marine spatial planning global

Engaging Offshore Wind Sector in Marine Spatial Planning

Volume 2 – Good Practices

unesco Intergovernmental Oceanographic Commission

United Nations Global Compact

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Engaging Offshore Wind Sector in Marine Spatial Planning

Volume 2 – Good Practices

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UNESCO 2025

Executive Summary

Introduction

The current global expansion of offshore wind (OW) energy is reshaping marine space use and governance. As countries scale up renewable energy to meet climate goals, the urgency of ensuring coherent and sustainable spatial planning increases. The Volume 2 of this joint publication by UNESCO-IOC and UN Global Compact, developed under the MSPglobal 2.0 project, aims to respond to this challenge by offering guidance and practical recommendations for improving the engagement of the OW in marine spatial planning (MSP) processes. It builds on Volume 1, which provided a sector overview, and is based on expert dialogues, workshops, and international case studies.

This volume is structured around four main sections, starting with an overview of the MSP process and its relevance to OW, followed by a summary of key challenges that hinder the integration of OW in MSP, and finally ending with overarching and phase specific recommendations. Case studies from Asia, Europe and Latin America are included throughout the document to illustrate the various dimensions of OW's integration into MSP frameworks worldwide.

Marine spatial planning and offshore wind

MSP is an integrated, strategic, and participatory process to managing maritime territories, addressing maritime uses competing for space, while promoting the ecosystem-based approach. MSP can serve as both a driver and an enabler of OW deployment, providing an added value to the OW development by:

- Aligning OW development with national marine and energy policies.
- Facilitating cross-sectoral coordination (e.g., with fisheries, shipping, conservation).
- Reducing spatial conflicts and uncertainty for investors.
- Accelerating permitting through pre-identified OW zones and early-stage environmental and social assessments.

Challenges for engaging the offshore wind sector in MSP

Despite the many benefits of MSP, integrating OW into these processes faces multiple challenges such as the following:

- **Governance and institutional framework misalignment:** Differing mandates and institutional priorities can lead to fragmented planning and delays. OW projects often follow shorter, market-driven cycles, whereas MSP operates on longer, policy-led timelines.
- **Planning and spatial considerations:** Limited high-quality marine data hinders assessment of cumulative impacts and co-location opportunities.
- **Public engagement and social acceptance:** Exclusion of local communities, particularly Indigenous Peoples and local communities (IPLCs), can lead to project opposition and legal disputes, and possible project cancellation.

Recommendations

Overarching recommendations

The report identifies four strategic pillars for improving OW integration into MSP:

- **Spatial and temporal planning:** MSP should facilitate coordinated siting of OW infrastructure, account for land-sea interactions, and promote transboundary collaboration.
- **Stakeholder engagement:** Stakeholder engagement must be early, continuous, and adapted to local cultural and political contexts. Tools such as participatory mapping and public surveys may increase trust and help identify co-existence opportunities.
- **Environmental considerations:** Applying the mitigation hierarchy and integrating Nature-based Solutions (NbS) and Nature-Inclusive Design (NID) from early planning phases can prevent or minimise harmful environmental impacts.

- **Data sharing and technological innovation:** Data visualisation/exchange platforms advance in OW technologies require marine planners to stay up to date and promote data transparency across sectors.

Structured around the six phases of the MSP process presented in the ***"MSPglobal International Guide on Marine/Maritime Spatial Planning"*** (UNESCO-IOC and European Commission, 2021), this section provides tailored recommendations for each step of the MSP process.

Phase specific recommendations

MSP Phase	Key Recommendations
1. Setting the scene	• Conduct a legal and institutional review of marine renewable energy (MRE) frameworks early in the MSP process. • Conduct early stakeholder mapping to identify both relevant and potentially affected stakeholders related to the OW sector, as well as their planning needs. • Identify funding opportunities that could arise from leasing and taxation of OW sites to MSP.
2. Designing the planning process	• Design a strategy of participation and a communication plan that includes the key OW-related stakeholders identified in the previous phase. • Anticipate the timeline of the OW process to try and align with the MSP cycle. • Incorporate a specific target for OW as part of MSP.
3. Conducting assessments for planning	• Conduct an OW diagnosis, including environmental and social considerations as well as interactions with other users. • Engage in defining and detailing distinct alternative planning scenarios based on different OW scenarios. • Use climate and human impact data (including habitat displacement) to assess OW pressures and inform mitigation strategies. • Share OW project data and statistics in the public domain.
4. Developing the marine spatial plan	• Integrate pre-defined OW zones or priority areas into the marine spatial plan. • Explore sectoral synergies (e.g., fisheries, tourism, defence). • Incorporate measures from the mitigation hierarchy throughout the OW lifecycle. • Develop a continuous consultation plan and involve stakeholders in refining OW allocations.
5. Enabling implementation of the marine spatial plan	• Provide guidance and training on the role of MSP in OW development to OW developers and operation managers. • Develop community benefit programmes that contribute to raising awareness and fostering public acceptance within local communities. • Facilitate collaboration between OW developers and government agencies to align MSP with national energy policies and the development of future strategies.
6. Monitoring, evaluation and adaptation of the process & the plan	• Focus on outcomes, processes, and context for a comprehensive evaluation of the integration of OW into MSP. • Align MSP evaluation with OW monitoring frameworks. • Adopt iterative planning to integrate OW considerations and its evolving priorities, allowing for continuous refinement and improvement over time.

(Source: Elaborated by author)

This Volume 2 underlines that engaging the offshore wind sector in MSP requires coordinated governance, adaptive policy making, informed planning and inclusive public participation. By drawing from a global array of practices, this report aims to equip marine planners and energy experts with good practices needed to navigate the growing complexity of ocean use, contributing to a sustainable energy transition.

Foreword

The clean energy transition is essential to meet the targets set by the Paris Agreement, which aims to limit global warming to well below 2°C, preferably 1.5°C above pre-industrial levels. Ocean-based solutions are rapidly expanding, and offshore wind is becoming a key stakeholder for Marine Spatial Planning (MSP).

The Intergovernmental Oceanographic Commission (IOC) of UNESCO has been a leading UN agency to develop international guidelines and strengthen the capacities of MSP practitioners from around the world. The UN Global Compact is the world's largest corporate sustainability initiative and is focused on accelerating and scaling the global collective impact of business through accountable companies and ecosystems that enable change.

Both organizations started working together on Marine Spatial Planning and Offshore Wind in 2021, when the UN Global Compact led the co-development of the *'Roadmap to Integrate Clean Offshore Renewable Energy into Climate-smart Marine Spatial Planning'*. This roadmap supports a more rapid, socially acceptable and just implementation of offshore renewable energy in the context of Marine Spatial Planning.

As a follow-on from the 2021 report, IOC and the UN Global Compact partnered once again on the publication you are now reading. This work is a call to action for MSP and Offshore Wind practitioners to foster meaningful engagement and support for MSP processes. It charts the MSP path towards a sustainable ocean economy.

At the core of Volumes 1 and 2 is the challenge of disseminating the multi-sectoral paradigm of MSP to all ocean users. Further highlighted is the need for MSP practitioners to become more familiar with sectoral spatial characteristics, demands and sustainable practices to mitigate the impacts on socio-ecological systems.

While Volume 1 serves as a guide to navigate through Offshore Wind concepts, status, practices and interactions with other maritime sectors, Volume 2 focuses on the key challenges and good practices to improve the engagement of the offshore wind sector in MSP. Both documents were based on desk review as well as consultations with MSP and Offshore Wind experts.

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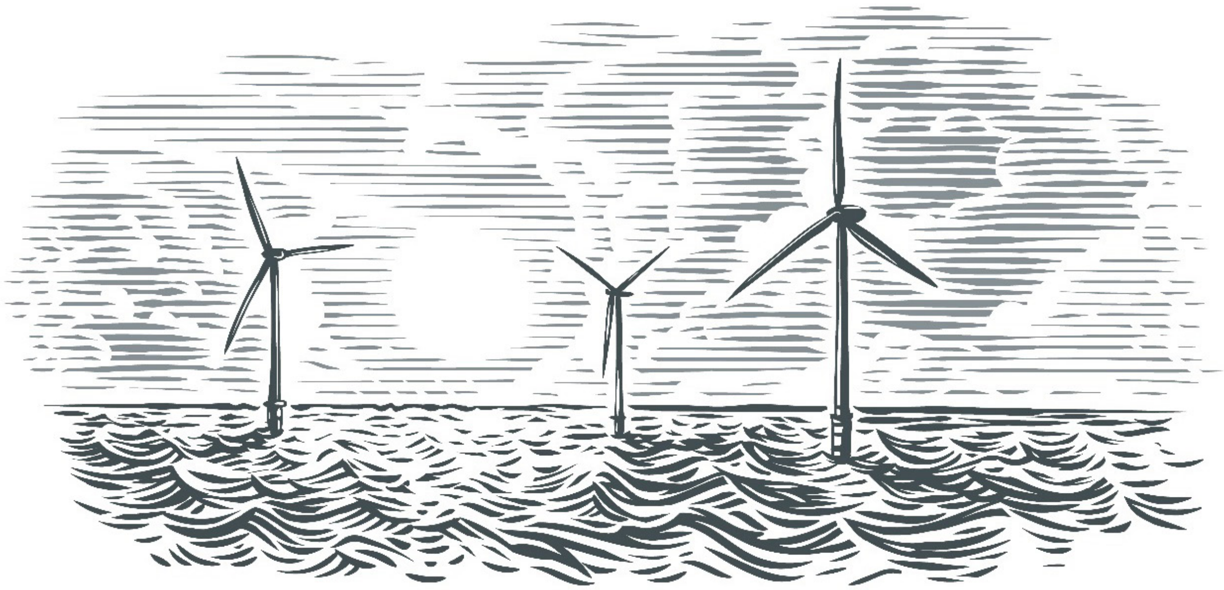
Acknowledgements

The Intergovernmental Oceanographic Commission of UNESCO[1] and UN Global Compact[2] express their gratitude to the 29 experts who participated in the consultation process for their valuable knowledge shared during the discussions. We thank particularly those who dedicated time to review the draft publications, provided further inputs and insights, and agreed to be listed as contributors.

The two volumes reflect the collective effort undertaken within the offshore wind and MSP communities, and will hopefully support a smooth transition to offshore renewable energy via sustainable MSP practices.



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1. UNESCO-IOC: https://www.ioc.unesco.org/en
2. UNGC: https://unglobalcompact.org/

List of acronyms and abbreviations

DCEE	Department of Climate, Energy and the Environment (Government of Ireland)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Government of Australia)
DEA	Danish Energy Agency
DG MARE	Directorate-General for Maritime Affairs and Fisheries
EC	European Commission
EMODnet	European Marine Observation and Data Network
EU	European Union
FPIC	Free, prior and informed consent
GIS	Geographic Information System
GWEC	Global Wind Energy Council
IBAMA	*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* (Brazilian Institute of Environment and Renewable Natural Resources)
ILK	Indigenous and local knowledge
IOC	Intergovernmental Oceanographic Commission of UNESCO
IPLC	Indigenous People and local communities
IRENA	International Renewable Energy Agency
MDE	Marine Data Exchange
MFZ	Marine Functional Zoning
MRE	Marine Renewable Energy
MSP	Marine Spatial Planning
NbS	Nature-based Solutions
NCEA	Netherlands Commission for Environmental Assessment
NGO	Non-governmental organisation
NID	Nature-Inclusive Design
NREL	National Renewable Energy Laboratory
OW	Offshore Wind
RVO	Netherlands Enterprise Agency
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEI	Stockholm Environment Institute
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

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1. Introduction

1.1 Background and rationale

MSPglobal is a joint initiative by UNESCO's Intergovernmental Oceanographic Commission (IOC) and the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE). Its mission is to develop and implement international guidelines on marine/maritime spatial planning (MSP) as policy tools for advancing global ocean governance and achieving the 2030 Agenda, particularly SDG 14.2, which focuses on sustainably managing and protecting marine and coastal ecosystems. MSPglobal supports the implementation of the Joint Roadmap to accelerate MSP processes globally (MSProadmap), adopted by UNESCO-IOC and DG MARE[3].

During its first phase (2018-2021), MSPglobal developed an international guide on MSP (UNESCO-IOC and European Commission, 2021) and performed two regional pilot projects in the West Mediterranean and Southeast Pacific. In its second phase, **MSPglobal 2.0** (2023-2025) aims to build a larger, more skilled network of practitioners and stakeholders to support MSP. This includes the co-development of tools such as new methodologies, assessments, good practices, toolboxes, and complementary guidelines. Such publications have benefited from the organisation of online and face-to-face events where MSP practitioners and stakeholders are invited to share experiences.

In fact, the UNESCO-IOC has played the role of bringing together the scientific community, the governmental decision-making system, and a broader set of stakeholders and rights-holders to promote sustainable ocean planning and management, including MSP (UNESCO-IOC and European Commission, 2021).

MSP requires that marine planners are familiar with the key characteristics of the socio-ecological system and maritime sectors that will be planned. The prioritization of offshore wind (OW) energy development is a rapidly growing trend around the world, as governments seek to incorporate this technology into their strategies to meet climate targets (GWEC, 2021). This OW rush adds additional urgency to MSP processes, which need to manage potential conflicts between this growing industry and other sectors and local communities, while also trying to avoid further impacts on marine ecosystems and biodiversity.

The Volume 2 of this publication is intended for MSP practitioners and their respective government agencies which have the mandate to conduct a holistic MSP, as well as to offshore wind experts that seek to streamline planning and consenting processes.

