



**PHAROS4MPAS**

# SAFEGUARDING MARINE PROTECTED AREAS IN THE GROWING MEDITERRANEAN BLUE ECONOMY



**Front cover:** Immature great black-backed gull (*Larus marinus*) in the Thornton Bank wind farm in the Belgian North Sea  
© Nicolas Nicolas Vanermen

#### Publication

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# CONTENTS

EXECUTIVE SUMMARY	3
INTRODUCTION	5
<b>PART ONE</b>	
<b>BACKGROUND INFORMATION:</b>	
OFFSHORE WIND FARM (OWF) SECTOR	7
<b>PART TWO</b>	
ENVIRONMENTAL IMPACTS OF OWFS ON MARINE ECOSYSTEMS	15
2.1. Impacts on the abiotic environment	19
2.2. Impacts on benthic habitats and communities	20
2.3. Impacts on fish	23
2.4. Impacts on birds	24
2.5. Impacts on marine mammals	27
2.6. Impacts on other animals	28
2.7. Cumulative impacts	28
<b>PART THREE</b>	
TECHNICAL RECOMMENDATIONS AND BEST AVAILABLE REGULATIONS	31
3.1. Avoidance and mitigation measures	32
3.1.1. Mitigation of noise	34
3.1.2. Mitigation of light	36
3.1.3. Avoidance and mitigation of habitat loss	37
3.1.4. Avoidance and mitigation of bird collisions	38
3.1.5. Mitigation of collision with vessels	40
3.1.6. Mitigation of waste	40
3.1.7. Mitigation of electromagnetic fields and temperature	41
3.2. Monitoring and scientific research	42
<b>PART FOUR</b>	
RECOMMENDATIONS ON INTERACTIONS BETWEEN OFFSHORE WIND FARMS AND MARINE PROTECTED AREAS	45
4.1. Public authorities	52
4.2. MPA managers	54
4.3. OWF business sector	58
ACRONYMS	60
BIBLIOGRAPHY	61



# EXECUTIVE SUMMARY

Wind power is a key form of renewable energy. Within the EU it represents one of the most promising tools for reducing greenhouse gas emissions, and hence diminishing the consequences of climate change.

The offshore wind energy sector has been expanding since 1991 when the first OWF was built, and today it is full of potential. **However, the rapid increase of the OWF sector is raising concerns over its effects on marine wildlife: research in pioneer countries has shown that offshore wind development has potential negative impacts on the surrounding environment.**

In addition, the expansion of the OWF sector adds to spatial competition with other economic sectors (e.g. fisheries) in an already busy seascape. Some ecological interests may conflict with other nature conservation targets.

Meanwhile, the role of Marine Protected Areas (MPAs) is becoming more important all the time: in recent years they have been increasing in number and area covered, as the global community aims to protect 10% of the world's oceans by 2020 and a larger proportion by 2030. As key tools for protecting marine biodiversity and ecosystems, it's essential that their relation to activities such as OWFs is well defined. This report provides recommendations to support public authorities, MPA managers and the OWF business sector in working together to minimize the environmental impacts of OWF development.

**Decision-making processes regarding future locations for OWFs should take into account conservation objectives, and aim to avoid ecologically valuable and protected areas.**

Ecosystem-based marine spatial planning (MSP) and strategic environmental assessments (SEA) should as far as possible ensure that OWFs are not deployed in areas that contain habitats, species and/or ecological processes that are particularly sensitive to its impacts, whether during construction or operation. Active cross-sectoral participation is essential for successful MSP that ensures both marine wildlife conservation and the sustainable development of OWFs in the Mediterranean.

In countries where renewables have already been deployed in MPAs, or which are at the planning and assessment stage, the environmental impacts of each development should be robustly scrutinized on a case-by-case basis under relevant nature conservation legislation. A precautionary approach should be taken, to ensure that site conservation objectives are met.

Compared to other industries, the construction and operation of OWFs is relatively well studied in terms of marine conservation concerns. **Lessons learned in northern Europe show that efficient mitigation measures for key pressures do exist, and they have been highly successful in reducing adverse effects on marine wildlife.**

However, knowledge gained from pioneer countries can only be partially applied to OWF development in the Mediterranean Sea, since the region has its own set of unique characteristics. With this in mind it's crucial that research and monitoring programmes, tailored to the specific conditions of the Mediterranean marine environment, are developed.



# INTRODUCTION

Today, there are increasing attempts to combat climate change by replacing energy from fossil fuels with energy from renewable sources. EU renewable energy targets developed in 2008 and renewed in 2014 aim for a 40% cut in greenhouse gas emissions compared to 1990 levels, and at least a 27% share of renewable energy consumption by 2030.

Energy generated from wind power is one of the most promising tools for reaching these targets. It's a point reinforced by the latest IPCC report, which also recommends the development of renewable energies. However, research has also raised concerns about the potential impacts of offshore wind energy on the marine environment.

**To date, the development of the sector in the Mediterranean is in its infancy: there are currently no OWFs in operation in the region. The first is due to be completed by early 2020 in Italy, while several projects are in a pilot phase in France, and Greece is considering potential development of the sector.**

Marine conservation finds a focus in MPAs, which are an important tool in managing anthropogenic activities at sea. Under the Aichi targets of the Convention on Biological Diversity and the UN's Sustainable Developments Goals the ultimate aim is to establish MPAs covering least 10% of coastal and marine areas "consistent with national and international law" by 2020,<sup>[2]</sup> and this target will probably be upscaled in the next decade. Clearly, their role in relation to new developments such as OWFs needs to be well defined.

**In some countries today a highly restrictive approach to MPAs completely excludes the possible development of OWFs. In others, however, MPAs overlap with either planned or existing OWFs, and there's an urgent need to address the potential implications of these interactions.**

In taking into account the different roles and objectives of public authorities, MPA managers and the OWF sector, this document presents practical recommendations which address the potential interactions between OWFs and MPAs. The guidelines are informed by an 'Avoid - Mitigate - Compensate' approach.

There is more detail on these recommendations, including the case studies presented, in the capitalization baseline report prepared to provide exhaustive background information to this research <sup>[1]</sup>.

The PHAROS4MPAs project explores how Mediterranean MPAs are affected by activities in the growing Blue Economy, and provides a set of practical recommendations for regional stakeholders on how the environmental impacts of key sectors can be prevented or minimized. Encouraging international collaboration across MPA networks and cooperation between state, industry and other actors, PHAROS4MPAs aims to enhance MPA management effectiveness and improve the conservation of marine ecosystems across the whole of the Mediterranean.

PHAROS4MPAs focuses on the following sectors of the Blue Economy:

- Maritime transport and industrial ports
- Cruise
- Leisure boating
- Offshore wind farms
- Aquaculture
- Recreational fisheries
- Small-scale fisheries



SPARROWHAWK MIGRATING  
THROUGH THE BUTENDIEK OWF  
IN THE GERMAN NORTH SEA

© MICHAEL HEISS





**PART ONE**  
**BACKGROUND**  
**INFORMATION:**

# OFFSHORE WIND FARM SECTOR

# OFFSHORE WIND ENERGY

is a new industry developing swiftly in many countries.

Currently, the majority of offshore wind energy is produced by fixed turbines in the North Sea, Irish Sea and Baltic Sea in water less than 40m deep, relatively close to the shore. However, floating wind farms are currently in development further offshore, and 'Hywind Scotland', the first floating OWF in the world, reaches a depth of almost 100m. The industry expects that depths of 200m could be reached in the future <sup>[93]</sup>.

The first pilot OWF 'Vindeby' was installed in Denmark in 1991 and have already been dismantled allowing a unique return of experience among marine infrastructure of reversibility and impact throughout the entire lifecycle.

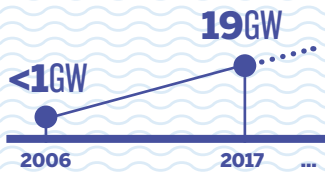
At present **17** countries worldwide have developed OWFs in their marine areas <sup>[3]</sup>.



THE INSTALLATION OF THE WORLD'S FIRST FLOATING OWF, PETERHEAD, SCOTLAND

ØRJAN RICHARDSSEN / WOLDCAM / © EQUINOR

## KEY FACTS



Between 2006 and 2017 the capacity of offshore wind has grown worldwide from less than **1 GW** to over **19 GW** <sup>[4]</sup>, whereas Europe holds the biggest share with around 85% and total installed offshore wind capacity of almost 16 GW.

  
**92**

  
**11** countries

  
**4000**

**92** offshore wind farms in **11** European countries with more than **4000** turbines are installed <sup>[5]</sup>. The United Kingdom, Germany, Denmark, Netherlands and Belgium represent the biggest market.

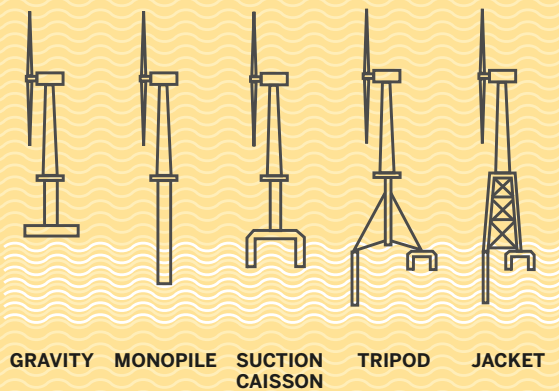


# DEFINITION

The offshore wind energy sector develops wind farms in the marine environment which harvest wind energy to generate electricity.

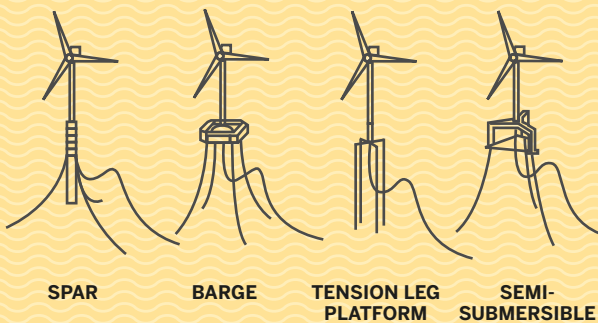
## Fixed foundation types [6]

In shallow waters (0-30 m), gravity and monopile foundations are mainly used. In transitional waters (30-50 m) monopiles are deployed, usually tripods and jacket foundations. After this point waters are too deep for grounded foundations.



## Floating foundation types [7]

Floating OWF foundations target very deep sites (50-200 m) and have high capacity (usually 5-8 MW). Most are still at the demonstration stage. In most types of floating foundation (spar-buoy, barge and semi-submerged) the mooring chains are not under tension but consist of high tenacity steel, four to six times the water depth in length.



# OWF CHARACTERISTICS AND COMPONENTS

Modern wind turbines can reach total heights of >110m above the water, with rotor diameters up to 164m [8]. The largest turbine in the world reaches 260m (see Figure 1). One single OWF may be composed of several dozen turbines: the largest currently in development will have 174 of them.

All OWFs include substations which transform the electricity they generate to a very high voltage. A system of inner-array-cables and export cables connect the turbines together and the OWF to the electrical grid. For safety reasons, all offshore turbines are equipped with aviation lights on top and ship navigation lights lower down.

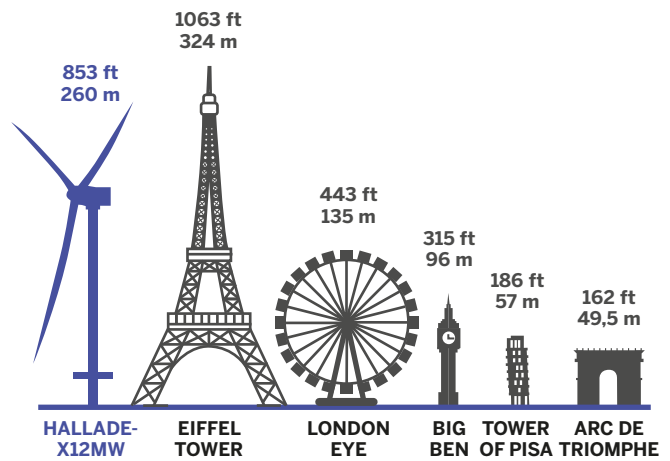
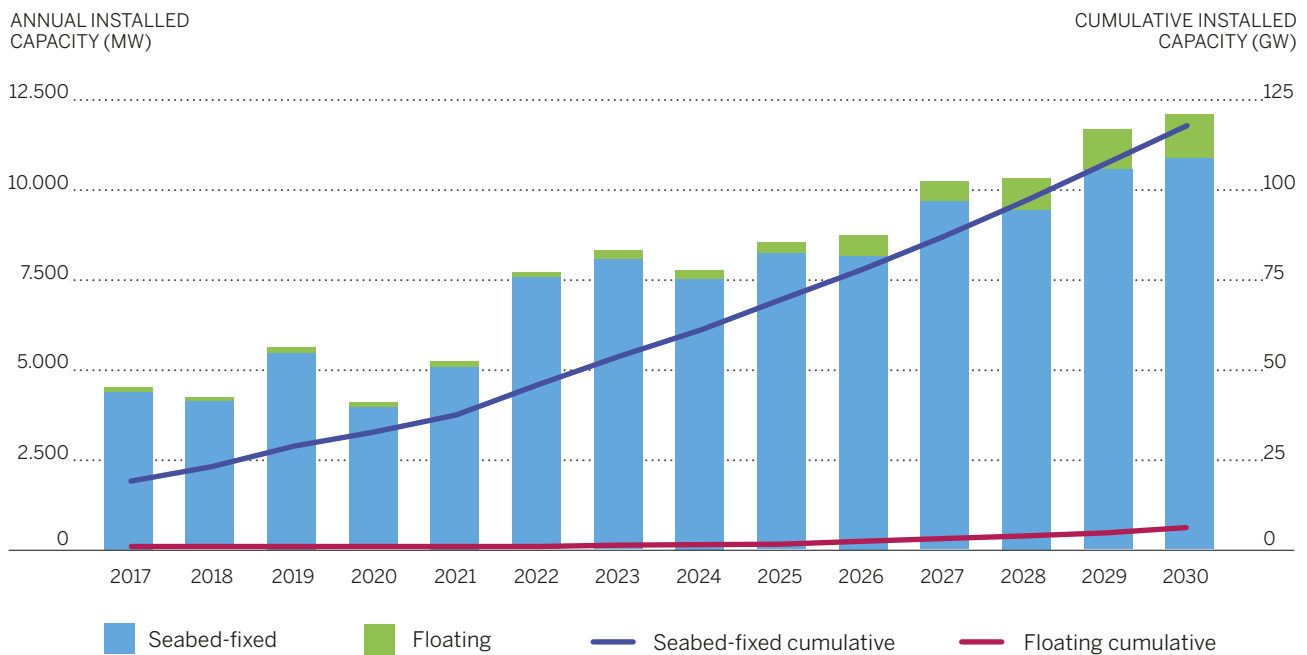


FIGURE 1. The size proportion of the world tallest offshore turbine (SOURCE: GENERAL ELECTRIC RENEWABLE ENERGY)

# OWF LIFE CYCLE

Countries usually initiate the development of offshore wind energy by setting capacity targets and creating economic incentives through feed-in tariffs. There are then four main phases during the OWF lifecycle: Planning & Siting, Construction, Operation & Maintenance and Decommissioning. The operation phase may span as much as 25 years.



