

	muds more sensitive than highly mobile clays and sands [Defingou., 2019].						Modification of the chemical and physical properties of the substrate; Modification of the oxygen concentration profile and development of microbial/bacterial communities; Impact on the physiology of benthic organisms [ICES., 2019].						

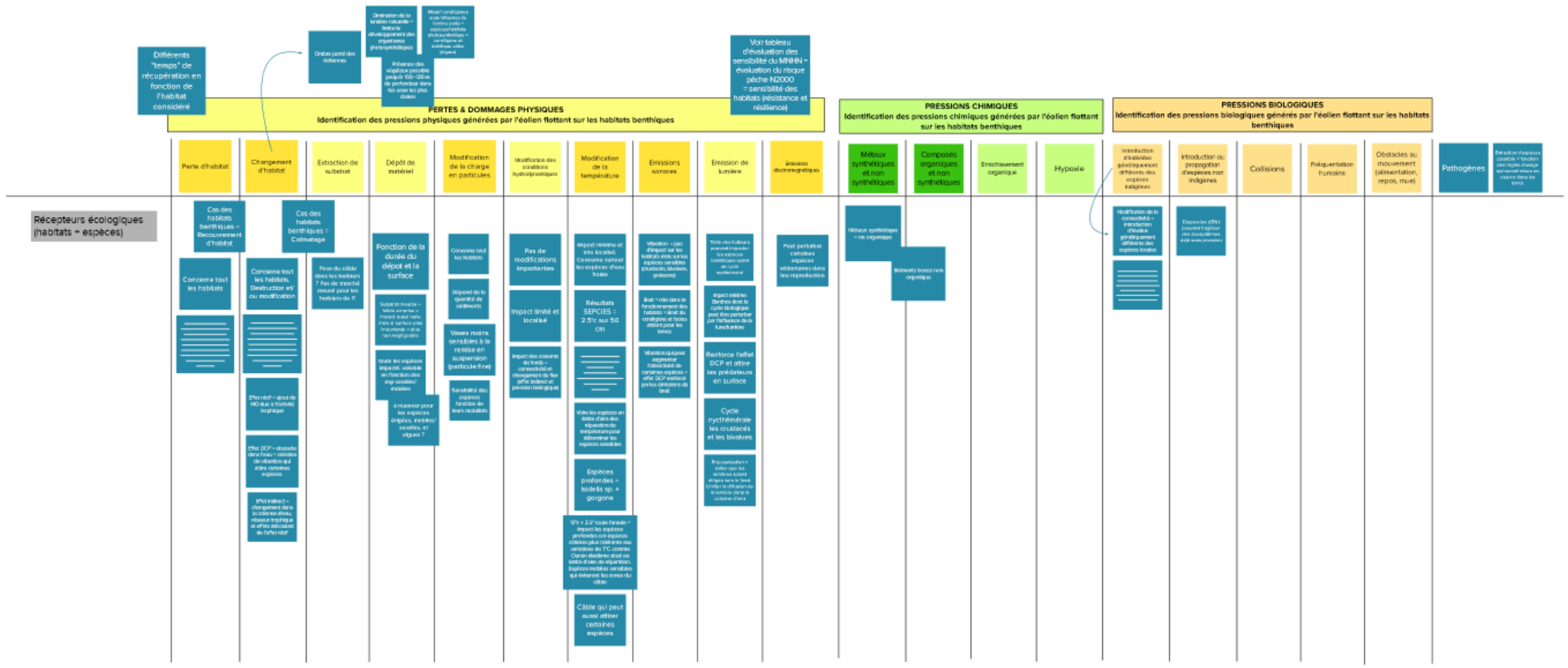

Illustration 3: Screenshot of the online workspace provided (on MURAL) to identify the pressure-receptor pairs with the "Benthic communities and habiats" working group (French only)

Annex 10

Synthesis of "pressure – receptor" matrix for "Planktonic communities"

This table results from the work carried out by the "Planktonic communities" MSP-MED working groups (*see illustration below*) and additional bibliography (Belmonte G., & Rubino F., (2019); Jiang Z., & al., (2010); Sardou J., & Andersen V., (2019)). **This methodological and prospective table derived from a risk-based approach and cannot be applied to a specific site or a defined project**.

	Changes of habitat	Changes in turbidity	Changes in hydrodynamic conditions	Change in temperature	Noise emissions	Light emissions	Chemical pollution	Introduction of individuals genetically different from local species
PLANKTONIC COMMUNITIES	Linked to hydrodynamic changes; Changes in primary production; Modification of the distribution of zooplankton and predators; Increase in benthic species; Local increase in plankton with meroplanktonic phase (polyps/medusae); Increase in the development area of cnidarian polyps	Resuspension of dinoflagellate sedimentation cysts; Loss of habitat (polyps and colonising species); Disrupts benthic larval phases; Potential effect on community stability (threshold effect - e.g. change in dominant species); Limits access to nutrients for species hidden during the day; Favours some more competitive species; Physiological stress; Disrupts growth; Resuspension of cysts(germination or damage) [Belmonte & Rubino., 2019]	Disrupts phytoplankton dynamics; Modification of stratification; Increase/reduction of primary production; Modification of particle transport and zooplankton communities; Increase/concentration effect of meroplankton density; Indirect effect on the food web; Indirect effect on hydrographic conditions; Modification of community composition (especially phytoplankton); Modification of food access (local agitation); Physiological stress due to continuous turbulence; Reorganisation of planktonic communities (observable during strong gales); Modification of nutrient transfers; Accentuation of vertical mixing. Increased energy expenditure; Favours more generalist species (range of tolerance)	Effects on metabolism and physiology (development, growth); Limits the establishment of some polyp species; Effect on species at the edge of their range	Behavioural changes; Sensory and physiological damage; Larval malformation; Growth and reproduction retardation	Changes in the development of planktonic organisms; Reduction in the efficiency of photosynthesis; Changes in reproductive rates; Impacts on survival rates, fecundity rates, hatching rates and feeding activities; Behavioural changes (limits upwelling of some species, increases predation); Modification of nychthemeral migrations [Sardou & Andersen, 1993]	Bio-accumulation / amplification along trophic web and differential impacts on predators; Changes in reproduction rates [Jiang & al., 2010]	Establishment of meroplanktonic species (hydromedus); Modification of connectivity; Facilitates the expansion of some exotic (potentially invasive) species; Modification of connectivity; Possible anchorage point for hydromedusae