1.2 Objectives

In this framework, with the overarching goal to achieve a better integration of all maritime sectors within the MSP processes worldwide, MSPglobal aims to develop guidance on engaging the OW sector in MSP initiatives. This is especially relevant since OW is often considered a driver for developing MSP in many countries (Spijkerboer et al., 2020). This aligns with the goal of mitigating potentially harmful interactions between OW development and the marine environment.

Building on this publication's Volume 1, which set the stage by providing an overview of the OW sector, the main objective of Volume 2 is to provide guidelines for MSP practitioners and governmental planning authorities, as well as offshore wind experts to enhance the sector's engagement in MSP processes based on global good practices. Objectives include understanding sector-specific challenges relevant to MSP, and providing recommendations for each phase of the MSP process, supported by various case studies.

1.3 Methodology

To develop this publication and achieve the stated objectives, the MSPglobal team relied on the expertise of selected professionals that expressed interest in contributing, coupled with a review of relevant literature. This publication is the result of three expert dialogues, one joint workshop and a consultation review process through online forms, all organised from October 2024 to February 2025. It also builds upon the proceedings of the 6th International MSPforum that was held in Bali (Indonesia), in October 2024.

3. DG MARE: https://commission.europa.eu/about/departments-and-executive-agencies/maritime-affairs-and-fisheries_en

This publication is the second of two volumes addressing the engagement of the OW sector in MSP processes. This volume consists of an overview of MSP and the role it can play in the offshore wind sector process, supported by global examples and case studies. For the recommendations section, good practices build on input from contributors with recommendations compiled systematically to best inform the six phases of the MSP process described in the ***"MSPglobal International Guide on Marine/Maritime Spatial Planning"*** (UNESCO-IOC and European Commission, 2021):

1. Setting the scene
2. Designing the planning process
3. Conducting assessments for planning
4. Developing the marine spatial plan
5. Enabling implementation of the marine spatial plan
6. Monitoring, evaluation, and adaptation of the process and the marine spatial plan

It complements **Volume 1 - Sector Overview**, which provides an overview of the OW sector, with an emphasis on spatial and technical requirements relevant to marine planners, in addition to potential conflicts and synergies with other maritime sectors, and a glimpse of the projected global offshore wind trends that may affect current and future marine spatial plans.

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2. Marine spatial planning and offshore wind

2.1 Overview of Marine Spatial Planning

Definition and purpose of marine spatial planning

"Marine spatial planning is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process." (UNESCO-IOC, 2009)

"MSP is a comprehensive and strategic process to analyse and allocate the use of the sea areas to minimise conflicts between human activities and maximise benefits, while ensuring the resilience of marine ecosystems. It typically addresses many sectors, their interrelationships and cumulative impacts, and provides for spatial and temporal measures to steer different uses of the sea areas or resources." (UNESCO-IOC and European Commission, 2021)

The marine spatial planning (MSP) process distinguishes itself from sectoral policies through a set of guiding principles on how the process is conducted, how the plan needs to be developed or what the plan needs to deliver (Spijkerboer, 2020; UNESCO-IOC, 2009; UNESCO-IOC and European Commission, 2021). These interrelated principles also provide an added value to sectors such as offshore renewable energy, and include:

a) **Ecosystem-based**: balancing objectives and maintaining ecosystem-services.

b) **Area-based:** accounting for the specificity of the proposed marine area.

c) **Integrated**: engaging different uses and organisations across sectors.

d) **Participative**: involving stakeholders early and continuously.

e) **Strategic**: providing a forward-looking perspective.

f) **Adaptive**: allowing for flexibility, learning and innovation.

In many countries, MSP is intended to be complementary to the existing marine management structures and is an opportunity to integrate terrestrial, coastal and marine planning. This integrated approach is particularly relevant for maritime sectors requiring both coastal and marine infrastructure, such as offshore wind (OW). Several countries have integrated coastal zone management plans and marine spatial plans (e.g., Belize, and Trinidad and Tobago). This coastal-marine systems articulation remains a challenge, in part because terrestrial planning has a long-standing history whereas marine planning is rather recent in most countries. Adding to that challenge is the international dimension whereby MSP needs to consider what is happening beyond national borders, requiring transboundary collaboration (UNESCO-IOC and European Commission, 2021).

It is important to note that the legal authority of MSP varies across jurisdictions, depending on the national planning and legislative frameworks. In some contexts, marine spatial plans are legally binding, as seen in Denmark, Portugal, and South Africa. In others, such as Sweden and Italy, they serve more as guiding policy documents (UNESCO-IOC and European Commission, 2021).

Beyond its legal and political dimensions, MSP is fundamentally a participatory process. It requires involving key stakeholders from public and private sectors, starting with an identification and mapping process. Considering good practices for engagement, and respecting privacy and confidentiality measures, a participation strategy needs to be developed to ensure inclusive, equitable and transparent engagement.

Moreover, MSP is an iterative process. A full cycle of MSP typically spans 4 to 7 years including preparation, planning, implementation, monitoring, and adaptation phases. Marine Spatial Plans are not static, they are expected to evolve through successive cycles informed by new data, climate conditions and policy goals (UNESCO-IOC, 2009, 2014).

While MSP does not follow a 'one size fits all' approach, the **"MSPglobal International Guide on Marine/Maritime Spatial Planning"** by UNESCO-IOC and European Commission sought to establish a baseline for framing the main tasks required throughout the process within a six-phase cycle, illustrated in **Figure 1.**

Figure 1

Planning phases of an MSP process and key tasks.

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2.2 Relevance of MSP to the OW sector

MSP is strategic in nature, focusing on broad management principles and objectives, including the spatial allocation of activities across multiple maritime sectors. Understanding the relationship between MSP and marine renewable energy (MRE) in a particular country requires evaluating how OW planning is undertaken.

Countries at differing stages of OW development can adopt different approaches: (i) integrating MRE site identification directly into MSP; (ii) developing national strategies and policies for MRE which are later incorporated into existing MSP processes; or (iii) in contrast, developing OW in the absence of MSP.

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Offshore wind (OW) has in some cases served as a driver for MSP, as seen in countries like Belgium and the United States of America (UNESCO-IOC and European Commission, 2021). Key factors for the successful development of offshore wind markets include strategy, policy, frameworks, and delivery. MSP supports offshore wind development by linking strategic energy goals with practical implementation through the following mechanisms (Alder and Castaño-Isaza, 2022):

- **Strategy**: by aligning marine spatial plans with national energy objectives.
- **Policy**: by enabling policies that protect local interests while supporting offshore wind.
- **Frameworks**: by balancing competing uses and identifying suitable locations for OW, including co-location opportunities.
- **Delivery**: by facilitating infrastructure planning, such as for ports, cables, and shipping routes.

Through these functions, MSP acts as a key enabler of sustainable and coordinated offshore wind deployment (Alder and Castaño-Isaza, 2022) and can accelerate the environmental licensing and consenting processes of offshore wind projects (Vasconcelos et al., 2022).

Strategic alignment and policy integration

MSP contributes to the establishment of clear, forward-looking plans that attract investment and offer predictability for users of the maritime territory. As a future-oriented approach usually situated within established legislative processes, MSP can offer structured guidelines that improve clarity around marine space use and making it a more predictable process, and thus providing greater certainty for stakeholders (World Bank Group, 2021).

Deliberate integration of MRE into existing planning frameworks ensures connectivity between offshore energy projects, other maritime uses, as well as with essential infrastructure such as cables, grids and ports, all whilst accounting for environmental considerations. By coordinating across diverse sectors and policy areas, MSP facilitates the spatial articulation of government policies and encourages stakeholder involvement in their implementation.

While some countries are still working to incorporate MRE considerations into MSP, others —such as EU Member States— have made notable progress. This is largely attributed to the EU MSP Directive (2014/89/EU), which promotes the sustainable development of marine energy sectors (Article 5(2)) and considers renewable energy production in spatial allocations (Article 8(2)) (EUR-LEX, 2014). Broader environmental legislation on the assessment of the effects of certain plans and programmes on the environment —such as the EU Directive 2001/42/EC (EUR-Lex, 2001)— supports this momentum by requiring early-stage environmental assessments (O'Hagan, 2020). Such cross-sectoral coordination can also streamline permitting and licensing requirements and procedures through integrated use of environmental and social assessment tools and data collection.

Knowledge-based development

MSP processes support environmental and social assessments and planning by building a knowledge-based foundation that identifies needs, opportunities, and priority areas. Early-stage assessments and sensitivity mapping can benefit from existing and available data sets, improving feasibility assessments and suitable area selections (World Bank Group, 2021). The OW sector can contribute valuable data (e.g., information on spatial and temporal patterns of animal migration) which can inform future spatial allocations. This approach facilitates coexistence between human activities and the natural environment and reduces time and cost at the project decision-making stage (Bates, 2017).

Planning and site selection

When siting OW farms, MSP needs to consider turbine locations, electrical connections, substations, and efficient onshore grid connections. Interactions with other maritime sectors (e.g., recreation, oil and gas, telecommunication cables, fisheries, and aquaculture) are also key (UNESCO-IOC and European Commission, 2021).

Typically, sites for large-scale OW development have been designated either by governmental authorities or through developer proposals. Quantitative planning methods can help address competing ocean uses, leading to more optimal siting of OW facilities and delivering broader economic benefits —both to the OW sector and to other industries, such as commercial fisheries (White et al., 2012). Another example from a cost-effectiveness analysis found that altering shipping transit routes —shifting them farther offshore— can allow for greater nearshore wind development, yielding construction, operation, and maintenance savings with relatively low additional costs to the shipping sector (Samoteskul et al., 2014).

Public acceptance

MSP provides a platform for stakeholder consultation, reflecting the diversity of ocean users. Engaging stakeholders early in the planning process can lead to better decisions, reduce delays, and avoid public opposition or negative media attention (Bates, 2017). Effective stakeholder engagement includes a range of actors —from the public to specific sectoral or representative organisations— and fosters a more transparent, trusted planning process. It also promotes public understanding and awareness. Stakeholder engagement ultimately helps de-risk future investment and can identify sites that are more likely to gain public acceptance (Alder and Castaño-Isaza, 2022).

Risk mitigation

Additionally, the risks associated with OW development can be reduced by identifying strategies that mitigate unavoidable impacts, avoid irreducible risks, and apply adaptive and cost-effective measures (Bates, 2017). MSP can help by providing clarity and confidence that marine stakeholders broadly support the allocation of specific areas for OW, and that necessary infrastructure development in those areas has already been considered (HMC, 2024). MSP can also help defining geographical limits of leasing rounds, reducing permitting risks and conflicts with other users in the sea (World Bank Group, 2021).

Limitations of MSP in OW development

While MSP offers a strategic policy for sustainable maritime development, it has limitations. It does not define specific project-level details or replace regulatory or commercial processes, such as permitting, leasing, or subsidy allocation. Sector-specific planning responsibilities often remain with relevant authorities different from the MSP authority. Rather, MSP serves as a complementary framework that fosters coordination and integration. Its participatory approach adds value to large-scale projects like MRE by offering an inclusive forum for stakeholder input.

However, challenges remain. For example, while MSP entails multi-objective planning, it does not substitute for single-sector planning and may operate concurrently with them. Sectoral development plans —such as for OW or aquaculture— may precede or run parallel to MSP processes, often on differing timelines. MSP authorities must therefore identify and promote synergies across these efforts. An example from Estonia (**Box 1**) illustrates potential shortcomings in the MSP process.

Case Study

Box 1: MSP limitations in planning for OW development – Hiiumaa, Estonia

While MSP is often promoted as a participatory planning process that fosters trust among stakeholders and aims to resolve conflicts through scientific evidence, clear communication, and negotiated solutions, it has its limitations. The case of Estonia's MSP and offshore wind development highlights shortcomings in the MSP process.

In Estonia, plans to construct an OW farm in Hiiumaa began in 2006, with the goal of increasing the country's renewable energy output and exporting surplus energy to nearby countries. However, objections arose from various stakeholders, including local residents, municipal governments, and central state actors such as the Ministry of Defence. Strong opposition led to the suspension of all OW proposals, pending the establishment of a proper legal framework to regulate the process. As a result, Estonia's first MSP was introduced.

The public consultation process initially showed approval during the pre-MSP phase, but later, rejection and conflict escalated after the adoption of the maritime spatial plan, leading to legal challenges. Residents expressed concerns over environmental impacts (potential marine protection area), social issues (inter-generational justice), economic risks (decline in tourism and recreation), health concerns (infrasound and noise pollution), and the place-based effects of large OW farms. They requested additional research on these impacts as well as potential alternative renewable solutions. Municipalities argued that the project would industrialize Hiiumaa, interfere with its scenic uniqueness, and conflict with the proposed marine protected area (MPA). The Ministry of Defence raised concerns about radar interference and national security risks.

The MSP process facilitated some concessions to appease stakeholders, such as the cancellation of an OW farm area in shallow waters and the extension of a proposed OW site 12 km further offshore. However, opposition persisted, as key requests were not fully addressed. The ongoing conflict led to the formation of a divide between the local community and the Estonian government, culminating in a 16-month legal battle that ultimately resulted in the abolishment of the OW sections in the Hiiumaa MSP in August 2018.

While MSP created a space for discussions and resulted in some compromises, it fell short in effectively integrating the community and achieving a rational consensus, leaving many demands unaddressed. Critics argue that the MSP process "spatially and temporally" displaced the debate instead of fully resolving it. The rejection of municipal concerns regarding the potential impacts of OW on land-based planning objectives exposed weaknesses in the consideration of land-sea interactions.