**FIGURE 2.** Projections for development of global offshore wind capacity. The projected share of floating OWFs is in green (SOURCE: [3])

## CURRENT TRENDS

The growth of the offshore wind energy sector will undoubtedly continue swiftly (Figure 2). Offshore wind speeds are faster and steadier than on land. Faster wind speeds mean much more energy can be generated, and a steadier supply of wind means a more reliable source of energy. Many coastal areas have very high energy demands, which could be partly met by building OWFs in those same areas.

Further expansion offshore can also avoid conflicts with the tourist industry and secondary residents and other stakeholders on the coast. Floating OWFs offer potential access to new marine zones. At the same time technical progress is bringing down OWF production costs, making further offshore development more likely. The sector may also benefit from financial support for sustainable energy initiatives through the World Bank, the EU etc.

Today, construction techniques are still focused on fixed structures, such as monopile or jacket foundations (> 80%). The size and capacity of a single turbine has increased about tenfold since the beginning of offshore wind power, and modern turbines now have a capacity above 10MW. To put this in perspective, 1MW is enough electricity for 1,000-1,500 households.

Technical progress is enabling the industry to plan and install OWFs with an increasing capacity, at greater depth and further offshore. It's also making the use of floating turbines more feasible<sup>[5]</sup>, enabling the industry to expand into deeper waters. However, current predictions indicate that floating foundations will only be used in a minority of turbine installations, since most development is expected to focus instead on shallow areas close to the coasts.

## FORECASTS FOR THE MEDITERRANEAN REGION

To date, there are no OWFs in the Mediterranean. The first is due to be completed by early 2020 in Taranto, Italy (Renexia's Project).

According to specific forecasts for the Mediterranean region, offshore wind energy is the most promising future source of renewable power; particularly in light of a projected reduction in costs of up to 50% by 2021. The geomorphology of the region suggests that floating foundations may be the most appropriate installations in many areas<sup>[9]</sup>.

Despite the leading role played by European countries in the offshore wind energy sector, the development of OWFs in the Mediterranean is still in its infancy. However, the wind potential is high enough to support the development of the sector in the region.

Figure 3 shows potential locations for siting OWFs in the Mediterranean, both with fixed and floating foundations. The most promising areas include the Gulf of Lion, the Adriatic Sea, the Straits between Sicily and Tunisia and Sicily and Malta, and the Gulf of Gabes. Two projects have been approved so far: Renexia's Project in Italy with fixed foundations, and one in France with floating foundations. Fixed foundation projects are planned in Greece and Italy, while all projects developing in France intend to use floating foundations.

OWFs may adversely affect marine habitats and wildlife, and their development comes with the very active participation of environmental agencies, NGOs and the public. It's worth noting that because of the high attention paid to it as a developing industry, offshore wind is one of the most studied renewable technologies in terms of its environmental implications – a body of knowledge on the effects of OWFs on marine wildlife is swiftly growing.

While the OWF sector is still in its early planning stages in the Mediterranean, there are concerns about what this new industry will do to the marine environment, particularly in sensitive areas [5]. Since most MPAs are located in coastal areas, some overlap with cable grid connections and vessel routes is inevitable. In this regard, to protect Mediterranean species and habitats and to safeguard the conservation role of MPAs, important lessons can be learned from pioneer countries in other regions.

To date:

- > In **Italy**, OWF development does not currently impact MPAs. The first OWF is due to be completed in Taranto in early 2020 (Renexia's Project).
- > In **France**, three pilot floating wind farms have been approved and are due to be built before 2022. Two of them impact MPAs, the Gulf of Lion Marine Park and the Camargue Natural Regional Park.
- > In **Greece** – especially after the 2017 update of the Greek Natura 2000 Network which led to the designation of new marine areas – there are currently 24 OWFs proposed in 14 Natura sites, and one in the outer limits of a National Park/Ramsar site.

To date there are no OWFs in the Mediterranean. The first is due to be completed by early 2020 in Taranto, Italy (Renexia's Project).

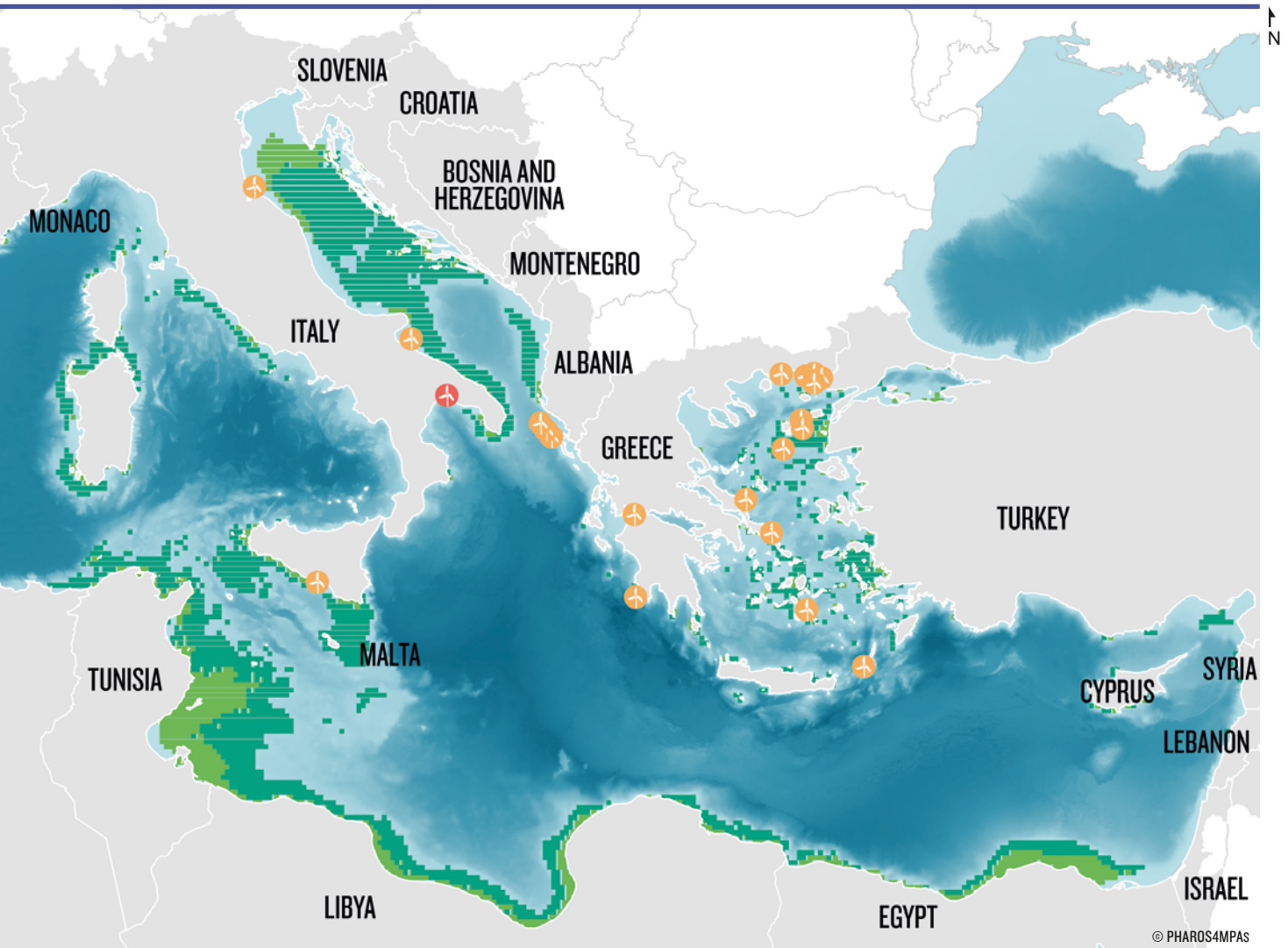


Potential locations  
SOURCE: MedTrends (2015)  
Windfarm project  
SOURCE: EMODNET (2017), revised by WWF

## KEY FACTS

The most promising OWF areas in the Mediterranean include the Gulf of Lion, the Adriatic Sea, the Straits between Sicily and Tunisia and Sicily and Malta, and the Gulf of Gabes.



The OWF lifecycle (installation, connection to the electrical grid by submarine cable, maintenance and eventual decommissioning) has the potential to adversely affect marine habitats and wildlife.



### WINDFARM PROJECTS

-  Planned OWF
-  Authorised OWF

### POTENTIAL SUITABLE AREAS FOR OWF DEVELOPMENT

-  Suitable area for fixed OWF (water depth < 50 m and wind speeds greater than 5m/sec at 80 m height above sea level)
-  Suitable area for floating OWF (water depth 50 to 200 m and wind speeds greater than 5m/sec at 80 m height above sea level)

**FIGURE 3.** Potential areas suitable for OWF development, and planned and authorized OWF projects in the Mediterranean Sea



SHOREBIRDS PASS BY AN OWF

© TERENCE A R WATTS / SHUTTERSTOCK



**PART TWO**

# ENVIRONMENTAL IMPACTS OF OFFSHORE WIND FARMS ON MARINE ECOSYSTEMS



As OWFs increase in number and size, there's a growing need to consider their cumulative impacts on marine habitats and wildlife. Stressors causing these impacts are shown below in Table 1. Even so, OWFs may also have beneficial effects for some organisms, for instance by acting as artificial reefs, which can enhance biodiversity and increase food sources.

The level of OWF impacts is highly dependent on the habitat characteristics of an individual site, the types of turbines and foundations used, and the installation techniques involved. Floating wind farms will likely have different impacts to fixed wind farms, but they are a recent development and research is so far scarce.

Previous experience from pilot and commercial floating OWFs (Hywind 1 and 2, FloatGen, WindFloat) shows no pile driving is needed to secure the foundations on the sea bottom, thus noise levels are lower. Also the turbines were fully constructed on land, and no heavy vessels were needed to put them in place, minimizing the duration and extent of the resulting impacts (e.g. collision risk, noise, ship presence, sea bottom disturbance) (Table 1).

In general there are still substantial knowledge gaps concerning the quantification of the environmental impacts of OWFs. Impacts occur at different times in the lifecycle phases of an OWF, and their strength varies in terms of duration and spatial extent.

PRESSURE	IMPACT	TAXONOMIC GROUP / HABITATS
Cable laying	Habitat loss	<b>Habitats/ benthic communities</b>
Cable laying	Physical damage, disturbance	
Foundations occupation	Habitat loss/ Physical damage, disturbance	
Submerged structures	Reef effect	
Underwater operating cables	Electromagnetic fields/Temperature increase	
Piling noise	Physical damage, disturbance	<b>Fish</b>
Underwater operating cables	Electromagnetic fields	
Submerged structures	Reef effect	
Foundations occupation	Habitat loss	
Piling noise	Physical damage, disturbance	<b>Marine mammals</b>
Ship traffic / Ship presence	Collision / displacement	
Ship traffic - noise	Displacement	
Ship traffic	Displacement	<b>Birds</b>
Light	Collision	
Operating wind turbines	Collision	
Operating wind turbines	Barrier effect	
Operating wind turbines	Collision	<b>Bats</b>
Ship traffic	Collision	<b>Sea turtles</b>
Piling noise	Physical damage, disturbance	
Light	Disorientation	
Underwater operating cables	Disorientation due to EMF	
Waste and pollution	Habitat degradation, disturbance, physical damage	<b>All taxonomic groups and habitats</b>
Sacrificial anodes	Habitat degradation, disturbance, physical damage	

**TABLE I.** Pressures, intensity and occurrence of impacts on marine habitats and animal groups during the four OWF lifecycle phases

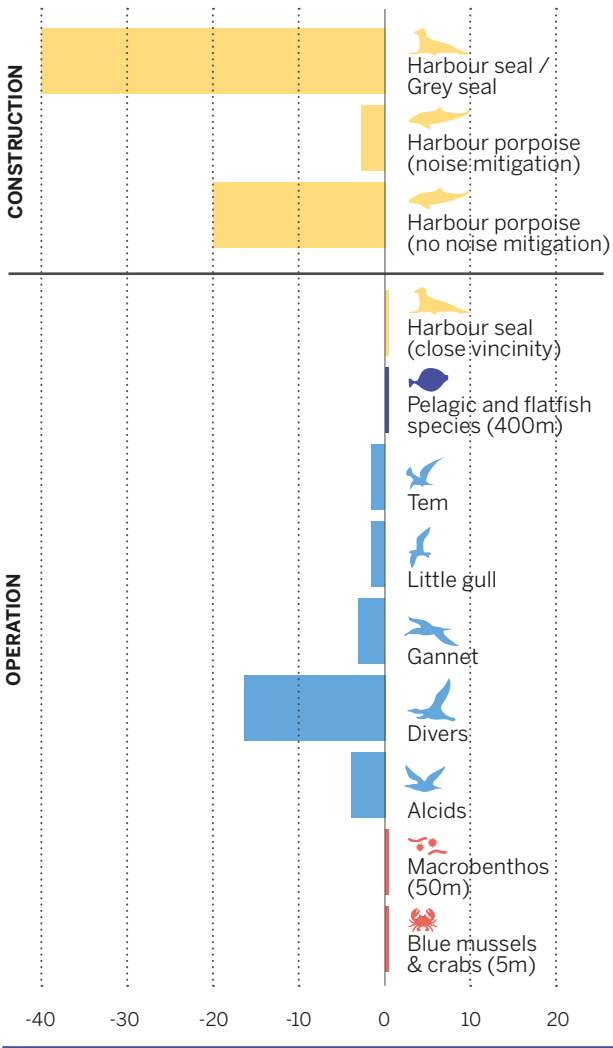


A TURBINE IS TOWED OUT OF STORD, NORWAY, HEADING FOR THE HYWIND PILOT OWF 25KM OFF THE COAST OF PETERHEAD (SCOTLAND)

© EVA SLEIRE / STATOIL

IMPACT INTENSITY DURING:				
	Siting phase	Construction	Operation	Decommissioning
	—	MEDIUM/HIGH	LOW	LOW/UNKNOWN
	—	MEDIUM/HIGH	LOW	UNKNOWN
	—	MEDIUM/HIGH	LOW	—
	—	—	UNKNOWN	UNKNOWN
	—	—	UNKNOWN	—
	—	HIGH	—	—
	—	-	UNKNOWN	UNKNOWN
	—	-	UNKNOWN	UNKNOWN
	—	MEDIUM/HIGH	LOW	—
	—	HIGH	—	—
	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
	LOW/MEDIUM	MEDIUM/HIGH	MEDIUM/HIGH	MEDIUM/HIGH
	LOW/MEDIUM	LOW/MEDIUM/HIGH depending on species		
	LOW	LOW/MEDIUM/HIGH depending on species		
	—	—	LOW/MEDIUM/HIGH depending on species	—
	—	—	LOW/UNKNOWN	—
	—	—	UNKNOWN	—
	LOW/MEDIUM	MEDIUM/HIGH	LOW/MEDIUM	LOW/MEDIUM
	—	HIGH	—	—
	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
	—	—	UNKNOWN	—
	LOW	LOW	LOW	LOW
	—	UNKNOWN	UNKNOWN	UNKNOWN

The radius in which the turbines or the entire OWF cause either avoidance or attraction behaviour in species or animal groups is known in a few cases (see Figure 4). While impacts on marine mammals on a large spatial scale are expected mainly during the construction phase, many water birds avoid the operating turbines to a distance of several kilometres. A potential reef effect can be expected directly at the turbine foundations to a maximum radius of 400m.



