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Agenda Item 7: Marine renewable Energies

Analysis on existing regulatory measures and impacts on marine and coastal environment from Marine Renewable Energies

UNEP/MAP
Athens, 2025

Note by the Secretariat

In line with Decision IG.26/14 on the Programme of Work (PoW) and Budget for 2024–2025 (Activity 1.2.1), MEDPOL was mandated to conduct a comprehensive analysis of existing regulatory measures, drivers, and impacts of Marine Renewable Energies (MREs) on the marine and coastal environment, and to identify necessary measures to prevent, reduce, and eliminate pollution in the Mediterranean Sea Area.

This report presents an in-depth assessment of the current legal frameworks at both national and regional levels, evaluates the potential environmental impacts of MRE development, and proposes measures to mitigate these impacts. It also offers recommendations for regional action to enhance the coherent management of MRE installations in the Mediterranean, recognizing MRE as an emerging sector with increasing relevance.

The meeting is expected to review and approve this report during the MED POL Focal Points Meeting scheduled for 17–19 June 2025, with recommendations for further work to be included in the Programme of Work for 2026–2027.

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List of acronyms

ADD	Acoustic Deterrent Device
dB	decibel
DSS	Decision Support System
EIA	Environmental Impact Assessment
EMB	European Marine Board
EMF	Electromagnetic Field
EMODNET	European Marine Observation and Data Network
EU	European Union
FOW	Floating Offshore Wind
FOWF	Floating Offshore Wind Farm
FOWT	Floating Offshore Wind Turbine
GES	Good Environmental Status
GHG	Greenhouse Gas
HSD	Hydro Sound Dampers
HVDC	High-Voltage Direct Current
IEA	International Energy Agency
LCA	Life Cycle Assessment
LED	Light Emitting Diode
Lpeak	Peak Level (sound)
MAP	Mediterranean Action Plan
MF	Magnetic Field
MPA	Marine Protected Area
MR	Marine Renewable
MRE	Marine Renewable Energy
MRED	Marine Renewable Energy Development
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
NIS	Non-Indigenous Species
O&M	Operations and Maintenance
OI	Offshore Installation
ORE	Offshore Renewable Energy
OT	Offshore Technology
ORT	Offshore Renewable Technology
OWE	Offshore Wind Energy
OWF	Offshore Wind Farm
OWT	Offshore Wind Turbine
R&D	Research and Development
SBC	Small Bubble Curtain
SDG	Sustainable Development Goal
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SIA	Social Impact Assessment
SME	Small and Medium-sized Enterprise
SPC	Submarine Power Cable
WF	Wind Farm
WT	Wind Turbine

1 Background

1. The 2030 Agenda for Sustainable Development, adopted by all United Nations Members in 2015, includes Sustainable Development Goal (SDG) 7: Affordable and Clean Energy. To ensure universal access to energy by 2030, policy actions must accelerate electrification, boost investments in renewable energy (RE), improve energy efficiency, and establish enabling regulatory frameworks (United Nations, 2023).

2. In pursuit of the EU Green Deal objectives, the adoption of alternative and clean energy systems such as Offshore Wind Energy (OWE) is essential. By the end of 2022, European sea basins accounted for approximately 50% of the global installed offshore wind capacity. The Green Deal sets targets of at least 60 GW of installed offshore wind and 1 GW of other offshore energy by 2030, increasing to 300 GW and 40 GW, respectively, by 2050. Achieving the 2050 goal will require a roughly 30-fold increase in marine renewable energy (MRE) capacity—specifically, 25 times more offshore wind capacity and 3,000 times more other offshore energy capacity. EU Member States have collectively set an even more ambitious target of 111 GW of offshore renewables by 2030, nearly double the European Commission's initial goal (Soukoussian et al., 2023; European Commission, 2023).

3. The Mediterranean Energy Observatory's 'Energy Transition Scenario to 2040' projects that renewable energy use in the Mediterranean region will triple by 2040, reaching 27% of total energy consumption. While offshore wind development in the Mediterranean has been limited due to deep waters and narrow continental shelves, these conditions present an opportunity for Floating Offshore Wind Farms (FOWFs). Projections estimate OWF capacity in EU Mediterranean countries could reach 12 GW by 2030 and 40 GW by 2050 (UfM, 2021).

4. The EU strategy to integrate offshore renewable energy (ORE) as a core component of its energy system by 2050 requires a diversified approach tailored to regional and technological contexts. The strategy outlines a general enabling framework that addresses cross-cutting challenges while proposing specific policy solutions adapted to the development stages of different technologies and sea basins. Each basin's unique geological conditions and varying levels of ORE maturity demand tailored strategies.

5. Currently, most large-scale offshore wind projects in European waters are bottom-fixed OWFs. However, emerging technologies are rapidly advancing. Several Member States have announced large commercial FOWF projects, signalling a shift in maturity that makes these technologies increasingly viable. Notably, many planned Mediterranean projects focus on FOWFs.

6. As a global leader in ORE technology and innovation, the EU enjoys a first-mover advantage, particularly in bottom-fixed wind turbines. In 2019, 93% of Europe's installed offshore capacity was produced within the EU (SWD (2020) 953 final). The region also leads in floating offshore wind (FOW) technologies, with various designs under development and 150 MW of floating offshore wind turbines (FOWTs) expected to be commissioned by 2024.

7. The EU offshore renewable energy sector consists of hundreds of operators and thousands of skilled workers, engineers, and researchers across a robust supply chain. This includes small and medium-sized enterprises (SMEs), turbine manufacturers, foundation and tower constructors, cable suppliers, and vessel operators. The region thus possesses the industrial capacity and technical expertise to lead the global transition. However, the regulatory framework has yet to keep pace with this rapidly advancing sector.

8. Although offshore wind energy is critical to the Mediterranean region's decarbonization goals, the sector faces significant investment risks (Dukan et al., 2023). Supply chain constraints, combined with the absence of a comprehensive regulatory framework, present key challenges. Effective policies will be essential to mitigate these risks and ensure the continued development and deployment of offshore wind energy infrastructure.

2 Introduction

9. The energy transition toward decarbonization necessitates a shift from fossil fuels to renewable energy (RE) sources. Marine renewable energy developments (MREDs) are expanding rapidly in both scale and number as society seeks to sustain electricity production while simultaneously reducing greenhouse gas (GHG) emissions—particularly CO_2, the primary driver of anthropogenic climate change.

10. Offshore Wind Farms (OWFs) are considered one of the most viable options for generating renewable "green energy," as supported by studies such as Soares-Ramos et al. (2020), Telsnig (2020), Nielsen (2022), and Glasson et al. (2022). Globally, and in the Mediterranean Sea, most planned and operational MREDs are offshore wind facilities, including both fixed OWFs and Floating Offshore Wind Farms (FOWFs).

11. The Mediterranean Sea features a narrow continental shelf and deep waters close to shore, making it more suited to floating wind technologies. While fixed OWFs benefit from decades of development and proven technology, deep-water sites in the Mediterranean demand the deployment of FOWFs.

12. FOWF technology is relatively new and currently undergoing initial deployment phases. As of now, there are no fully operational FOWFs worldwide; however, this technology is anticipated to be essential for the Mediterranean due to its geographic and bathymetric conditions.

13. The structural and technological differences between floating (FOWFs) and fixed (OWFs) offshore wind installations are illustrated in Figure 2.1 below.

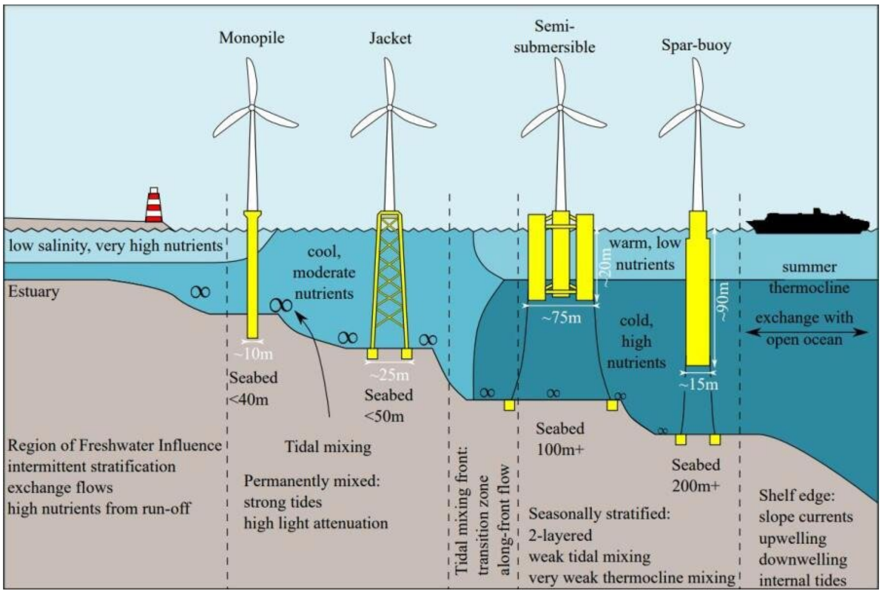

Fig. 2.1 Schematics of fixed OWTs for OWFs and floating OWTs for FOWFs. Source *https://phys.org/news/2022-09-environmental-impact-turbulence-deep-water-farms.html*

14. Offshore Wind Farms (OWFs) were initially developed as fixed structures—such as monopiles, tripods, jackets, and gravity-based foundations—designed for shallow waters typically up to approximately 50–60 meters deep, with an average global distance from shore of around 20 km (Díaz & Soares, 2020). However, these are increasingly being replaced by floating offshore structures, including semisubmersibles, tension-leg platforms, and spars anchored to the deeper seafloor using dead weights (Castro-Santos et al., 2020). Floating Offshore Wind Farms

(FOWFs) can now be installed at depths exceeding 900 meters (Sclavounos et al., 2008). Deeper waters offer both stronger and more consistent wind conditions, and technological advancements are enhancing energy output per turbine while reducing installation costs at greater depths (Philipp et al., 2020). Consequently, FOWFs are widely regarded as the most viable option to meet future renewable energy (RE) demands (Myhr et al., 2014).