To improve future MSP processes, it is essential to create mechanisms that allow stakeholders to voice their demands and values while acknowledging their rivals' opposing viewpoints and interests. Although the early stages of Estonia's MSP faced challenges, it remains an ongoing political process, offering opportunities to achieve better outcomes in the future.

Sources: Tafon et al., 2019; Ministry of Economic Affairs and Communications of the Republic of Estonia, 2024, 2025.

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3. Challenges for engaging the offshore wind sector in marine spatial planning

Acknowledging marine spatial planning (MSP)'s limitations, this chapter presents some of the challenges that could be faced while trying to articulate offshore wind (OW) processes and MSP. It addresses issues related to governance, planning and public engagement as expressed during the dialogues with MSP practitioners and OW experts organised online by MSPglobal.

3.1 Governance and institutional framework

Authorities

One of the key challenges in integrating OW into MSP is the lack of alignment among ministries, sectors, and governance levels. Conflicting interests —such as between the fisheries sector and offshore wind development— often result in disputes on strategic priorities, and ultimately over space. This institutional ambiguity frequently results from overlapping mandates and fragmented decision-making, which in turn creates power imbalances, inefficiencies in implementation, and subsequently project execution delays.

Moreover, the diverse requirements and expectations of stakeholders involved in MSP —such as environmental agencies, marine renewable energy (MRE) experts, and local authorities— are often poorly coordinated. This lack of cohesion can lead to conflicting demands, regulatory bottlenecks, and difficulties in ensuring a streamlined and integrated planning process.

Policy coherence and spatial targets

Government targets for climate mitigation and OW expansion can also create governance challenges when they are not aligned with MSP's spatial and environmental constraints. Ambitious objectives may be set without fully considering available maritime space or technological feasibility, leading to unrealistic expectations. This can place undue pressure on marine planners and energy stakeholders alike to meet goals that are difficult to achieve within existing MSP frameworks.

Moreover, MSP itself may pursue different priority objectives —such as marine conservation or conflict resolution between users— which do not always align with OW development plans. Ensuring coherence between national energy strategies and marine planning processes is therefore critical for facilitating the effective integration of offshore wind into MSP.

Procedural and permitting misalignment

A further challenge lies in the misalignment between MSP frameworks and OW planning, consenting, and leasing procedures. These processes often operate on different timelines and are governed by separate authorities, which complicates regulatory compliance and contributes to delays. The discrepancy between the long-term vision of MSP and the relatively shorter development cycles of OW projects make it difficult to synchronise planning objectives with energy deployment milestones.

Bureaucratic inefficiencies and the frequent absence of a centralized permitting authority hinder progress and create uncertainty for developers. In addition, a lack of shared understanding between project promoters and regulatory bodies regarding permitting procedures further increases the risk of non-compliance and slows the pace of offshore wind deployment (IRENA, 2024).

MSP awareness

OW stakeholders often have limited familiarity with MSP concepts, terminology, and planning phases. This gap can lead to miscommunication and misalignment with MSP objectives. Additionally, there is often an insufficient understanding of MSP requirements —such as stakeholder engagement procedures and environmental assessments— which becomes particularly problematic when OW projects span multiple jurisdictions with differing legal and regulatory standards.

3.2 Planning and spatial considerations

Beyond institutional and regulatory challenges, OW engagement and integration into MSP must address spatial conflicts, data limitations, and technical complexities related to land–sea interactions and transboundary coordination.

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Spatial conflicts and coexistence

Spatial integration of OW into marine areas requires addressing coexistence with other sectors such as fisheries, shipping, and tourism. These interactions frequently lead to competition over limited maritime space and resources. Addressing spatial conflicts is central to ensuring a balanced allocation of uses within MSP *(for a detailed analysis of sectoral spatial conflicts, please see* ***"Volume 1 – Sector Overview"****).*

Land-sea interactions

Effective OW development depends on the integration of offshore and onshore planning systems. Coordinated development of transmission infrastructure is essential for connecting OW farms to land-based energy grids. However, disconnects between marine and terrestrial planning processes often result in logistical and regulatory inefficiencies. Marine planners can support integration by ensuring land-sea interactions are considered during MSP processes, including siting, permitting, and decommissioning phases.

Transboundary and cross-border coordination

OW development that spans national jurisdictions introduces further complexity. Differences in permitting processes, data policies, and regulatory priorities across borders —such as within the European Union— can lead to inefficiencies, duplication, and increased infrastructure and operational costs. Transboundary MSP coordination mechanisms are necessary to address these challenges.

Data availability and environmental considerations

Access to reliable, high-quality spatial data remains a critical enabler for effective planning. In many jurisdictions, data scarcity or fragmentation hinders the ability to assess spatial conflicts, environmental risks, and cumulative impacts. For example, data gaps have been identified in relation to recreational tourism, artisanal fisheries, and ecological features (Depellegrin et al., 2024). The lack of streamlined digital tools and data-sharing platforms further complicates permitting processes.

Spatial planning for OW also requires mapping of ecologically and culturally sensitive areas, including protected areas and Other Effective Area-Based Conservation Measures (OECMs). Comprehensive environmental assessments are necessary to avoid negative impacts on marine biodiversity and heritage sites but are often constrained by limited data availability and methodological complexity.

Additionally, marine planners must consider risks from natural hazards such as hurricanes, tsunamis, and earthquakes. Integrating this data into MSP allows for more informed siting of OW projects and supports the development of resilient, adaptive planning scenarios (Bhattacharya et al., 2021; Kaynia, 2019; Rose et al., 2012).

Addressing these spatial and planning challenges can support better integration of OW within MSP frameworks, balancing economic, social, and environmental interests effectively.

3.3 Public engagement and social acceptance

Improving engagement in OW requires understanding how different sectors interact with MSP. While some sectors and stakeholders, such as marine conservation, have well-established practices for engagement and planning integration, others —particularly emerging sectors like MRE— are still building this capacity. Strengthening this interface through inclusive stakeholder processes can support better alignment between sectoral goals and MSP (Alder and Castaño-Isaza, 2022).

Another significant challenge in OW development is the exclusion of certain rights-holders and stakeholders, particularly local or marginalized groups —such as Indigenous Peoples and local communities (IPLCs)— from the planning and decision-making process. Limited opportunities for participation, or an incomplete mapping of affected rights-holders and stakeholders can result in a lack of representation and consideration of the marine areas' diverse perspectives. Concerns around social acceptance are also related to perceived and actual loss of livelihoods, reduced access to marine areas, impacts on cultural connections and limited distribution of socio-economic benefits (Haggett, 2011). These situations, in turn, may result in public opposition for OW projects and delays in implementation. Experiences from Australian and Colombian Indigenous communities' interactions with OW projects are described in **Box 2.**

Case Study

Box 2: OW planning and Indigenous communities - Australia and Colombia

Australian and Colombian experiences highlight the complex intersection between OW development and Indigenous territories, where projects often overlap with areas of cultural, spiritual, and ancestral importance.

Australia's Aboriginal and Torres Strait Islander Peoples (First Nation People) consider, and value 'sea Country' as a space of profound cultural, spiritual, and ecological significance. In Colombia, La Guajira region is home to the Wayuu Indigenous People, whose territories and livelihoods intersect with many of designated OW project sites.

Despite differing legal frameworks —Australia's Offshore Electricity Infrastructure Act 2021 and its Native Title Act 1993 as well as Colombia's constitutional requirement for Free, Prior and Informed Consent (FPIC)— implementation challenges persist in both contexts.

In Australia, the absence of a formal FPIC requirement has led to growing concerns among Aboriginal and Torres Strait Islander Peoples, while in Colombia, FPIC processes have been undermined by limited State presence, insufficient information, and weak procedural safeguards.

In both countries, asymmetries in legal and technical capacity between communities and developers have contributed to mistrust, social resistance, and project delays.

To address these issues, Australia has introduced institutional mechanisms such as the **First Nations Offshore Wind Working Group** and promoted benefit-sharing arrangements, including co-management and **Indigenous Land Use Agreements (ILUAs**).

In contrast, Colombia's regulatory environment has lacked clarity around benefit-sharing, contributing to limited progress on community development outcomes.

Both cases underscore the need for early and sustained engagement, culturally appropriate consultation, and integration of local and Indigenous knowledge (ILK) systems. These insights are highly relevant to MSP, where inclusive governance, cultural mapping, and recognition of Indigenous marine and territorial governance can contribute to more equitable, conflict-sensitive, and resilient planning outcomes.

Sources: DCCEEW, 2023; Hamilton Locke 2023; Vega-Araújo et al., 2024

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3.4 Others

While many of the challenges facing the OW sector are not directly related to MSP nor solvable through planning processes, they are to be taken in consideration while planning.

Risk management and security

The development of OW farms present unique security challenges, particularly in military-sensitive areas. A significant concern is the potential for submarines and other vessels to use OW farms as cover and disrupt radar, posing risks to national security and complicating maritime defence operations. Geopolitical tensions and risks of sabotaging critical energy infrastructure can also affect offshore installation. These concerns call for coordination with national defence authorities to integrate security consideration into spatial planning.

Technical and operational challenges

With emerging offshore technologies such as floating wind platforms and substations making their way, marine planners need to stay informed about their spatial requirements and potential implications on the marine spatial plan and siting process. Additionally, supply chain limitations (e.g., the availability of dedicated port areas, global raw material shortages, etc.) can impact project timelines and costs, and should be integrated in the adaptive planning process.

Economic and financial challenges

Although MSP does not control project financing, marine planners need to be aware of the financial risks linked to OW —such as fluctuating energy and raw material prices, evolving regulatory frameworks, and long project timeline (Pacheco Ramos, 2023). An example of the impact of government financing on OW project is the decision to reduce national subsidies in China as of 2021, after the country became the world leader in the OW sector regarding installed capacity (RVO, 2022; Li et al., 2023). It is also important to note that failure to realise OW projects may leave designated or reserved marine areas in the MSP underused.

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4. Overarching recommendations for engaging the offshore wind sector in marine spatial planning

Literature contains several sources that provide recommendations for the OW sector, focusing on emerging markets (World Bank Group, 2021), specific geographies such as the Mediterranean Sea (Plan Bleu, 2024) or particular countries (GWEC India and UK Government, 2023), specific technologies (IRENA, 2024) or on integration with other sectors and stakeholders such as marine conservation (Bailey et al., 2014) and fisheries (European Commission: Executive Agency for Small and Medium-sized Enterprises et al., 2020).

This chapter aims to consolidate recommendations that are specifically relevant to the integration of OW in MSP, beginning with overarching considerations linked to spatial and temporal planning, stakeholder engagement, environment and, finally, data sharing and technology. This will be complemented in the following chapter by a set of phase-specific recommendations.

4.1 Spatial and temporal planning considerations

Key considerations for planning include **spatial dimensions** —such as infrastructure installation, land-sea interactions, transboundary and cross-border planning— as well as temporal ones —such as alignment of MSP and OW cycles. MSP typically focuses on designating suitable areas and corridors for energy installations, while more detailed planning of how to locate the turbines and electricity transmission infrastructure within the designated areas is usually left for the private operators.

Considering the **temporal dimension** of both MSP and OW development is important, particularly given the discrepancies in their respective timeframes. MSP typically follows a cycle of 4 to 7 years (UNESCO-IOC, 2009), whereas the technical planning, permitting, and implementation of OW projects can span 7 to 11 years (Iberdrola, 2025), with another additional 30 years average for operation (RenewableUK, 2020). These differing timelines highlight the need to account for both slow and rapid processes in the implementation of marine spatial plans. As such, MSP is better conceived as an ongoing, adaptive process that extends across planning cycles, incorporating regular follow-up measures to accommodate dynamic developments (UNESCO-IOC and European Commission, 2021).

Beyond planning for the sector's infrastructure, aligning **land and ocean use** can contribute to accelerating OW permitting processes. MSP can play that role, by helping governments develop guidance on the utilisation of coastal and ocean space for OW infrastructure (IRENA and GWEC, 2023). The Scottish experience can provide lessons learnt for coordination between terrestrial and marine planning systems (**Box 3).**

Case Study

Box 3: Coordination between terrestrial and marine planning systems - Scotland

In order to achieve effective terrestrial and marine planning coordination —as stipulated in the **Marine Acts and the Town and Country Planning Regulations 2008**— Scotland relies on aligning legislative frameworks, fostering institutional cooperation and integrating planning processes. Mechanisms include liaison between terrestrial and marine authorities (marine planning partnerships are expected to include local development planners and authorities), shared evidence bases (facilitating environmental assessments coordination such as **Strategic Environmental Assessment (SEA)** and **Habitats Regulations Appraisal (HRA)**, and joint consultation processes —namely for offshore renewables and coastal infrastructure.

Overlapping jurisdictions in the intertidal zone, as well as the multi-regime consenting processes highlight the need for early engagement and streamlined approvals. As such, temporal alignment of plan and consultation cycles, the utilisation of common spatial data tools (e.g., **Marine Scotland's National Marine Plan interactive (NMPi)**[4] and integration of coastal zone management tools in complex coastal areas support coherence and efficiency in planning for site-specific complexities.

Source: Scottish Government, 2015

In many sea basins, particularly within the European Union, **transboundary or cross-border** spatial issues related to offshore wind development require coordination. MSP can support marine renewable energy (MRE) by enhancing cross-border and transboundary cooperation, which in turn contributes to greater planning efficiency, reduced uncertainty for developers, and expanded deployment opportunities or cost savings through shared infrastructure. Such coordination is particularly relevant for grid planning, the multi-use of maritime space, and the quality and accessibility of data.