**FIGURE 4.** Maximum response distances (avoidance or attraction) of different animals around OWFs during construction or operation. Response distance is defined as the distance around an OWF where the abundance of the animals is significantly reduced.

REFERENCES: HARBOUR PORPOISE [15 AND REFERENCES THEREIN]\* MOST RECENT DATA SHOW AVOIDANCE GRADIENT OF UP TO 15 KM (BIOCONSULT SH ET AL., UNPUBL.) BOTTLENOSE DOLPHIN [15 AND REFERENCES THEREIN], HARBOUR SEAL [16,17], GREY SEAL [18], FISH, MUSSELS & CRABS [10], MACROBENTHOS [19], DIVERS [20], OTHER BIRDS [21 AND REFERENCES THEREIN]

As OWFs increase in number and size, there's a growing need to consider their cumulative impacts on marine habitats and wildlife. Impacts occur depending on the lifecycle phases of an OWF, and their strength varies in terms of duration and spatial extent.



INSTALLING TURBINE BLADES ON A MONOPILE TYPE OWF

© DOTI - MATTHIAS IBELER

## FACTS

The main OWF pressures are from operating turbines which birds collide with, and noise disturbing or damaging marine mammals (from the construction phase and then from shipping traffic during the exploitation phase)



# 2.1. IMPACTS ON THE ABIOTIC ENVIRONMENT

Offshore wind turbines function as an artificial barrier to wind and ocean currents, producing a so-called 'wind-wake' effect. Depending on atmospheric stability, these wind-wakes and an associated increase in air turbulence can span a distance between 10 to 20 times the rotor diameter <sup>[22,23]</sup>.

In addition, **OWF foundations induce water turbulence, leading to a significant increase in suspended sediments:** this can result in 30-150m wide plumes, which may extend for several kilometres <sup>[24]</sup>. Pollution from turbines themselves – deliberate or unintended – may also affect the water quality. Each year, sacrificial anodes cause the input of about 0.5 to 1 tons of metals (mostly Al and Zn) per turbine, as well as other heavy metals (mostly In) <sup>[25]</sup>.

# 2.2.

## IMPACTS ON BENTHIC HABITATS AND COMMUNITIES

The Mediterranean has a relatively narrow continental shelf and is characterized by steep bathymetry<sup>[9]</sup>. It includes many important benthic habitats such as seagrass meadows, reefs, coralligenous concentrations, shallow sublittoral rock, sandy sediments, seamounts, deep-sea coral reefs, and abyssal plains.

**Benthic habitats and communities are likely to be harmed by the foundations of turbines and associated infrastructure (offshore converter station platforms, offshore masts etc.), scour protection, and cable laying and trenching on the seafloor.**

Additional impacts result from anchoring and other physical disturbances of the seafloor, including sediment suspension and the remobilization of nutrients and contaminants, secondary degradation of adjacent habitats, and indirect sedimentation in areas close to construction zones.

In the longer term, heat emission and electromagnetic fields can alter habitats or communities on a local scale.

The magnitude of these impacts depends on the characteristics of the seabed in a given location, ranging from the destruction of sensitive habitats to minor impacts from temporary and localized sediment suspension.

- Estimated footprints depending on wind turbine foundation: Monopile: 1,500-2,100m<sup>2</sup>, Gravity: 800-2,300m<sup>2</sup>, Jacket: 700-1,700m<sup>2</sup> <sup>[26,27]</sup>
- Scour protection may cover the seafloor 20-30m around the turbines. <sup>[28]</sup>
- For floating wind turbines seabed occupation and disturbance are still expected due to the need to stabilize the floating structures
- Temporary seabed occupation by the bases of the legs (spud cans) or anchors from construction vessels can cover an area of up to 575m<sup>2</sup>.
- In the case of cabling, seabed alterations are mainly created by equipment used for cable route preparation and installation. Trenching plough footprints vary from 0.7-3m.

It's difficult to draw a clear distinction between the impacts of fixed and floating OWFs, since most floating turbines are still in the early stages of development (despite their 'floating' tag, floating turbines still need some kind of foundation to keep them at the site). **Site selection, the underlying marine habitat, the technology used and the duration of the build will all affect the overall impact of OWF construction.**

<sup>1</sup> <https://eunis.eea.europa.eu/habitats/1639>

<sup>2</sup> <https://eunis.eea.europa.eu/habitats/5437> and <https://eunis.eea.europa.eu/habitats/423>

<sup>3</sup> [http://sdf.medchm.net/web/mimh/en/index.html?iv\\_3\\_1\\_15.htm](http://sdf.medchm.net/web/mimh/en/index.html?iv_3_1_15.htm)

MARINE HABITAT ZONING	BATHYMETRICAL DISTRIBUTION	FIX	FLO	CG
<b>I. SUPRALITTORAL</b>				
I.2. SANDS - I.2.1. Biocenosis of supralittoral sands	Upper level, rarely submerged			✓
<b>II. MEDIOLITTORAL</b>				
II.1. MUDS, SANDY MUDS AND SANDS-II.1.1. Biocenosis of muddy sands and muds	River level at times of low-water level or minor flooding	✓		✓
II.3. STONES AND PEBBLES -II.3.1. Biocenosis of mediolittoral coarse detritic bottoms	Mid-beach, with phases when it is above water	✓		✓
<b>II.4. HARD BEDS AND ROCKS</b>				
II.4.1. Biocenosis of the upper mediolittoral rocks	Above mid-level, subject to being uncovered by water and submerged			✓
II.4.2. Biocenosis of the lower mediolittoral rock	Middle level, subject to being out of the water and then being submerged			✓
<b>III. INFRALITTORAL</b>				
III.1. SANDY MUDS, SANDS, GRAVELS AND ROCKS IN EURYHALINE AND EURYTHERMAL ENVIRONMENT- III.1.1. Euryhaline and eurytherme biocenosis	0 to several metres	✓		✓
<b>III.2. FINE SANDS WITH MORE OR LESS MUD</b>				
III.2.2. Biocenosis of well sorted fine sands	2 to 25m	✓		✓
III.2.3. Biocenosis of superficial muddy sands in sheltered waters	1-3m	✓		✓
<b>III.3. COARSE SANDS WITH MORE OR LESS MUD</b>				
III.3.1. Biocenosis of coarse sands and fine gravels mixed by the waves	Under 1m			✓
III.3.2. Biocenosis of coarse sands and fine gravels under the influence of bottom currents (also found in the Circalittoral)	3-25m, exceptionally down to 70m	✓	✓	✓
III.5. POSIDONIA OCEANICA MEADOWS - III.5.1. <i>Posidonia oceanica</i> meadows ( <i>Cymodocea nodosa</i> formations can be found in waters down to 10m deep) <sup>1</sup>	0.5 to 40m	✓		✓
III.6. HARDS BEDS AND ROCKS- III.6.1. - Biocenosis of infralittoral algae	From the surface down to 35-40m	✓		✓
<b>IV. CIRCALITTORAL</b>				
IV.2. SANDS - IV.2.2. Biocenosis of the coastal detritic bottom	30-35m to 90-100m	✓	✓	✓
IV.3. HARD BEDS AND ROCKS - IV.3.1. Coralligenous biocenosis	10-90m	✓	✓	✓
Maerl beds (sediment habitats in the sublittoral near shore zone – i.e. covering the infralittoral and circalittoral zones) <sup>2</sup>	Up to 120m deep in the Mediterranean	✓	✓	✓
<b>V. BATHYAL</b>				
V.1. MUDS-V.1.1. Biocenosis of bathyal muds	Below 150-250m down to the lowest depths		✓	
V.3. HARD BEDS AND ROCKS-V.3.1. Biocenosis of deep sea corals	Below 200m		✓	

**TABLE 2.** Habitat typology according to water depth in the Mediterranean Sea<sup>3</sup> and potential overlaps for OWFs with fixed foundations 'FIX' (water depth 0-50m) , floating OWFs 'FLO' (50-200m) and their associated cable grids 'CG'.



HEALTHY *POSIDONIA OCEANICA* IN CÔTE BLEUE MARINE PARK (FRANCE)

© FRÉDÉRIC BACHET-CÔTE BLEUE MARINE PARK

In shallow coastal waters which may be suitable for the development of fixed OWFs, special attention should be given to *Posidonia oceanica* meadows as well as coralligenous reefs: these are priority habitats under Annex I of the EC Habitats Directive due to their endemism, productivity and ecosystem services. *Posidonia* beds are at risk from direct physical destruction and sedimentation changes in hydrographic regimes<sup>[29]</sup> – and it's important to note that they are slow to recover when disturbed.

At depths reaching down to 200m, maerl communities and reefs are habitats which host high biodiversity. OWF impacts on reef habitats are likely to be site-specific, depending on the sensitivity of the benthic communities to construction activities. Other marine habitats likely to be present at OWF sites are the muddy and sandy bottoms which range from the coast to depths of up to 200m.

Cable laying, foundation installation and mooring systems all have an impact on these habitats, including habitat destruction and sediment resuspension causing disturbance to benthic communities. Reef effects from the introduction of hard substrate into the water column may occur (promoting invasive species or enhancing biodiversity), but it is not clear how this will affect natural habitat in surrounding areas.

Cable landing and installation nearshore are likely to have similar impacts for both floating and fixed OWFs. These impacts may be significant in sensitive coastal habitats (estuaries, coastal lagoons, large shallow inlets and bays etc.) as well as in marine habitats with *Posidonia oceanica* meadows, maerl beds, reefs with sensitive benthic communities, or areas hosting important invertebrate species such as *Pinna nobilis*.



## 2.3.

# IMPACTS ON FISH

During construction, the **noise of pile driving may cause hearing loss, severe injuries or mortality among fish in the vicinity of the construction site, as well as changes in behaviour** <sup>[30–32]</sup>. The level of injuries a given noise level may induce is species-specific and varies depending on physiological features and life stages. Alterations in hearing thresholds – either temporary or permanent – may prevent fish from reaching spawning grounds, from communicating acoustically or from searching for food <sup>[32,33]</sup>.

**Bony fish and elasmobranchs (sharks and rays) can be affected during the OWF operational phase, for instance by the noise of the turbines <sup>[34]</sup> or by electromagnetic fields (EMFs) generated by cables transporting energy from the turbines to shore.** EMFs can cause disorientation in electrosensitive species (e.g. tunas) which rely on the Earth's magnetic field for their migration or use electroreception to locate prey.

The potential effects range from very short-term alterations in feeding patterns through to longer-term changes, such as reduced reproductive success or delayed migration due to serious large-scale avoidance of OWF sites <sup>[35]</sup>. The habitat loss for demersal species caused by seabed alteration during construction is regarded as a temporary effect and does not impact on the fish community, at least in soft sediments <sup>[19]</sup>.

**Fish may benefit from OWFs as they provide artificial hard substrate (the 'reef effect')** <sup>[36]</sup>, but this strongly depends on the type of reef created, the native populations, and the location. The effect is spatially limited to 400m around a turbine <sup>[10]</sup>. In addition, a partial or full fishery closure inside an OWF can provide a refuge for fish (the 'reserve effect'). Studies in existing OWFs have so far only demonstrated subtle effects on fish, but it is expected that reserve effects will increase with the size of the wind farms. However, current findings are based on Northern European species which don't necessarily occur in the Mediterranean – e.g. Atlantic cod <sup>[29]</sup> – so it's difficult to make specific predictions for fish in the Mediterranean Sea.



ATLANTIC BLUEFIN TUNA  
(*THUNNUS THYNNUS*) FEEDING  
IN THE MEDITERRANEAN SEA

© FRÉDÉRIC BASSEMAYOUSSE / WWF-MEDITERRANEAN

## 2.4.

# IMPACTS ON BIRDS

Birds can be affected by OWFs in four ways <sup>[37,38]</sup>:

- Collision
- Habitat loss
- Attraction
- Barrier effects

The most significant effects of OWFs on birds appear to be displacement of waterbirds and the collision risk for all birds flying over sea. Night-lighting of turbines may attract birds under bad weather conditions and increase the collision risk, especially for nocturnal migrants.

No direct measurements of bird mortality at OWFs yet exist. Estimated collision risks are often assessed with **collision risk models (CRM)**: these use various site-specific factors such as bird abundance/migration intensities in the vicinity of each OWF, avoidance rates, flight height, bird morphology, speed assumptions etc. According to Bray et al. (2016), high collision levels of migrating terrestrial birds at well-lit observing platforms during periods of bad weather and poor visibility indicate that OWFs located near the Mediterranean coast or prominent migration bottlenecks, such as the eastern or western European-African flyways, may pose a significant risk to migrating birds.

The projected rate, which has been estimated from collision risk models, ranges from a dozen to 1,000 fatalities/year/turbine per OWF in northern Europe.

CRM outcomes: highly dependent on site-specific assumptions

- 8-14 fatalities/year/turbine at Alpha Ventus OWF, Germany <sup>[39]</sup>
- 20 fatalities of nocturnal migrating songbirds/year/turbine at Egmond aan Zee OWF, Netherlands <sup>[40]</sup>
- 100-1,000 fatalities/year/turbine at OWFs in SW Baltic Sea <sup>[41]</sup>

Further equally variable collision mortality estimates are given for 27 seabird and 45 non seabird species under specific assumptions in the *Migratory species collision risk modelling assessments* report conducted for the Scottish government <sup>[42]</sup>.

In the case of barrier effects, even the cumulative effects of several OWFs are unlikely to have a significant negative impact on migrants <sup>[43]</sup>.

However, barrier effects on resident birds having to make regular deviations around a facility located between roosting and feeding sites, or between nesting and feeding sites, might be more significant.

Due to the bathymetry of the Mediterranean and the steep continental slope of most coastlines, deltas provide feasible sites for OWF construction.