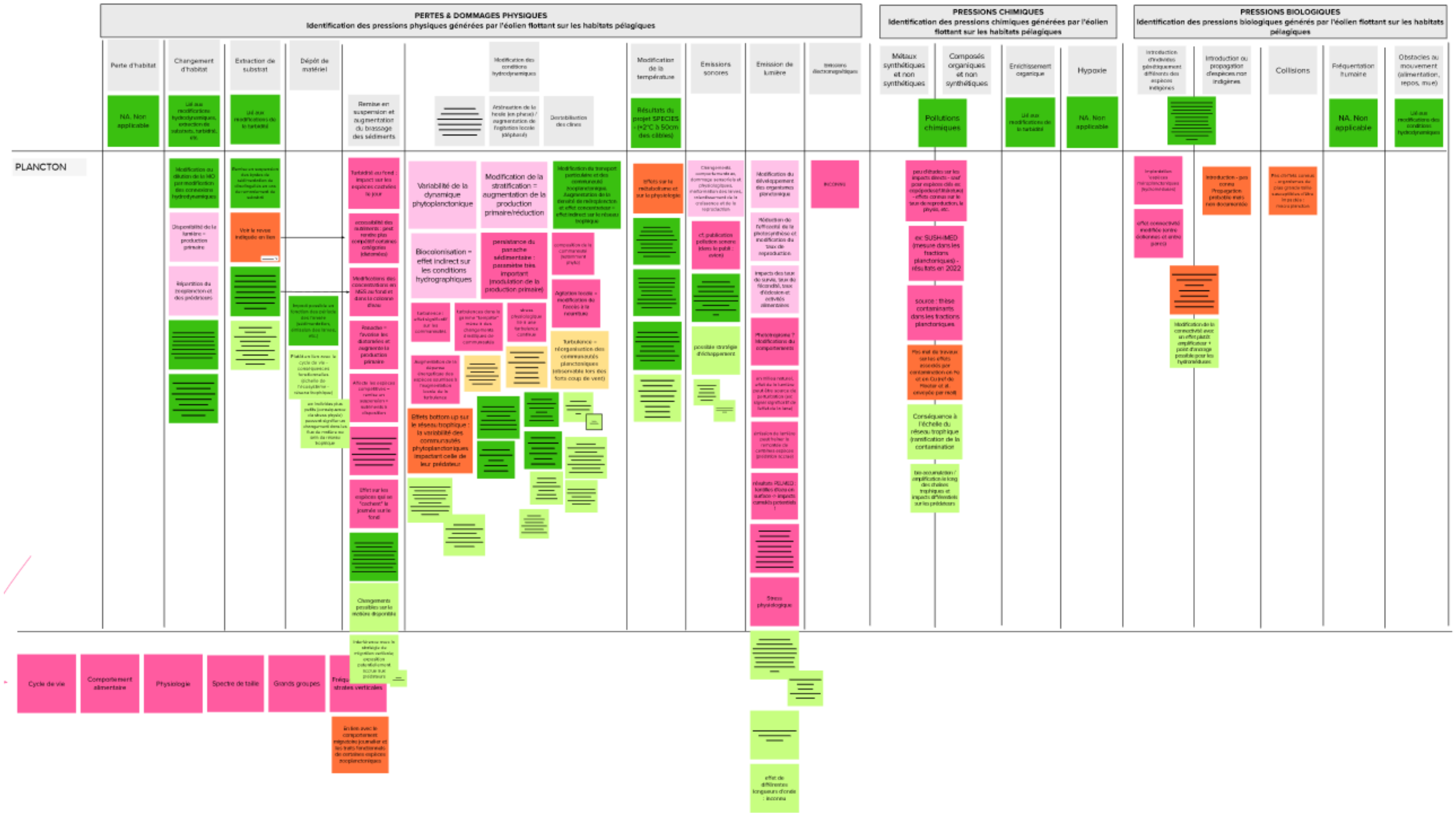

Illustration 4: Screenshot of the online workspace provided (on MURAL) to identify the pressure-receptor pairs with the "Planktonic communities" working group (French only)

Annex 11

Synthesis of "pressure – receptor" matrix for "Fish and cephalopods"

This table results from the work carried out by the "Flying fauna" MSP-MED working groups (*see illustration below*) and additional bibliography (Kjelland ME., (2015); Langhammer O., (2012); Popper AN., & Hawkins AD., (2019); Popper AN., & al., (2019); Stenberg C., & al., (2015); Van Hal R., & al., (2017); Wenger AS., & al., (2017)). **This methodological and prospective table derived from a risk-based approach and cannot be applied to a specific site or a defined project**.

	Part 1								
	Loss of habitat	Changes of habitat	Extraction of substrate	Changes in turbidity	Changes in hydrodynamic conditions	Change in temperature	Noise emissions (acoustic)	Noise emissions (vibration)	Electro-magnetic emissions
BENTHIC SOFT SUBSTRATE									
Eggs and larvae	Mortality and injury due to chain movements; Degradation of habitats and functional areas (nesting and larval rearing areas); Loss of support available for egg attachment	Degradation of habitats and functional areas (nursery, shelter, feeding areas); Loss of support available for egg attachment; Attraction of predators	Punctual/permanent loss of support available for egg attachment; Destruction or removal of eggs	Punctual loss of oxygenation ; Increased physiological stress ; Disruption of growth and development ; Reduced visibility and impact on the food web ; Influences growth, development and swimming ability [Wenger, 2017].	Physiological stress ; Mortality (drift of larvae to unfavourable areas) ; Loss of areas favourable to oxygenation of eggs	Changes in behaviour (attraction/repulsion depending on the species) and associated trophic relationships ; Physiological stress	Physiological stress (increased ambient noise) and auditory impact ; Changes in prey/predator relationships		
Juveniles	Degradation of habitats and functional areas (nursery, shelter, feeding areas)	Decrease in the recruitment rate; Attraction of predators; Decreased survival rate (less suitable habitat)	Degradation of habitats and functional areas (nursery, shelter, feeding areas); Habitat abandonment	Reduced visibility and impact on the food web ; Risk of anoxia ; Increased physiological stress ; Suffocation by clogging of the gills ; Behavioural changes (avoidance) ; Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Increased energy expenditure linked to search of preys ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Physiological stress ; Loss of food (indirect effect) ; Changes in prey/predator ratios	Changes in behaviour (attraction/repulsion depending on the species) and associated trophic relationships ; Physiological stress ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Disruption of phenology ; Increase in the rate of epizootics	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Behavioural changes (foraging, spawning, etc.)	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of predator/prey interactions ; Modification of behaviour (attraction/avoidance) ; Modification of navigation and orientation abilities of species ; Physiological and developmental effects
In transition	Change of migration routes.	Decreased survival rate (less suitable habitat); Change in connectivity; Barrier to migration (physiological stress and/or predation)	Degradation of habitats and functional areas (nursery, shelter, feeding areas)	Reduced visibility and impact on the food web ; Risk of anoxia ; Physiological and respiratory disturbances ; Suffocation by clogging of the gills ; Behavioural changes (avoidance) ; Influences growth, development and swimming ability [Wenger, 2017].	Physiological stress ; Change of migration routes ; Changes in prey/predator ratios	Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Disruption of phenology ; Increase in the rate of epizootics ; Change of migration routes	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Behavioural changes (foraging, spawning, etc.) ; Behavioural	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of behaviour ; Modification of specific interactions ; Modification of navigation and orientation abilities

							change (migration) [Popper, 2019]		of species
Adults	Degradation of habitats and functional areas (nursery, shelter, feeding areas)	Decreased survival rate (less suitable habitat); Change in connectivity; Variation in biomass and abundance; Changes of food web	Degradation of habitats and functional areas (nursery, shelter, feeding areas); Habitat abandonment	Reduced visibility and impact on the food web ; Risk of anoxia ; Physiological and respiratory disturbances ; Suffocation by clogging of the gills ; Behavioural changes (avoidance) ; Limits movement ; Increased energy expenditure linked to search of preys ; Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Physiological stress ; Change of migration routes ; Changes in prey/predator ratios	Disruption of egg-laying periods ; Changes in behaviour (attraction/repulsion depending on the species) ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Disruption of phenology ; Increase in the rate of epizootics	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Physical injuries and physiological changes ; Masking of important biological sounds ; Changes in predation and prey-seeking behaviour [Popper & Hawkins, 2019] ; Behavioural changes (spawning, foraging, feeding) ; Physiological changes (stress effects) [Popper 2019]	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of specific interactions ; Modification of predator/prey interactions ; Modification of behaviour (attraction/avoidance) ; Modification of navigation and orientation abilities of species ; Physiological and developmental effects
BENTHIC HARD SUBSTRATE									
Eggs and larvae	Mortality and injury due to chain movements ; Degradation of habitats and functional areas (nesting and larval rearing areas).	Decrease in the recruitment rate (function of type of substrate) ; Increases instability of egg attachment ; Attraction of predators.	Punctual/permanent loss of support available for egg attachment ; Destruction or removal of eggs	Punctual loss of oxygenation ; Increased physiological stress ; Disruption of growth and development ; Reduced visibility and impact on the food web ; Influences growth, development and swimming ability [Wenger, 2017].	Physiological stress ; Mortality (drift of larvae to unfavourable areas) ; Loss of areas favourable to oxygenation of eggs	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological stress	Physiological stress (increased ambient noise)		
Juveniles	Degradation of habitats and functional areas (nursery, shelter, feeding areas).	Degradation of habitats and functional areas (nursery, shelter, feeding areas) ; Variation in biomass and abundance ; Decrease in the recruitment rate (function of type of substrate) ;	Habitat abandonment	Reduced visibility and impact on the food web ; Behavioural changes (avoidance) ; Suffocation by clogging of the gills ; Changes in trophic relationships ; Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Limits movement ; Increased energy expenditure linked to search of preys ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Physiological stress ; Loss of food (indirect effect) ; Changes in prey/predator ratios	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Change in connectivity	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Behavioural changes (foraging, spawning, etc.)	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of behaviour (attraction/avoidance) ; Physiological and developmental effects
In transition	Change of migration routes.	Change in connectivity ; Increased stepping stones effect between habitats		Reduced visibility and impact on the food web ; Behavioural changes (avoidance) ; Suffocation by clogging of the gills ; Changes in trophic relationships ; Influences	Physiological stress ; Change of migration routes ; Changes in prey/predator ratios	Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ;	Physiological stress (increased ambient noise) ; Behavioural change (migration) [Popper, 2019]	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of navigation and orientation abilities