3 Marine Renewable Energy (MRE) Installations in the Mediterranean

15. The Mediterranean Sea hosts Marine Renewable Energy (MRE) installations at various stages of development (planned, pilot, under construction, operational, and decommissioned), as detailed in Annex I of this report. The majority remain in the planning phase, with only a few currently operational.

16. Overall, the current capacity of MRE installations in the Mediterranean is limited, though significant growth is anticipated. The EMODnet database provides geographic data for existing and planned MRE facilities, with most future offshore wind farms expected to be floating installations (FOWFs) due to the region's deep waters.

17. According to the International Energy Agency's (IEA) 2022 report, global renewable capacity is projected to expand by 2,400 GW between 2022 and 2027, with renewables accounting for over 90% of the total increase in electricity generation capacity.

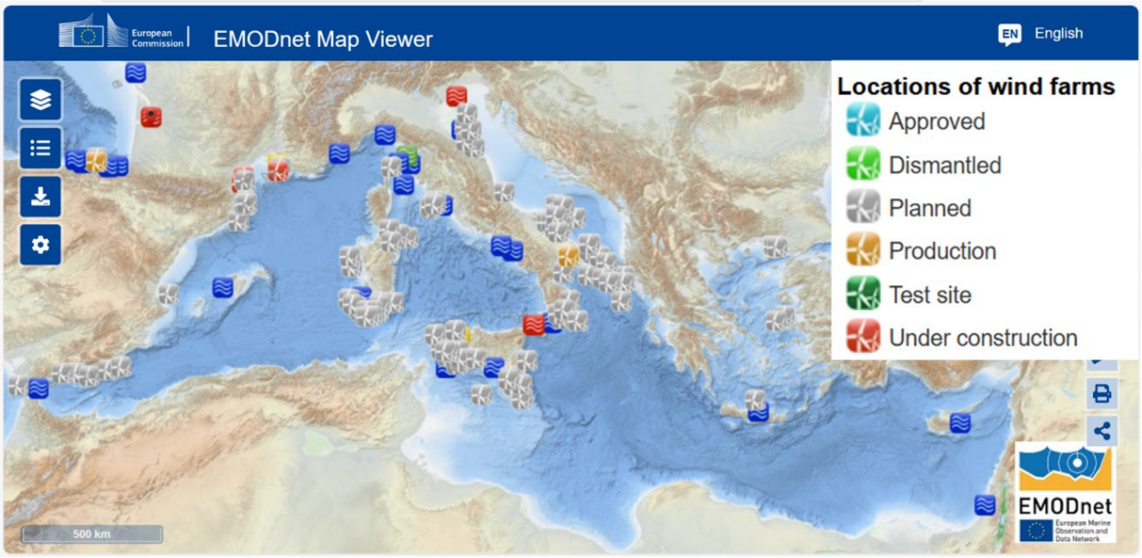

Fig. 3.1 Locations of Mediterranean Sea MRE facilities in the EMODnet database October 2024 https://blueindicators.ec.europa.eu/published-reports_en

18. Most Mediterranean MRE installations are in the northern Mediterranean region (Spain, France, Italy, Greece, Monaco), with a few in the eastern Mediterranean (Cyprus, Israel). A table of these installations is available in Annex II to this report.

4 Current legal framework in the Mediterranean

19. Currently, there is no specific Decision or approved Guideline under the UNEP/MAP framework governing policy, technical standards, or risk mitigation related to marine renewable energy (MRE) installations. Nevertheless, this issue is rapidly emerging, and policy-level action is needed in alignment with relevant articles of the Barcelona Convention and its protocols.

20. At the European level, the European Marine Board (EMB) plays a key role in bridging marine science and policy. The EMB Working Group (Soukissian et al., 2023) has reviewed critical offshore energy topics, including climate change, clean energy, environmental and

socioeconomic impacts, and existing knowledge gaps. Their recommendations emphasize the need to address policy inconsistencies, enhance financing mechanisms, improve data collection and monitoring, promote transdisciplinary collaboration, and establish best practices for material recycling.

21. Apolonia et al. (2021) identified significant legal and political barriers to offshore energy development, particularly related to fragmented governance, protracted permitting processes, and overly ambitious targets. These challenges are compounded by the absence of clear legislation, insufficient funding, and complex regulatory requirements. To address these obstacles, recommendations include streamlining licensing procedures through a “one-stop-shop” approach, ensuring transparent permitting processes, and increasing financial support. Marine Spatial Planning (MSP) is also highlighted as a valuable tool for integrated offshore development.

22. Within the EU, Marine Spatial Planning serves as the primary regulatory mechanism for MRE, with most Mediterranean EU Member States having transposed the EU MSP Directive into national legislation. Achieving the EU’s offshore targets—300 GW of wind and 40 GW of other offshore renewable energy (ORE) by 2050—will require careful spatial planning and extensive grid infrastructure. Among the Contracting Parties to the Barcelona Convention:

- Spain: Spanish Law 24/2013 supports RE development, targeting 3 GW of offshore wind capacity by 2030.
- France: Offshore wind is regulated under the Energy and Environment Codes, with a target of 5.2 GW by 2028. The National Maritime Strategy includes sea-basin plans and cross-border cooperation.
- Monaco: No OWFs to date; focus is placed on other RE sources, including wave energy.
- Italy: Governed by Ministerial Decree 23/2016, offshore wind zones are designated in the Adriatic and Tyrrhenian Seas. Italy has proposed an MSP strategy covering four marine areas.
- Greece: Law 3851/2010 governs offshore wind. The country aims for 2.6 GW capacity by 2030 and is active in MSP initiatives.

23. Several other Mediterranean countries are at varying stages of MRE exploration and regulatory development:

- Albania, Croatia, Montenegro: No OWFs yet; all are actively assessing offshore wind potential and drafting regulations.
- Slovenia: Passed the Spatial Planning Act (2017); MSP plan under development.
- Malta: No OWFs, but offshore wind potential is being explored, with an MSP plan in place.
- Cyprus: A small wave energy project is operational. Legislation for offshore wind is in place, though an MSP plan has not yet been finalized.
- Turkey: The first OWF project is underway in the Sea of Marmara, supported by favorable renewable energy regulations.
- Egypt: Offshore wind is in the exploratory phase, with no current installations.
- Morocco: Legal framework in place; offshore wind potential identified along the Atlantic coast and a wave energy project exists in the Mediterranean.
- Algeria: In early exploration phase, developing regulatory frameworks.
- Libya: No OWFs; progress is hindered by ongoing political instability.
- Tunisia: Exploring offshore wind potential, with several sites identified for future development. Regulatory frameworks are under development.

- Israel: Developing the Karin and Dolphin offshore wind projects (1.4 GW combined capacity). A regulatory framework for offshore wind is in place.
- Lebanon: Currently assessing offshore wind potential and developing relevant legislation.
- Syria: No offshore wind projects to date.

5 Potential Impacts of Marine Renewable Energy Installation (OWFs and FOWFs)

24. Although OWFs currently constitute the majority of MRE installations, their ecological impact remains a significant concern. It is essential that such developments proceed only if they are environmentally sustainable and do not compromise the delivery of vital ecosystem services. Fixed turbine OWFs have been associated with potential disturbances to marine mammals, fish populations, benthic habitats, and species sensitive to underwater noise and electromagnetic fields. The full list of Potential Impacts are presented in Annex III of this report.

25. In contrast, the environmental impacts of FOWFs are less well understood. While FOWFs may exert a lower direct footprint on the seafloor compared to fixed installations, their deployment in deeper waters and over larger areas introduces new environmental and logistical challenges. The processes of installation and decommissioning could still result in significant ecological disruptions.