**The high densities of seabirds in these regions should represent a key factor in guiding Mediterranean MSP regarding the siting of potential OWFs <sup>[29]</sup>.**



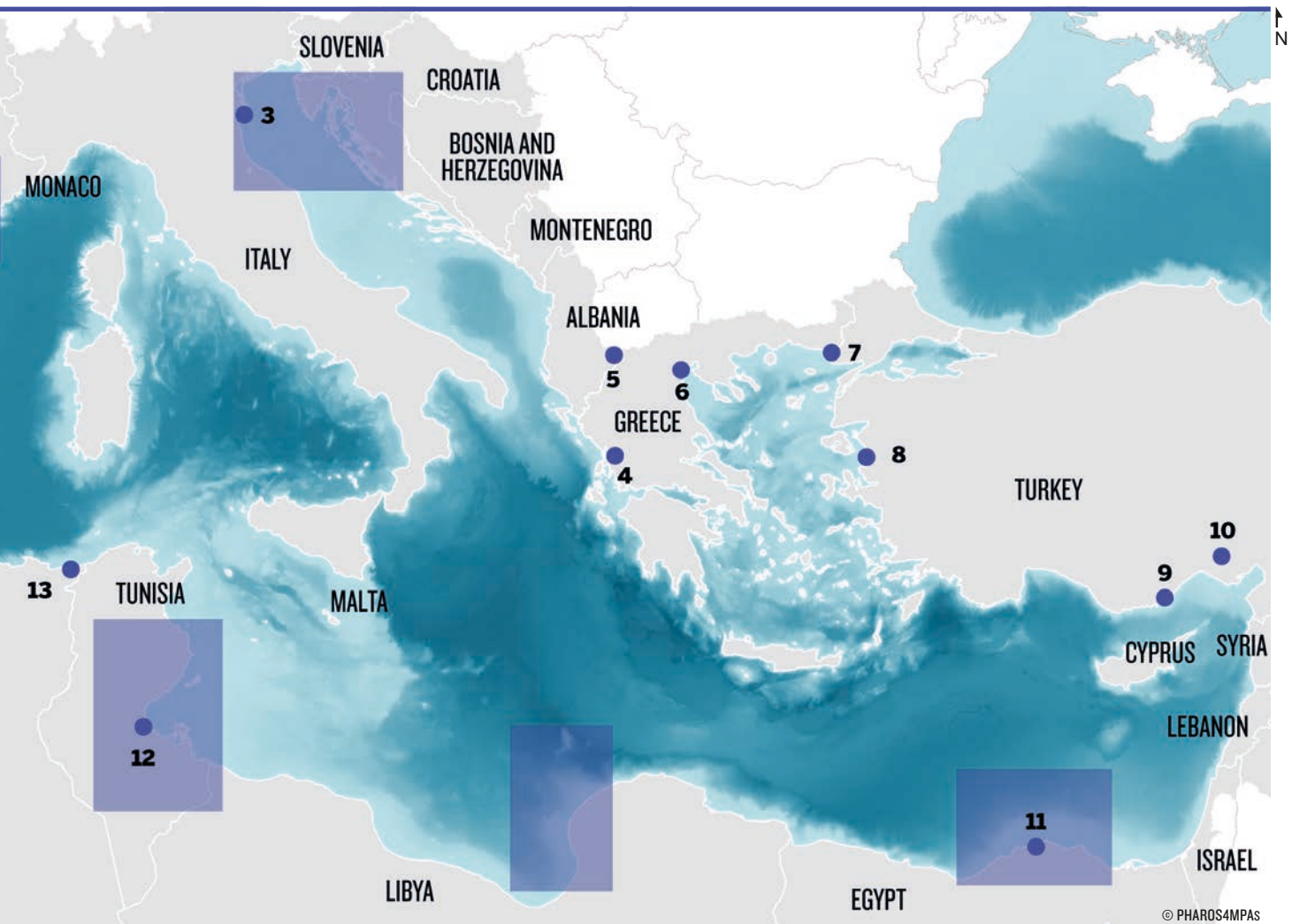
SOURCE: Bray et al. (2016)

**FIGURE 5.** Main Mediterranean wetland areas where birds halt,



**MEDITERRANEAN GULL**  
*(*ICHTHYAETUS MELANOCEPHALUS*)*

© MARIOS MANTZOUROGIANNIS



● **LOCATION OF MAIN MEDITERRANEAN WETLAND AREAS**

**1.** Ebro Delta; **2.** Camargue Delta; **3.** Po Delta; **4.** Amvrakikos Gulf; **5.** Prespa Basin; **6.** Aliakmonas Delta; **7.** Evros Delta; **8.** Gediz Delta; **9.** Göksu Delta; **10.** Seyhan Delta; **11.** Nile Delta; **12.** Gabès Delta; **13.** El Kala.

feed and reproduce and potential overlapping OWF hotspot areas



RED-THROATED DIVER  
(*GAVIA STELLATA*)

© WOLFGANG KRUCK / SHUTTERSTOCK

The potential effects of OWFs on Mediterranean species are likely to be similar to those in other areas and for other species, but the actual magnitude of these effects depends strongly on site-specific parameters like the marine area selected for the OWF, the abundance and composition of avian communities, the wind farm characteristics, availability of suitable alternative habitats nearby, etc.

Studies of seabirds in the North and Baltic Sea, made using vulnerability indices (although not taking into account avoidance behaviours), have provided assessments on 18 marine species that are also present in the Mediterranean. Of these, the black and red-throated divers, the sandwich tern and the great cormorant were identified as the most sensitive within their index, and the black-legged kittiwake and the black-headed gull as the least sensitive. The lesser black-backed gull and the northern gannet were assessed to be most sensitive to collision risk, and both the red and black-necked divers as most susceptible to long-term habitat displacement <sup>[29]</sup>. It's important to note, though, that there is no data at all for many endemic Mediterranean species that were not included in these assessments, such as the Yelkouan shearwater or Audouin's gull, which are however likely to be impacted by the development of the OWF sector.

# 2.5.

## IMPACTS ON MARINE MAMMALS

Marine mammals are exposed to various pressures during the different phases of the OWF lifecycle. Their ecological and life history traits (e.g long lifespan, low reproductive potential, small populations, late maturity) make them vulnerable to anthropogenic impacts.

**The most significant impacts on marine mammals result from underwater noise emitted during the construction process, especially pile driving, and to a lesser degree from increased motorized vessel shipping during the operational phase** <sup>[29]</sup>.

Anthropogenic noise may evoke behavioural reactions and communication alterations, and at high levels it can cause hearing damage <sup>[44]</sup>.

In addition, increased underwater noise levels may cause masking effects. Noise can mask signals such as communication sounds, echolocation, predator/prey sounds and environmental sounds, and may thus possibly impact population level, for example if mating sounds are masked by surrounding noise sources, preventing animals from finding partners to mate with.

**Construction noise impact on marine mammals and other marine fauna can be reduced by choosing foundation types (e.g. gravity-based or floating) that require limited pile driving activity**, if any. Floating turbines may generate underwater sound from their floating platforms moving on the swell and the interlocking chains of their anchoring systems.

### CONSTRUCTION

- During pile driving temporary displacement of 20km (harbour porpoise), 40km (grey seal) and up to 50km (bottlenose dolphin) can occur, lasting up to 4 days after termination of piling works <sup>[17, 45, 46]</sup>
- Longer term effects are limited to a 3km radius
- Temporary threshold shifts (TTS) can occur at distances up to 5km during pile driving without noise mitigation
- Permanent threshold shifts (PTS) are expected at distances of several hundred metres <sup>[46]</sup>
- There are changes in swimming behavior and diving duration during pile driving <sup>[45, 46]</sup>

### OPERATION

- The sound of an operating OWF may be audible to some whale species (e.g. minke whale) to a distance of 18km <sup>[47]</sup>
- Maintenance vessel traffic may disturb whales and other marine mammal species <sup>[48-50]</sup>

The Mediterranean contains some of the world's busiest marine traffic routes, which introduce a high level of background noise. Some of the areas which already have a high density of vessels overlap with potential locations for OWF development, e.g. the Gulf of Lion and North Adriatic Sea <sup>[29]</sup>. The extra noise generated by OWFs and their associated vessel traffic may lead to cumulative noise impacts on marine mammals in these areas.



HARBOUR SEALS NEAR AN  
OWF IN THE THAMES ESTUARY  
NATURA 2000 SITE (ENGLAND)

© LONDON ARRAY OPERATIONAL

## 2.6. IMPACTS ON OTHER ANIMALS

Little is known about the effects of OWFs on other taxonomic groups. Some studies indicate that underwater noise, e.g. from pile driving, may negatively affect cephalopods. Changes in the hydrography around OWFs may also impact on planktonic organisms, which depend on favourable water movements for nutrient/food supply and transport – and hence also the fish which feed on them.

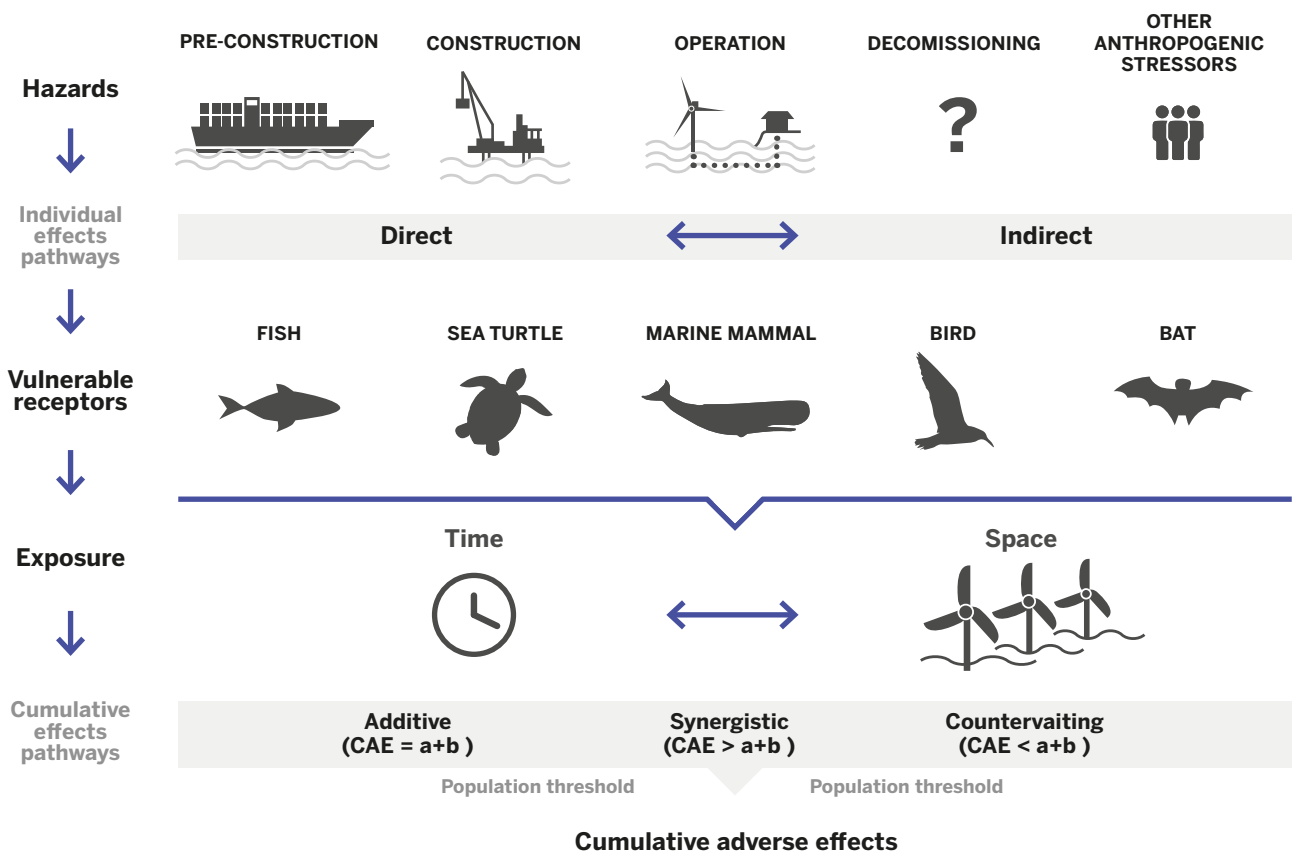
As for other organisms, the newly introduced hard substrate may provide stepping stones for native as well as invasive species to spread across wider areas. Increased vessel traffic during all phases of development may lead to higher rates of sea turtle/boat collisions. Although light is known to affect sea turtle behaviour, how sea turtles will respond to illuminated construction vessels, turbines and related infrastructure is poorly studied. As bats are present in some offshore areas collision mortality during OWF operation may be possible, mainly during seasonal migration times.

## 2.7. CUMULATIVE EFFECTS

While the effects of one wind farm on a particular wildlife population may be negligible, it is feared that the aggregate effects of multiple wind farms through space and time cause wildlife population declines <sup>[11]</sup>, while also adding to the pressures generated by other maritime sectors.

Cumulative effects are an important concern in terms of marine habitat fragmentation and degradation. For instance, although cable laying only needs relatively narrow trenches, multiple OWFs are likely to result in numerous trenches in the seabed, making for a significant overall footprint. MSP processes should recognize such cumulative effects, and they should be assessed under the SEA procedure.

More understanding of the cumulative effects of all impacts is needed at all potential development sites. Until then, all OWF MSP in the Mediterranean should take a precautionary approach.



**FIGURE 6.** Cumulative adverse effects of offshore wind energy development on wildlife<sup>[52]</sup>

### CONCLUDING REMARKS:

While environmental assessments for individual OWFs may evaluate their impacts as 'low', the cumulative impacts of OWF development can be substantial and must be considered. Strategic impact assessments (SEA) are crucial for addressing the implications of OWF development on a broader scale, and should make ecological considerations a priority. In addition, they should involve all stakeholders from the beginning of the planning process to agree the most effective solutions, for example choosing a foundation type based on habitat conditions, siting the OWF in an area that is already closed for fisheries etc. Thorough baseline studies and species and habitat sensitivity mapping should be conducted to reveal if a specific area is suitable for the development of OWFs.

### KEY FACTS

High densities of seabirds should be a key factor in guiding Mediterranean MSP for siting potential OWFs<sup>[29]</sup>

For birds, the largest OWF impacts appear to be that they displace waterbirds and pose a collision risk for all birds flying over sea

The most significant impacts on marine mammals result from underwater noise emitted during construction

While the effects of one wind farm on a particular wildlife population may be negligible, it's feared that the cumulative effects of multiple OWFs through space and time will cause wildlife population declines<sup>[10]</sup>.







**PART THREE**  
**TECHNICAL  
RECOMMENDATIONS  
AND BEST  
AVAILABLE  
REGULATIONS**

DURING PILE-DRIVING OPERATIONS FOR THE CONSTRUCTION OF AN OWF, VAN OORD USES A BIG BUBBLE SYSTEM TO REDUCE UNDERWATER NOISE

© VAN OORD

# 3.1.

## AVOIDANCE AND MITIGATION MEASURES

This section reviews the technical recommendations and regulations which are most useful for avoiding or mitigating the environmental impacts of OWF development. Most important of all, MSP authorities, MPA managers and the OWF industry need to work together to establish common ground and collaborate to put effective measures in place.

An overview of these technical solutions is included in the table below, and they are briefly discussed in the following sections of this chapter. The solutions are presented in more detail in the PHAROS4MPAs OWF capitalization baseline document<sup>[1]</sup>.



**HABITATS/  
BENTHIC COMMUNITIES**



**FISH**



**MARINE MAMMALS**



**BIRDS**



**BATS**



**SEA TURTLES**

**ALL GROUPS**

**TABLE 3.** Pressures and resulting impacts of OWF development on taxonomic groups/habitats, and suggested avoidance/mitigation measures.