				growth, development and swimming ability [Wenger, 2017].		Change in connectivity			of species
Adults	Degradation of habitats and functional areas (nursery, shelter, feeding areas).	Change in connectivity ; Variation in abundance ; Changes of food web	Degradation of habitats and functional areas (nursery, shelter, feeding areas) ; Habitat abandonment	Reduced visibility and impact on the food web ; Behavioural changes (avoidance) ; Suffocation by clogging of the gills ; Changes in trophic relationships ; Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Limits movement ; Increased energy expenditure linked to search of preys ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Physiological stress ; Change of migration routes ; Changes in prey/predator ratios	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Change in connectivity	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Physical injuries and physiological changes ; Masking of important biological sounds ; Changes in predation and prey-seeking behaviour [Popper & Hawkins, 2019] ; Behavioural changes (spawning, foraging, feeding) ; Physiological changes (stress effects) [Popper 2019]	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of predator/prey interactions ; Modification of behaviour (attraction/avoidance) ; Modification of navigation and orientation abilities of species ; Physiological and developmental effects
PELAGIC									
Eggs and larvae	Change of migration routes ; Changes in productivity	Possible colonisation of floats		Reduced visibility and impact on the food web ; Increased mortality rate ; Asphyxiation by suffocation ; Influences growth, development and swimming ability [Wenger, 2017].	Increased risk of predation ; Increased energy expenditure linked to search of food ; Physiological stress ; Mortality (drift of larvae to unfavourable areas)	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological stress	Physiological stress (increased ambient noise)		
Juveniles	Degradation of habitats and functional areas (nursery, shelter, feeding areas) ; Attraction of species and predators	Temporary aggregation effect ; Attraction of predators ; Variation in abundance ; Changes in community structure ; Reduction in the number of target species	Habitat abandonment	Reduced visibility and impact on the food web ; Behavioural changes (avoidance) ; Suffocation by clogging of the gills ; Changes in eating behaviour ; Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Limits movement ; Increased energy expenditure linked to search of preys ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Increased energy expenditure linked to search of food	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Change in connectivity	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Behavioural changes (foraging, spawning, etc.)	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.) ; Reinforcement of the FAD effect (increased attractiveness to vibration-sensitive species).	Changes in distribution and community structure ; Modification of behaviour (attraction/avoidance) ; Physiological and developmental effects
In transition	Loss of quality of nursery areas	Degradation of habitats and functional areas (nursery, shelter, feeding areas) ; Change in connectivity		Reduced visibility and impact on the food web ; Influences growth, development and swimming ability [Wenger, 2017].		Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and	Physiological stress (increased ambient noise) ; Behavioural change (migration) [Popper, 2019]	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging,	Changes in distribution and community structure ; Modification of navigation and

						species distribution ; Change in connectivity		spawning, etc.).	orientation abilities of species
Adults	Degradation of habitats and functional areas (nursery, shelter, feeding areas).	Temporary aggregation effect ; Attraction of predators ; Variation in abundance ; Changes in community structure ; Reduction in the number of target species ; Increase in population abundance and recruitment rate [Langamer, 2012 et Stenberg 2015] ; Modification of species communities [Van hal 2017]	Habitat abandonment	Reduced visibility and impact on the food web ; Behavioural changes (avoidance) ; Suffocation by clogging of the gills ; Changes in trophic relationships Increased risk of abrasion of protective mucus (favours the development of parasites and diseases) ; Limits movement ; Increased energy expenditure linked to search of preys ; Changes in feeding behaviour and trophic relationships [Kjelland, 2015].	Increased energy expenditure linked to search of food	Changes in behaviour (attraction/repulsion depending on the species) ; Physiological changes (respiration, metabolism, growth, etc.) ; Changes in reproduction ; Disruption of population dynamics and species distribution ; Change in connectivity	Physiological stress (increased ambient noise) and auditory impact (temporary disability) ; Changes in prey/predator relationships ; Physical injuries and physiological changes ; Masking of important biological sounds ; Changes in predation and prey-seeking behaviour [Popper & Hawkins, 2019] ; Behavioural changes (spawning, foraging, feeding) ; Physiological changes (stress effects) [Popper 2019]	Abandonment of habitats ; Modification of specific interactions ; Modification of behaviour (foraging, spawning, etc.).	Changes in distribution and community structure ; Modification of predator/prey interactions ; Modification of behaviour (attraction/avoidance) ; Modification of navigation and orientation abilities of species ; Physiological and developmental effects

	Part 2								
	Light emissions	Chemical pollution	Organic enrichment	Hypoxia	Introduction of individuals genetically different from local species	Dispersal of non-native species	Collision	Human activity	Obstruction to movement
BENTHIC SOFT SUBSTRATE									
Eggs and larvae		Physiological stress	Increased mortality/malformation ; Physiological changes (larval development)	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability				
Juveniles	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes ; Changes in spatial distribution and population dynamics.	Changes in physiology (growth) ; Changes in spatial distribution and population dynamics ; Increased mortality/malformation	Change in growth (increase in the quantity of food/prey) ; Changes in physiology (growth) ; Changes in spatial distribution and population dynamics	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity ; Abandonment of essential habitats

In transition	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Changes in reproduction	Increased mortality/malformation	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity
Adults	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes ; Changes in spatial distribution and population dynamics ; Attraction of visual predators	Changes in physiology (growth) ; Changes in spatial distribution and population dynamics ; Increased mortality/malformation ; Disruption of reproductive rate (gametes) ; Variation in biomass and abundance ; Physiological changes (reproduction)	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships	Increase of mortality and injury due to chain movements	Behavioural change (disturbance, flight)	Change in connectivity ; Abandonment of essential habitats
BENTHIC HARD SUBSTRATE									
Eggs and larvae		Physiological stress	Increased mortality/malformation ; Physiological changes (larval development)	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability				
Juveniles	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes ; Changes in spatial distribution and population dynamics.	Changes in physiology (growth) ; Changes in spatial distribution and population dynamics ; Increased mortality/malformation	Change in growth (increase in the quantity of food/prey) ; Changes in physiology (growth) ; Changes in spatial distribution and population dynamics	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity ; Abandonment of essential habitats
In transition	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Changes in reproduction	Increased mortality/malformation	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity
Adults	Changes in distribution and community	Physiological stress ; Behavioural and	Changes in physiology (growth) ; Changes in	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased	Increased predation ; Changes in abundance and	Increase of mortality and injury due to	Behavioural change (disturbance, flight)	Change in connectivity ;

	structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	trophic changes ; Changes in spatial distribution and population dynamics ; Attraction of visual predators	spatial distribution and population dynamics ; Increased mortality/malformation ; Disruption of reproductive rate (gametes) ; Variation in biomass and abundance ; Physiological changes (reproduction)		mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	biomass ; Changes in trophic relationships	chain movements		Abandonment of essential habitats
PELAGIC									
Eggs and larvae		Physiological stress	Increased mortality/malformation ; Physiological changes (larval development)	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability				
Juveniles	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes ; Attraction of visual predators [Keenan 2017]	Changes in physiology (growth) ; Changes in spatial distribution and population dynamics	Change in growth (increase in the quantity of food/prey) ; Changes in physiology (growth) ; Changes in spatial distribution and population dynamics	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity ; Abandonment of essential habitats ; Disruption of vertical migration
In transition	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes	Increased mortality/malformation	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships		Behavioural change (disturbance, flight)	Change in connectivity
Adults	Changes in distribution and community structure ; Physiological (respiration, etc.) and phenological (life cycle, etc.) changes ; Modification of specific interactions ; Behavioural change	Physiological stress ; Behavioural and trophic changes ; Attraction of visual predators [Keenan 2017]	Changes in physiology (growth) ; Changes in spatial distribution and population dynamics ; Increased mortality/malformation ; Disruption of reproductive rate (gametes) ; Variation in biomass and abundance ; Physiological changes (reproduction)	Change in growth (increase in the quantity of food/prey)	Physiological stress ; Increased mortality/malformation ; Physiological changes (growth) ; Disruption of swimming ability ; Behaviour changes	Increased predation ; Changes in abundance and biomass ; Changes in trophic relationships	Increase of mortality and injury due to chain movements	Behavioural change (disturbance, flight)	Change in connectivity ; Abandonment of essential habitats ; Obstacle to movement (loss of reproduction due to lack of access to spawning areas)

FRANCE ENERGIES MARINES

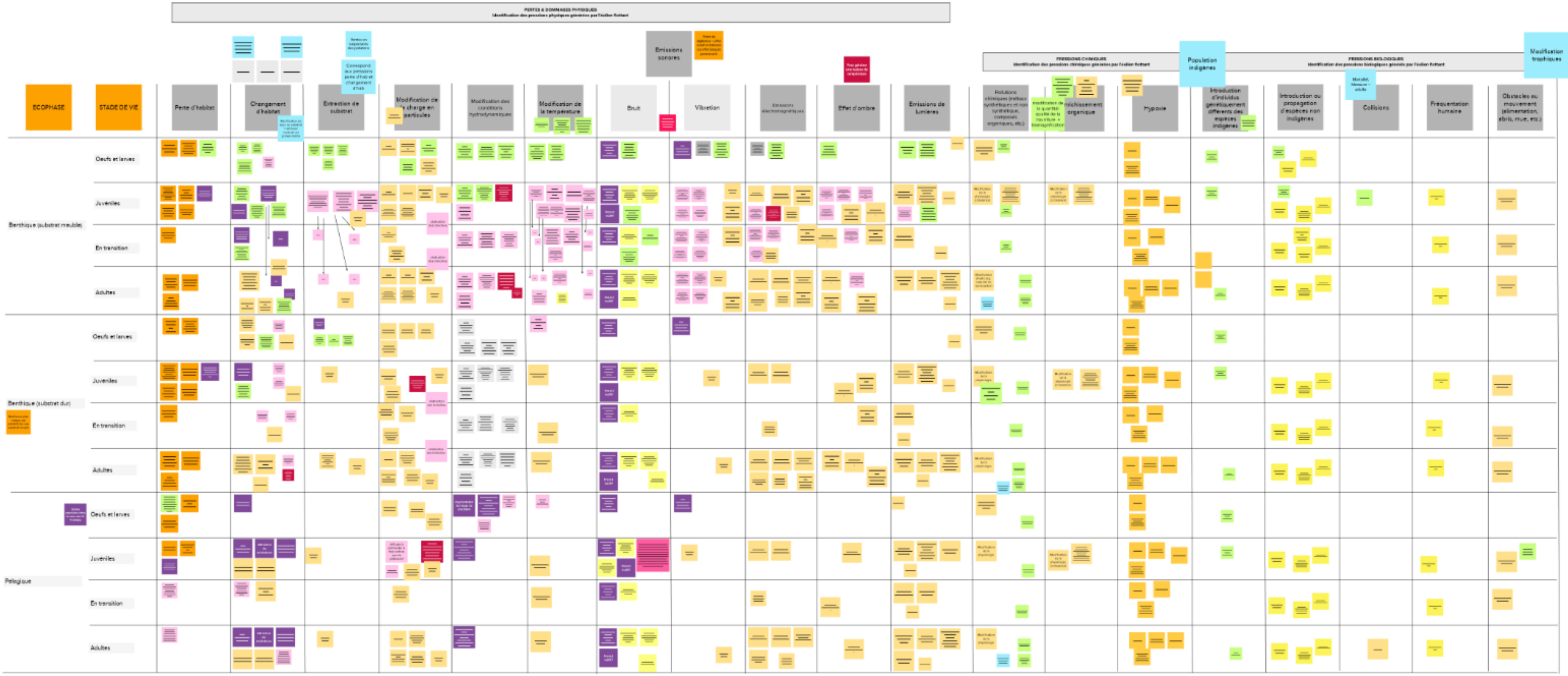

Illustration 5: Screenshot of the online workspace provided (on MURAL) to identify the pressure-receptor pairs with the "Fish and cephalopods" working group (French only)

Annex 12

Synthesis of preliminary results obtained for sensitivity for "cetaceans and sea turtles", "flying fauna" and "benthic communities and habitats" MSP-MED working group

/! The following results should be taken with caution and interpreted with all the methodological limits outlined in the report. By default, the score "grey - lack of knowledge" has been kept when the level of knowledge of the sensitivity level of a receptor to a pressure has been judged "null" by at least one expert. In this synthesis table, only the highest score has been retained, and it **does not reflect the diversity of the experts' opinions**. The * indicates interactions for which there was no scientific consensus (by default "grey - lack of knowledge" or highest score). Score are presented only for the "pressure – receptor" pairs identified during the different MSP-MED technical meetings.

Methodological and prospective table derived from a risk-based approach. Cannot be applied to a specific site or defined project

	Construction & Decommissioning																		
	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Changes in temperature	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement	Introduction of individuals genetically different from local species	Dispersal of non-native species
CETACEANS & SEA TURTLES																			
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)			*	*		*		*				*		*	*	*	*		
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)		*		*		*		*				*		*	*		*		
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)		*		*		*						*		*	*		*		
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)		*		*		*						*		*			*		
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)		*		*		*						*		*			*		
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)		*		*		*		*				*		*			*		
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)				*		*		*	*	*	*	*		*	*	*			
FLYING FAUNA																			
Migratory bats		*																	
Foraging bats		*																	
Passerines																			
Raptors																			
Anatidae & Rallidae																			
Shorebirds																			
Loons																			
Wader species																			
Herons and allies																			
Cormorants												*							
Shearwaters															*				
Gulls		*																	
Terns																			
Hydrobatidae																			
Razorbills																			
Puffins																			
Skua sp																			

Northern Gannet, Morus bassanus (Linnaeus, 1758)																			
BENTHIC COMMUNITIES AND HABITATS																			
Biocenosis of supralittoral sands																			
Biocenosis of mediolittoral sands																			
Biocenosis of the mediolittoral detritic																			
Biocenosis of mediolittoral rocks																			
Biocenosis of superficial muddy sands of calm mode																			
Biocenosis of infralittoral rocks																			
Biocenosis of rough sands and fine gravels tossed by the waves																			
Biocenosis of sands and gravels under the influence of bottom currents						*													
Biocenosis of the *P. oceanica* meadow																			
Biocenosis of high-level fine sands																			
Biocenosis of well calibrated fine sands																			
Biocenosis of infralittoral algae																			
Biocenosis of the *C. nodosa* meadow																			
Biocenosis of the meadows with *Z. noltii* and *Z. marina*																			
Perennial brown algae (ochrophytes, kelp, cystoseires)																			
Biocenosis of coastal terrigenous muds																			
Biocenosis of the offshore rock																			
Biocenosis of coastal detritic																			
Coralligenous biocenosis																			
Biocenosis of muddy detritic bottoms																			
Biocenosis of offshore detritic bottoms																			
Biocenosis of bathyal muds																			
Facies of soft mud with *F. quadrangularis* and *A. serresianus*																			
Biocenosis of bathyal detrital sands with *G. vitreus*																			
Biocenosis of bathyal rocks																			
Underwater structures caused by gas emissions (pockmark)																			
Hydraulic dunes																			
Canyon heads																			
Benthic species																			