26. As FOWFs expand, comprehensive and robust Environmental Impact Assessments (EIAs) are essential. Existing EIAs for fixed OWFs typically consider four biological components: marine mammals, birds, fish, and benthic organisms. However, these assessments often fall short of capturing the complexity of marine ecosystems. A more integrated and holistic approach to impact assessment is recommended, though standardized EIA methodologies, especially for deep-sea environments, are still under development.

27. Deep-sea ecosystems remain largely unexplored, warranting a precautionary approach to permitting FOWFs. In response to uncertainties and delays in permitting, some governments are adopting a more strategic approach, including preliminary environmental surveys, stakeholder consultations, and spatial planning. Despite the critical role that OWFs and FOWFs will play in meeting future renewable energy targets, the development of clear, science-based criteria and standardized procedures for planning, siting, and mitigating impacts remains in its early stages.

28. In general, Offshore Wind Farms (OWFs) and Floating Offshore Wind Farms (FOWFs) can have various impacts on marine ecosystems throughout their life cycle, many of which remain insufficiently documented and require further research.

29. While fixed OWFs and FOWFs may generate different types of environmental impacts, these can broadly be categorized into three main phases of their life cycle:

- Construction
- Operation and Maintenance
- Decommissioning

A- Construction Phase

- Visual and acoustic stress from construction activities
- Sound and light emissions from vessels and machinery
- Habitat loss, temporary or permanent
- Pollutant emissions
- Increased water turbidity from sediment disturbance

B- Operation (O&M) Phase

- Noise and visual impact from turbine operation
- Shadow flicker from rotor blades
- Vibration
- Changes in electromagnetic fields, water currents, and sediment dynamics
- Potential pollutant discharge
- Risk of bird and bat collisions with turbines
- Barrier effects on marine fauna
- Artificial reef creation
- Impact from O&M activities such as repairs and servicing

C- Decommissioning Phase

- Visual and acoustic impacts from dismantling activities
- Habitat loss
- Pollutant emissions
- Water turbidity from sediment disturbance

30. The following disruptors are examined in the different phases of the life cycle of OWFs/FOWFs. They can impact upon benthic deep-sea habitats, including the seafloor below 200m depth that includes complex and heterogeneous ecosystems (Danovaro et al., 2014). Such deep-sea systems of interest include continental slopes and submarine canyons; guyots, seamounts, and underwater mountains; deep-sea plains; carbonate mounds; and pockmarks and mud volcanoes.

5.1 Noise

31. Increasing anthropogenic noise from marine traffic, offshore construction, and marine renewable energy (MRE) installations presents a significant concern. Many marine species, particularly mammals, depend on sound for navigation and communication. Elevated noise levels, especially from pile driving during construction, can cause physical stress, mask biological communication, and disrupt critical habitats. Pile driving, among the loudest underwater noise sources, can have particularly severe effects on marine mammals when performed at high energy levels.

5.2 Pollution and Waste

32. Pollution associated with offshore wind developments can be either macroscopic (e.g., plastics, general waste) or chemical (e.g., toxic substances from coatings, oils, or corrosion prevention systems). Improper waste disposal during construction and operations and maintenance (O&M) phases can lead to ingestion or entanglement hazards for marine life. Chemicals, such as anti-fouling agents and compounds from sacrificial anodes, can leach into the marine environment and negatively impact ecosystems. These pollution-related threats remain a persistent environmental concern.

5.3 Electromagnetic Fields (EMFs)

33. Submarine power cables (SPCs) used to transmit electricity generate electromagnetic fields (EMFs). These fields may interfere with species that rely on the Earth's natural magnetic field for orientation and migration, such as fish, cetaceans, and sea turtles. Although EMFs are present during the operational phase of offshore wind farms (OWFs), their effects on marine fauna are not yet fully understood and warrant further investigation.

5.4 Temperature and Heat Emissions

34. SPCs generate heat during energy transmission, which can elevate temperatures in the surrounding sediment and water. This thermal change may influence microbial communities and benthic organisms. While AC cables tend to dissipate heat more efficiently than DC cables, the broader ecological implications remain under active research.

5.5 Artificial Light

35. Artificial lighting used during construction and O&M is essential for safety but can disturb wildlife, especially birds and sea turtles. Migratory birds may become disoriented, increasing the risk of collisions, while sea turtle hatchlings may be attracted to artificial lights, heightening their vulnerability to predation and misorientation.

5.6 Collision Risk

36. Offshore wind farms pose a collision risk to marine birds, bats, and other species, particularly from rotating turbine blades. Additionally, increased vessel traffic during construction and O&M activities may endanger marine mammals and sea turtles, especially in biodiversity-rich areas such as the Mediterranean Sea.

37. OWF and floating OWF (FOWF) structures can generate secondary environmental effects, including reef effect and reserve effect:

- Reef Effect**:** Hard structures like turbine foundations and scour protection can form artificial reefs, potentially enhancing biodiversity by providing new habitats. However, they may also facilitate the spread of invasive species.
- Reserve Effect**:** The physical shelter offered by OWFs may concentrate fish populations, improving survival rates locally but possibly increasing fishing pressure in surrounding areas.

38. Marine Renewable Energy (MRE) sources have a positive environmental impact by reducing carbon emissions and air and ocean pollution. However, climate change can affect the Offshore Wind Energy (OWE) sector by altering wind patterns and resource availability.

6 Mitigation of Potential Impacts of Marine Renewable Energy Installation (OWFs and FOWFs)

39. Marine renewable energies (MREs) offer significant potential for clean, sustainable power generation. However, their development and operation can have various environmental impacts on marine ecosystems, habitats, and species. To ensure the responsible growth of MREs, it is essential to implement effective measures to mitigate these impacts. These measures encompass site selection, and operational practices designed to protect marine life, preserve ecosystems, and promote biodiversity.

6.1 Site Selection

40. Site selection is a critical mitigation measure. Ideally, conflicts between offshore wind farms (OWFs) and nature conservation can be avoided or minimized by prioritizing areas with low ecological sensitivity. However, complete spatial separation is rarely feasible, so a balanced and informed approach is necessary. Several tools support this objective.

6.1.1 Marine Spatial Planning (MSP)

41. Coastal and marine areas are often subject to competing ecological and economic interests due to limited space. Long-term, strategic planning is essential for managing these competing uses. Marine Spatial Planning (MSP) was developed to balance human activities with environmental protection across broad spatial scales. MSP aims to reduce spatial conflicts between development and environmental priorities.

42. MSP is ecosystem-based, integrated, adaptive, strategic, and participatory. It incorporates ecological, economic, and cultural considerations to prioritize areas for protection. MSP should

operate on a 10–20-year planning horizon and evolve through adaptive management based on continuous monitoring.

43. MSP can also identify opportunities for co-use of marine areas, such as combining OWFs with marine conservation, tourism, or aquaculture.

44. In the Mediterranean, regulations are often sector specific. A UNEP report highlights the potential of MSP beyond national waters to adopt a more integrated approach to marine conservation and sustainable resource use (UNEP/MAP, 2017). EU-funded studies have identified key Mediterranean regions, such as the Adriatic Sea, Alboran Sea, and Western Mediterranean, as priority zones for MSP due to existing environmental pressures and economic activities (DECCEPR, 2010).

6.1.2 Strategic Planning

45. Strategic planning, including the use of Strategic Environmental Assessments (SEAs), is vital to addressing environmental impacts early in the planning process. SEAs are mandatory for certain projects under EU law, though implementation and rigor vary across member states.

46. SEAs are particularly useful for offshore wind energy (OWE) projects if informed by sufficient survey data. A SEA conducted for OWF site designation is typically followed by project-specific Environmental Impact Assessments (EIAs) to evaluate site-specific impacts. EIAs should include assessments of potential stressors, affected species, and cumulative effects.

47. SEAs and EIAs should be seen as complementary. SEAs focus on high-level strategic decisions, while EIAs assess the environmental consequences of individual projects. The SEA phase is the best opportunity to designate appropriate zones for both industrial use and conservation, while EIAs refine mitigation measures. Effective MSP also supports comparative evaluation of OWF site alternatives, minimizing environmental impacts.

6.1.3 Restrictions in Terms of Space and Time

48. The presence and vulnerability of species often vary by season, allowing for impact mitigation through temporal restrictions. These seasonal restrictions can reduce impacts while remaining manageable for developers. However, applying time-based restrictions across multiple species can prolong limited construction windows, complicating project timelines and coordination.

6.2 Mitigation of noise

6.2.1 Primary Mitigation Measures

49. Primary mitigation measures focus on modifying piling materials and processes to reduce underwater noise emissions during offshore wind farm (OWF) construction. One common method is the use of soft starts, which begin with low energy levels to allow mobile species to vacate the area before gradually increasing to full power. This staged approach helps reduce the risk of immediate acoustic trauma.

6.2.2 Secondary Mitigation Measures

50. Noise reduction devices are employed as secondary measures to further mitigate the impacts of pile driving. These include:

- Bubble Curtains: A ring of air bubbles is deployed around the pile to dampen noise. This method can reduce sound levels by up to 79%, although its effectiveness decreases at greater water depths.
- Casings (Pile Sleeves and Telescopic Tubes): These act as physical noise barriers, with potential reductions of up to 18 dB (SEL).
- Hydro Sound Dampers (HSDs): These flexible devices absorb and scatter sound across a wide frequency range, offering an alternative or complement to bubble curtains.