PRESSURE/IMPACT	AVOIDANCE/MITIGATION
Habitat loss from cable laying	<ul style="list-style-type: none"> <li>• Select most appropriate routes for cable trenches</li> <li>• Lay shortest possible length of cables</li> <li>• Bundle with existing cables</li> <li>• Minimize number of structures needed for cable crossing points</li> <li>• Allocate only minimum areas necessary for construction activities</li> <li>• Plan and share grid connections between several OWFs</li> </ul>
Physical damage, disturbance from cable laying	<ul style="list-style-type: none"> <li>• Use methods which minimize turbidity and sediment suspension (when buried cable : jetting / ploughing /horizontal drilling; when laid cable: seabed laying, rock dumping with on-site material, frond mattresses())</li> </ul>
Habitat loss from foundations	<ul style="list-style-type: none"> <li>• Select appropriate sites through MSP and EIA with detailed delineation of habitat/sensitive species distribution</li> </ul>
Physical damage, disturbance from foundations	<ul style="list-style-type: none"> <li>• Allocate only minimum areas necessary for construction activities</li> </ul>
Reef effect from submerged structures	<ul style="list-style-type: none"> <li>• None</li> </ul>
Displacement/disorientation due to electromagnetic fields and heat from underwater operating cables	<ul style="list-style-type: none"> <li>• Bury/shield cables</li> </ul>
Physical damage, disturbance from piling noise	<ul style="list-style-type: none"> <li>• Use noise mitigation techniques – modified hydraulic piling hammers, bubble curtain types, soft starts, casings, cofferdams</li> </ul>
Displacement/disorientation due to electromagnetic fields from underwater operating cables	<ul style="list-style-type: none"> <li>• Bury/shield cables</li> </ul>
Reef effect from submerged structures	<ul style="list-style-type: none"> <li>• None</li> </ul>
Habitat loss from foundations	<ul style="list-style-type: none"> <li>• Select appropriate sites through MSP</li> <li>• Allocate only minimum areas necessary for construction activities</li> </ul>
Physical damage, disturbance from piling noise	<ul style="list-style-type: none"> <li>• Use noise mitigation techniques – modified hydraulic piling hammers, bubble curtain types, soft starts, casings, cofferdams</li> <li>• Establish and take into account threshold values</li> <li>• Use deterrence devices</li> </ul>
Collision with vessel traffic	<ul style="list-style-type: none"> <li>• Speed regulations</li> </ul>
Displacement from vessel traffic – noise/presence	<ul style="list-style-type: none"> <li>• Routing regulations</li> </ul>
Displacement from vessel traffic	<ul style="list-style-type: none"> <li>• Routing regulations</li> </ul>
Increased collision due to artificial light	<ul style="list-style-type: none"> <li>• Avoid lighting where possible</li> <li>• Install lighting-on-demand with radars</li> <li>• Use deflectors</li> </ul>
Collision with operating wind turbines	<ul style="list-style-type: none"> <li>• Develop sensitivity maps and select appropriate sites through MSP</li> <li>• Temporary complete/partial shutdown</li> <li>• Increase turbine visibility</li> <li>• Use deterrents</li> </ul>
Barrier effect from operating wind turbines	<ul style="list-style-type: none"> <li>• Develop sensitivity maps and select appropriate sites through MSP</li> </ul>
Collision with operating wind turbines	<ul style="list-style-type: none"> <li>• None</li> </ul>
Collision with vessel traffic	<ul style="list-style-type: none"> <li>• Speed and routing regulations</li> </ul>
Physical damage, disturbance from piling noise	<ul style="list-style-type: none"> <li>• Use noise mitigation techniques – modified hydraulic piling hammers, bubble curtain types, soft starts, casings, cofferdams</li> </ul>
Disorientation due to artificial light	<ul style="list-style-type: none"> <li>• Avoid lighting where possible</li> <li>• Install lighting-on-demand with radars</li> <li>• Use deflectors</li> </ul>
Disorientation due to electromagnetic fields from underwater operating cables	<ul style="list-style-type: none"> <li>• Bury/shield cables</li> </ul>
Habitat degradation, disturbance, physical damage from pollution and sacrificial anodes	<ul style="list-style-type: none"> <li>• Consider alternative corrosion protection and alternative paints</li> <li>• Follow appropriate disposal protocols</li> </ul>

# 3.1.1.

## MITIGATION OF NOISE

### MITIGATION REGULATIONS

Mitigation regulations differ between countries depending on the species present and the approach taken to noise levels by national authorities. For EU countries the need to regulate underwater noise from OWF construction is clear under the requirements of Article 12 of the Habitats Directive, which prohibits the killing and significant disturbance of strictly protected species. Projects involving pile driving require a noise prognosis as part of their Environmental Impact Assessments (EIA), and the inclusion of appropriate mitigation measures.

In Germany, the Ministry of the Environment sets a maximum noise level equal to the threshold for reversible hearing damage (temporary threshold shift, TTS) of the most sensitive species in German waters, the harbour porpoise. This equates to 160dB at a distance of 750m – as all OWF projects using steel foundations exceed this value, active noise mitigation has become a standard in German projects.

#### MITIGATION TECHNIQUES:

- Choose a suitable time and location to avoid migration/spawning periods and nursery/ breeding areas
- Employ marine mammal observers (MMOs) and deterrence devices to prevent the abundance of animals in noise-impacted areas. Passive acoustic monitoring along with aerial and ship-based surveys can be used to detect their numbers before, during and after construction
- Use special low-noise construction processes (soft-start/ramp-up etc)
- Consider technical solutions to reduce piling energy: new techniques under development include vibratory piling (if grounds permit) and blue piling (a combustions-accelerated water body provides the energy)
- Use alternative foundation types (e.g. suction buckets, floating foundations and gravity basements)
- Reduce piling noise, e.g. by bubble curtains, noise mitigation screens (NMS) or a combination.

As active noise reduction has proved to be efficient and technical feasible<sup>[53,54]</sup>, it is increasingly seen as the optimum method for noise mitigation. If environmental conditions hinder adequate noise reduction, other mitigation techniques – e.g. surveillance and deterrence – may be preferable. As MMOs require daylight and calm weather conditions, passive acoustic monitoring (PAM) is the most suitable surveillance method for marine mammals.

#### NOISE REDUCTION: BUBBLE CURTAIN

- Layer of air bubbles over the full height of the water column
- Compressed air is pumped through a perforated hose
- Pre- or post-layed around the construction site
- Bubble curtains need their own vessel
- Performance depends on water depth, current, deployment and maintenance
- Hydro-acoustic forecasts and modelling allow assessment of expected noise levels, thus highlight reductions needed to meet threshold values.

#### CHALLENGES IN THE MEDITERRANEAN

- Feasibility in depth >40 m unclear
- Reduced efficiency due to elevated pressure
- Further research required: tested only for hearing thresholds of harbour porpoise

Sources of continuous noise – e.g. vessel noise – are more difficult to control and minimize, especially during the construction process. Special shipping lanes (e.g. at a fixed distance from Natura 2000 areas and other sensitive sites) and mooring buoys where vessels wait can concentrate the noise in smaller areas and thus reduce its impact. Lower speeds and the use of quieter modern vessels can also reduce ship noise.

## FURTHER RESEARCH/ADJUSTMENT TO MEDITERRANEAN

The mitigation methods described above have been evaluated in R&D projects and tested in harsh offshore environments. The deterrence measures mentioned

have been evaluated for harbour porpoises, dolphins and seals, but they might well work on all cetaceans sensitive to high frequencies. The specific physiology, lifecycle, behavioural features and habitat requirements of Mediterranean species (fish, marine mammals, sea turtles) must be considered in choosing sites and construction methods with the least negative impacts.



LARGE BUBBLE CURTAIN

© TRIANEL GMBH-LANG

## 3.1.2. MITIGATION OF LIGHT

OWFs introduce many new light sources into the marine environment. **Turbine lighting should be limited to what is needed for operations and what is required legally.**

Light emissions from OWFs are a potential threat to migratory birds and other wildlife (e.g. fish, sea turtles), and may also be a nuisance for coastal communities. There are various opinions on how best to deal with this issue, but everyone agrees turbine lights should be reduced as much as possible<sup>[55]</sup>.

### MITIGATION REGULATIONS

OWF turbines are equipped with red lights on top for aviation and white lights lower down for shipping. **They should be set to flash with the minimum intensity and frequency permissible under relevant national regulations<sup>[56]</sup>.** OWF lighting usually follows recommendations drafted by the International Association of Lighthouse Authorities (IALA): so far, there are few national regulations in existence which limit night lighting.

The US Bureau of Ocean Energy Management drafted the following recommendations<sup>[57]</sup>:

1. Fewer lights are preferable to more lights
2. Lower intensity lights are preferable to higher intensity lights
3. White lights are the least favourable choice for lighting structures
4. Strobing lights are preferable to steady lights.

**In Germany, 'light on demand' aviation lights on the top of turbines have become mandatory for any proposed OWFs in coastal waters.** Denmark is preparing to change OWF lighting regulations in a similar way. 'Light on demand' means there are no red or white lights permanently turned on for aviation safety; but a sensor (either radar or transponder system) detects approaching air traffic and turns the lights on when needed. As there is no regular air traffic at night in the vicinity of OWFs it is expected that night-lighting can be reduced substantially – this solution should in the future also be evaluated for vessel traffic.



### MITIGATION TECHNIQUES:

- **'Light on demand'** should be given priority as a mitigation technique for all OWFs<sup>[58]</sup>, both for aviation and possibly vessel navigation lighting.
- **Light colour, intensity and frequency:** Low-frequency red lights (as well as green and blue lights) seem to attract fewer birds than normal white or red lights. Lights with low frequency and short wavelength radiation are thought to decrease collision risk. Use flashing lights instead of steady lights and keep the luminescent phases as short as possible, the dark phases as long as possible<sup>[59]</sup>.
- **Light emission** can be further minimized for example by not illuminating large areas, or by using inverse LED plates/letters/numbers and other distinctive recognition elements. The radiation angle should be kept as small as possible, upwards radiation should be avoided, and indirect radiation should be preferred over direct radiation<sup>[59]</sup>. Deflectors are recommended: traditionally lit markings may potentially be replaceable by self-reflective imprints<sup>[60]</sup>.



## FURTHER RESEARCH

Despite a wealth of research on the effects of artificial night lighting in the marine environment, current knowledge on the effects of OWF lighting is still limited owing to the inherent difficulties in studying bird attraction, avoidance and collision risk. Consequently, the effects of mitigation measures can so far only be predicted: there is little evidence for exactly how beneficial such measures might be for birds and other marine wildlife. Further research on this aspect of the subject is needed.

### 3.1.3. AVOIDANCE AND MITIGATION OF HABITAT LOSS

Direct habitat loss from OWF structures such as turbine foundations covers a relatively small proportion of an overall wind farm area: however, in light of the increasing numbers of OWFs a general mitigation strategy is needed, especially in relation to protected habitats.

## AVOIDANCE AND MITIGATION REGULATIONS

All OWF projects should aim to avoid – or where this is impossible, minimize – impacts on Marine Protected Areas and other ecologically important areas hosting protected habitat types included in Annex I and protected species included in Annexes II and IV of the EU Habitats Directive 92/43/EEC. The SEA and EIA procedures, and the appropriate assessments of projects affecting Natura 2000 sites under Article 6 of Habitats Directive, should ensure that the conservation status of protected species and habitats will not be degraded and conservation targets will be maintained.

### AVOIDANCE AND MITIGATION TECHNIQUES:

- Careful MSP should be used to select appropriate sites for OWF installation as well as the most appropriate routes for cable laying in order to limit impacts on habitats and benthic communities. This requires good data collection to reduce the uncertainties (mapping of species distribution ranges, spatial and temporal use, etc) and the mapping of species and habitat sensitivity to OWFs.
- Where sensitive or protected habitats are present, detailed delineation of their distribution and of the seabed in general is needed, so individual wind turbines can be sited to avoid them. This can also help identify the most appropriate cable routes and other micro-scale planning adjustments.
- It is important to minimize areas needed for OWF construction and operation, either individually or from clusters of projects, due to their cumulative impacts. For example, use the shortest possible area for laying cables, bundle new cables with existing cables, and minimize the number of crossings with other cables to avoid the need for more structures<sup>[61]</sup>.
- Construction zones should be minimized and activities should stay within them. Effort should be made to avoid or minimize the resuspension of sediment and turbidity plumes. How and at what depth cables are buried is also important: appropriate techniques will depend on the type of substrate.

- OSPAR guidelines recommend jetting or ploughing for cable burying. In sensitive habitats (e.g. salt marshes) horizontal drilling could prove to be the least environmentally damaging method, but the timing of the drilling has to be considered – breeding seasons etc should be avoided.
- If solid rock is present on cable routes and cannot be avoided, horizontal directional drilling may be the most suitable protection method – blasting through the rock would have significant environmental impacts. Further offshore, a rock ripping plough, rock wheel cutter or vibratory share plough may be the best option<sup>[62]</sup>.

## FURTHER RESEARCH

As habitat composition and benthic communities are site-specific, each proposed OWF site needs research and evaluation. There is a knowledge gap over the removal of foundations during decommissioning. Foundation reef effects and the composition of the new hard substrate communities should be evaluated prior to seabed restoration.

## 3.1.4. AVOIDANCE AND MITIGATION OF BIRD COLLISIONS

### MITIGATION REGULATIONS

Liechti et al.<sup>[63]</sup> discuss the application of a wind turbine shut-down regime via thresholds based on bird migration intensity.

The shut-down of turbines in future OWFs in the Netherlands is explicitly written into the license for a specific wind farm area (in Dutch: Kavelbesluiten). For example, in the Kavelbesluit of Borssele I the current cut-off point is 500 birds/km/hr: above this, turbines need to be shut down.

In Germany, a threshold based shut-down regime is being tested in a near-shore wind farm in the North Sea; and the approach may be rolled out in future projects in the Baltic Sea. However, there is currently no generally agreed best approach for curtailing OWF operations to reduce the collision risk for birds.



FOOT END OF AN OWF STRUCTURE WHICH IS RAMMED INTO THE SEABED DURING CONSTRUCTION

© DOTI / MATTHIAS IBELER





BARROW OWF, EIGHT MILES NORTH OF WALNEY ISLAND, ENGLAND

© HARVEY DOGSON

## MITIGATION TECHNIQUES:

- MSP can to an extent reduce the impacts of OWFs on migrating birds and bats by selecting sites outside areas of special importance to either group. Collision risk for seabirds can also be reduced by ensuring OWFs are sited at a distance from breeding colonies.
- For operating OWFs, temporary shutdown during mass migration events (especially in bad weather or poor visibility) has often been recommended as collision risk mitigation measure. Whenever a dangerous situation occurs – e.g. birds flying in a high collision risk area or within a safety perimeter – the turbines presenting the greatest risk should stop spinning. This strategy can operate year-round or be limited to a specific period. For example, wind turbines on migratory routes could be shut down on nights of poor weather to protect nocturnal bird migration<sup>[64]</sup>. However, detecting birds at risk requires a real-time surveillance programme and significant resources. Although various OWF monitoring systems have been developed (overview in<sup>[65]</sup>), there is no single convincing solution yet at hand.
- For onshore wind farms, a growing number of technical systems which aim to curtail wind turbines when birds approach a risk zone<sup>[e.g. 66]</sup> are applied in various countries. The efficiency of such systems has not yet been thoroughly tested and is thus uncertain, as are the costs involved. However, overall progress is promising, and in future such collision avoidance systems may also be used in OWFs.

- The efficacy of other approaches, such as increasing turbine visibility, has not yet been demonstrated in the field. Various attempts to increase blade visibility have been made by using patterns and colors that are conspicuous to birds (e.g. square-wave black-and-white bands across the blade<sup>[67]</sup>; single black blade paired with two white blades<sup>[68]</sup>, ultraviolet-reflective paint<sup>[64 and references therein]</sup>).
- Deterrent devices scare birds away from a specific area. However, there is no empirical proof of the effectiveness of deterrents when it comes to wind turbines. Deterrents can be activated by automated real-time surveillance systems as an initial mitigation step prior to blade curtailment<sup>[69,70]</sup>. Although test results are only preliminary, it appears deterrent devices may have an unpredictable effect on the flight path of a bird, so caution is needed if they are used at a short distance from a turbine or within an OWF. Nevertheless, this measure may divert birds from flying straight at a wind turbine<sup>[64]</sup>.