	Operation																		
	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Changes in temperature	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement	Introduction of individuals genetically different from local species	Dispersal of non-native species
CETACEANS & SEA TURTLES																			
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)								*											
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)								*											
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)																			
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)																			
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)																			
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)																			
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)								*		*									
FLYING FAUNA																			
Migratory bats																			
Foraging bats																			
Passerines															*				
Raptors		*																	
Anatidae & Rallidae																			
Shorebirds																			
Loons																			
Wader species																			
Herons and allies																			
Cormorants	*														*				
Shearwaters																			
Gulls		*													*	*			
Terns															*				
Hydrobatidae	*	*													*				
Razorbills																			
Puffins																			
Skua sp																			
Northern Gannet, Morus bassanus (Linnaeus, 1758)																			
BENTHIC COMMUNITIES AND HABITATS																			
Biocenosis of supralittoral sands																			
Biocenosis of mediolittoral sands																			
Biocenosis of the mediolittoral detritic																			
Biocenosis of mediolittoral rocks																			
Biocenosis of superficial muddy sands of calm mode																			
Biocenosis of infralittoral rocks																			
Biocenosis of rough sands and fine gravels tossed by the waves																			
Biocenosis of sands and gravels under the																			

influence of bottom currents																			
Biocenosis of the *P. oceanica* meadow																			
Biocenosis of high-level fine sands																			
Biocenosis of well calibrated fine sands																			
Biocenosis of infralittoral algae																			
Biocenosis of the *C. nodosa* meadow																			
Biocenosis of the meadows with *Z. noltii* and *Z. marina*																			
Perennial brown algae (ochrophytes, kelp, cystoseires)																			
Biocenosis of coastal terrigenous muds																			
Biocenosis of the offshore rock																			
Biocenosis of coastal detritic																			
Coralligenous biocenosis																			
Biocenosis of muddy detritic bottoms																			
Biocenosis of offshore detritic bottoms																			
Biocenosis of bathyal muds																			
Facies of soft mud with *F. quadrangularis* and *A. serresianus*																			
Biocenosis of bathyal detrital sands with *G. vitreus*																			
Biocenosis of bathyal rocks																			
Underwater structures caused by gas emissions (pockmark)																			
Hydraulic dunes																			
Canyon heads																			
Benthic species																			

Annex 13

Synthesis of preliminary results obtained for knowledge for “cetaceans and sea turtles”, “flying fauna” and “benthic communities and habitats” MSP-MED working group

/! The following results should be taken with caution and interpreted with all the methodological limits outlined in the report. By default, the lower score has been retained, and it **does not reflect the diversity of the experts' opinions**. The * indicates interactions for which there was no scientific consensus. Score are presented only for the “pressure – receptor” pairs identified during the different MSP-MED technical meetings.

	Construction & Decommissioning																		
	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Changes in temperature	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement	Introduction of individuals genetically different from local species	Dispersal of non-native species
CETACEANS & SEA TURTLES																			
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)		3	0	1	0	0		3	2	0		2			3	2	1		
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)		1		1	0	0		3	1	0		2			3	2	1		
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)		1		1	0	0		3	1	0		1			3	2	0		
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)		1		1	0	0		3	1	0		1					0		
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)		1		1	0	0		2	1	0		1					0		
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)		1		1	0	0		1	1	0		1					0		
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)		2*	1*	1	1*	0		1*	1*	0*	0	1*	0	0	2	1*	1		
FLYING FAUNA																			
Migratory bats	0	0						0		0					1		0		
Foraging bats	0	0						0		0					0		0		
Passerines										0									
Raptors																			
Anatidae & Rallidae																			
Shorebirds																			
Loons	3																		
Wader species																			
Herons and allies																			
Cormorants	3	3			1	1						2*	1	1					
Shearwaters	3				1					3		2	1	1	3	2	2		
Gulls	2	2										2	1	1					
Terns					1	1						2	2	2					
Hydrobatidae	3				1					3		2	1	1	2	2	2		
Razorbills												2*	1	1					
Puffins												2*	1	1					
Skua sp												2	1	1					
Northern Gannet, Morus bassanus (Linnaeus, 1758)	2				1							2	1	1					
BENTHIC COMMUNITIES AND HABITATS																			

Biocenosis of supralittoral sands	3	3				1						0							
Biocenosis of mediolittoral sands	3	3			1	1						0							
Biocenosis of the mediolittoral detritic	3	3			1	1						0							
Biocenosis of mediolittoral rocks	3	3										0							
Biocenosis of superficial muddy sands of calm mode	3	3				2						0							
Biocenosis of infralittoral rocks	3	3			1							0							
Biocenosis of rough sands and fine gravels tossed by the waves	3	3			1	1						0							
Biocenosis of sands and gravels under the influence of bottom currents	3	3			1	2						0							
Biocenosis of the *P. oceanica* meadow	3	3	3		3	3						0							
Biocenosis of high-level fine sands	3	3			1	1						0							
Biocenosis of well calibrated fine sands	3	3			1	2						0							
Biocenosis of infralittoral algae	3	3			1	1						0							
Biocenosis of the *C. nodosa* meadow	3	3			3	3						0							
Biocenosis of the meadows with *Z. noltii* and *Z. marina*	3	3			3	3						0							
Perennial brown algae (ochrophytes, kelp, cystoseires)												0							
Biocenosis of coastal terrigenous muds		3				1						0							
Biocenosis of the offshore rock	3	3			1							0							
Biocenosis of coastal detritic		3			1	1						0							
Coralligenous biocenosis	3	3			2	1						0							
Biocenosis of muddy detritic bottoms		3				1						0							
Biocenosis of offshore detritic bottoms		3			1	1						0							
Biocenosis of bathyal muds		3				1						0							
Facies of soft mud with *F. quadrangularis* and *A. serresianus*		3				1						0							
Biocenosis of bathyal detrital sands with *G. vitreus*		3			3	3						0							
Biocenosis of bathyal rocks		3			1							0							
Underwater structures caused by gas emissions (pockmark)	0	0			0	0						0							
Hydraulic dunes																			
Canyon heads																			
Benthic species																			

FRANCE ENERGIES MARINES

	Operation																		
	Loss of habitat	Changes of habitat	Extraction of substrate	Material deposition	Changes in turbidity	Changes in hydrodynamic conditions	Changes in temperature	Noise emission (acoustic)	Noise emission (vibration)	Light emissions	Electromagnetic emissions	Chemical pollution	Organic enrichment	Hypoxia	Collision	Human activity	Obstruction to movement	Introduction of individuals genetically different from local species	Dispersal of non-native species
CETACEANS & SEA TURTLES																			
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)		3	0	1	0	0		3	2	0		2			3	2	1		
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)		1		1	0	0		3	1	0		2			3	2	1		
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)		1		1	0	0		3	1	0		1			3	2	0		
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)		1		1	0	0		3	1	0		1					0		
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)		1		1	0	0		2	1	0		1					0		
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)		1		1	0	0		1	1	0		1					0		
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)		2*	1*	1	1*	0		1*	1*	0*	0	1*	0	0	2	1*	1		
FLYING FAUNA																			
Migratory bats	0	0								0					1		0		
Foraging bats	0	0								0					1		0		
Passerines										3					1				
Raptors																			
Anatidae & Rallidae	0																		
Shorebirds															3				
Loons	2*	2																	
Wader species															3		2		
Herons and allies																			
Cormorants	3	3			1	0						2*	1	1					
Shearwaters					1					3		2	1	1		2	2		
Gulls	2	2										2	1	1	3				
Terns		3			1	0						2	2	2					
Hydrobatidae	0*	0*			1					3		2	1	1	3	2	2		
Razorbills												2*	1	1					
Puffins												2*	1	1					
Skua sp	0	0										2	1	1	1				
Northern Gannet, Morus bassanus (Linnaeus, 1758)	2											2	1	1					
BENTHIC COMMUNITIES AND HABITATS																			
Biocenosis of supralittoral sands	3	3				1													
Biocenosis of mediolittoral sands	3	3			1	1													
Biocenosis of the mediolittoral detritic	3	3			1	1													
Biocenosis of mediolittoral rocks	3	3																	
Biocenosis of superficial muddy sands of calm mode	3	3				2													
Biocenosis of infralittoral rocks	3	3			1														
Biocenosis of rough sands and fine gravels	3	3			1	1													