These transboundary challenges can be addressed at the sea basin level through regional forums and initiatives such as the EU NorthSEE project[5]. These platforms facilitate improved coordination across several MSP-related aspects, including planning timeframes, communication, onshore and offshore grid infrastructure planning, data standards and availability, research methodologies, and certain management measures such as permitting processes (NorthSEE project, 2020; European MSP Platform, 2025).

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4. NMPi: https://marinescotland.atkinsgeospatial.com/nmpi/
5. NorthSEE project: https://northsearegion.eu/northsee/e-energy/index.html

4.2 Stakeholder engagement considerations

The process for stakeholder engagement is widely documented in literature, and specific actions for MSP can be explored in Quesada-Silva et al. (2019). Overall, the process entails **identifying key stakeholders** (or stakeholder mapping), defining **when they should be involved** (which phase of the MSP process), and identifying the **best way to engage them** (via vertical or horizontal interactions, through an informative or decision-making procedure). It is important to tailor the process, the methods and the communication pathways to individual countries, societies, and contexts, factoring in cultural sensitivities and political fragilities. This includes consideration for Indigenous Peoples and local communities (IPLCs) which are often greatly affected by MSP decisions yet under-represented in engagement processes (UNESCO-IOC and UNESCO-LINKS, 2024*a*; 2024*b*).

In the specific context of OW development, involving stakeholders promotes active engagement of local communities, increases public support, ultimately reducing consent timing (IRENA and GWEC, 2023). **Public opinion research** can be incorporated into MSP to assess potential community responses before energy developments begin. Such research can improve economic efficiency and help avoid costly delays. As ocean space is allocated for new uses, public sentiment may significantly influence implementation timelines (Bates, 2017).

Engagement aims to build trust, enhance project acceptability, support environmental and social sustainability, and reduce risks of delays or conflict. Good practices include **initiating engagement early in the planning phase** and maintaining open and continuous communication throughout the OW project lifecycle in order to address concerns, incorporate local insights, and foster a sense of ownership and cooperation. Finally, it is important to tailor engagement approaches to local contexts and to adapt communication pathways in order to reach the right stakeholders and promote active engagement with local communities (Efthimiou, 2022). Effective methods —such as appointing fishery liaisons, holding pre-permitting consultations, and adapting project design based on feedback, as seen in the Pentland Floating Offshore Wind Farm in the UK—demonstrate how inclusive engagement can improve outcomes and support the coexistence of OW with other marine users (Efthimiou, 2022), ultimately reducing consent timing (IRENA and GWEC, 2023). A valuable method applied in stakeholder engagement for MSP processes, **participatory mapping** allows for the integration of stakeholders' knowledge and practices into the planning and decision-making processes *(for case studies on participatory mapping, please see the* ***"MSPglobal Data Toolbox: Volume 1 – How to develop a Spatial Data Infrastructure for Marine Spatial Planning"****).*

Other experiences reveal the need to adapt policy frameworks and to conduct legislative reforms to achieve a more successful process in the future (such as the case of France, see **Box 4**). Evidently, these gains require significant resources, and outcomes from such participatory processes are not always included in decision-making.

Case Study

Box 4: Public participation in OW and MSP - France

Over the past decade, France has significantly restructured its approach to OW farm planning and MSP, particularly regarding public participation processes. Initially, planning was marked by a lack of long-term vision, pre-established projects with public debates often occurring after the selection of project developers, insufficient environmental data available during consultations, and the exclusion of local citizens and communities from OW and energy discussions and decision-making processes. These limitations led to strong criticism from local stakeholders, highlighting the need for greater transparency and inclusion to enhance public participation.

In response, several legislative reforms occurred — most notably the 2018 ESSOC Law (*'État au service d'une société de confiance'*), the 2020 ASAP Law *('Accélération et de simplification de l'action publique')* and the 2023 APER Law *('Accélération de la production d'énergies renouvelables')* — and allowed a shift in the timing of public consultations to occur before the selection of OW developers as well as enabled organising joint OW and MSP public debates at the regional maritime façade level. Additionally, CEREMA — a public environmental institution— established a participatory online mapping tool to facilitate interactive and data driven public engagement to co-develop scenarios based on real life constraints.

These measures have improved early-stage engagement and fostered dialogue among diverse stakeholders. However, despite these advances, some challenges remain as participatory processes require substantial resources, and outputs are not always reflected in the final decisions. Moreover, the regional focus of consultations continues to fall short of local expectations, especially in the Mediterranean, where the absence of community-level deliberative spaces still limits the social acceptability of OW farm projects.

Source: MSP-GREEN, 2024

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4.3 Environmental considerations

As with any large-scale infrastructure, OW development can have adverse effects on local ecosystems and biodiversity. While efforts to restore ecosystems are increasing, they continue to face significant challenges, particularly due to complex environmental conditions. Therefore, prioritizing prevention of impacts is key, and this is where MSP can play a particularly relevant role when exploring pathways to integrate sensitivity mapping and Strategic Environmental Assessment (SEA) (UNESCO-IOC and European Commission, 2025; World Bank Group, 2024). *For more detailed information on SEA and MSP, please see the* ***"MSPglobal International Guide on Marine/Maritime Spatial Planning: Volume 2 – Biodiversity Inclusive Principle."****)*.

Although complete avoidance of impacts is the preferred outcome, it is often not feasible in practice. In such cases, applying a mitigation hierarchy —a widely used framework to inform environmental conservation decisions— can be applied during different stages of the OW development cycle, from planning to decommissioning, providing a structured approach to guide decision-making (WREN, 2023) (**Table 1).**

Table 1

Four levels of the mitigation hierarchy that can be applied for offshore wind. *(Source: WREN, 2023)*

Level	Description
Avoidance	One of the most important and most effective steps is to anticipate and prevent impacts altogether. Mostly applicable during the planning phase.
Minimisation	Implementation measures to reduce the duration, intensity, and/or extent of impacts that cannot be avoided. It may occur during the construction, operational, or decommissioning phases of OW development.
Restoration	Implement measures that aim to repair specific features damaged by project impacts that could not be completely avoided or minimised.
Offsetting	The last and least effective step is to implement measures to compensate for significant adverse residual impacts.

Note: The last two terminologies are often used interchangeably, alongside 'compensation'. They are often implemented in last stages of OW development such as decommissioning.

Examples of mitigation measures can be applied at different stages of OW planning and development stages. **Box 5** presents a few examples of measures applied to reduce visual impacts from OW, to avoid bird collision and to reduce animal entanglement with floating turbines mooring cables.

Case Study

Box 5: Mitigation measures applied for OW

- **Reducing OW visual impacts: The Seascape, Landscape and Visual Impact Assessment – United Kingdom**

The Seascape, Landscape and Visual Impact Assessment (SLVIA) applied for the Berwick Bank Wind Farm in the United Kingdom evaluates the potential visual and landscape effects of the proposed offshore infrastructure and is integrated in the offshore environmental Impact assessment (EIA) report.

The assessments examine how the OW farm may alter the character and visual quality of seascapes and landscapes from turbines on residents, tourists and mariners. It analyses viewpoints from different locations and proposes mitigation measures to reduce adverse visual impacts.

These measures range from interventions on the turbine itself (e.g., turbine colours and finishes) to ecosystem restoration (e.g., the revegetation of affected terrestrial areas, incorporation of landscape design elements, planting of native vegetation, creation of green zones, rehabilitation of natural environment, etc.) implemented to restore —to the best possible extent— the original landscape appearance.

Source: Berwick Bank Wind Farm, 2023

- **Curtailing bird collisions: The start and stop system for OW turbines - The Netherlands**

As the Netherlands expand their OW capacity in the North Sea, it became necessary to design solutions to ensure that MRE development aligns with ecological considerations. As such, a 'start and stop system' was designed to reduce bird collisions with OW turbines. This works by temporarily shutting turbines down during peak migration periods. By integrating real-time data on bird movements, the project seeks to balance ecological protection with minimal loss of energy production.

Additional examples on bird curtailment strategies can be explored in Machado et. al (2024).

Sources: Noordzeeloket, 2024a, 2024b

- **Reducing entanglement in floating OW**

While floating OW technology holds promise for accessing deeper waters and increasing energy production, it may also pose specific environmental risks to marine mammals, seabirds, fishes, and benthic ecosystems. Potential impacts include entanglement in debris caught on mooring lines and degradation of benthic habitats from infrastructure such as anchors and inter-array cables. To address these risks, mitigation measures —either implemented by managers or required through policy— may include entanglement deterrents, monitoring technologies for cables and mooring lines, and careful siting to avoid sensitive habitats.

Source: Maxwell et al., 2022

Additional measures that can be integrated in the design of the OW farms include nature inclusive design (NID) or nature-based solutions (NbS). These measures need to be tailored to the specific ecosystem and are usually designed and implemented in close collaboration with local ecologists and scientists (Hermans et. al, 2020). Examples of such measures are presented in **Table 2**.

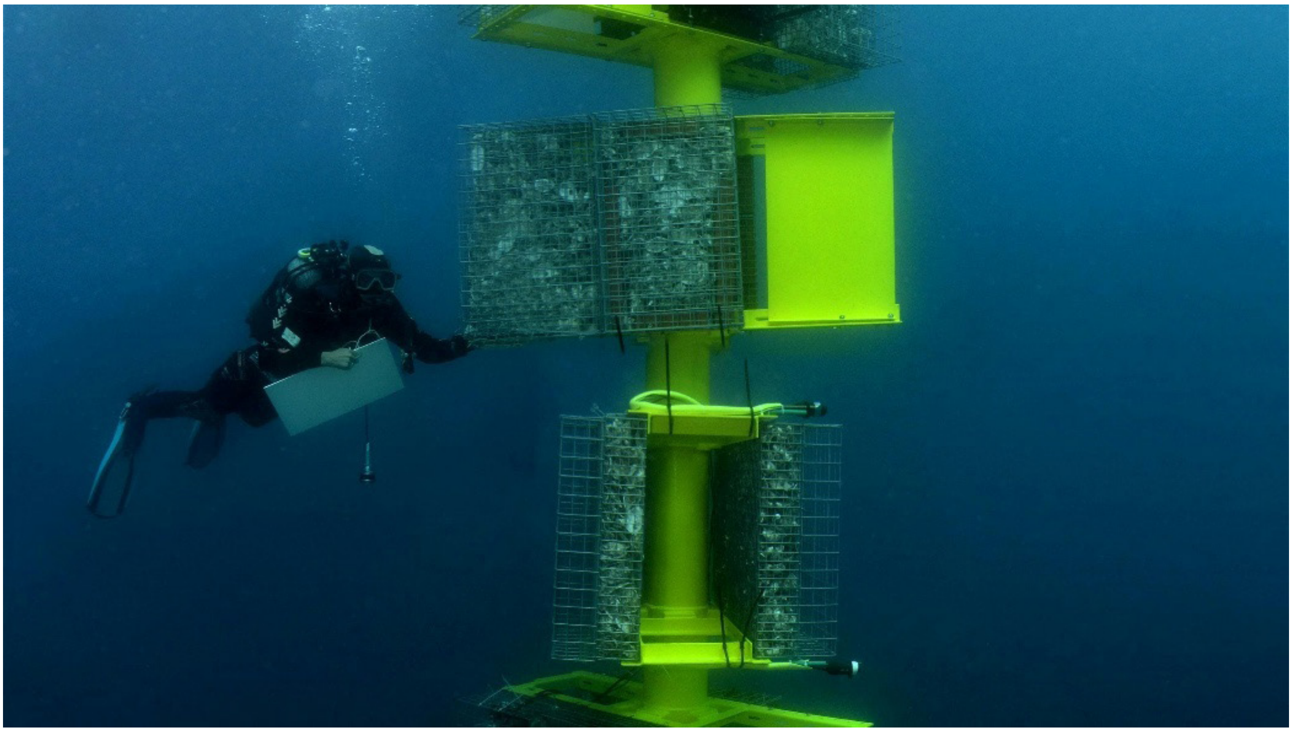
Table 2

Examples of environmental measures applicable in OW development projects.
(Sources: Boggis, 2023; Ecocean, 2025; European MSP platform, 2025; NREL, 2024; Preston et. al, 2020; Unsworth et al, 2023; van Katwijk et. al, 2016)

Measure	Description
Seagrass (re)planting	Planting or restoring seagrass meadows in areas affected by dredging to enhance/ rehabilitate biodiversity (during installation and cable laying activities).
Oyster reef restoration	Reintroducing oysters around turbine foundations to improve water quality, biodiversity, and ecosystem function.
Structures for bird colonies	Creating artificial nesting platforms to support seabird populations displaced or impacted by OW farms (e.g., 'kittiwake hotels').
Ultrasonic deterrents for bats	Installing ultrasonic deterrents to reduce bat activity near turbines and mitigate collision risks.
Biohuts for juvenile fish	Integrating artificial structures known as 'biohuts' on OW turbines to provide shelters for juvenile fish, helping to offset habitat loss and enhance local biodiversity.

Investing in large scale restoration projects can have stronger effects than small patches of localised efforts, such as the example of The Rich North Sea programme[6]. The programme integrates OW development with marine biodiversity restoration in the North Sea. Examples include placing artificial reefs and releasing oysters with the aim to restore North Sea reefs ecosystems. The programme also developed an open-source toolbox to support nature inclusive wind farms developments, in collaboration with industry, science and governments (The Rich North Sea, 2025).