## FURTHER RESEARCH

Control and surveillance systems might in future become beneficial for not only reducing collision risk but also in monitoring at-risk species and the efficiency of other mitigation techniques such as 'light on demand' (see above). More investment in research and development for real-time monitoring of birds within OWFs is required.

## 3.1.5. MITIGATION OF COLLISION WITH VESSELS

Collisions with vessels are mainly a risk to marine mammals and sea turtles. In areas where this risk is elevated, reduced speeds (particularly for fast vessels) and defined ship lanes can be effective mitigation measures. Vaes et al.<sup>[71]</sup> suggest a 10 knots maximum speed for Mediterranean areas with high marine mammal abundance; and 2 knots in the case of sea turtles<sup>[72]</sup>.

## 3.1.6. MITIGATION OF WASTE

### MITIGATION REGULATIONS

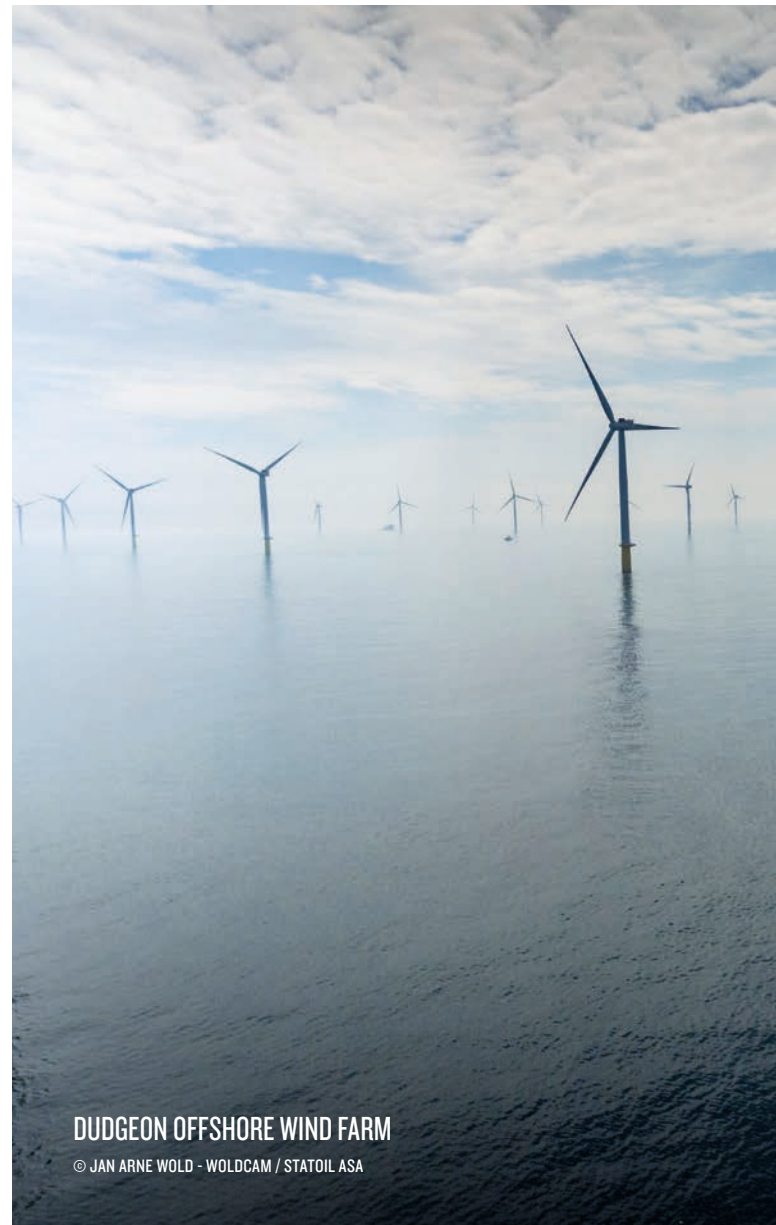
Marine waste and contamination is a growing global problem. OWFs should have a waste management strategy to guarantee zero emissions of micro- or macroscopic waste, as well as any contamination with pollutants. Where waste cannot be avoided it should be taken back to shore and properly recycled or disposed of<sup>[73]</sup>.

#### MITIGATION TECHNIQUES

To avoid the use of sacrificial anodes for corrosion protection – and the associated release of (heavy) metals in the water – alternative methods for corrosion control have been suggested or are already in use (e.g. at Trianel Windpark Borkum in the German North Sea). One of these alternatives is the impressed current cathodic protection (ICCP) system, which consists of titan-anodes with a mixed metal oxide coating that gives an estimated lifespan of more than 25 years. Their release of metals is relatively low compared to the use of sacrificial anodes. However, ICCP is a source of electromagnetic fields, and thus has potential impacts on marine biota.

## FURTHER RESEARCH/ADJUSTMENT TO MEDITERRANEAN

More investigation is needed of the impacts on the marine environment of chemicals used in paints and corrosion protection, and the use of alternatives should be considered. The EU publishes assessment reports for some chemicals (e.g. Bisphenol A, used in certain coatings) which include risk characterizations for the marine environment<sup>[74]</sup>. Further studies are needed to investigate the electromagnetic fields generated by ICCP systems and their potential disturbance of marine animals.



DUDGEON OFFSHORE WIND FARM

© JAN ARNE WOLD - WOLDCAM / STATOIL ASA

## 3.1.7. MITIGATION OF ELECTROMAGNETIC FIELDS AND TEMPERATURE



### MITIGATION REGULATIONS

Cables interconnecting turbines and transferring the energy generated to the shore emit heat and produce a surrounding electromagnetic field. **Burying the cables in the sea floor significantly reduces electromagnetic fields but increases seabed temperatures.**

Regulations concerning burial depth are country-specific and area-dependent. In Germany, for example, the minimum depth ranges from 0.6m within a wind farm to 3m in areas with high traffic<sup>[61]</sup>. Furthermore, in order to limit the heat emitted by the cables, the so called '2K-criterion' is a condition to all projects: this states that the increase in temperature must not exceed 2K in the upper 20cm of the seabed. In the UK a minimum depth of 1.5m is recommended to minimize impacts above the seafloor and in the most active biological upper layer, and to increase the distance between the cables and electromagnetically sensitive marine species<sup>[75]</sup>.

#### AVOIDANCE AND MITIGATION TECHNIQUES:

- Thoroughly plan cable routes and laying techniques to avoid/mitigate impacts on sensitive habitats
- Bundle cables to reduce area impacted by heat and EMFs<sup>[61]</sup>
- Bury cables to decrease EMFs above the seabed – appropriate burial depth varies with seabed properties<sup>[e.g. 75, 76]</sup>

#### Challenges in the Mediterranean

- Substrate conditions might not allow cable burial for cable protection and reduction of EMFs: coverage of cables with rocky material may be the most suitable option in many areas<sup>[76]</sup>
- Favour onsite rocky material or concrete to reduce the risk of introducing invasive species<sup>[77]</sup>

# 3.2.

## MONITORING AND SCIENTIFIC RESEARCH

Monitoring of species and habitats which may be affected by OWF developments is crucial to provide a scientific basis for (future) decision-making, both at the strategic and the project level. Developing monitoring programmes has to be included in the planning of the OWF, or as part of MSP. Fortunately, in comparison to other industries, offshore wind farming appears to be well studied in marine conservation terms.

### TRANSFERABILITY TO THE MEDITERRANEAN SEA

OWF monitoring concepts have thus far been based on experiences in the North Sea and the Baltic Sea, so they cannot necessarily be directly applied to Mediterranean projects.

Broad-scale research programmes are crucial for determining OWFs' potential environmental impacts, and to identify the most appropriate monitoring methods (either using existing guidelines or developing additional ones). Since the development of turbines with floating foundations has recently been gaining increased attention, new monitoring and research programmes should be established to investigate the technique further.

#### MONITORING APPROACH AND DURATION

**The 'before after control impact' (BACI) approach is often considered as a useful method to assess OWF impacts.** Effective monitoring covers timeframes before, during and after construction. German experiences <sup>[78]</sup> suggests that around eight years of data – comprising the pre-construction phase (three years), the construction phase (two years or more) and operational phase (three years) – is needed to build a strong database to show effects of the OWF, e.g. a potential change in distribution and numbers of species and individuals. Monitoring requirements during decommissioning correspond to those in the construction phase. Possible environmental impacts depend mainly on the dismantling techniques used. Clear definition of impact and reference areas (e.g. for habitats) is a prerequisite for effective monitoring.

# MONITORING CONCEPTS

---

## ABIOTIC ENVIRONMENT



- Monitoring of several abiotic factors (e.g. grain size distribution, temperature, oxygen levels)
  - Developing monitoring strategies for chemical emissions
  - Monitoring of heavy metals and other chemical pollutants in the water column and in sediments
- 

## HABITATS / BENTHIC COMMUNITIES



- Investigation of the sediment and habitat structure and their dynamics
  - Video survey of epifauna, macrophytes and habitat structure
  - Grab sampling survey of infauna, beam trawl survey of epifauna
  - Investigation of growth and demersal megafauna on the underwater construction structure, of benthos and habitat structures for installation of cable routes
- 

## FISH



- Trawl surveys
  - Use of existing sampling and survey data
  - Non-invasive methods (e.g. hydroacoustic methods, scuba diving surveys in shallow waters)
- 

## BIRDS



- Ship-based and (digital) aircraft-based surveys (video/photo) along transects
  - Use of radars for long-term monitoring data on seabird behaviour around OWFs and to monitor migration intensity, flight direction and flight altitude
- 

## MARINE MAMMALS



- Passive acoustic monitoring from temporary and permanent monitoring-stations
  - (Digital) aircraft-based surveys
- 

## SEA TURTLES



- Monitoring through ship surveys or (digital) aircraft-based surveys
  - Satellite or acoustic tracking of tagged animals
- 

**TABLE 4.** OWF monitoring approaches (monitoring techniques are presented in more detail in the PHAROS4MPAs capitalization baseline document available on OWF<sup>[1]</sup>)



TRIPODS BEING TRANSPORTED  
TO AN OWF CONSTRUCTION SITE

© STIFTUNG OFFSHORE-WINDENERGIE / JAN OELKER 2008

An aerial photograph of a harbor area. In the foreground, a red and white tugboat named 'BUGSIER 8' is moving through the water. In the background, a large crane with a blue and orange striped boom is positioned on a barge. The harbor is surrounded by buildings and greenery. A blue semi-transparent banner is overlaid on the right side of the image, containing white text.

## **PART FOUR**

# RECOMMENDATIONS ON INTERACTIONS BETWEEN OFFSHORE WIND FARMS AND MARINE PROTECTED AREAS

At a time when demand for renewable energy is growing as the need for marine conservation increases, it is crucial to address the issue of the interactions between the OWF sector and MPAs.

The following recommendations are based on case studies and lessons learned from pioneer countries, and are intended for key stakeholders involved in decision-making processes:

- Public authorities
- MPA managers
- OWF industry

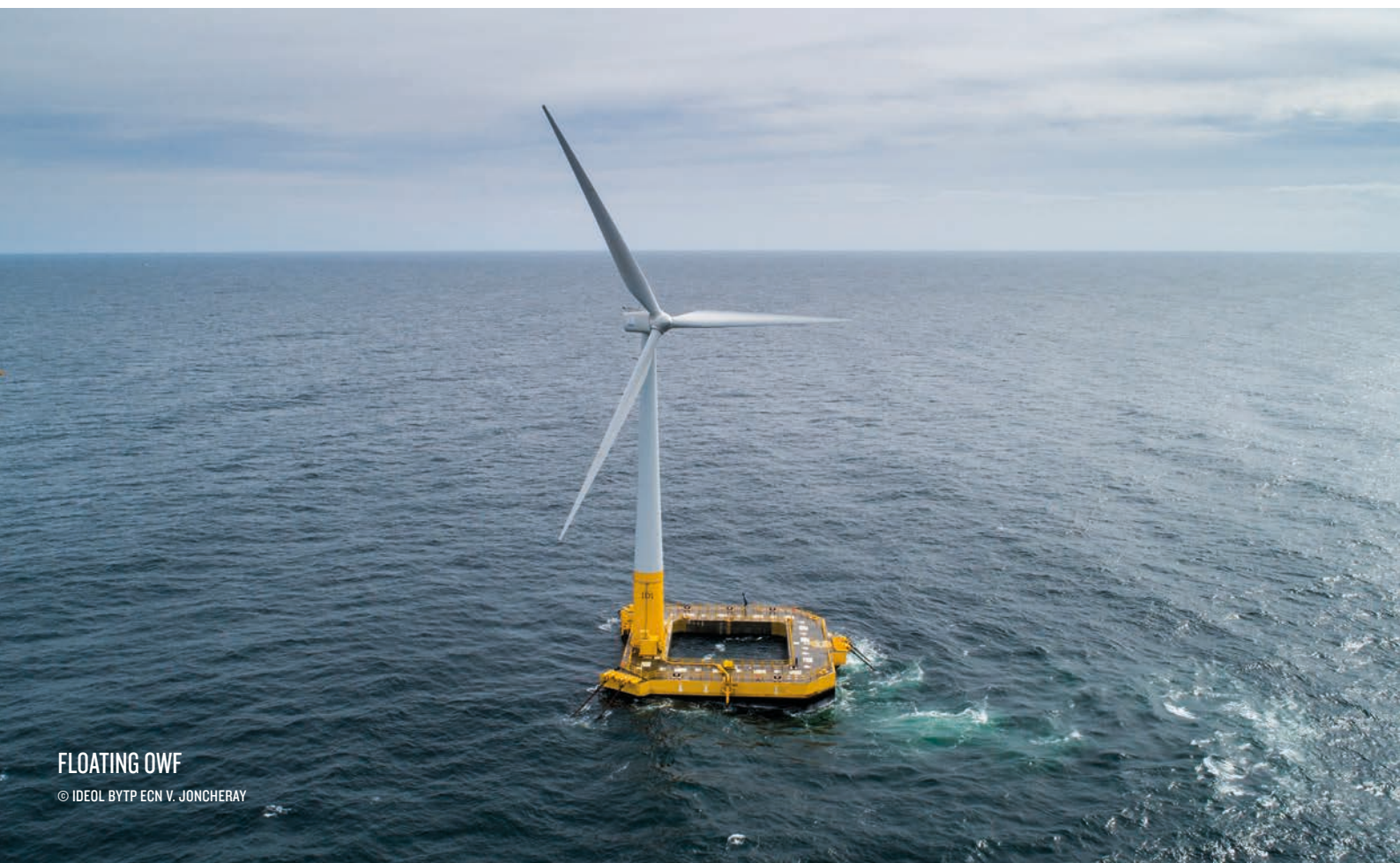
## MPAS IN THE MEDITERRANEAN SEA

The Mediterranean Sea is a sensitive marine basin with high levels of biodiversity and many ecologically important areas. Within it, anthropogenic activities such as transport, tourism and fisheries have potential negative impacts on marine wildlife and ecosystems. Nature protection in the region needs to be considerably strengthened.

Designating MPAs is an important tool for protecting marine habitats and biodiversity. Nevertheless, the term 'marine protected area' does not have a standard definition: MPAs differ in their conservation targets (e.g. specific animals or habitat types) and their sustainable development goals, and can be designated under national, regional or international frameworks and legislations (Figure 8). This means there is no single generic protection status for the areas designated as MPAs in the Mediterranean Sea. In total there are almost 50 different names for MPAs or other effective area-based conservation measures (OECMs), and they offer a range of different levels of protection. Figure 8 illustrates the development of MPAs in the Mediterranean Sea since the 1950s.