tossed by the waves																			
Biocenosis of sands and gravels under the influence of bottom currents	3	3			1	2													
Biocenosis of the *P. oceanica* meadow	3	3	3		3	3													
Biocenosis of high-level fine sands	3	3			1	1													
Biocenosis of well calibrated fine sands	3	3			1	2													
Biocenosis of infralittoral algae	3	3			1	1													
Biocenosis of the *C. nodosa* meadow	3	3			3	3													
Biocenosis of the meadows with *Z. noltii* and *Z. marina*	3	3			3	3													
Perennial brown algae (ochrophytes, kelp, cystoseires)																			
Biocenosis of coastal terrigenous muds		3				1													
Biocenosis of the offshore rock	3	3			1														
Biocenosis of coastal detritic		3			1	1													
Coralligenous biocenosis	3	3			2	1		0	0										
Biocenosis of muddy detritic bottoms		3				1													
Biocenosis of offshore detritic bottoms		3			1	1													
Biocenosis of bathyal muds		3				1													
Facies of soft mud with *F. quadrangularis* and *A. serresianus*		3				1													
Biocenosis of bathyal detrital sands with *G. vitreus*		3			3	3													
Biocenosis of bathyal rocks		3			1														
Underwater structures caused by gas emissions (pockmark)																			
Hydraulic dunes																			
Canyon heads																			
Benthic species																			

Annex 14

Synthesis of preliminary results obtained for ecological stakes for "cetaceans and sea turtles", "flying fauna" and "benthic communities and habitats" MSP-MED working group

/! The following results should be taken with caution and interpreted with all the methodological limits outlined in the report. The ecological stakes scores were carried out by numerical retranscription of the expert evaluations from: 1/ Conservation status of species (UICN) and 2/ Ecological stakes of the maritime spatial planning (MSP) documents in France (environmental stakes). The equivalence table used is presented below:

UICN status		MSP ecological stakes	
CR	10	Major	10
EN	8	High	8
VU	7	Medium	6
DD	5	Not determined	5
NT	4	Low	4
LC	1	No stakes	2

	Gulf of Lion continental shelf	Gulf of Lion canyons (southwest)	Gulf of Lion (central and North-eastern)	UICN – Mediterranean status	Final score
CETACEANS & SEA TURLES					
Common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)	5	5	5	7	7
Fin whale, *Balaenoptera physalus* (Linnaeus, 1758)	5	5	5	7	7
Sperm whale, *Physeter macrocephalus* (Linnaeus, 1758)	5	5	5	8	8
Cuvier's beaked whale, *Ziphius cavirostris* (Cuvier, 1823)	5	5	5	5	5
Long-finned pilot whale, *Globicephala melas* (Traill, 1809)	5	5	5	5	5
Risso's dolphin, *Grampus griseus* (Cuvier, 1812)	5	5	5	5	5
Loggerhead sea turtle, *Caretta caretta* (Linnaeus, 1758)	5	2	2	1	5
FLYING FAUNA					
Migratory bats	2	2	2		2
Foraging bats	2	2	2		2
Passerines	2	2	2		2
Raptors	2	2	2		2
Anatidae & Rallidae	8	2	2		8
Shorebirds	2	2	2		2
Loons	2	2	2		2
Wader species	10	2	2		10
Herons and allies	8	2	2		8
Cormorants	10	8	8		10
Shearwaters	10	8	8		10
Gulls	10	8	8		10
Terns	10	8	8		10
Hydrobatidae	10	8	8		10
Razorbills	10	8	8		10
Puffins	10	8	8		10

Skua sp	10	8	8		10
Northern Gannet, *Morus bassanus* (Linnaeus, 1758)	10	8	8		10
BENTHIC COMMUNITIES AND HABITATS					
Biocenosis of supralittoral sands	10	8	8		10
Biocenosis of mediolittoral sands	10	8	8	7	10
Biocenosis of the mediolittoral detritic	10	8	8	5	10
Biocenosis of mediolittoral rocks	8			5	8
Biocenosis of superficial muddy sands of calm mode	10	8	8	5	10
Biocenosis of infralittoral rocks	8			8	8
Biocenosis of rough sands and fine gravels tossed by the waves	10	8	8	5	10
Biocenosis of sands and gravels under the influence of bottom currents	10	8	8	5	10
Biocenosis of the *P. oceanica* meadow	10			7	10
Biocenosis of high-level fine sands	10	8	8		10
Biocenosis of well calibrated fine sands	10	8	8		10
Biocenosis of infralittoral algae	8				8
Biocenosis of the *C. nodosa* meadow	10	8	8	1	10
Biocenosis of the meadows with *Z. noltii* and *Z. marina*	10	8	8	1	10
Perennial brown algae (ochrophytes, kelp, cystoseires)	8			8	8
Biocenosis of coastal terrigenous muds	10	8	8	4	10
Biocenosis of the offshore rock	8			5	8
Biocenosis of coastal detritic	10	8	8	5	10
Coralligenous biocenosis	10			4	10
Biocenosis of muddy detritic bottoms	10	8	8	7	10
Biocenosis of offshore detritic bottoms	8	10	10	5	10
Biocenosis of bathyal muds	8	10	10		10
Facies of soft mud with *F. quadrangularis* and *A. serresianus*	8	10	10		10
Biocenosis of bathyal detrital sands with *G. vitreus*	8	10	10		10
Biocenosis of bathyal rocks	8	10	10		10
Underwater structures caused by gas emissions (pockmark)		8	8		8
Hydraulic dunes		8	8		8
Canyon heads		8	8		8
Benthic species					

Annex 15

Synthesis of recommendations (generals and specifics) for the authorities responsible of the implementation of the MSP and for developers to improve the consideration of marine ecosystems in future offshore windfarm projects

Improving ecological knowledge

- Encouraging the implementation of standardized monitoring protocols at a European scale. Such cooperation will make it possible to increase knowledge with homogeneous and comparable data at the scale of the Gulf of Lion and the Mediterranean Sea;
- Providing the necessary means (technical, financial, human, etc.) for the exploitation of existing data - mainly resulting from cetacean and seabird monitoring - for which the processing and analysis could not be carried out exhaustively due to the lack of means;
- In partnership with the scientific community (and the coordinators of campaigns and national observation services in particular), improving the monitoring of hydrological (salinity, temperature, etc.), physico-chemical (turbidity, dissolved oxygen, pH, etc.) and biological (fluorescence) parameters to better understand the local functioning of the ecosystems and to monitor their responses to the pressures generated by offshore floating windfarms. This cooperation could take the form of (i) the instrumentation of new sites next to offshore windfarms according to the protocols set up and tested by the existing national observation services[98] and (ii) the addition of complementary equipment in existing instrumented sites[99] to mutualize collect and monitoring efforts;
- Improving monitoring protocols (i.e. duration and frequency) so that the sampling effort is sufficient and relevant to assess long-term changes in species distribution and density within the Gulf of Lion;
- Improving knowledge of the life cycle and movements/migrations of species at different spatial (e.g. horizontal, vertical) and temporal (e.g. daily, seasonal, annual) scales in order to better identify the connections between the different areas of the Gulf of Lion, and between the benthic and pelagic compartments, which are closely linked in their functioning;
- Improving knowledge in the identification of functional species/habitats.