6. The Rich North Sea programme: https://www.therichnorthsea.com



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4.4 Data sharing and technological innovation considerations

Continuous research and innovation are essential to address current and emerging operational challenges. Optimizing OW turbines technologies for specific site conditions helps maximize energy output and efficiency, enhance grid connectivity and reduce the need for extensive seabed infrastructure —ultimately reducing environmental impacts. Marine planners need to remain informed with technological advancements, integrating their implications into spatial plans.

Technological advancements such as digital twin technology[7] offer promising opportunities for cost reduction during maintenance. By creating virtual replicas of OW farm assets —and other types of marine infrastructure— operators can monitor performance in real-time, predicting potential failures, and optimizing maintenance schedules. This contributes to greater operational efficiency and reduced downtime (Majidi Nezhad et al., 2024).

Given that the collection of baseline data for OW may take over two years —a process that should be factored in planning timescales— effective planning will require data sharing and coordination across various sectors, but also across the OW supply chain (World Bank Group, 2021). Marine planners can benefit from this data for the coordination of the different maritime activities, using it to advance knowledge and improve operational efficiency.

Mandatory data-sharing mechanisms can also help filling data gaps. For example, the UK's Marine Data Exchange (MDE)[8] platform was established by the Crown Estate to facilitate data sharing in the UK. In fact, UK developers are obliged to provide all survey data to the Crown Estate, which will later be integrated into the MDE (The Crown Estate, 2022).

7. Digital twin technology refers to the creation of a virtual, real-time simulation of marine environments that replicates physical ocean systems.
8. Marine Data Exchange (MDE): https://www.marinedataexchange.co.uk/

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5. Specific recommendations per phase of the marine spatial planning process

The ***"MSPglobal International Guide on Marine/ Maritime Spatial Planning"*** (UNESCO-IOC and European Commission, 2021) proposes six phases to organise the MSP process, which are:

1. Setting the scene
2. Designing the planning process
3. Conducting assessments for planning
4. Developing the marine spatial plan
5. Enabling implementation of the marine spatial plan
6. Monitoring, evaluation, and adaptation of the process and the marine spatial plan

This chapter also reflects the results of the dialogues with and between marine spatial planning (MSP) practitioners and offshore wind (OW) experts. Recommendations were integrated within the six phases to the best extent possible. Knowing that countries can be in varying MSP development situations when planning for OW, these recommendations would need to be adjusted accordingly.

5.1 Phase 1 – Setting the scene

Key tasks for setting the scene (Phase 1):

- ❑ **Create an MSP working group.**
- ❑ **Identify existing legal and institutional frameworks to develop MSP.**
- ❑ **Identify stakeholders and rights-holders, their customary systems of governance, and their planning needs.**
- ❑ **Identify sources of funding for MSP.**
- ❑ **Define an institutional framework for MSP.**

Source: UNESCO-IOC and European Commission, 2021

a) **Conduct a legal and institutional review of marine renewable energy (MRE) frameworks early in the MSP process.** This includes relevant OW legislation, safeguards, and performance standards that must be adhered to throughout the planning process, thus allowing better understanding and alignment of policies, planning cycles and consenting processes. Identify. See **Box 6** for example of alignment between MSP and OW policies.

b) **Conduct early stakeholder mapping to identify both relevant and potentially affected stakeholders related to the OW sector, as well as their planning needs.** This includes OW managers, developers as well as Indigenous Peoples and local communities (IPLCs).

c) **Identify funding opportunities that could arise from leasing and taxation of OW sites to MSP.** This includes leasing part of the seabed, staging and pre-assembly area and create a rental income from the lease, that can support the development and implementation of marine spatial plans, including management measures related to coastal restoration, environmental hazard prevention, infrastructure improvements- green ports, marine data funds.

Case Study

Box 6: The integration of OW into planning systems – China

China's OW development history showcases its ability to align MRE goals with MSP reforms. Over the past two decades, China has advanced the development of MRE, driven by its commitments to achieve carbon neutrality by 2060, and subsequent policy incentives (Zhang and Wang, 2022). From the first installed OW farm in 2008, to the construction of mega OW farms projects, China is currently leading the OW market accounting for over than 50% of global OW production (GWEC, 2024).

The establishment of MSP frameworks has played a pivotal role in enabling this growth, despite remaining unresolved issues in planning and implementation priorities. China's multi-plan system underwent several reforms, which can be divided into the following stages:

- **Initial Exploration (1989–2001):** Marine functional zoning (MFZ) was introduced, laying the groundwork for regulated resource use and spatial planning. MFZ refers to the division of the sea into different types of functional zones, based on the location's conditions, the natural environment, natural resources, development and conservation status of the marine area, as well as the demand of economic and social development. The **National Ocean Development Plan (1994)** proposed five key coastal areas and three special development zones.
- **System Formation (2002–2017):** Legal frameworks such as the **Law on the Administration of Sea Areas (prolongated in 2002)** formed the fundamental basis of China's sea area management and established an integrated administration system based on MFZ. It operates on three administrative levels (national, provincial, municipal/county levels). The **National Marine Functional Zoning (2011–2020)** categorized marine areas into four types managed by supporting policies (key, optimized, restricted, and prohibited development zones). This law also defined the right to use sea areas, and the paid use of sea areas which establishes a legal framework for charging fees for sea use rights, including leasing or concessions for industrial, tourism, or renewable energy projects like offshore wind. The paid use system serves multiple purposes such as regulation and control, economic incentives and promoting fair use.
- **Deepening Reform (2018—present):** A process to integrate both terrestrial and marine spatial planning into a unified **territorial spatial planning (TSP) system**. It emphasizes a multi-plan integration to address conflicts between ecological conservation and industrial growth. The TSP system has identified seven categories of primary zoning and secondary zoning at a municipal level. The marine space was divided into ecological protection areas, ecological control areas, and marine development areas, which can be further divided into secondary zoning for fisheries, transportation, industrial and mining communication, recreational marine areas, special-purpose marine areas, and marine reserve areas.

The **coastal spatial planning (CSP)** is the specialized TSP for land and sea coordination framework and is focused on both coastal space and offshore areas. It deepens national strategy, industrial development and integrated management of coastal space. Under the CSP system, and within the implementation of national strategies aspect, OW is planned to achieve carbon emissions reduction goals. Its development also contributes to the promotion of industrial development target, which promotes the synchronized design for coastal and marine infrastructure. CSP establishes requirements and spatial layouts for specific industries such as OW. There is a specific zone for MRE (including OW) under the **'minerals and energy zone'**.

Sources: Gao et al., 2024; Teng et al., 2021; Zhang and Wang, 2022.

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5.2 Phase 2 – Designing the planning process

Key tasks for designing the planning process (Phase 2):

- ❑ **Establish a technical MSP team and define its work plan.**
- ❑ **Develop a strategy of participation and a communication plan.**
- ❑ **Define the planning boundaries and time frame for implementing the plan.**
- ❑ **Define principles, vision, goals and objectives.**

Source: UNESCO-IOC and European Commission, 2021

a) **Design a strategy of participation and a communication plan that includes the key OW-related stakeholders identified in the previous phase.** This includes early participation of energy authorities, OW experts and developers, as well as IPLCs and NGOs active in community engagement. It is also important to recognize local governance structures and adapt engagement methods to prioritize inclusivity and accessibility. Continuous engagement and consultation can help build consensus and acceptance for the marine spatial plan. For that, stakeholders need to be informed via accessible communication pathways, while engagement techniques need to be tailored to reach different groups and remote communities. Stakeholder engagement is also critical to complement findings and fill data gaps through methods such as surveys and interviews.

b) **Anticipate the timeline of the OW process to try and align with the MSP cycle.** This includes understanding the current status and trends of OW development, upcoming leasing rounds and construction plans.

c) **Incorporate a specific target for OW as part of MSP.** This includes clarifying OW development objectives and priorities (e.g., decarbonization, energy security, economic strategies, etc.) as well as promote coexistence between OW and other marine sectors as an objective (namely fisheries, shipping and navigation, marine conservation) to encourage investments and help the OW sector achieve a balance.

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5.3 Phase 3 – Conducting assessments for planning

Key tasks for conducting assessments for planning (Phase 3):

- ❑ **Define the different planning scales.**
- ❑ **Identify existing conditions to map and diagnose environmental, socio-cultural and economic parameters, as well as conflicts and compatibilities.**
- ❑ **Analyse future conditions and trends, define alternative scenarios as well as assess trade-offs to select the preferred scenario.**
- ❑ **Develop a public information system.**

Source: UNESCO-IOC and European Commission, 2021

a) **Conduct an OW diagnosis, including environmental and social considerations as well as interactions with other users.** Seasonality must be considered in data collection and visualization to ensure accurate decision-making for OW site selection and scheduling. Participatory mapping, embracing Indigenous and local knowledge (ILK) and ensuring gender representation can provide relevant data and information that are not easily available**.** See **Box 7** for examples of initiatives and tools for an MSP process well-informed by OW. *For more detailed information of OW technical and spatial needs, as well as impacts and interactions please see **"Volume 1 – Sector Overview"**).*

For OW suitability:

- Collect area-based information on wind conditions, water depth, seabed characteristics and distance to shore.

For environmental conditions:

- Collect seasonally informed data such as species migration, dynamic ecological patterns and weather events.
- Recognise predefined marine protected areas (MPAs) and OECMs.
- Assess environmental sensitivities to identify areas of ecological importance.
- Develop robust environmental baselines to understand natural systems that could be at risk before OW development begins.

For socio-cultural conditions:

- Collect area-based information on cultural values, community vulnerability, current and historical conflicts.
- Ensure the respect of tangible and intangible cultural heritage and uphold specific community rights such as Free Prior and Informed Consent (FPIC).
- Ensure the respect of ILK as well as different world views and community dynamics, ensuring open and transparent dialogue.

For spatial interactions:

- Evaluate conflicts and synergies between OW and other maritime uses and activities (fisheries, conservation, navigation, etc.).
- Identity exclusion zones, and permitted activities within the planning framework.

b) Engage in defining and detailing distinct alternative planning scenarios based on different OW scenarios. Through a participatory and transparent process, each alternative should be thoroughly identified, described, and evaluated for its potential impacts, allowing for the selection of the most suitable option. Variables such as distance to shore, number of turbines, infrastructure used and socio-economic implications should be explicit.

c) Use climate and human impact data (including habitat displacement) to assess OW pressures and inform mitigation strategies. This includes integrating climate change scenarios to enhance resilience and adaptability as well as seascape/landscape visual analyses to identify impacts on ecologically significant areas, and aesthetic effects of OW developments.

d) Share OW project data and statistics in the public domain. The availability of OW data and information can increase support, and drive competition across the supply chains. For instance, on a European Level, Member States can upload their offshore wind deployment on the European Marine Observation and Data Network (EMODnet)[9]. Another such example is the Danish Master Data Register of Wind Turbines[10] (maintained by the Danish Energy Agency) which is more specific to wind turbines.

Case Study

Box 7: Evidence-based initiatives and tools supporting OW integration in MSP – United Kingdom

Hosting 43% of European OW capacity, the United Kingdom's experience offers a mature and evolving model for integrating OW development into MSP. The legislative foundation was laid by the **Marine and Coastal Access Act (2009)**[11], which introduced statutory marine planning and enabled the production of sub-national Marine Plans, underpinned by the **UK Marine Policy Statement (2011)**[12]. These plans are legally binding and provide a spatial framework to guide the sustainable use of marine resources, including the development of MRE.

A central actor in this framework is The Crown Estate, which manages the seabed around England, Wales, and Northern Ireland and aligns seabed leasing with planning and environmental objectives. Since the early 2000s, The Crown Estate has delivered successive leasing rounds.

To meet climate and energy targets set for 2030 and 2050, the UK has developed a systems-level approach called **The Marine Delivery Routemap (2024)**[13], which is a strategic framework that coordinates marine activities by integrating energy transition and environmental protection, prioritizing net zero, nature recovery, community benefits, and marine economic growth. It is supported by the **Whole of Seabed Programme**[14], which uses

9. EMODnet: https://emodnet.ec.europa.eu/en
10. Master Data Register of Wind Turbines: https://turbines.dk/
11. Marine and coastal Access Act (2009): https://www.legislation.gov.uk/ukpga/2009/23/contents
12. UK Marine Policy Statement: https://assets.publishing.service.gov.uk/media/5a795700ed915d042206795b/pb3654-marine-policy-statement-110316.pdf
13. Marine Delivery Routemap: https://www.thecrownestate.co.uk/our-business/marine/Marine-Delivery-Routemap
14. Whole of Seabed Programme: https://www.thecrownestate.co.uk/our-business/marine/marine-overview

advanced digital seabed mapping and spatial modelling to identify suitable offshore wind areas and to assess trade-offs across marine sectors.

A set of integrated evidence-based initiatives and tools support this planning framework:

- The **Offshore Wind Evidence and Change (OWEC) Programme**[15], launched in 2020, funds over 30 collaborative projects with more than £50 million committed by The Crown Estate and partners.
- The **Marine Data Exchange (MDE)**[16] holds over 300 TB of open marine data from more than 2,600 surveys, supporting transparent and data-driven marine management.
- The **Offshore Wind Evidence and Knowledge Hub (OWEKH)**[17] improves environmental assessment workflows and data access.
- Several **specialised tools** (such as POSEIDON[18], ECOFLOW[19], BOWIE[20], PrePARED[21], and ProcBe[22]) address environmental baselining, benthic habitats, and ecological modelling.
- The **Strategic Spatial Energy Plan (SSEP)**[23], led by the National Energy System Operator (NESO), aligns grid development with future OW deployment areas.