- Blue Piling Technology: This method uses gas combustion to move water mass, reducing pile-driving noise by approximately 20 dB.
- Vibratory Piling: Replaces hydraulic impact hammers with vibratory mechanisms, achieving noise reductions of 15–20 dB.
- Offshore Foundation Drilling (OFD): Suitable for rocky seabeds, OFD can lower sound levels to approximately 117 dB (SEL) and is effective at depths up to 80 meters.
- Suction Buckets/Cans: These foundations are installed using suction pumps, generating minimal underwater noise.
- Gravity-Based and Floating Foundations: These types eliminate the need for impact pile driving. While operational noise data is limited, installation noise is significantly reduced.

6.2.3 Noise Threshold Values

51. In the Mediterranean Sea, it is essential to establish noise threshold levels and species-specific exposure zones that reflect the region's unique marine fauna and ecological characteristics. For reference, Germany has set protective thresholds for species like the harbour porpoise at 160 dB (SEL) and 190 dB (Lpeak), measured at a distance of 750 meters from the noise source. These limits are designed to prevent physiological impacts such as Temporary Threshold Shift (TTS).

6.2.4 Acoustic Deterrence Devices

52. These tools, including Acoustic Deterrent Devices (ADDs), Acoustic Harassment Devices (AHDs), and Acoustic Mitigation Devices (AMDs), are used to temporarily displace sensitive species from construction zones. Devices like pingers and seal scarers emit irregular sound patterns to prevent habituation. While effective, their use must be carefully managed in sensitive areas such as fish spawning grounds to avoid unintended displacement of target species.

6.3 Mitigation of Pollution and Waste

53. To prevent pollution from both micro- and macroscopic waste, a comprehensive waste management plan must be implemented to ensure zero emissions at the offshore wind farm (OWF) site. In cases where waste generation is unavoidable, all waste must be properly collected, recycled, or disposed of onshore in compliance with environmental regulations.

54. To reduce contamination from sacrificial anodes, alternative corrosion protection methods are recommended. One such method is the Impressed Current Cathodic Protection (ICCP) system, which uses titanium anodes coated with mixed metal oxides. ICCP systems offer a longer operational lifespan and release fewer metals into the marine environment compared to sacrificial anodes. However, they produce electromagnetic fields (EMFs), which may affect marine organisms. Further research is needed to assess the intensity of these EMFs and their potential impacts on marine life.

6.4 Mitigation of Electromagnetic Fields, Temperature, and Heat Emissions

6.4.1 EMFs

55. EFs can be avoided with adequate shielding, such as sheaths within cables. Armoured SPCs are recommended to prevent EMFs. For DC cables, placing two cables parallel to each other can neutralize MFs. For AC cables, bundling reduces MFs but cannot prevent EF induction in surrounding conductive materials.

56. Burial of SPCs reduces EMFs above the seabed. Alternatively, covering SPCs with rocky materials or concrete mattresses can reduce EMFs but might introduce new habitats, potentially aiding invasive species. Modelling of field strength should be conducted to assess the effectiveness of mitigation.

6.4.2 Temperature

57. HVDC cables are recommended over AC cables to reduce heat emissions. Bundling cables minimizes the total area affected by heat.

6.4.3 Heat Emissions

58. To mitigate heat emissions, burying or covering SPCs is suggested. Adequate burial depths help achieve this, with variations based on seafloor properties.

6.5 Mitigation of Light

59. Artificial lighting on offshore structures attracts migrating birds, especially under poor weather conditions, thereby increasing the risk of collisions. Therefore, minimizing lighting is essential to reduce attraction of birds and other wildlife. While lights may also attract marine species such as fish and turtles, no major impacts have been reported to date, and no targeted mitigation measures are currently required.

60. Aviation lights at turbine height are generally only necessary during helicopter operations for rescue or maintenance. Significant light reduction—up to 99%—can be achieved by using “light-on-demand” systems that activate only when aircraft are present. While this approach currently applies to aviation lights, the necessity of continuous navigation lights should be reconsidered in light of modern GPS- and radar-based vessel navigation.

61. Research on the influence of light color on bird attraction has yielded mixed results. However, broad-spectrum and white lights should generally be avoided. Green and blue lights are preferred, while red and white lights are more likely to cause disorientation.

62. Steady or non-flashing lights should be eliminated, particularly on communication towers, to reduce bird attraction, Light phases should be minimized, with longer dark intervals.

63. Although the specific effects of light intensity on bird behaviour are not yet fully understood, it is widely accepted that reduced lighting levels are beneficial. Research indicates that lower light intensity attracts fewer seabirds. While safety lighting must comply with national regulations, both light intensity and the number of flashes should be minimized to reduce attraction.

6.6 Mitigation of Collision

64. Marine mammals and sea turtles are particularly vulnerable to vessel collisions. Large, slow-swimming whale species are at greatest risk, but dolphins, smaller cetaceans, and agile sea turtles also sustain severe injuries from ship strikes. Site selection for Offshore Wind Farms (OWFs) must take into account the proximity of ship traffic and sensitive marine species. Since 2004, passenger and commercial vessels over 299 gross tonnes are required to carry an Automatic Identification System (AIS) transponder, which facilitates the monitoring of vessel movements and supports environmental protection (Coomber et al., 2016). AIS data can inform traffic routing and speed adjustments related to OWFs. Key mitigation strategies include reducing vessel speeds—especially for service and crew vessels—and defining dedicated shipping lanes or corridors.

65. AIS and monitoring data can be used to create maps identifying marine mammal hotspots, thereby guiding effective collision mitigation strategies. A speed limit of 10 knots has been proposed for regions with high marine mammal densities in the Mediterranean, as it significantly reduces the risk of ship strikes (Vaes et al., 2013). Speed reductions are also recommended to protect sea turtles; speeds above 4 km/h significantly increase collision risks (Hazel et al., 2007). Reducing vessel speed is a cost-effective and practical mitigation measure, whereas many other strategies are more expensive and less effective (Carrillo & Ritter, 2010). The International Whaling Commission (IWC) has developed a “Strategic Plan to Mitigate the Impacts of Ship Strikes,” aiming to reduce ship collisions globally (IWC, 2018).

66. The risk of bird and bat collisions with turbines can be minimized by locating OWFs outside major migration corridors. These corridors are typically concentrated in narrow straits or

specific sites, presenting limited conflict with wind energy planning.

67. Temporary shutdowns of wind turbines during peak migration periods or adverse weather can significantly reduce collision risks. Turbines in high-risk zones should be deactivated when birds enter designated safety perimeters. Cameras are effective for targeted applications, while radar is better suited for large-scale and night-time monitoring.

68. Enhancing the visibility of turbine blades may help reduce bird collisions. Laboratory studies suggest that high-contrast patterns, such as black-and-white square-wave bands or a single black blade with two white ones, improve visibility. UV-reflective paints, visible to some bird species, have also been proposed (Marques et al., 2014). Additional options include bird-friendly markings and lighting on turbines and converter platforms, especially under poor visibility conditions.

6.7 Additional Mitigation Measures

69. During the construction phase, efforts should focus on avoiding or minimizing erosion, sediment suspension, and turbidity plumes. Offshore wind turbine (OWT) construction and subsea power cable (SPC) laying techniques should be selected to reduce sediment resuspension and water column turbidity. The burial method and depth used during both the construction and operation and maintenance (O&M) phases are critical. Cable route planning should prioritize techniques that minimize sediment displacement and morphological alteration, particularly in soft substrates. Burial techniques must be adapted to substrate type and aim to minimize sediment disturbance. If natural infill of the cable trench does not occur, it should be backfilled with surrounding native material.

70. Jetting or ploughing are recommended for SPC burial. In sensitive habitats, such as salt marshes or intertidal zones, horizontal directional drilling (HDD) is considered the least invasive technique. Timing of HDD operations should be optimized to reduce environmental impact. "Horizontal Directional Drilling (HDD) can be employed in areas where tidal conditions are taken into account to minimize environmental disturbance. However, SPC burial may not be feasible in regions with hard substrates or deep waters.

71. In locations where burial is not possible, such as at cable crossings or hard substrate zones, alternative protection measures should be employed. Rock dumping is a commonly used method to shield SPCs along routes or at crossings. Whenever possible, local rocky materials should be used instead of imported rock or artificial materials like concrete, which may introduce invasive species. Anti-scour frond mattresses can also be applied to encourage sediment deposition, thereby covering the SPCs with native materials. However, these materials can be displaced during storm events, potentially reducing effectiveness.

72. In areas with solid rock near landfall points, where route avoidance is not feasible, horizontal directional drilling is the preferred technique to avoid extensive environmental damage associated with rock blasting. Offshore, alternative tools such as rock-ripping ploughs, rock wheel cutters, or vibratory share ploughs are more appropriate for installing cables through hard seabed substrates.