About 7% of the total marine area of the Mediterranean Sea (including both EU and non-EU countries) is protected under different legislative frameworks (Figure 8).

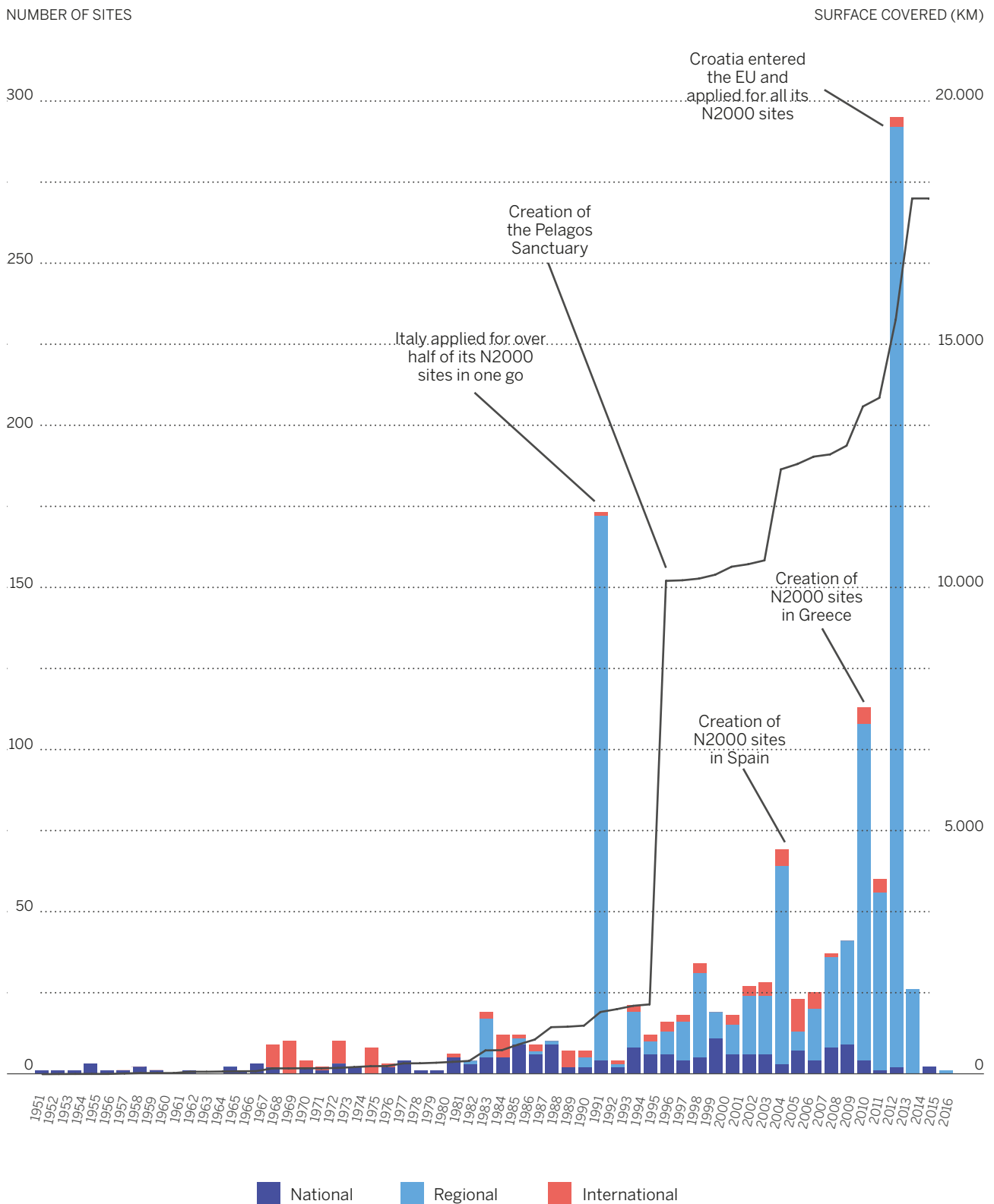
<sup>4</sup> National park, natural reserve, marine park etc



FLOATING OWF

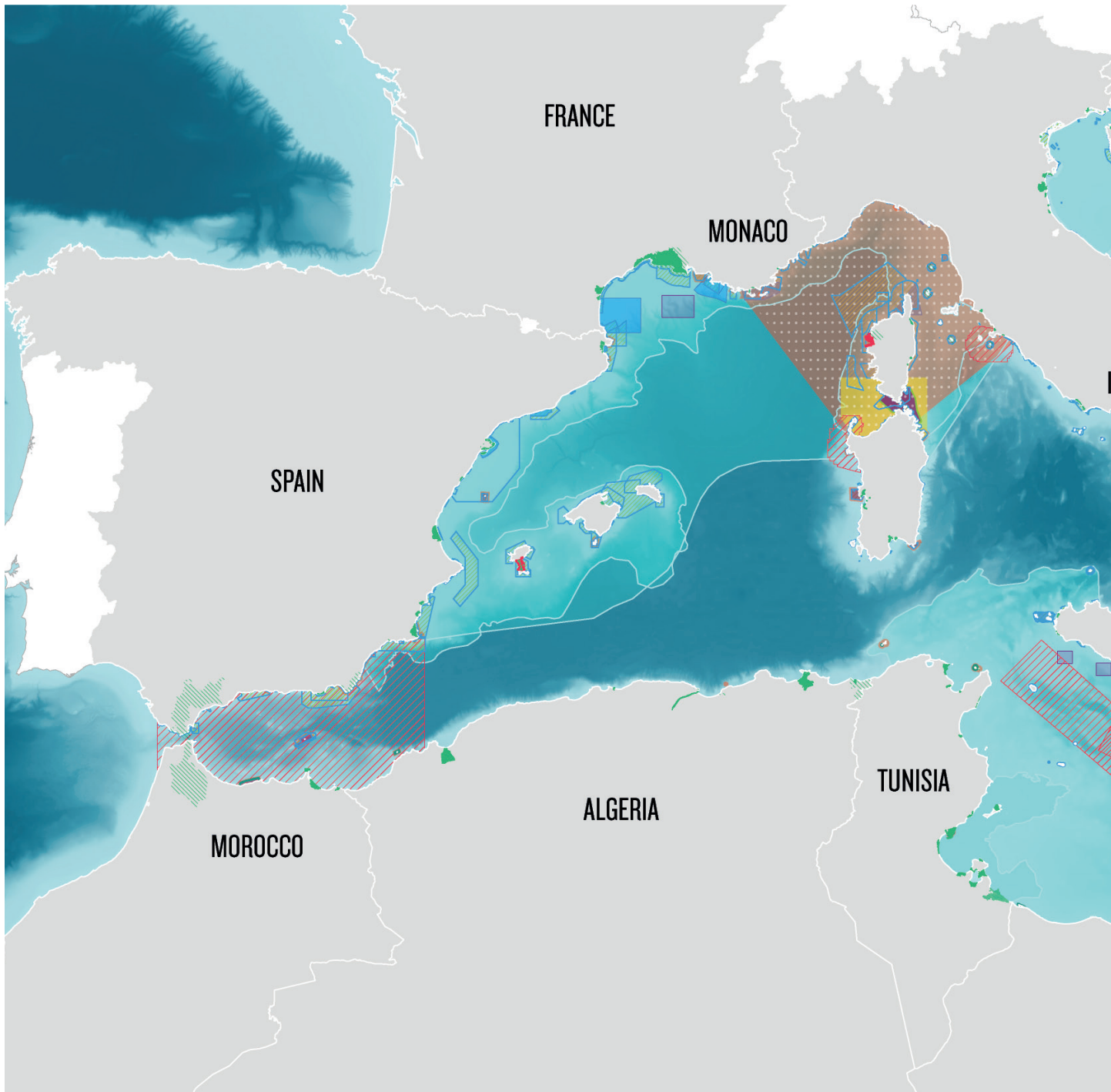
© IDEOL BYTP ECN V. JONCHERAY





**FIGURE 7.** Development of MPAs in the Mediterranean Sea since the 1950s. Bars show the number of newly designated MPAs per year. The black line indicates the cumulative surface of protected area.

SOURCE: MEDPAN & UN ENVIRONMENT/MAP-SPA/RAC, 2016<sup>[2]</sup>.

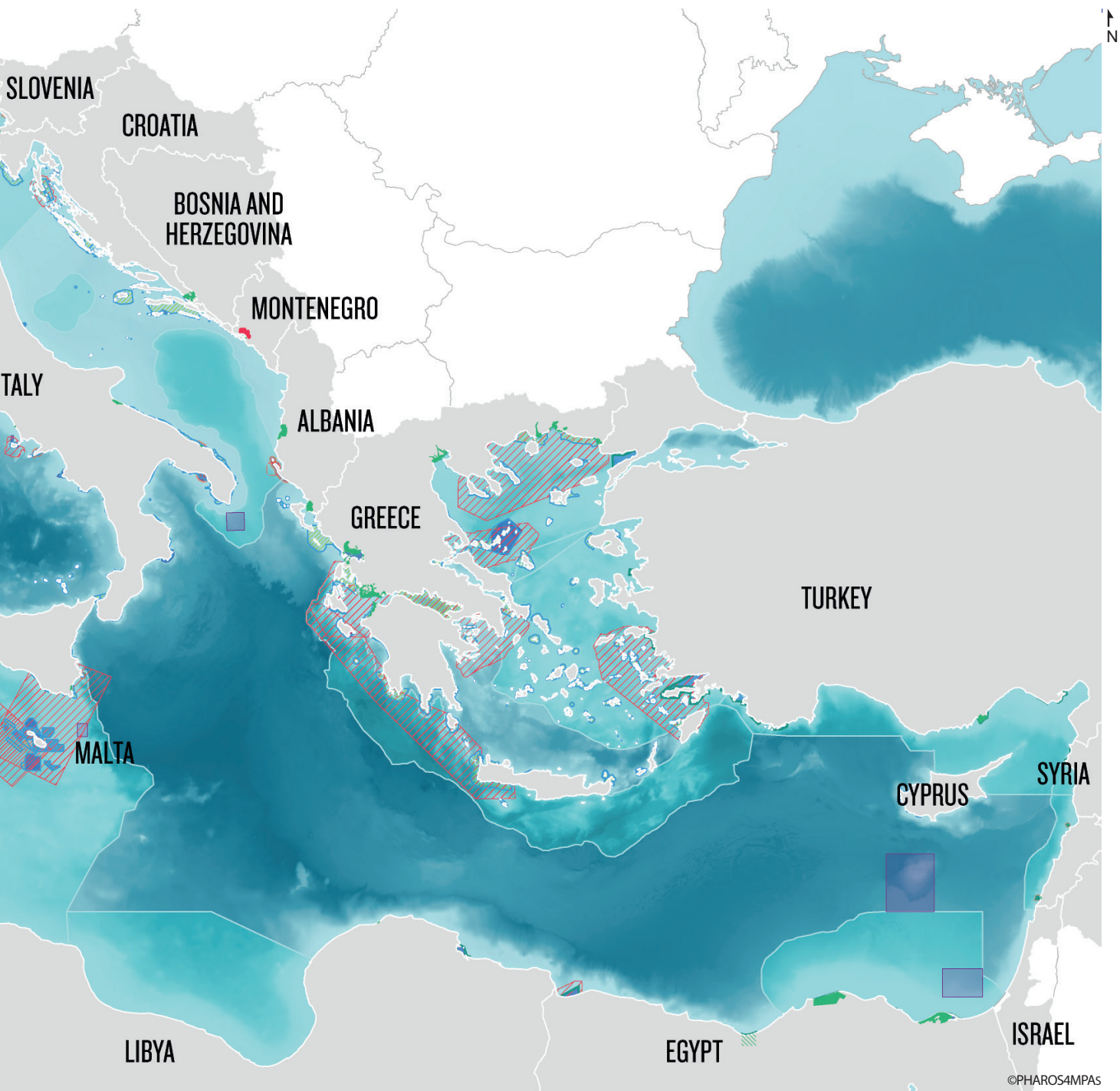


0 250 500 750km

SOURCE: MAPAMED (2017)

- National MPA
- Natura 2000 site
- Pelagos Sanctuary for marine mammals

**FIGURE 8.** MPAs in the Mediterranean. Different designation types are colour-coded



©PHAROS4MPAS

**CONSERVATION AREAS**

**AREAS OF CONSERVATION INTEREST**

- International Marine Park of the Bonifacio Strait
- SPAMI
- Fisheries Restricted Area (FRA)

- World Heritage Site
- UNESCO Biosphere Reserve
- RAMSAR site

- PSSA
- EBSA
- CCH

## MPAS AND OWFS

All Mediterranean countries are committed to fulfilling the Aichi targets and establishing MPAs covering at least 10% of coastal and marine areas by 2020, and these target may be further increased in the next decade. By the same date EU member states aim to achieve or restore Good Environmental Status for all EU marine waters and Favourable Conservation Status for protected habitats and species, under the Marine Directive and Habitats Directive respectively. On the other hand they also need to meet the EU target of generating 27% of energy from renewable sources by 2030 – and OWFs are expected to be a main contributor to this total.

MPAs do not usually exclude human activities per se, but they restrict them to the extent that an area's conservation targets suffer no serious impairment. The IUCN, however, takes the view that industrial development should never be permitted in MPAs<sup>[88]</sup>.

## AVOID – MITIGATE – COMPENSATE APPROACH

The potential environmental impacts of OWFs are diverse and require a range of mitigation strategies. **The most effective method for limiting negative impacts is spatial segregation, i.e. careful initial site selection to avoid areas of high conservation value: this would exclude MPAs as potential locations for OWFs.**

However, full segregation of OWFs and MPAs may not always be possible. In the case of cable connections to the mainland or for service vessels it may sometimes be very difficult to avoid protected areas.

Thorough MSP is an effective tool for selecting or ruling out possible locations for OWFs and MPAs, and avoiding or mitigating spatial conflicts on a longer time-scale. However, as the designation of MPAs focuses on scientific criteria, their delineation can be compromised by other plans. Especially where MPAs cover a high proportion of a marine area, segregation will become difficult and interactions with OWF activities may become inevitable.