These tools are embedded within national initiatives such as the **Marine Spatial Prioritisation Programme (MSPri)** led by the Department for Environment Food and Rural Affairs (DEFRA), and updates to statutory **Marine Plans in England**[24] led by the Marine Management Organisation (MMO). Together, they support early identification of spatial conflicts, opportunities for co-location, and risk reduction through evidence-led site selection.

Several good practices have emerged from the UK's evolving experience and its response to the growing pressure on the seabed from marine activities and infrastructure:

- Early investment in data and digital infrastructure (e.g., OWEC, MDE) enhances environmental understanding and streamlines licensing.
- Scenario-based spatial planning via the Whole of Seabed Programme allows decision-makers to visualize trade-offs and co-location potential.
- Pre-consenting activities —including environmental surveys and grid coordination— de-risk deployment and enable anticipatory investment.
- Cross-sector governance, through programme steering groups and structured stakeholder engagement, increases policy alignment and public legitimacy.
- Nature recovery is pursued as a proactive goal, with habitat creation and marine natural capital investment piloted alongside OW development
- Importance of aligning marine planning, leasing, infrastructure, and nature protection through shared data, tools, and collaborative governance. By embedding offshore wind into MSP processes rather than treating it as an isolated sector, the UK has fostered a holistic, long-term approach capable of supporting climate action and sustainable ocean use in parallel.

Sources: The Crown Estate, 2023, 2024a, 2024b, 2024c

15. Offshore Wind Evidence and Change Programme: https://www.thecrownestate.co.uk/our-business/marine/offshore-wind-evidence-and-change-programme
16. Marine Data Exchange (MDE): https://www.marinedataexchange.co.uk/
17. Offshore Wind Evidence and Knowledge Hub: https://owekh.com/home
18. POSEIDON: https://poseidon-dn.eu/projects/
19. ECOFLOW: https://www.ecoflow.org.uk/
20. BOWIE: https://ecowind.uk/projects/bowie/
21. PrePARED:https://owecprepared.org/
22. ProcBe: https://jncc.gov.uk/our-work/procbe
23. Strategic Spatial Energy Plan: https://www.neso.energy/what-we-do/strategic-planning/strategic-spatial-energy-planning-ssep
24. Marine Plans in England: https://www.gov.uk/government/collections/marine-planning-in-england

Case Study

Box 8: Social mapping for OW – Brazil

By December 2024, 103 OW projects have been proposed in Brazil for electricity and green hydrogen production, and were in the environmental licencing phase, among which 25 were in Ceara Federal State (Northeast of Brazil).

One of the proposed OW farm projects, called Caucaia, submitted an Environmental Impact Assessment (EIA) that was ultimately rejected by Brazil's federal environment agency (IBAMA) for being environmentally unviable. Key weaknesses in the assessment included failure to consider potential impacts on underwater cultural heritage (UCH), a flawed socioeconomic study that overlooked the effects on artisanal fishing communities (i.e., potential fishing disruption due to OW projects), underestimation of environmental impacts (including cumulative negative effects), lack of seafloor mapping and inadequate consideration of impacts on unique habitats, absence of decommissioning plans.

Other identified key social challenges linked to the OW licencing in Brazil are the federal ownership and elite control in licensing (mirroring patterns seen in onshore wind projects), exclusion of affected groups from the decision-making process, and the impact on the high biodiversity of the tropical coastal areas, as well as the mobility of marine resources upon which local communities rely on.

A social mapping exercise by the Federal University of Ceara aimed to understand the potential social and environmental impacts caused by the deployment of OW. The structure for building the social mapping was conducted in three steps:

- **Pre-Workshop**
  - Planning and mobilization of stakeholders.
  - Selection of the core fishers' communities for the workshops.
  - Preparation of workshop logistics.
- **Workshop**
  - Collection of spatial data with stakeholders.
  - Construction of social maps based on freehand drawings on satellite images.
  - Completion of a SWOT (strengths, weaknesses, opportunities and threats) matrix and a fishing summary table.
  - Documentation through audio recording and writing of a logbook with observations and comments from the workshop.
- **Post-Workshop**
  - Systematization and processing in a Geographic Information System (GIS).
  - Validation of mapped information.
  - Adjustments and finalization of the products.
  - Return to the community to deliver the social maps.

The process helped map fishing activities, including fishing grounds, landing sites, wind classifications influencing fishing activities, fishing techniques and gear distribution along the coastline, types of fish caught, etc. Recognizing the importance of marine space to local communities and the impact its varying characteristics have on their lifestyle, the results were distributed along three main zones, namely short, medium and long-distance marine areas (measured from the coastline). Within each zone, the study looked into vessel routes, fishing zones as well as tradition, religion, culture and leisure components, and explored the potential impacts of offshore wind development on each of them, within the three identified zones.

The use of spatial and qualitative analysis with social cartography as a participatory methodology helped to map the complexity of coastal systems and to highlight the symbiosis between land and sea in the construction of community territories.

Sources: Balbino da Silva, 2024; Gorayeb et al., 2024; IBAMA, 2024

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5.4 Phase 4 – Developing the marine spatial plan

Key tasks for developing the marine spatial plan (Phase 4):

- ❑ **Define management actions and spatial allocation of uses (zones or priority areas).**
- ❑ **Draft the marine spatial plan and related documents.**
- ❑ **Evaluate the draft marine spatial plan.**
- ❑ **Launch a consultation process of the draft marine spatial plan.**
- ❑ **Endorse and approve the marine spatial plan.**

Source: UNESCO-IOC and European Commission, 2021

a) **Integrate pre-defined OW zones or priority areas into the marine spatial plan.** This includes applying zoning strategies that avoid culturally and ecologically sensitive areas as well as MPAs and Other Effective Area-Based Conservation Measures (OECMs). See **Box 9** for example of suitable and exclusion zones for OW in marine spatial plans.

b) **Explore sectoral synergies (e.g., fisheries, tourism, defence).** This includes using examples from other jurisdictions to inform balanced OW integration strategies and different zoning methodologies.

c) **Incorporate measures from the mitigation hierarchy throughout the OW lifecycle** (see Chapter 4). This includes considering conservation-compatible OW design and explore integrated conservation goals within OW footprints.

d) **Develop a continuous consultation plan and involve stakeholders in refining OW allocations.** This includes tracking issues that were raised, follow up via a feedback loop and ensure transparent responses when addressing demands or justifying not acting on them as well as establishing a grievance mechanism for OW-affected stakeholders to raise concerns and complaints throughout the process. It might be relevant to establish a flexible compensation framework —in the case that impacts cannot be mitigated— in order to support stakeholders impacted by OW farms (including monetary and non-monetary compensation to fishers, for example). See **Box 10** for example of compensation mechanism.

Case Study

Box 9: Identification of suitable and exclusion zones for OW in marine spatial plans - Spain

The Spanish waters, while showing potential for marine renewables, have not yet any installed OW, and the significance of developing MRE is emphasized in the Spanish Maritime Space Management Plans (POEMs, in Spanish) which are subdivided into 5 marine sub-national regions. In fact, these plans identify 'high potential zones for offshore wind' using criteria such as biodiversity impacts, protected areas, various maritime activities and shipping routes.

However, the zoning process shows gaps, and additional techno-economic considerations are required. A study by Martinez and Iglesias (2024) suggested considering port facilities, water depth, availability factor of wind turbines, estimated energy production and the impact of the wave climate on maintenance scheduling as additional factors for siting considerations.

Another study, by Rodríguez-Rodríguez et al. (2016) assessed the potential for OW energy development by incorporating newly designated MPAs into Spain's official Strategic Environmental Assessment (SEA) for OW installations. This update reflected the significant expansion of MPAs since 2009.

The SEA provides a comprehensive analysis of marine and coastal socio-economic uses alongside environmental and cultural values in Spanish marine areas. These include fishing activities, coastal public domain, biodiversity and protected areas, archaeological heritage, maritime and air traffic safety zones, and seascape value. The SEA categorizes Spanish waters, up to 24 nautical miles (NM), into three zones based on their suitability for commercial wind farms: 'suitable', 'suitable with conditions', and 'exclusion zones'.

The study suggests integrating all newly designated MPAs and applying a 10 km buffer around these sites as a precautionary measure. By intersecting these updated protected areas with the SEA suitability zones to identify potential and optimal OW development areas, the results reveal a significant reduction in OW suitable areas. Only 0.7% of the waters up to 24 NM is deemed optimal for OW development using fixed-bottom turbines, while over 88% of all OW farm projects are within the SEA's exclusion zones. This indicates that Spain's set national OW energy targets are unachievable under current conditions. However, advancements in floating OW technologies can offer a viable path to meet these goals.

In fact, another recent study focusing on the Canary Islands region, by Martin Betancor et. al (2024) found that less than 1% of the marine area is suitable for OW generation. The study compared areas proposed in the Spanish Marine Spatial Plan, previous academic research, and suitable marine areas for OW identified by the authors, using the US National Renewable Energy Laboratory (NREL) framework. Offshore resource restrictions are defined by various laws and decrees and include military areas, fish farms, MPAs, airports, ports, and maritime routes.

Additional exclusion criteria that were applied in this study were restrictions within the 24 NM jurisdictional waters, depth (greater than 1000 m), geology (areas with rocky soils or gravel sediments on the seabed), seabed slopes (greater than 15%), average annual wind speed (below 5m/s), distance to shore (area within the 8 km marine strip), fisheries, special protection areas for birds, special areas of conservation.

The results of existing studies highlighted differences in OW resource capacity potential based on the criteria applied. For example, some studies aimed to maximize suitable areas for OW facilities and minimize costs, while others prioritized lowering environmental impacts and stakeholder conflicts. The official MSP seeks a balance across social, technical, economic, and environmental considerations. However, this balanced approach has its challenges. The designated areas for OW often overlap with the EU Natura 2000 network and are relatively close to the coast (3 km), leading to conflicts with stakeholders from the tourism and fishing sectors.

Overall, and as the studies show, challenge remains to identify suitable areas that satisfy all (or a maximum of) social, technical, economic, and environmental criteria, rendering the decision for OW suitable sites a complex one. Additionally, these decisions must involve conversations on co-existence of uses, land-sea interactions, stakeholder involvement, political leadership and transboundary cooperation.

Sources: Abramic et al., 2021; Martín-Betancor et al., 2024; Martinez and Iglesias, 2024; Rodríguez-Rodríguez et al., 2016

Case Study

Box 10: OW compensation mechanisms for fishers - Denmark

In Denmark, OW developers must also consult the local fishers and discuss potential mitigation measures or financial compensation to the estimated loss of income. As a general rule, negotiations on compensation are carried out by the Danish Fishermen's Association under the Fisheries Act. The developer must negotiate compensation with every affected fisher, and the license to produce electricity from the OW farm can be granted only if an agreement has been made with all affected fishers. An impact assessment on commercial fisheries is prepared as part of the EIA of the predetermined OW site.

Source: Vasconcelos et al., 2022

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5.5 Phase 5 – Enabling implementation of the marine spatial plan

Key tasks for implementing the marine spatial plan (Phase 5):

- ❑ Establish a regulation to implement the plan.
- ❑ Raise awareness and establish regular dialogues with rights-holders and stakeholders to follow up and support implementation.
- ❑ Build capacities for competent authorities, rights-holders and stakeholders on the implementation of the plan.
- ❑ Comply with the marine spatial plan.
- ❑ Enforce the marine spatial plan.

Source: UNESCO-IOC and European Commission, 2021

a) **Provide guidance and training on the role of MSP in OW development to OW developers and operations managers.** This includes practical MSP handbooks and guidelines as well as development of workshops and training sessions that provide tools for understanding the basics of MSP, legal frameworks, multi-use and co-location principles, stakeholder engagement, adaptive MSP and climate scenarios, good practices for collecting data, and creating simulation scenarios.

b) **Develop community benefit programmes that contribute to raising awareness and fostering public acceptance within local communities.** This includes ocean literacy workshops not only to understand the marine environment but to connect it with sustainable blue economy opportunities that OW can provide. Visual platforms with videos, interactive maps and games where the community can get familiar with the OW. Keep the community informed, with small bulletins.

c) **Facilitate collaboration between OW developers and government agencies to align MSP with national energy policies and the development of future strategies.** This includes strengthening inter-agency coordination to support OW permitting and policy development.

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5.6 Phase 6 – Monitoring, evaluation and adaptation of the MSP process and the marine spatial plan

Key tasks for monitoring, evaluation and adaptation of the process and the plan (Phase 6):

- ❑ **Evaluate the planning process and stakeholder engagement.**
- ❑ **Evaluate the marine spatial plan and its relevance.**
- ❑ **Evaluate the implementation of the marine spatial plan.**
- ❑ **Evaluate the MSP results and define how to report it.**
- ❑ **Review and revise the marine spatial plan.**

Source: UNESCO-IOC and European Commission, 2021

a) **Focus on outcomes, processes, and context for a comprehensive evaluation of the integration of OW into MSP.** This includes assessing whether OW objectives have been effectively reached; if not, determine whether this results from a lack of adherence, unclear policies, or changing strategic targets. It is also relevant to identify what OW changes, either directly, indirectly, or partially, can be attributed to the MSP. Moreover, context evaluation is key to maintaining the plan's relevance, especially as offshore energy goals and geopolitical dynamics evolve.

b) **Align MSP evaluation with OW monitoring frameworks.** This includes defining OW-specific criteria and robust indicators relevant for MSP, as well as optimizing the use of existing data gathered.

c) **Adopt iterative planning to integrate OW considerations and its evolving priorities, allowing for continuous refinement and improvement over time.** MSP is a living document that needs to be periodically updated to reflect the dynamic conditions affecting the marine environment and OW markets. Adopting an adaptive approach helps MSP to stay responsive to external factors such as changes in marine conditions, climate change impacts, OW policy shifts and regulatory changes, as well as OW technological advancements.