73. To mitigate impacts on submerged cultural heritage sites, these areas should be excluded from OWF construction zones and SPC cable routes.

7 Conclusions

74. The global energy transition, driven by the urgent need to reduce greenhouse gas emissions, is propelling the rapid expansion of marine renewable energy developments (MREDs), particularly Offshore Wind Farms (OWFs). As part of this movement, the Mediterranean Sea is emerging as a key frontier for renewable energy, albeit with unique geographic and ecological challenges. While fixed OWFs dominate current installations globally, the region’s deep waters necessitate a shift towards Floating Offshore Wind Farms (FOWFs), which offer promising potential due to their ability to harness stronger, more consistent winds in deeper offshore areas.

75. However, despite that the potential impacts of the MRE Sector are listed in Annex III of this report, the deployment of FOWFs introduces a range of environmental uncertainties. Unlike fixed technologies, FOWFs operate in less-studied deep-sea ecosystems, where potential impacts, from noise and light pollution to habitat disruption and EMFs, are not yet fully understood. Sensitive marine habitats such as submarine canyons, coral gardens, and sea mountains may face significant risk, and knowledge gaps persist regarding the effects on migratory species, benthic organisms, and overall biodiversity.

76. To ensure that renewable energy development in the Mediterranean is both effective and sustainable, several critical actions are necessary. First, robust environmental safeguards and guidelines must be integrated into all stages of OWF and FOWF lifecycles, from planning and construction to operation and decommissioning. Comprehensive Life Cycle Assessments (LCAs) should be standard practice, accounting for the full environmental footprint, including raw material extraction and the impacts of dismantling infrastructure.

77. Second, current Environmental Impact Assessments (EIAs) must evolve from their narrow species focus to embrace holistic, ecosystem-based approaches. The outline of the EIA for the MRE should be prepared and agreed at the regional level. This should be coupled with detailed Environmental Monitoring Plans that extend across the entire project footprint, including subsea power cables, should be aligned with the ecological descriptors of the Marine Strategy Framework Directive (MSFD). Such EMPs should include the IMAP CIs as well.

78. Third, regional policy framework tailored to the Barcelona Convention and its Protocols is urgently needed. Such framework should include the principles of Sustainable Development articulating the necessary measures to combat pollution, mitigate impacts, and promote sustainability. This should foster diversified renewable energy portfolios, prioritize energy efficiency, and establish clear regional standards for MRED deployment.

79. Ultimately, while the technological and climatic potential of floating offshore wind energy in the Mediterranean is substantial and has the potential to grow as an emerging sector, its success will depend on how responsibly and strategically it is implemented. Balancing renewable energy expansion with environmental stewardship will be key to meeting international climate goals without compromising the health and integrity of Mediterranean marine and coastal ecosystems.

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Annex I

List of National installation (planned/under construction/ installed) in Mediterranean

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
- Northern Med.	Spain	13.6km offshore (os) Estepona-Marbella Area 534 km^2	ZAPER ESAL 1	Planned	0	Wind farm (polygon pg)
		7km os Malaga – Nerja Area 689 km^2	ZAPER ESAL 2	Planned	0	Wind farm pg.
		8km os Malaga	Nao Victoria	Planned	990	Wind farm (point pt)
		6.9 km os Nerja	Albaicin	Planned	610	Wind farm pt.
		23.6 km os Motril	La Pinta	Planned	990	Wind farm pt.
		4.8 km os Almeria	Alwind	Planned	300	Wind farm pt.
		9.5 km os Mojacar	Mar de Agata	Planned	300	Wind farm pt.
		37.6 km os Valencia	Ocean H2	Planned	6	Wind farm pt.
		0.1 km os Port Adriano Mallorca	Eco Wave Power	Early concept	2	Wave clapper Hydraulic sys
		4.8 km os Son Parc Es Grau Area147 km^2	ZAPER_LEBA 2	Planned	0	Wind farm pg.
		10.8 km os Mahon Area 77.7 km^2	ZAPER_LEBA 3	Planned	0	Wind farm pg.
		18.6 km os Lloret de Mar	Creus	Planned	510	Wind farm pt.
		11km os L'Estartit-Cadaqués Area 250 km^2	ZAPER_LEBA 1	Planned	0	Wind farm pg.
		20.3 km os L'Estartit	Catwind (2pt)	Planned	1200	Windfarm 2pt
		16.3 km os L'Escala	Gavina (2 pt)	Planned	500	Windfarm 2pt
		15.2 km os Cadaqués	Tramuntana Phase 1 (2pt)	Planned	450	Wind farm 2 pt
		10 km offshore Cadaqués	Medfloat Pilot Parc	Planned	50	Wind farm pts
		18.4 km os L'Escala	L'Emporda	Planned	510	Windfarm 2pt
	France	23.3 km os Perpignan-Narbonne Area 363.4 km^2	Méditerranée (1)	Planned	250	Wind farm pg. 1

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		18.8 km os Perpignan-Narbonne	Golfe du Lion	Constr -uction	30	Wind farm pt
		14.9 km os Perpignan Area 5.1 km^2	Leucate-Le Barcarès	Test site - Pilot	30	Wind farm pg.
		27.9 km offshore Perpignan-Narbonne	Ideol Quadran FloatingProject	Planned	500	Wind farm pts
		22.2km os Narbonne Area 295.8 km^2	Méditerranée (2)	Planned	250	Wind farm pg. (2)
		17.7km os Narbonne Area 5.6 km^2	Gruissan	Const. - Pilot	30	Wind farm pg.
		33.5 km os Montpellier Area 267.5 km^2	Méditerranée (3)	Planned	0	Wind farm pg. 3
		22.1 km os Montpellier Area 311.9 km^2	Méditerranée (4)	Planned	0	Wind farm pg. 4
		14.4 km os Montpellier Area 0.8 km^2	Faraman-Port-Saint-Louis-du-Rhône	Test site - Pilot	25	Wind farm pg.
		16.8 km os Marseille	Provence Grand Large	Construction	25.2	Wind farm pts
		Port-Saint-Lois-de-Rhone Position: estimated	Sarbacanne	In devel -opment	n/a	Salinity gradient
		4.8 km os Marseille	NextFloat	Planned	6	Wind farm pt
		5.5km os Marseille	AFLOWT	Planned	6	Wind farm pt
	Monaco	0.2 km Port of Monaco	WEC S3 sea trial	Early concept	n/a	WEC S3 Bulge Wave
	Italy	1 km os Lavagna	Lavagna WEP	n/a	4	Submerged Pressure Differential (SPD, Wave)
		288 m to coast Marina di Pisa	Marina di Pisa H-WEP 1	Operational	50 (kW)	Wave/tidal Pressure Differential
		282 m to coast Gorgona Island	Gorgona WEP	n/a	n/a	SPD
		24.7 km os Livorno	Atis	Planned	864	Wind farm pt
		2.8 km offshore Castiglioncello	Punta Righini R-WEP	Completed	150 (kW)	SPD
		641m to coast Pomonte (Elba isl.)	Elba R-WEP	n/a	100 (kW)	SPD
		10.7 km os Montalto di Castro	MoDiCa	Planned	510	Wind farm pts
		21.2 km os	Seabass	Planned	n/a	Wind farm pts

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		Montalto di Castro				
		22.7 km os Civitavecchia	Civitavecchia A	Planned	225	Wind farm pts
		23.9 km os Civitavecchia	Civitavecchia B	Planned	375	Wind farm pts
		27.2 km os Civitavecchia	Bluwind Civitavecchia	Planned	870	Wind farm pts
		576m to coast Civitavecchia	REWE C3 @ Civitavecchia	Partly oper - ational	2.5	OWC Oscillati ng Water Col.
		7m to coast Port of Naples	Overtopping Breakwater for Energy Conver	n/a	8 (kW)	Wave
		81m to coast Port of Salerno Breakwater	REWE C3 @ Salerno	In planning	n/a	OWC
		12 km os Isola Maddelena	Tibula Energia	Planned	875	Wind farm pts
		25.4 km os Porto Cervo	Nurax	Planned	462	Wind farm pts
		32.7 km os Sardinia Northeast	AvenHexicon	Planned	2150	Wind farm pts
		2 km os Olbia	Zefiro	Planned	2016	Wind farm pt
		49.3 km os NW Tyrrhenian Sea	Poseidon	Planned	1008	Wind farm pts
		13.8 km os Villasimius	Nora Energia 2	Planned	600	Wind farm pts
		7.3 km os Sarroch	Nora Energia 1	Planned	795	Wind farm pt
		10.2 km os Nora	San Pietro Sud	Planned	504	Wind farm pts
		25.1 km os Chia	Nuovo Porto Pino	Planned	705	Wind farm pts
		15.5 km os Chia	Sardegna 1	Planned	550	Wind farm pt
		36.1 km os Chia	Sardinia So. 2	Planned	750	Wind farm pt
		16 km os Porto Pino	Sardegna 2	Planned	825	Wind farm pt
		37 km os Porto Pino	Thalassa	Planned	525	Wind farm pt
		37.2km os PortoPino	Sardinia Sou.1	Planned	1600	Wind farm pt
		15.4km os PortoPino	Del Toro 1	Planned	293	Wind farm pt
		21.8km os PortoPino	Del Toro 2	Planned	293	Wind farm pt
		27.8km os PortoPino	S. Pietro Nord	Planned	510	Wind farm pt