Specific measures for flying fauna

- Extending GPS monitoring to migratory and keys species to better understand their movements and distribution in the Gulf of Lion, prior to the development of offshore windfarms;

- Monitoring seabirds populations breeding in the Gulf of Lion, in order to identify their feeding areas and thus estimate the distribution of potential impacts of offshore windfarms development on different species, populations or colonies;

- Extending the French MIGRALION program to the Spanish coast (Girona and the Balearic Islands) by deploying radars, combined with visual observations and acoustic recordings to increase knowledge of migratory bird flows in the Gulf of Lion;

- Conducting research programs to improve knowledge of (i) the ecology of chiropterans at sea (distribution, functional areas, migration routes, etc.) in the Gulf of Lion and (ii) the influence of environmental and meteorological conditions (e.g. wind patterns) on habitat use by birds and bats. The monitoring strategy would include the deployment of fixed radars on land and at sea, combined with visual observations and acoustic recorders. GPS tracking of seabird species and some bat species, at high frequency and using accurate altimeters, will provide a better understanding of changes in flight altitude (and collision risk) in relation to weather conditions;

[98] Gathered in the ILICO research infrastructure (national observation services COAST-HF, MOOSE, etc.): https://www.ir-ilico.fr/

[99] MESURHO station of COAST-HF network, MOLA station of MOOSE network, etc.

- Becoming more involved in monitoring the demography of several key bird populations and species in order to collect and share baseline demographic data prior to the development of offshore windfarms.

Specific measures for fish and cephalopods

- Improving knowledge of fish and cephalopod communities and their structure in order to better understand the interactions between the different components of the ecosystem and the impact of offshore windfarms on the whole food web.

Specific measures for planktonic communities

- Based on existing monitoring, increasing the frequency of data acquisition, such as those carried out during the annual PELMED campaigns[100] (June/July), to a minimum of 4 campaigns/year (e.g. March, June (PELMED), September, December to cover the whole year) in order to better integrate the seasonal and interannual variability (late bloom, etc.) of planktonic communities. Standardised protocols[101] for monitoring planktonic communities (zooplankton and phytoplankton) implemented within national observation services (SNO PHYTOBS) and existing campaigns (e.g. PELMED, MOOSE-GE[102]), for example, should be maintained to ensure homogeneity in data collection and their inter-comparability over time.

Improving knowledge of environmental conditions

- Modelling currents and hydrodynamics conditions in the area to (i) produce scenarios for the evolution of currents (locally and at the scale of the Gulf of Lion) according to the types of infrastructures and their location, and (ii) to estimate the repercussions of the hydrodynamic modifications due to the transport of passive organisms or life stages (plankton, including eggs, larvae) in order to choose the infrastructure designs.

Developing relevant monitoring for the study of interactions and experimenting technologies to benefit from feedback

- Waiting for the results and feedback from the pilot offshore windfarms before deploying commercial offshore windfarms, to know the main impacts and determine the best "pressure-receptor" pairs to be monitored. This feedback will also help to select the least impacting technology regarding ecosystems and to identify the possibilities of eco-design of floats in favour of indigenous biodiversity;
- Based on the feedback from the pilot offshore windfarms, quantifying the effects (volume, surface area impacted, etc.) to allow the scientific community to make relevant and operational recommendations;
- Equipping the pilot offshore windfarms areas with the tools needed to benefit from solid feedback on the best monitoring methods. From this experience, equipping this area with precise and adapted tools to identify interactions and study their effects (short and long term) at the scale of species, communities and ecosystem;
- Developing systematic sampling protocols on board of all vessels involved in the development and maintenance of offshore windfarms to be performed by qualified observers. Direct observations will provide information on the behaviour and concentration of species in the area and will document collisions and entanglements with existing infrastructure and equipment;
- Implementing monitoring programs for monitoring all species frequenting this area. In particular, the distribution and abundance of cetaceans and sea turtles can be monitored by visual and acoustic methods (e.g. fixed devices) and the distribution of seabirds during the day and night can be monitored by fixed radars

[100] Bourdeix J.H., Hattab T., (1985): PELMED - PELAGIQUES MEDITERRANÉE, https://doi.org/10.18142/19

[101] Plankton net type WP2 (200 µm size; opening diameter 0.25m²) deployed along a vertical line then taxonomic determination under binocular. For phytoplankton, collection of water samples in a Niskin bottle for the measurement of chlorophyll-a concentration (or pigment groups) at 3 depths (surface, maximum depth and bottom).

[102] Testor P., Durrieu De Madron X., Mortier L., D'ortenzio F., Legoff H., Dausse D., Labaste M., Houpert L., (2020): LION observatory data. https://doi.org/10.17882/44411

at sea. These programs should be implemented both, in the area of offshore windfarms and in adjacent 'control' areas;

- Extending monitoring to contaminants that may have an impact on the food web and its functioning, so as not to be limited to the prism of human health. Dedicated monitoring of chemical pollution within the pilot offshore windfarms would make it possible to identify the different types of pollutants emitted into the marine environment - in particular from sacrificial anodes - and to implement specific monitoring for distinguish punctual and chronic pollution;
- Improving knowledge of the reef effect in order to assess the attraction/repulsion effect on various species, including the species that constitute the food resources of top-predators (cetaceans, marine turtles, etc.);
- Implementing adapted monitoring to the duration of the life cycle of species and the renewal/recovery time of populations. Three-year impact studies do not make it possible to predict the effects on the entire life cycle of a species and on trophic levels. In order to study the indirect effects on the whole food-web, even longer monitoring times (> 10 years) should be envisaged;
- In this sense, project developers (pilot or commercial offshore windfarms) should be encouraged to implement multi-annual contracts to monitor the impacts of infrastructures on communities over the long term. The implementation of this type of long-term cooperation agreement offers the guarantee of relevant and comparable monitoring over time (protocol, experts mobilized, constant sampling effort, operators mobilized for analyses, etc.). Several contracts of this type already exist for some industrial projects and should be applied to offshore windfarms;
- Using the pilot offshore windfarms to study their effects on hydrodynamics conditions and currents by setting up ADCP[103] directly in the area of the offshore windfarms and outside, focusing on the east and west areas that corresponding to the direction of the prevailing winds (in the Gulf of Lion);
- Prioritizing the acquisition of knowledge on the study of interactions and effects of offshore windfarms at a local scale, with an emphasis on monitoring material flows, changes in hydrodynamic conditions and potential changes in light (natural light and attenuation; light generated by the structures themselves).

Specific measures for cetaceans and sea turtles

- Implementing protocols allowing the comparison of species distributions and, in particular *Bottlenose dolphins*, between the area of offshore windfarms and adjacent areas. Photo-identification of individuals (dorsal fins) in the vicinity of the area will provide relevant information on their distribution and their use of the area (e.g. regular visits). This data can be cross-referenced with data obtained through monitoring programmes;

- Use *Bluefin tuna* as an indicator for monitoring the effects of offshore windfarms on fisheries, by adapting standard ICCAT protocols to the scale of offshore windfarms in the Gulf of Lion;

- Combining monitoring protocols with biomass monitoring (by echo sounders) to study the potential evolution of prey distribution.

Specific measures for flying fauna

- Monitoring mortalities caused by existing offshore windfarms using robust protocols and, in the event that the protocols in use do not allow for a robust estimation of collisions, develop methods to address them, at least on a national scale (homogeneous and therefore comparable data). In particular, determine whether actual collisions are the result of blade or mast movement in order to propose appropriate mitigation measures and to reduce the risk of collision (reduction of rotation speed or even stopping the blades);

[103] ADCP: Acoustic Doppler Current Meters are used to determine the speed of currents

- Testing different intensity and wavelength ranges and monitor the effect of light emissions on the trajectories of seabird and bat populations that regularly frequent the area (feeding area, etc.) in order to better understand the behaviour of these species in response to these emissions.