Case Study

Box 11: Evaluating the performance of MSP principles for OW - The Netherlands

Over the period of 2004—2018, a study examined the performance of MSP in coordinating OW with other energy uses (round II and III), to understand how the following six key MSP principles are understood within MSP processes and how they are used in decision making for OW: (1) area-based; (2) integrated; (3) participative; (4) strategic; (5) adaptive; and (6) ecosystem-based.

The Dutch government utilized several tools in the process, which were adapted with each round and following new regulatory and legislative frameworks. For instance, in round II, market parties had the opportunity to apply for OW permits anywhere in the Dutch EEZ with some exceptions laid down in the **Spatial Planning Document** (such as shipping routes, defence areas and safety zones/maintenance areas around existing installations). In round III, the government took control of the spatial/temporal development of OW, and permit applications were only allowed in 'wind energy areas' appointed in the **National Water Plan**.

In round II, permits were assessed using the **Integrated Assessment Framework** laid down in the Integrated Management Plan for the North Sea, which required developers to provide information on environmental impacts and impacts on other users in the North Sea, whereas in round III permits for specific plots were issued on the basis of the **Offshore Wind Act (2015)**[25]. Through the 'plot decision instrument' the government determines the coordinates of plots within 'wind energy areas' and include provisions to reduce environmental impact and coordination with other users (such as distance to cables and pipelines, turbine colours, allowed construction periods, as well as minimum height and capacity of turbines).

25. Offshore wind Act: https://wetten.overheid.nl/BWBR0036752/2021-11-11/0

Crossing the different MSP principles' performance during rounds II and III of OW development revealed evolution in the application of most principles. Knowledge, feasibility and legitimacy were measured according to a set framework. Overall, the ecosystem-based principle was regarded as established practice, reflecting its widespread acceptance and effective implementation. In contrast, the area-based, organizational integration, and participative principles were categorized as experiencing a 'legitimacy misfit'. These principles are acknowledged and pursued in terms of their feasibility and the benefits they offer to OW development but are not consistently embraced as guidelines for action. Functional integration was identified as a 'feasibility misfit,' characterized by reliance on international sustainability discourses and targets to ensure rapid and cost-efficient development, yet practical implementation remains constrained. Finally, the strategic and adaptive principles, while recognized, were not actively applied in practice.

In summary, while MSP in the Netherlands advanced the integration of OW development in ocean governance through various tools, gaps remain, and MSP still needs to form a systematic and integrated ocean governance approach. Future efforts should aim for a more critical approach to the operationalisation of the MSP principles considering conflicts and interdependencies with other users and sectors.

Source: Spijkerboer et al., 2020

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6. Conclusions

The engagement and integration of offshore wind (OW) into marine spatial planning (MSP) represents both a strategic opportunity and a complex governance challenge. As demands for renewable energy intensify, countries are increasingly turning to MSP to provide structured, inclusive, and evidence-based approaches for allocating marine space to OW (and other uses). This **Volume 2** presents recommendations that support such integration, drawing on global good practices and practical experiences from diverse planning systems.

MSP can serve as a key enabling framework for OW development by aligning sectoral policies, identifying suitable areas, coordinating land-sea infrastructure, and enhancing environmental and social safeguards. It also highlights MSP's added value in favouring public acceptance and promoting equitable participation, particularly among marginalized and Indigenous Peoples and local communities.

Nonetheless, the publication also underscores persistent challenges. These include governance and permitting misalignments, spatial conflicts, data limitations and social opposition. MSP alone cannot resolve all issues, but it can provide a platform to align processes, timelines, and interests across ocean sectors.

To address these challenges, the volume proposes a set of overarching and phase-specific recommendations tailored to the six phases of the MSP process. These include early legal and stakeholder mapping, coordination of terrestrial and marine planning policies, conduction of socio-ecological assessments, application of mitigation hierarchies, and the development of monitoring indicators tailored to OW. The guidance also emphasizes the importance of adaptive planning cycles, technology-informed decision-making, and transparent data-sharing mechanisms.

A set of case studies from around the world are presented and demonstrates that no single model applies across all contexts. Rather, integrating OW in MSP requires a flexible, context-sensitive approach that can adapt to the country's OW development stage, its national priorities, governance frameworks, marine ecosystem characteristics, and stakeholder dynamics.

As maritime territories under national jurisdictions become increasingly contested and multifunctional, the strategic use of MSP can foster more coordinated, inclusive, and sustainable OW development. This volume provides a step forward in supporting that vision, offering a practical reference for MSP practitioners, OW developers, and decision-makers working to balance renewable energy expansion with ocean sustainability.

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7. References

Abramic, A., García Mendoza, A., and Haroun, R. 2021. Introducing offshore wind energy in the sea space: Canary Islands case study developed under Maritime Spatial Planning principles. *Renewable and Sustainable Energy Reviews*, Vol. 145, Article 111119. https://doi.org/10.1016/j.rser.2021.111119

Alder, J. and Castaño-Isaza, J. 2022. *Marine Spatial Planning for a Resilient and Inclusive Blue Economy: Integrating Cross-Cutting Themes into Marine Spatial Planning*. Washington, D.C., World Bank Group. http://documents.worldbank.org/curated/en/099300106102258666

Bailey, H., Brookes, K. L., and Thompson, P. M. 2014. Assessing environmental impacts of offshore wind farms: Lessons learned and recommendations for the future. *Aquatic Biosystems*, Vol. 10, No.1, pp. 1–13. https://doi.org/10.1186/2046-9063-10-8

Balbino da Silva, R. 2024. *Cartografia social do mar do Ceará: perspectivas da pesca artesanal e os potenciais conflitos com a energia eólica offshore*. Ph.D. Thesis, Federal University of Ceara, Brazil. https://repositorio.ufc.br/handle/riufc/78324

Baltic Lines. 2018. A *practical guide to the designation of energy infrastructure in maritime spatial planning*. BalticLInes Project. https://vasab.org/wp-content/uploads/2019/01/BalticLINes_Guidance_Energy_final.pdf

Bates, A. W. 2017. Revisiting Approaches to Marine Spatial Planning: Perspectives on and Implications for the United States. *Agricultural and Resource Economics Review*, Vol. 46, No. 2, pp. 206–223. https://doi.org/10.1017/age.2017.11

Berwick Bank Wind Farm. 2023. *Offshore EIA Report – Volume 2, Chapter 15: Seascape, Landscape and Visual Impact Assessment (SLVIA)*. https://berwickbank-eia.com/offshore-eia/vol2-ch15-slvia/

Bhattacharya, S., Biswal, S., Aleem, M., Amani, S., Prabhakaran, A., Prakhya, G., Lombardi, D., and Mistry, H. K. 2021. Seismic design of offshore wind turbines: Good, bad and unknowns. *Energies*, Vol. 14, No. 12, pp. 1–27. https://doi.org/10.3390/en14123496

Boggis, M. 2023. Two new 'kittiwake hotels' completed offshore Lowestoft. *Lowestoft Journal*. https://www.lowestoftjournal.co.uk/news/23534342.two-new-kittiwake-hotels-completed-offshore-lowestoft/

Burnett C. M. 2020. Incorporating the participatory process in the design of geospatial support tools: Lessons learned from SeaSketch. *Environmental Modelling & Software*, Vol. 127, Article 104678. https://doi.org/10.1016/j.envsoft.2020.104678

DCCEEW. 2023. *Offshore renewables and First Nations people*. Canberra, DCCEEW. https://www.dcceew.gov.au/sites/default/files/documents/offshore-renewables-first-nations-people.pdf

Depellegrin, D., Ambrosino, M., Roy, S., Sanabria, J., and Llambrich, C. M. 2024. More robust offshore wind energy planning through model ensembling. *NPJ Ocean Sustainability*, Vol. 3, No. 58, pp 1-16. https://doi.org/10.1038/s44183-024-00080-8

Ecocean. 2025. *Projet CONNEXSTERE (FINISHED)*. https://www.ecocean.fr/projets-ecocean/projet-connexstere/

Efthimiou. 2022. *Environmental stakeholder engagement in offshore wind: What is it exactly?* Tokyo, WFO. https://wfo-global.org/environmental-stakeholder-engagement-in-offshore-wind-what-is-it-exactly/

EUR-LEX. 2001. *Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment*. (EUR-Lex 32001L0042) https://eur-lex.europa.eu/eli/dir/2001/42/oj

EUR-LEX. 2014. *Directive 2014/89/EU of the European Parliament and of the Council of 23 of July 2014 establishing a framework for maritime spatial planning*. (EUR-Lex 32014L0089). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0089

European Commission: Executive Agency for Small and Medium-sized Enterprises, Dupont, C., Herpers, F., and Le Visage, C. 2020. *Recommendations for positive interactions between offshore wind farms and fisheries – Short background study*. Brussels, Publications Office of the European Union. https://data.europa.eu/doi/10.2826/017304

European MSP Platform. 2025. *Understanding specific cross-border issues in MSP: Offshore renewable energy and shipping*. https://maritime-spatial-planning.ec.europa.eu/practices/understanding-specific-cross-border-issues-msp-offshore-renewable-energy-and-shipping

Gao, J., An, T., Zhang, K., and Zhao, R. 2024. Development and reform of marine spatial planning in China under the new territorial spatial planning system. *Marine Development,* Vol. 2, No. 1, pp. 1–14. https://doi.org/10.1007/s44312-024-00014-5

Gorayeb, A., Brannstrom, C., Xavier, T., de Oliveira Soares, M., Teixeira, C. E. P., dos Santos, A. M. F., and de Carvalho, R. G. 2024. Emerging challenges of offshore wind energy in the Global South: Perspectives from Brazil. *Energy Research and Social Science,* Vol. 113, Article 103542. https://doi.org/10.1016/j.erss.2024.103542

GWEC. 2021. *Global Offshore Wind Report 2021*. Brussels, GWEC. https://www.gwec.net/reports/globaloffshorewindreport/2021

GWEC India and UK Government. 2023. *An Ocean of potential: Recommendations for Offshore Wind Development in India.* Brussels, GWEC. http://www.indiaenvironmentportal.org.in/files/file/Offshore%20Wind%20development%20in%20india.pdf

GWEC. 2024. *Global Wind Report 2024*. Brussels, GWEC. https://26973329.fs1.hubspotusercontent-eu1.net/hubfs/26973329/2.%20Reports/Global%20Wind%20Report/GWR24.pdf

Haggett, C. 2011. Understanding public responses to offshore wind power. *Energy Policy*, Vol. 39, No.2, pp. 503–510. https://doi.org/10.1016/j.enpol.2010.10.014

Hamilton Locke. 2023. *Finding common ground between offshore wind farms and the rights of Aboriginal and Torres Strait Islander people*. Melbourne, AU, Hamilton Locke. https://hamiltonlocke.com.au/finding-common-ground-between-offshore-wind-farms-and-the-rights-of-aboriginal-and-torres-strait-islander-people

HMC. 2024. *Review of the Jersey Marine Spatial Plan for the States of Jersey Environment, Housing and Infrastructure Scrutiny Panel.* Jersey, States Assembly. https://statesassembly.je/getmedia/c63f6365-22ca-4da2-b001-9e7a5258a16b/2024-10-17-S-R-6-2024-Review-of-the-Marine-Spatial-Plan.pdf?ext=.pdf

IBAMA. 2024. *Complexos eolicos offshore: Projetos com processo de licensiamento ambiental aberto no IBAMA (Atualizacao: 10 de dezembro de 2024)*. https://www.gov.br/ibama/pt-br/assuntos/laf/consultas/arquivos/20241211_Mapa_CEM_dezembro_2024.pdf

Iberdrola. 2025. *Construction of an offshore wind plant*. https://www.iberdrola.com/about-us/our-activity/offshore-wind-energy/offshore-wind-park-construction

IRENA and GWEC. 2023. *Enabling frameworks for offshore wind scale up: innovations in permitting.* Abu Dhabi, International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Sep/IRENA_GWEC_Enabling_frameworks_offshore_wind_2023.pdf

IRENA. 2024. *Floating offshore wind outlook*. Abu Dhabi, International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_G7_Floating_offshore_wind_outlook_2024.pdf

Kaynia, A. M. 2019. Seismic considerations in design of offshore wind turbines. *Soil Dynamics and Earthquake Engineering*, Vol. 124, pp. 399–407. https://doi.org/10.1016/j.soildyn.2018.04.038

Li, A., Sun, Y., and Song, X. 2023. Gradual improvement and reactive intervention: China's policy pathway for developing the wind power industry. *Renewable Energy*, Vol. 216, Article 119068. https://doi.org/10.1016/j.renene.2023.119068

Machado, R., Nabo, P., Cardia, P., Moreira, P., Nicolau, P., and Repas-Goncalves, M. 2024. *Bird Curtailment in Offshore Wind Farms: Application of curtailment in offshore wind farms at a sea basin level to mitigate collision risk for birds*. Brussels, Birdlife Europe and Central Asia and STRIX. https://www.birdlife.org/wp-content/uploads/2024/08/Curtailment_Report_Digital_Spreads.pdf