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		38.5km os PortoPino	Molise	Planned	1800	Wind farm pt
		Piana Island, Sardinia	W2EW	Consented	n/a	OWSC
		38.6km Bosa	Sardegna	Planned	480	Wind farm pt
		30kmos Sardinia NW	AvenHexicon	Planned	1350	Wind farm pt
		53.4 km os Marsala	MedWind	Planned	2793	Wind farm pt
		58.6 km os Trapani	Ostro	Planned	600	Wind farm pt
		28.9 km os Marsala	Calypso	Planned	600	Wind farm pt
		16.2 km os Marsala	Ichnusa	Planned	504	Wind farm pt
		196 m from coast Marsala	REAPower Project	Completed	1 (kW)	Salinity gradient
		61.6 km os Mazara del Vallo	Mazara del Vallo Offshore	Planned	1110	Wind farm pt
		62 km os Mazara	Trinacria	Planned	840	Wind farm pt
		36.1 km os Mazara	Hannibal	Planned	250	Wind farm pt
		41.9 km os Mazara	Mazara del Vallo Offshore 3	Planned	810	Wind farm pt
		40.8 km os Mazara	Seawind Mazara	Planned	798	Wind farm pt
		53.3 km os Mazara	Elymo A	Planned	858	Wind farm pt
		52.7 km os Mazara	Sicily	Planned	504	Wind farm pt
		26.2 km os Mazara	HyMed	Planned	3200	Wind farm pt
		46.3 km os Mazara	Sicilia 495 MW	Planned	495	Wind farm pt
		52.7 km os Mazara	Mazara del Vallo Offshore 2	Planned	795	Wind farm pt
		30 km os Agrigento	Elymo B	Planned	435	Wind farm pt
		592 m to coast Pantelleria Island	ISWEC Project	Completed	100 (kW)	Wave
		30.5km os Gela, ENI Prezioso platform	MaREnergy ISWEC 2	In planning	100 (kW)	Wave
		48.9 km os Licata	Sicilia A, B	Planned	1020	Wind farm pt
		48.9 km os Scicli	Scicli	Planned	750	Wind farm pt
		17.8 km os Scicli	Eureka Wind	Planned	570	Wind farm pt
		32.5 km os Pozzallo	Bluwind Pozzallo	Planned	975	Wind farm pt
		40.5 km os Pozzallo	Euribia	Planned	660	Wind farm pt
		42.6 km os Licata	Pozzallo Offsh	Planned	800	Wind farm pt
		52.5 km os Portopalo	Gulf of Gela	Planned	384	Wind farm pt
		3.5 km os Siracusa	Ragusa Offshore	Planned	945	Wind farm pt

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		1170m to coast Strait of Messina-1	FRI-EL Seapo -wer Messina III	Consented	500 (kW)	Tidal
		140m to coast Strait of Messina-2	Kobold 1	Completed	50 (kW)	Tidal
		15m to coast Porto de Grazie	REWEC3 Roccella Jonica	Early concept	n/a	Wave OWC
		66.1km os Le Castella	RepowerFOWT Scandale Sicilia	Planned	495	Wind farm pt
		25.2km os Monasterace	Calabria	Planned	555	Wind farm pt
		8.5 km os Monasterace	Fortevento	Planned	585	Wind farm pt
		8.5 km os Le Castella	Minervia Energia	Planned	675	Wind farm pt
		2.2 km os Crotone	Krimisa	Planned	1100	Wind farm pt
		23.3 km os Policoro	Ionio	Planned	420	Wind farm pt
		9 km os Taranto	Golfo di Taranto	Planned	1500	Wind farm pt
		1.4 km os Taranto	Taranto Offshore	Production	30	Wind farm pt
		9.5 km os Taviano	Dorada	Planned	1620	Wind farm pt
		15.7 km os S Mar di Leuca	Odra Energia	Planned	1350	Wind farm pt
		41.5 km os S Mar di Leuca	S. Mar di Leuca	Planned	675	Wind farm pt
		39.1 km os S Mar di Leuca	Puglia 1	Planned	900	Wind farm pt
		25.8km Gagliano Capo	Messapia	Planned	1300	Wind farm pt
		18.6 km os Lecce	Lupiae Maris	Planned	525	Wind farm pt
		5.6 km os Brindisi	Centrale Eolica Offshore Brindisi	Planned	108	Wind farm pt
		3.6 km os Brindisi	Kailia Energia	Planned	1176	Wind farm pt
		25.8 km os Brindisi	Bluwind Brindisi	Planned	840	Wind farm pt
		24.9 km os Brindisi	Vieste	Planned	1200	Wind farm pt
		22.8 km os Brindisi	Brenda Energia	Planned	741	Wind farm pt
		25 km os Brindisi	BRN	Planned	504	Wind farm pt
		6.7 km os Bari	Puglia B	Planned	930	Wind farm pt
		9.5 km os Bari	Puglia A	Planned	1005	Wind farm pt
		15.9 km os Bisceglie	MoDiCa 2	Planned	510	Wind farm pt
		29.2 km os Bari	Barletta Offshore	Planned	840	Wind farm pt
		80.3 km os Bari	Bari	Planned	600	Wind farm pt
		35.7 km os Bari	BNW	Planned	504	Wind farm pt
		16.7 km os Barletta	Gargano Sud	Planned	340	Wind farm pt
		24.3 km os Barletta	Maxima Energia 1, 2	Planned	1140	Wind farm pt

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		19.7 km os Manfredonia	Barium Bay	Planned	1100	Wind farm pt
		33.3 km os Vieste	NEREUS Offshore	Planned	2205	Wind farm pt
		41.6 km os Vieste	Bluwind Manfredonia	Planned	825	Wind farm pt
		54.8 km os Vieste	Hope Group Manfredonia	Planned	945	Wind farm pt
		32.6 km os Vieste	APENESTE Offshore	Planned	915	Wind farm pt
		15.7 km os Pescara	Abruzzo 1	Planned	1760	Wind farm pt
		11.6 km os Pesaro	Marche 1	Planned	500	Wind farm pt
		15.8 km os Rimini	Rimini	Planned	330	Wind farm pt
		33.5 km os Rimini	Agnes 1	Planned	120	Wind farm pt
		51.1 km os Ravenna	Romagna 3	Planned	320	Wind farm pt
		21.7 km os Ravenna ENI PC80 platform	MaREnergy PB3	Operational	n/a	Wave Attenuator
		35.5 km os Ravenna	Agnes 2	Planned	400	Wind farm pt
		21 km os Chioggia	Veneto 1	Planned	500	Wind farm pt
		251 m from coast Venice Lagoon	GEM – the Ocean's kite	Completed	20 (kW)	Tidal
		10.5 km os Corfu	Medio Adriatico	Planned	800	Wind farm pt
	Greece	4.1 km os Othonoi	Diapontia Wind phase Seven	Planned	15	Wind farm pt
		510 m to coast Othonoi	Diapontia Wind phase Five	Planned	20	Wind farm pt
		1.5 km os Othonoi	Diapontia Wind phase Six	Planned	20	Wind farm pt
		4.9 km os Othonoi	Diapontia Wind phase Nine	Planned	30	Wind farm pt
		510 m to coast Port of Heraklion	SINN Power Crete	Decommissioned	72 (kW)	Wave pt absorber
		31.9 km os Heraklion	Aegean Islands	Planned	n/a	Wind farm pt
		1.2 – 3 km os of Alexandroupoli	Thrakiki Wind 1 9 sites	Planned	24 x 9	Wind farm pts
		2.8 km os Chios	Musica 1	Planned	n/a	Wind farm pt
		4 km os Chios	Musica 2	Planned	n/a	Wind farm pt
		4.9 km os Othonoi		Planned	n/a	Wind farm pt
		4.9 km os Othonoi		Planned	n/a	Wind farm pt
Eastern Med.	Cyprus	3.3 km os Larnaca Bay	SWEL-WLM	Operational	1(kW)	Wave Attenuator
	Israel	Port of Jaffa n/a	ECO Wave Power EDF 1	In Const.	125 (kW)	Wave clapper

	MRE installations in the Mediterranean region					
Region	Country	Location	Name	Status	Size (MW)	Type
		Port of Jaffa	ECO Wave Power EDF 1	Completed	100 (kW)	Wave clapper
		Port of Jaffa	SDE Sea Wave Power Plant	Completed	40 (kW)	Wave Hyd Sys

Annex II

List of National Strategies and Plans for the MRE in Contracting Parties of Barcelona Convention

List of National Strategies and Plans for the MRE in Contracting Parties of Barcelona Convention