Specific measures for fish and cephalopods

- Developing and programming monitoring protocols adapted to pelagic communities (fish, elasmobranchs and, cephalopods - all life stages) on the pilot offshore windfarms areas;

- Considering an ecosystemic approach for the study of effects using ecosystem modelling software.

Specific measures for planktonic communities

- Increasing the temporal scale of monitoring beyond the 3 years generally proposed before, during and after the construction phases: monitoring should be carried out for at least 5 years, ideally 10 years, so that several years (at least 3) can be used to define the initial state regarding the strong interannual variations that exist in planktonic communities. Long-term taxonomic monitoring on a large scale (area and area of influence) will provide information on possible changes in the communities and will help to better distinguish the potential effects of offshore windfarms from those induced by more global changes (e.g. hydro-climatic forcing);

- Do not limit the monitoring of planktonic communities to the study of variations in chlorophyll a. Although the "chlorophyll a" parameter provides information on the total phytoplankton biomass of the area studied, this proxy is insufficient to consider the response of the phytoplankton community to a given pressure. It must be based on an integrative approach combining stock (biomass) - functional groups and diversity;

- Implementing dedicated monitoring of meroplankton communities[104] within offshore windfarms in order to study the effects of the addition of a fixation support on these communities. Given the small size of meroplanktonic organisms (often individuals in the larval stage), their sampling requires the deployment of plankton nets with a size of 80 µm in order to obtain a reliable quantitative estimate of their abundance;

- Comparing the different knowledge of the selected area in order to carry out a relevant impact study (type of sediments, hydrodynamics, external forcing, estimate of biodiversity, etc.). This state of knowledge must be completed by monitoring the relevant hydrodynamic, hydrological and physico-chemical parameters (temperature, salinity, turbidity, dissolved oxygen, pH, etc.) and the phyto- and zooplanktonic communities (adding proxies to reflect the physiological state of the communities) over a period of at least 3 years, prior to the works.

Specific measures for benthic communities and habitats

- Developing and implementing monitoring adapted to the study of the interactions and effects of floating infrastructures and their anchoring systems on the seabed at a relevant spatiotemporal scale. At a local scale, to focus on the major pressures identified for benthic habitats, i.e. physical pressures related to: seabed abrasion, and resuspension.

Improving the consideration of interaction risks and effects

- According to stakeholders, defining a common protocol to harmonise the monitoring carried out in impact studies and sharing the results by making them public, accessible and interoperable;
- Improving knowledge of the pressures generated by all human activities in order to consider their cumulative effects on ecosystems and integrate these cumulative effects into impact risk assessments. The synergistic effect of pressures on species is poorly known and should be allowed for studying and assessing interactions;
- Integrating the study of oceanographic conditions and their evolution in the analysis of the potential effects of offshore windfarms on ecosystems;

[104] Meroplankton corresponds to planktonic organisms of which only a part of the life cycle is planktonic. Temporary plankton are often planktonic larvae of benthic organisms (e.g. larvae of bivalves and gastropods).

- Allowing the differences in resilience between habitats and communities on hard substrates (very long and limited recovery) and soft substrates (greater and faster recovery) during the area's selection;
- Identifying, by ecological compartment, the species for which there is no alternative in the event of habitat destruction, in order to preserve their functional areas (particularly egg-laying and larval dispersal areas) by directing the definition of the areas for offshore windfarms towards areas of lesser functional importance or better represented. This identification and location work allow the determination of the possible existence and extent of ecologically redundant areas (same functionalities) at the Gulf of Lion scale. Their protection (total or partial) will ensure the sustainability of the species affected;
- Considering the impacts of offshore windfarms beyond the ecosystem according to the potential indirect effects on society and other economic activities in the impacted area (in particular fishing, tourism and maritime transport);
- Giving priority to study the functional impact of offshore windfarms development in order to understand (i) how the installation of one (or more) wind-turbine(s) will impact a species and its environment and (ii) how these impacts will affect the whole food-web;
- Considering the size of the projects (number of infrastructures, impacted surface, etc.). The observations made at the scale of the pilot offshore windfarms cannot be extrapolated to a larger dimension. If the degradation of a habitat over a small area can be considered acceptable depending on its characteristics and the duration and frequency of the pressure, it may be considered unfavourable if the entire area of this habitat is impacted;
- Identifying the sources of chemical emissions resulting from the development of offshore windfarms in order to know the types and nature of the pollutants that will potentially be emitted into the water column in order to study, in a second phase, their effects on the different ecological compartments;
- Encouraging cross-border cooperation in the study of long-term effects, particularly for projects located on the border of the Gulf of Lion, in order to mutualise monitoring and data. This cooperation would make it possible to monitor and study the effects of offshore windfarms at a large scale (western Mediterranean);
- Considering potential effects at the appropriate geographic scale for each species, population, parameter or type of monitoring. The national scale is often too small to provide information on the spatio-temporal distribution of highly mobile species;
- In this sense, encouraging cross-border cooperation at a Mediterranean scale by including European and North African countries in order to obtain a global vision of the migratory routes and distribution of species (among fish, cetaceans, birds, etc.);
- Encouraging the continuation of the cross-border cooperation initiated within the framework of the MSFD in order to harmonize monitoring and to facilitate data exchange;
- Encouraging the implementation of standardized protocols on a cross-border scale and the use of common tools (models, satellite images) in order to carry out large-scale comparative studies.

Reducing potential impacts

- Developing and testing eco-design methods to limit the environmental impact of infrastructures;
- Encouraging the development of alternative mooring techniques and technologies that have little or no impact on the seabed (particularly dredging). Float designs that limit the number of chains, such as TLP

designs, could reduce the level of impact of dredging on the seabed and limit the area of destruction of substrates (soft or hard);

- Defining, in consultation with scientific experts, a maximum surface area acceptable for the degradation of the seabed by all human activities carried out in the Gulf of Lion and integrate it into maritime spatial planning documents in order to reconcile all activities generating destruction (punctual or permanent) of the seabed. Reducing the surface area of degradation will ensure the functionality of habitats at a large scale and thus limit the risks of collapse of ecosystems dependent on soft substrate habitats. According to the experts, agreements with other activities that cause seabed degradation should be reached so as not to increase the degradation surface of soft substrates;
- Maintaining a functional network in the installation scheme of offshore windfarms to ensure that a minimum of habitats or migration routes are maintained in the vicinity of the areas, ensuring rapid recolonization of the substrates after the work and guaranteeing a minimum of functionality in these habitats;
- Ensuring that the size of offshore floating infrastructures and the distance between them do not impact the natural light of the water column so that the natural functioning and productivity of the euphotic zone is preserved;
- Considering the biological cycles and rhythms of species during the installation, maintenance and decommissioning work (particularly for avifauna: wintering period, migration, etc.);
- Excluding potential offshore windfarms development areas from "major" migration routes;
- Setting up offshore windfarms as far as possible from the coast (for birds) and functional areas (feeding, breeding, etc.);
- Testing and improving scaring methods to reduce collision rates (specially for cetaceans, sea turtles and seabirds);
- Considering all the alternatives to the development of offshore windfarms that could have less impact on biodiversity and marine ecosystems. This initiative would enable the different marine renewable energy technologies to be put into perspective, despite their different stages of development, and to choose the most suitable technology to limit the impact on biodiversity;
- Identifying and assessing the ecosystem services (direct and indirect, etc.) of the concerned coastal zones concerned in order to better guide the choice of areas for the deployment of offshore windfarms.

Raising awareness among stakeholders, citizens and decision makers

- Raising awareness among stakeholders and citizens about the risks of interactions between offshore windfarms activities and ecosystems, such as the risks of habitat loss and population displacement;
- Advocating a reduction in energy consumption at different scales (European, national, regional and, individual) by inducing new laws (national and European) but also encouraging a change in individual behaviour.