Majidi Nezhad, M., Neshat, M., Sylaios, G., and Astiaso Garcia, D. 2024. Marine energy digitalization digital twin's approaches. *Renewable and Sustainable Energy Reviews*, Vol. 191, Article 114065. https://doi.org/10.1016/j.rser.2023.114065

Martín-Betancor, M., Osorio, J., Ruiz-García, A., and Nuez, I. 2024. Evaluation of maritime spatial planning for offshore wind energy in the Canary Islands: A comparative analysis. *Marine Policy*, Vol. 161, Article 106046. https://doi.org/10.1016/j.marpol.2024.106046

Martinez, A., and Iglesias, G. 2024. Evaluation of offshore wind energy zones within marine spatial planning: A case study in the Spanish Mediterranean Sea. *Energy Reports*, Vol. 11, pp. 3461–3473. https://doi.org/10.1016/j.egyr.2024.03.018

Maxwell, S. M., Kershaw, F., Locke, C. C., Conners, M. G., Dawson, C., Aylesworth, S., Loomis, R., and Johnson, A. F. 2022. Potential impacts of floating wind turbine technology for marine species and habitats. *Journal of Environmental Management*, Vol. 307, Article 114577. https://doi.org/10.1016/j.jenvman.2022.114577

Ministry of Economic Affairs and Communications of the Republic of Estonia. 2024. *County plan for the maritime area bordering Hiiu County*. https://www.riigiplaneering.ee/en/node/1216

Ministry of Economic Affairs and Communications of the Republic of Estonia. 2025. *Estonian Maritime Spatial Plan*. https://www.riigiplaneering.ee/en/maritime-spatial-plan/maritime-spatial-plans/estonian-maritime-spatial-plan

MSP-GREEN. 2024. *Valuable Practice: Public debates on offshore wind farms planning and MSP–The case of France*. https://mspgreen.eu/wp-content/uploads/2024/05/VP-France-Public-debates-on-offshore-wind-farms-planning-and-MSP.pdf

Noordzeeloket. 2024*a*. *Shutting down offshore wind turbines during peak migration periods*. https://www.noordzeeloket.nl/en/functions-use/offshore-wind-energy/start-stop/movie-start-stop/shutting-down-offshore-wind-turbines-during-peak/

Noordzeeloket. 2024*b*. *Start and stop system for offshore wind turbines*. https://www.noordzeeloket.nl/en/functions-use/offshore-wind-energy/start-stop/

NorthSEE Project. 2020. *The role of MSP for offshore energy developments*. https://northsearegion.eu/northsee/e-energy/the-role-of-msp-for-offshore-energy-developments/

NREL. 2024. *Ultrasonic Deterrents To Reduce Bat Mortality at Wind Turbines—Short Science Summary*. Denver, NREL. https://docs.nrel.gov/docs/fy25osti/90840.pdf

O'Hagan, A. M. 2020. Marine Spatial Planning and Marine Renewable Energy. A.E. Copping, and L.G. Hemery (eds), *OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES)*. pp. 214- 241. https://www.osti.gov/servlets/purl/1632878/

Plan Bleu. 2024. *Recommendations to enhance Offshore Wind Energy in the Mediterranean Sea*– Policy brief. Marseille, UNEP/MAP Regional Activity Centre. https://planbleu.org/wp-content/uploads/2024/07/EMR-Note-48.pdf

Preston J., Gamble C., Debney A., Helmer L., Hancock B., zu Ermgassen P.S.E. (eds.). 2020. *European Native Oyster Habitat Restoration Handbook– UK & Ireland*. London, The Zoological Society of London. https://nativeoysternetwork.org/wp-content/uploads/sites/27/2020/11/ZSL00150%20Oyster%20Handbook_WEB.pdf

Quesada-Silva, M., Iglesias-Campos, A., Turra, A., Suárez-de Vivero, J. L. 2019. Stakeholder participation assessment framework (SPAF): A theory-based strategy to plan and evaluate marine spatial planning participatory processes. *Marine Policy*, Vol. 108, Article 103619. https://doi.org/10.1016/j.marpol.2019.103619

Pacheco Ramos, A. 2023. Offshore Wind's Financial Challenges in A Shifting Economic Climate. *The London Financial*. https://thelondonfinancial.com/markets/offshore-winds-financial-challenges-in-a-shifting-economic-climate

RenewableUK. 2020. *Your career in offshore wind*. London, RenewableUK https://www.bluegemwind.com/wp-content/uploads/2020/07/your_career_in_offshore_wind.pdf

Rodríguez-Rodríguez, D., Abdul Malak, D., Soukissian, T., and Sánchez-Espinosa, A. 2016. Achieving Blue Growth through maritime spatial planning: Offshore wind energy optimization and biodiversity conservation in Spain. *Marine Policy*, Vol. 73, pp. 8–14. https://doi.org/10.1016/j.marpol.2016.07.022

Rose, S., Jaramillo, P., Small, M. J., Grossmann, I., and Apt, J. 2012. Quantifying the hurricane risk to offshore wind turbines. *Proceedings of the National Academy of Sciences of the United States of America*. Vol. 109, No. 9, pp.3247-3252. https://doi.org/10.1073/pnas.1111769109

RVO. 2022. *China offshore wind– Factsheet for Dutch companies*. The Hague, Netherlands, RVO. https://www.rvo.nl/files/file/2022/03/Rapport-Offshore-wind-China.pdf

Samoteskul, K., Firestone, J., Corbett, J., and Callahan, J. 2014. Changing vessel routes could significantly reduce the cost of future offshore wind projects. *Journal of Environmental Management*, Vol. 141, pp. 146–154. https://doi.org/10.1016/j.jenvman.2014.03.026

Scottish Government. 2015. *Planning Circular 1/2015– The relationship between the statutory land use planning system and marine planning and licensing*. https://www.gov.scot/publications/circular-1-2015-relationship-between-statutory-land-use-planning-system/documents/

Spijkerboer, R. C., Zuidema, C., Busscher, T., and Arts, J. 2020. The performance of marine spatial planning in coordinating offshore wind energy with other sea-uses: The case of the Dutch North Sea. *Marine Policy*, Vol. 115, Article 103860. https://doi.org/10.1016/j.marpol.2020.103860

Tafon, R., Howarth, D., and Griggs, S. 2019. The politics of Estonia's offshore wind energy programme: Discourse, power and marine spatial planning. *Environment and Planning C: Politics and Space*, Vol. 37, No. 1, pp. 157–176. https://doi.org/10.1177/2399654418778037

Teng, X., Zhao, Q., Zhang, P., Liu, L., Dong, Y., Hu, H., Yue, Q., Ou, L., and Xu, W. 2021. Implementing marine functional zoning in China. *Marine Policy*, Vol. 132, Article 103484 https://doi.org/10.1016/j.marpol.2019.02.055

The Crown Estate. 2022. *Offshore Wind Evidence and Change Programme– Annual Report 2021: Unlocking the sustainable expansion of offshore wind in the UK*. https://www.datocms-assets.com/136653/1720791248-22_01_26_owec-annual-report_final.pdf

The Crown Estate. 2023. *UK Offshore Wind Report 2023*. London, The Crown Estate. https://www.datocms-assets.com/136653/1720789954-11964_offshorewindreport_2023_final300424.pdf

The Crown Estate. 2024*a*. *Offshore Wind Evidence and Change Programme– Annual report 2024: Driving Nature Positive Offshore Wind Development*. https://www.datocms-assets.com/136653/1744107121-owec-2024-annual-report.pdf

The Crown Estate. 2024*b*. *Future of offshore wind: Considerations for development and leasing to 2030 and beyond*. London, Great British Energy and The Crown Estate. https://www.datocms-assets.com/136653/1742378325-future-offshore-wind-2024.pdf

The Crown Estate. 2024*c*. *Marine Delivery Routemap: Towards a shared vision for our seabed and coastline*. London, The Crown Estate. https://www.datocms-assets.com/136653/1742378449-marine-delivery-routemap-2024.pdf

The Rich North Sea. 2025. *Our approach*. https://www.derijkenoordzee.nl/en/our-approach

UNESCO-IOC. 2009. *Marine Spatial Planning: a step-by-step approach toward ecosystem-based management*. Paris, UNESCO. (IOC Manuals and Guides No. 53). https://unesdoc.unesco.org/ark:/48223/pf0000186559

UNESCO-IOC. 2014. *A Guide to Evaluating Marine Spatial Plans*. Paris, UNESCO. (IOC Manuals and Guides No. 70). https://unesdoc.unesco.org/ark:/48223/pf0000227779

UNESCO-IOC and European Commission. 2021. *MSPglobal International Guide on Marine/ Maritime Spatial Planning*. Paris, UNESCO. (IOC Manuals and Guides No. 89). https://unesdoc.unesco.org/ark:/48223/pf0000379196

UNESCO-IOC and European Commission. 2025. *MSPglobal International Guide on Marine/Maritime Spatial Planning: Volume 2 – Biodiversity Inclusive Principle*. Paris, UNESCO. (IOC Manuals and Guides No. 89, Volume 2). https://www.mspglobal2030.org/resources/msp-global-documents/

UNESCO-IOC and UNESCO-LINKS. 2024*a*. *Engaging Indigenous Peoples and Local Communities, and Embracing Indigenous and Local Knowledge in Marine Spatial Planning: Volume 1 – Basic Concepts*. Paris, UNESCO. (IOC Technical Series No. 189, Volume 1). https://unesdoc.unesco.org/ark:/48223/pf0000389940

UNESCO-IOC and UNESCO-LINKS. 2024*b*. *Engaging Indigenous Peoples and Local Communities, and Embracing Indigenous and Local Knowledge in Marine Spatial Planning: Volume 2 – Good Practices*. Paris, UNESCO. (IOC Technical Series No. 189, Volume 2). https://unesdoc.unesco.org/ark:/48223/pf0000390615

Unsworth, R. K. F., Bertelli, C. M., Coals, L., Cullen-Unsworth, L. C., den Haan, S., Jones, B. L. H., Rees, S. R., Thomsen, E., Wookey, A., and Walter, B. 2023. Bottlenecks to seed-based seagrass restoration reveal opportunities for improvement. *Global Ecology and Conservation*. Vol. 48, Article e02736. https://doi.org/10.1016/j.gecco.2023.e02736

van Katwijk, M. M., Thorhaug, A., Marbà, N., Orth, R. J., Duarte, C. M., Kendrick, G. A., Althuizen, I. H. J., Balestri, E., Bernard, G., Cambridge, M. L., Cunha, A., Durance, C., Giesen, W., Han, Q., Hosokawa, S., Kiswara, W., Komatsu, T., Lardicci, C., Lee, K.-S., … Verduin, J. J., 2016. Global analysis of seagrass restoration: the importance of largescale planting. *Journal of Applied Ecology*, Vol. 53, pp.567–578. https://doi.org/10.1111/1365-2664.12562

Vasconcelos, R. M. de, Silva, L. L. C., González, M. O. A., Santiso, A. M., and de Melo, D. C. 2022. Environmental licensing for offshore wind farms: Guidelines and policy implications for new markets. *Energy Policy*, Vol. 171, Article 113248. https://doi.org/10.1016/j.enpol.2022.113248

Vega-Araújo, J., Muñoz Cabré, M., Ramirez, Y., and Lerma, R. 2024. *Enabling factors of social acceptance of wind energy projects in La Guajira* (Report No. SEI 2024:001). Stockholm, Stockholm Environment Institute. https://doi.org/10.51414/sei2024.001

White, C., Halpern, B. S., and Kappel, C. V. 2012. Ecosystem service tradeoff analysis reveals the value of marine spatial planning for multiple ocean uses. *Proceedings of the National Academy of Sciences*, Vol. 109, No. 12, pp. 4696–4701. https://doi.org/10.1073/pnas.1114215109

World Bank Group. 2021. *Key Factors for Successful Development of Offshore Wind in Emerging Markets*. Washington, DC, World Bank Group. https://documents1.worldbank.org/curated/en/343861632842395836/pdf/Key-Factors-for-Successful-Development-of-Offshore-Wind-in-Emerging-Markets.pdf

World Bank Group. 2024. *Integrated Environmental & Social Sensitivity Mapping: Guidance for Early Offshore Wind Spatial Planning*. Washington, DC, World Bank Group. https://documents1.worldbank.org/curated/en/099060424173523666/pdf/P1700901ab099e04a1ad5e19ad8ccceea4a.pdf

WREN. 2023. *Short Science Summary: The Mitigation Hierarchy*. https://tethys.pnnl.gov/summaries/short-science-summary-mitigation-hierarchy

Zhang, J., and Wang, H. 2022. Development of offshore wind power and foundation technology for offshore wind turbines in China. *Ocean Engineering*, Vol. 266, No. 5, Article 113256. https://doi.org/10.1016/j.oceaneng.2022.113256

Offshore wind (OW) development is rapidly expanding as a key component of the global energy transition, yet its integration into marine spatial planning (MSP) frameworks remains uneven across regions. To support more coordinated and sustainable planning, this publication has been developed alongside experts to present basic concepts (Volume 1) and good practices (Volume 2) for engaging the offshore wind sector in MSP processes. It aims to strengthen the knowledge, tools and collaborative capacity of marine planners, authorities and energy stakeholders to ensure that MSP facilitates the efficient deployment of offshore renewables while balancing environmental, social and economic objectives.

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