Region	Country	Strategies/Plans	References
Northern Mediterran	Albania	No existing projects; actively exploring offshore wind potential. Developing regulations and policies for future implementation.	Ministria e Infrastrukturës dhe Energjisë
	Croatia	No existing offshore wind energy projects. Actively exploring offshore wind potential. Creating regulations and policies for future implementation	mzoe.hr
	Greece	**Law** 3851/2010. Defines licensing and environmental assessments. 2.6 GW offshore wind target by 2030. EU MSP Directive incorporated: Law 4546 (2018). Ministry of Environment and Energy's Directorate of Spatial Planning responsible for MSP. The National Spatial Planning Council was created for stakeholder input. No current legally enforceable national MSP. Active in European marine spatial planning initiatives.	www.rae.gr www.ypen.gr
	Slovenia	**Foundation Act:** Slovenian Spatial Planning Act (2017). **MSP Execution:** Ministry of Environment and Spatial Planning. **Draft MSP:** Created in early 2020 (AP SPRS). **Consultations:** Open consultations in 2020 and 2021. **Environmental Report:** Contract finalized.	Ministrstvo za infrastrukturo | GOV.SI
	Spain	Law 24/2013 provides a stable legal framework for renewable energy projects. **Target:** Spain aims to install 3 GW of offshore wind capacity by 2030. **Wind Float Atlantic Project:** One of the largest offshore wind energy projects in Spain. **Supportive Regulations and Policies:** Spain has implemented regulations and policies to foster renewable energy growth, including offshore wind.	Energía Ministerio para la Transición Ecológica y el Reto Demográfico
	Malta	**Offshore Wind Exploration:** No existing offshore wind energy projects. The country is exploring offshore wind potential. Developing regulations and policies for future projects. **Malta's Spatial Planning:** Replaced Structure Plan with SPED in 2015. SPED outlines strategic spatial policy up to 2020. The National Spatial Framework applies to marine waters up to the 25 nm limit of the Fisheries Management Conservation Zone. Integrates coastlines and marine zones as a single spatial unit.	Energy and Water Agency - EWA
	Monaco	No existing offshore wind energy projects.	en.gouv.mc

Region	Country	Strategies/Plans	References
		Country prioritizes other forms of renewable energy. Specific regulations and policies for offshore wind are yet to be developed.	
	Montenegro	No Existing Offshore Wind Projects. Early Exploration Phase. Regulations and Policies Under Development.	mek.gov.me
	France	**French Offshore Wind Regulations:** Governed by Code de l'Énergie and Code de l'Environnement. Define permitting, environmental assessments, and grid connection requirements for offshore wind farms. France targets 5.2 GW of offshore wind capacity by 2028. **National Maritime Strategy:** Outlined in the Stratégie Nationale pour la Mer et le Littoral. Adopts sea-basin plans to meet MSFD and MSPD criteria. **Sea-Basin Policies (DSF):** Include preliminary evaluation, strategic goals, and MSP-related fact sheets. Developed in collaboration with key players and neighboring nations. Environmental review by the French Environmental Authority. Authorization granted for each marine basin. **Floating Offshore Wind Turbine (FOWT) Project:** Located in the Mediterranean Sea near Marseille. Features a single 2 MW floating wind turbine.	www.ecologie.gouv.fr www.cre.fr
	Italy	**Italian Offshore Wind Regulations:** Governed by Decreto Ministeriale 23/2016. Sets criteria for permits and authorizations for offshore wind projects. **Offshore Wind Areas:** Identified in the Adriatic Sea and southern Mediterranean. **Marine Strategy Framework:** Four marine zones based on marine sub-regions concept. Each zone has planning units with tactical goals and "vocations." **MSP Strategies Proposal:** Italian government presented MSP strategies proposal for four marine areas to the European Commission in June 2021. The proposals will undergo public discussions in each of the Regions after authorization.	www.gse.it
Eastern Mediterran	Cyprus	**Cyprus Offshore Wind Development:** No existing offshore wind energy projects. Introducing legislation and regulations to support offshore wind projects. Licensing process established, regulations and policies under development.	meci.gov.cy/meci/ meci.nsf/ page24_gr/

Region	Country	Strategies/Plans	References
		Maritime Spatial Planning (MSP): Cyprus implemented the MSP Directive via the MSP Law ratified in October 2017. Ministry of Transport, Communication, and Works (Department of Merchant Shipping) is responsible for MSP. An MSP Committee supervises the draft MSP. Cyprus has not yet produced an MSP Plan but has engaged in various MSP related European initiatives.	page24_gr? OpenDocument
	Lebanon	**Lebanon Offshore Wind:** Exploring potential. Developing regulations and policies. No existing projects yet.	www.energyandwater. gov.lb
	Syria	No existing offshore wind energy projects in the country.	www.moe.gov.sy
	Türkiye	**Marmara Offshore Wind Farm (Türkiye):** The first and only offshore wind energy project in Turkey. Supported by implemented regulations and policies for renewable energy growth.	enerji.gov.tr csb.gov.tr
	Palestine	Currently, there are no existing offshore wind energy projects in Israel. The country has set a target to generate 10% of its electricity from renewable sources by 2020, which includes offshore wind energy.	Survey
	Israel	**Israeli Offshore Wind Initiatives:** Recognizes offshore wind's potential for energy diversification and emissions reduction. Awarded licenses for "Karin" and "Dolphin" projects with a combined capacity of 1.4 GW. Aimed to reach 10% electricity from renewables by 2020. **Regulatory Framework:** Established to facilitate offshore wind development. Specific Mediterranean Sea area allocated. Licensing and permitting guidelines defined. **Incentives with Feed-In Tariff:** Introduced to attract investments. Guarantees fixed electricity prices over a specified period for financial stability. **Environmental Impact Assessments:** Conducted to minimize ecological and environmental impact. Assess effects on marine ecosystems, wildlife, and the overall marine environment. **R&D Investment:** Collaborates with academic institutions and industry partners. Aims to advance offshore wind technology and enhance efficiency.	משרד האנרגיה והתשתיות
Southern Mediterran	Egypt	**No existing offshore wind turbine still under studies considered as exploring level**	Survay
	Morocco	**Moroccan Offshore Wind Interest:**	Accueil

Region	Country	Strategies/Plans	References
		Interest in offshore wind energy development. **Legal Framework:** Established through Law No. 13-09. Covers renewable energy projects, including offshore wind. **Renewable Energy Strategy:** Aims for 52% renewable energy in electricity mix by 2030. **Offshore Wind Potential:** Identifies potential areas on the Atlantic coast. **Key Offshore Wind Project:** Tarfaya Offshore Wind Farm, Morocco's first. **Regulations and Policies:** Implemented to support renewable energy, including offshore wind.	www.masen.ma
	Algeria	**Algerian Offshore Wind Interest:** Early exploration and development stages. **Offshore Wind Potential Assessment:** Exploring potential sites along the Mediterranean coast. **Energy Mix Diversification:** Increasing the share of renewable energy. **Regulations and Policies:** In the process of developing regulations and policies. **No Current Offshore Wind Projects:** No existing offshore wind energy projects.	energy-transition.gov.dz
	Libya	No existing offshore wind energy projects. Political situation impacts the development of regulations and policies for renewable energy, including offshore wind.	ministryofelectricity.ly
	Tunisia	Exploring the potential for projects in its coastal areas. Identified areas along its coast, such as Bizerte and Gabes, as potential sites for offshore wind development. No existing offshore wind energy projects. The country is in the early stages of exploring the potential for offshore wind and is in the process of developing regulations and policies.	energiemines.gov.tn

Annex III

List of potential impacts of the FOWFs/OWFs

List of potential impacts of the FOWFs/OWFs

Issue	Type of MRE installation	Stage	Potential impacts	Cause - Considerations for minimisation of impacts Comments
Impacts of noise and pollution	Fixed OWFs Floating OWFs (FOWFs) All OWFs	Construction Construction Operation & Maintenance	Noise pollution in the ocean impacting upon marine life, including functioning and life. Cable laying produces underwater noise and vibrations. Overall: Impact upon reproduction of marine mammals – greatest during piling, fixed OWFs, negligible during O&M Noise detection by fish depends on: size and number of turbines; fish hearing abilities; background noise level; blade design and wind speed; water depth; and bottom type.	Hammers for pile driving during construction. Vibrations. Working vessels. Cable laying. Reduced impact – no foundation, no piling required. Working vessels. Anchoring. Cable laying. Blade and tower vibration. Working vessels. Reducing noise during construction activities is important, especially during sensitive seasons (breeding, feeding), which can be obtained using electric vessels or suspending construction activities.
Impact of collisions on birds and bats	All OWFs	Operation & Maintenance	20% of all bird species migrate annually, about 1800 species in total, and these have the potential to collide with OWF blades. Impact includes collision-induced mortality and foraging habitat loss. Nine factors influencing bird vulnerability to FOWFs. These factors integrated into a vulnerability index that helps predict the impact and thus for applying mitigation measures. Increasing blade size, spatial area covered, and maximum tip height increase, have consequences of increased risk of bird and bat collision. Bats comprise approx. 1100 species, some of which are migratory. No data about the collision and mortality of bats due to OWFs. Data from land windfarms they might have a high mortality rate with 10–12 bats killed/turbine annually.	Seabirds' behavioural responses to the presence of OWFs include avoiding, indifference, or attraction. They may exhibit two types of avoidance behaviour at OWFs: macro-avoidance is when birds alter their flight path to avoid the entire wind farm; while micro-avoidance is when birds enter the OWF while avoiding individual turbines. A knowledge of seabird species present in OWF areas is mandatory for adopting adequate mitigation measures since species flying most of the time will be more vulnerable than those mostly swimming. Seabirds typically collide with OWFs at night or at times of low visibility when they cannot avoid the turbines. Birds partly attracted to OWFs due to their reef effect; whereby local turbulences result in major prey availability for the birds feeding at the surface.

Issue	Type of MRE installation	Stage	Potential impacts	Cause - Considerations for minimisation of impacts Comments
				Bats change altitude rapidly when near tall vertical obstacles such as ships, bridges, and wind turbines. All migrating bats observed over the sea fly at relatively low altitudes (*N. noctula* flies <10 m above the surface although a few can reach 40 m). Since the lowest altitude of the blades is 60–70 m from the sea surface, the collision risk of bats with turbines of the FOWFs could be very limited if not negligible.
Impacts on the water column and ecosystem functioning	FOWFs Fixed OWFs	Operation & Maintenance	FOWFs can impact upon water circulation and plankton dynamics. They can increase turbulence and enhance mixing at local scale, but effects are expected to be very localised downstream of the turbine. A single fixed turbine can increase local mixing and TKE by 7-10%, can result in reduction of peak water velocity by 5% up to ~1 km from each turbine	OWFs can alter the stratification on a larger scale, which is on average 1–2 m shallower in and around OWF clusters, while altering current speed by up to ±10%. The influence of FOWFs on natural upwellings is small. Large FOWFs can change (+/-) net primary production with consequences on fish larvae survival. Increased vertical mixing leading to a doming of the thermocline and subsequent transport of nutrients into the upper mixed layer, whereas a video plankton recorder revealed potential effects on meroplankton and nekton species distribution.
Impact on fish and fisheries	All OWFs FOWFs	Operation & Maintenance	Wind turbines can attract marine life due to a reef effect depending on their location. With increased catches in adjacent area. Fisheries restriction in OWF areas can increase both size and biomass of commercial fish species, effect detected to 500m from the turbines. Effects limited to anchoring on the seafloor, that can cause a temporary resuspension of the bottom sediments, but do not significantly impact negatively on fish assemblages. Can attract several fish that can find refuge areas and considerable sources of food on the structures. Preferred by plankton consuming species.	Noise detection by fish depends on: size and number of turbines; fish hearing abilities; background noise level; blade design and wind speed; water depth; and bottom type Turbines do not determine significant changes in pelagic fish assemblages. No effects were observed in terms of fish diversity and abundance compared to adjacent areas. Vibrations from FOWFs impacts might be negligible if blades rotated at around 170m from the sea surface and in the absence of pile foundations, with vibration and noise transmission expected to be negligible or absent in deeper waters.

Issue	Type of MRE installation	Stage	Potential impacts	Cause - Considerations for minimisation of impacts Comments
			Turbine chains and anchors represent an additional hard substrate for organism colonisation that can attract several fish species.	Turbines act as FADs that are known to concentrate various fish species. Marine wind farms often conflict with industrial fisheries as the longline is impossible within and around the FOWF, and trawling should be avoided for safety reasons.
Impact on marine mammals and large migratory species	FOWFs OWFs	Operation & Maintenance Construction Operation & Maintenance	Risk of collision with floating structures should be considered as potential sources of impact on marine mammals and large migratory species. Noise can affect marine mammal reproduction, capacity to communicate, hearing prey and predatory species and feeding ability.	The larger the space/area occupied by OWF the higher the possibility of collision of large cetaceans with the floating systems. Risk appears negligible when compared to the impact of collision with ships, one of the main causes of whale deaths. The more limited the ship traffic within the FOWF area, the more beneficial are the effects on the marine mammals. Marine mammals are sensitive to noise impact, especially during pile driving for OWFs and during the O&M phase. Underwater noise of OWFTs is of low frequencies and intensity, considerably lower than ship noise. The noise impact on marine mammals is limited to the range frequency at which a marine mammal can detect the noise. Ship noise produced can impact mammals only during farm construction.
Impact on the seafloor and benthic habitats	FOWFs	Construction Operation & Maintenance	Mooring system, that includes chains and cables connecting the FOWTs to the anchors. FOWFs require a mooring system consisting of two to four anchors deployed on the seafloor. Deployment of these anchors can determine, along with the chain of connection to the turbine, impacts on deep-sea habitats. Impact of anchoring on the seafloor is likely to be one of the most relevant direct physical impacts of FOWFs. Anchors represent an additional hard substrate introduced on the bottom, can be rapidly colonized by benthic fauna.	Localised impact is expected during installation, especially when ships need anchoring for the works, and this can cause sediment resuspension as well as mechanical disturbance due to the displaced sediments. Anchors might also require the deposition of chain on the seafloor before anchor release that can penetrate soft sediments. This may result in physical disturbance or resuspension of contaminants and buried pollutants into the water column and may impact upon the feeding apparatus of suspension-feeding organisms. For floating systems, biofouling colonising the structure can cause trophic enrichment, potentially altering the structures. The presence of the submerged part of the turbines and anchors in the open sea can increase the local relevance of hard bottom fauna that

Issue	Type of MRE installation	Stage	Potential impacts	Cause - Considerations for minimisation of impacts Comments
				in turn can influence local food webs while attracting species that prey upon these taxa.
Impact of submarine power cables (SPCs)	All OWFs FOWFs	Operation & Maintenance Construction Operation & Maintenance	Three main effects of SPCs on marine ecosystems: physical damage on the seafloor. creation of a hard substrate available for colonization; generation of EMFs SPCs connected to FOWFs are partly suspended in the water column though they lay down on the seafloor. They are often covered by sediment through a cutting wheel in rocky sediments and ploughing or water jetting in soft sediments. Their impact on the seafloor can be exacerbated by large ships during deployment, where a considerable number of anchoring stabilisers are used, producing a plume of resuspended sediments.	Displacement of deployed cable on a soft bottom can cause disturbance, sediment resuspension that increases turbidity. Sealines create new hard substrates that are rapidly colonised by a variety of organisms. Although this can be seen as an alteration of habitat features, the ultimate effects are potentially positive for the local assemblages, contributing to enhancing the biomass and possibly creating refugia for some species. These plumes can affect pelagic fish eggs, decrease megafaunal abundance along the sealine track that can have long-lasting effects (Dunham et al., 2015). It is reasonable to assume that without dredging and sealine displacements no significant impacts can be detected.
Specific impacts of fixed OWFs – shallow water	OWFs	Operation & Maintenance	The wind wake effect of OWFs affects the hydrodynamical conditions in the ocean, this is hypothesized to impact marine primary production (PP). Most studies conclude that the direct hydrodynamic consequences of the windfarm structures are mainly restricted to the area within the wind farms. For the marine ecosystem the effects of OWFs might or might not be severe, positive or negative. Modifications in mixing and stratification also impacts nutrient availability in the euphotic zone.	To date, only little is known about the ecosystem response to wind wakes under the premisses of large OWF clusters. Model results provide evidence that the ongoing OWF developments can have a substantial impact on the structuring of coastal marine ecosystems on basin scales. There is some speculation that cumulative impacts of an increasing number of OWFs might result in substantial impacts on larger scale stratification. The evaluation of ecosystem effects through BACI surveys are challenging due to the spatiotemporal variability of the natural system, regional and global trends, as well as other anthropogenic impacts, such as changes in fishing effort, eutrophication, and noise levels, while the focus of investigations is on selected fish and seabird species.

Issue	Type of MRE installation	Stage	Potential impacts	Cause - Considerations for minimisation of impacts Comments
			Daewel et al. (2022) studied how OWF clusters might affect marine ecosystem productivity. **NOTE** Impacts, including those above, are not yet well understood and are the subject of ongoing and future research.	Exactly how the ecosystem is impacted is not so clear for some reasons: changes in nutrient concentration would start a cause-effect chain that translates into changes in PP that effectively alters the food chain. Results show clearly defined upwelling and downwelling cells in the vicinity of OWF clusters (North Sea). The ocean response to the substantial amount of energy extracted from the lower atmosphere is a clear and systematic change in stratification, in both seasonal mixed layer depths (~1-2m shallower in and around OWF clusters) and stratification strength. It is not relevant for OWFs in mixed areas. Substantial decrease in annual mean vertically averaged horiz. Current velocities across the southern N. Sea will strongly alter large-scale circulation of the area with potential impacts on sediment transport.