## CASE STUDIES: CURRENT OWF DEVELOPMENTS

### GERMANY

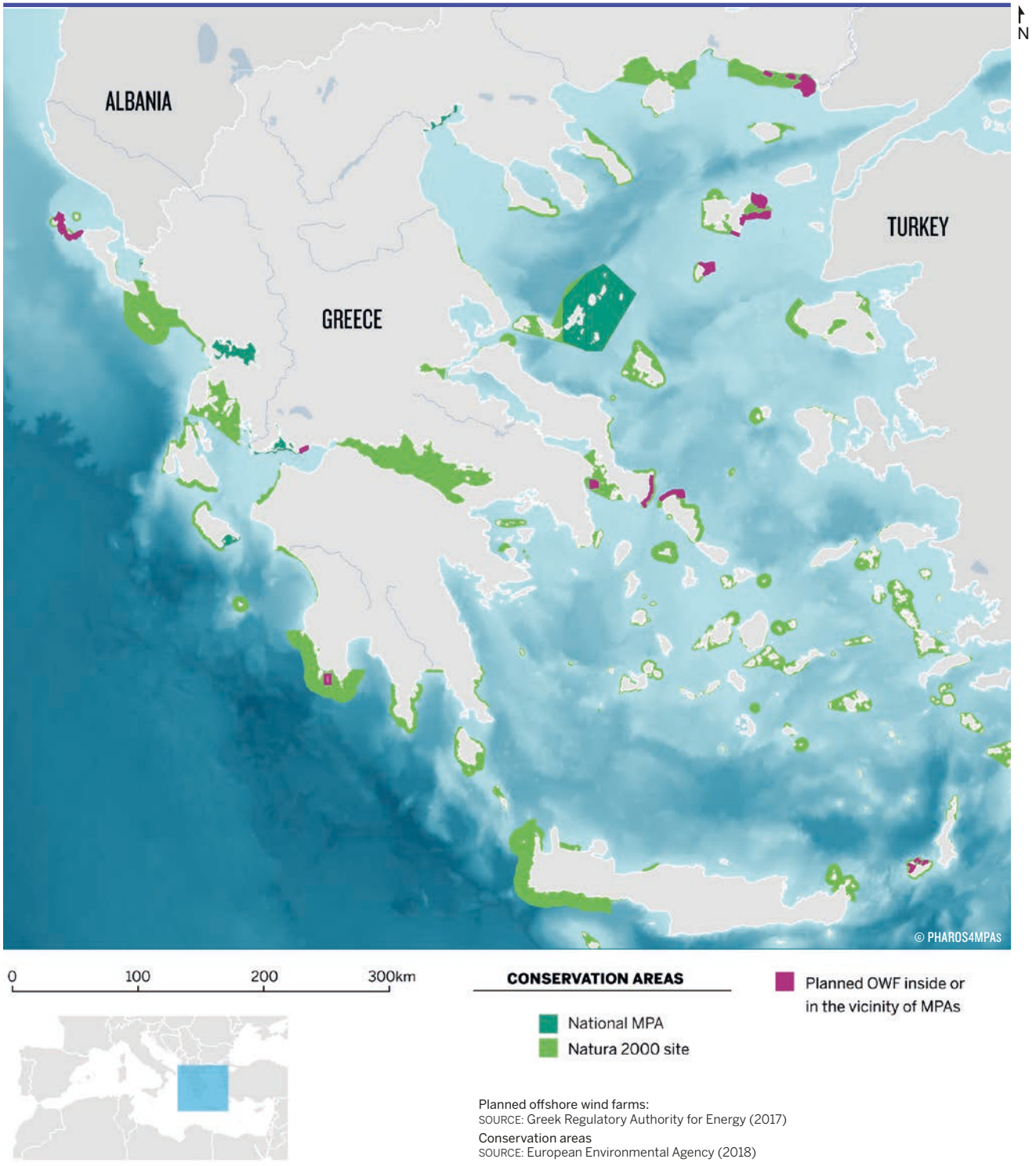
- **Marine situation:** MSP regulates use of space in German EEZ.
- **Current situation:** One OWF ('Butendiek,' approved in 2002) is located inside a Natura 2000 site (designated in 2004), various cable connections and service traffic cross Natura 2000 marine areas. Two projects in Natura 2000 areas were denied approval in 2002, and since then no further applications within Natura 2000 areas have been put forward. Today, planning regulations do not allow OWFs in Natura 2000 areas, but cable connections still need to cross some MPAs.

### BELGIUM

- **Marine situation:** Limited space for OWFs due to small EEZ. MSP regulates use of space in EEZ.
- **Current situation:** No OWFs in or near Natura 2000 sites.
- **Future:** New MSP regime adopted in 2018 includes planned concession zones in Natura 2000 areas.

### GREECE

- **Marine situation:** Limited space for OWFs due to small EEZ. No MSP in force. Initial SEA conducted for MSP excluded OWFs from Natura 2000 sites and important bird areas (IBAs).
- **Current situation:** No OWFs yet constructed. There are individual initiatives for developing OWFs, but without national MSP. Following the 2017 update of the Greek Natura 2000 Network, which included new marine areas, there are 20 proposed OWFs in 14 different Natura sites. One is also proposed in the outer limits of a National Park/Ramsar site.



**FIGURE 9.** National MPAs (dark green) and Natura 2000 marine sites (light green) in Greek national waters with proposed OWF projects (purple)

# 4.1.

## PUBLIC AUTHORITIES

Public authorities involved in the development of the OWF sector, including MSP authorities, should follow the Avoid – Mitigate – Compensate approach, and prioritize the spatial segregation of protected areas and areas designated for OWFs.

### KEY RECOMMENDATIONS FOR PUBLIC AUTHORITIES

- MSP should follow the ecosystem approach to reach or maintain Good Environmental Status as well as Favourable Conservation Status. This needs strong strategic environmental assessment (SEA) to identify potential future locations for OWFs and guide renewable energy away from ecologically sensitive areas in general and MPAs in particular. MSP should also consider cumulative impacts and assess them more broadly.
- Decision-making processes regarding future locations for OWFs should carefully consider aspects of nature conservation and aim to avoid ecologically valuable and protected areas. Effective, ecosystem-based MSP and SEAs should as far as possible ensure that renewable energy is not deployed in those areas that contain habitats, species and/or ecological processes that are particularly sensitive to its impacts, whether during construction or operation. Sensitivity mapping is one of the most valuable tools for effective renewable energy planning, helping developers and regulators in the early stages of decision-making to steer wind energy development away from sensitive areas where negative interactions are most likely to happen. This also reduces business risk.
- In those countries where renewables deployment already lies within MPAs or which are at the stage of environmental impact and appropriate assessment, OWF developments should be robustly assessed on a case-by-case basis according to the relevant nature conservation legislation, taking a precautionary approach to ensure that site conservation objectives are met.
- When a wind farm is planned in a sensitive area, including marine protected areas, and when the knowledge of impacts' levels is non-existent or insufficient, it is recommended, to start the commercial stage production with small-size wind farms projects (around 10-20 wind turbines). This will enable monitoring of environmental impacts and provide sufficient data to define the no-go criteria that should be taken in account in further development. As regards environmental conservation objectives, specifications for small-scale wind farms proposals should be set by a national scientific expert group involving MPA's managers. This will enable monitoring of environmental impacts and provide sufficient data to define the no-go criteria that should be taken in account in further development. As regards environmental conservation objectives, specifications for pilot/small-size wind farms proposals should be set by a national scientific expert group involving MPA's managers.
- When avoidance is impossible, mitigation measures must be implemented by the competent authority (for mitigation measures see chapter 3). Ultimately, ecological compensation may be needed if there are still significant residual impacts. These could include the adoption of measures to restore degraded habitat or create new habitat areas. However, such measures are generally considered as a last resort, due to their uncertainties, complexity and costs<sup>[80]</sup>, and they are not discussed in this document.
- Collaborations between countries and areas sharing sea space or transborder MPAs is essential for the exchange of information, and for setting unified conservation goals, monitoring concepts and action plans.



ALPHA VENTUS PROJECT  
TURBINES, THE FIRST OWF  
OFF THE COAST OF GERMANY

© DOTI MATTHIAS IBELER 2009

## THE ROLE OF STRATEGIC ENVIRONMENTAL ASSESSMENTS

Strategic environmental assessments (SEAs) are conducted on a large spatial scale, and are a prerequisite for effective MSP. There are many species (e.g. migratory species) and marine environmental issues which are not restricted within national borders, so some recent EU projects (e.g. SEANSE) have focused on how

SEAs can be improved to support international MSP protocols and facilitate cross-border collaborations. The outcomes of these projects will enable Mediterranean countries to develop MSP on an international basis, meaning they can account for the cumulative impacts of large-scale development, including of OWFs. Successful MSP – and thus the SEAs that support it – depends in this context on thorough baseline investigations and research to assess the potentially affected animal groups and the expected impacts of OWFs.

## RECOMMENDATIONS FOR ECOLOGICAL ASSESSMENTS:

- Consider the entire lifecycle of the OWF and all its associated infrastructure (offshore infrastructure and cable installation)
- Create a national scientific expert group to advise OWF developers and MPA managers
- Conduct baseline studies prior to construction
- Start long-term monitoring programmes to investigate impacts on species, protected ecosystem features and general ecosystem development in order to assess future project proposals
- Share monitoring data with all stakeholders
- For multiple OWFs, consider cluster analysis to detect cumulative impacts. Develop shared monitoring protocols and methods across entire species distribution areas.
- Develop regulations and best practice standards for future OWF development
- Balance negative impacts against positive effects.

# 4.2. MPA MANAGERS

For OWF projects which have been approved in MPAs, the question is how the two can best co-exist. Certainly, some impacts can be significantly reduced through available mitigation technologies and careful site planning including micro-siting of individual turbines.

### **There are two possible ways in which OWFs and MPAs may interact:**

#### **1. The area of a new OWF is designated as a new MPA**

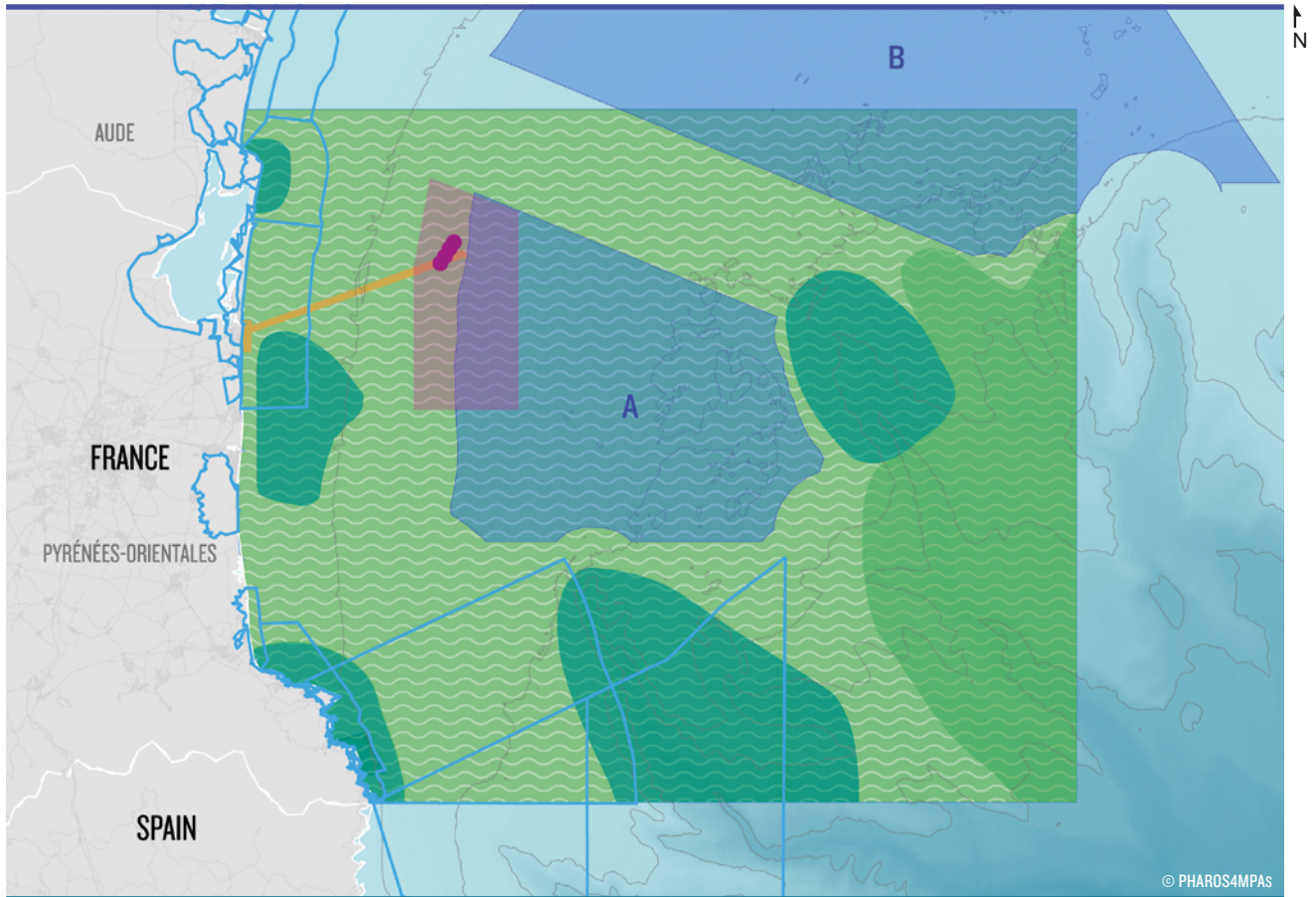
The area of an OWF could be designated as a permanent no-take zone, protecting animals present from any further anthropogenic harm and attracting other animals/predators to the new feeding ground. It's essential that appropriate assessments confirm that the potential benefits of this approach will outweigh the negative impacts of construction and operation. OWFs in remote areas offer opportunities for designating protected areas further offshore.<sup>[60]</sup>

#### **2. The OWF is constructed in an existing MPA**

The presence of a management body in the MPA which speaks for all stakeholders will make it much easier to set up negotiations with the OWF developer. These bodies can form working groups and provide recommendations for how to make projects in or near the MPA a success.

As an example of this second situation, the Natural Marine Park of the Gulf of Lion (NMPGL) was designated in 2011 and is located in the southern part of the French Mediterranean coastline. Through an MSP process started in 2015, the government decided to site an OWF inside the Park, the grid connection of which will in addition cross a marine Natura 2000 site (Figure 10).





0 10 20 30km



Windfarm project  
 SOURCE: EMODNET (2017), revised by WWF  
 Marine Natural park of the Gulf of Lion  
 SOURCE: EMODNET 2017  
 Zoning of the Marine Natural park of the Gulf of Lion  
 SOURCES: Agence Française de la Biodiversité / PNMGL (2018)  
 Marine Natura 2000 sites  
 SOURCE: Cerema, ONML (2018)  
 Area favorable to the development of a pilot wind farm  
 SOURCE: LEFG, RTE (2018)  
 Grid connection plan of the pilot wind farm  
 SOURCE: LEFG, RTE (2018)

**CONSERVATION AREAS**

- Marine Natural Park of the Gulf of Lion
- Marine Natura 2000 Site

**ZONING OF THE NATURAL MARINE PARK OF THE GULF OF LION (NMGPL)**

- ZONE 1: Protection of marine heritage by limiting anthropogenic impacts
- ZONE 2: Conservation of a low pressure area and anthropogenic impact
- ZONE 3: Sustainable socio-economic development of maritime activities in respect of ecosystems
- Macro zone identified after consultation on localisation of OWF commercial projects
- Area identified for the development of a pilot windfarm
- Grid connection plan of the pilot windfarm
- OWF project position in the MNPGL

**FIGURE 10.** Area suitable for a pilot OWF project in the NMPGL, shaded red. The different zones of the Park are shaded green.

Here, the NMPGL Management Board, composed of elected local representatives, established an **OWF working group**. This consisted of 20 people representing all stakeholders, including the OWF industry, and aimed to minimize as far as possible the environmental impact of the project. As a result of the efforts and recommendations of the working group, the final project proposal differed significantly from the initial proposal (Figure 11).

The decision process for this development is a good example of how a specific governance mechanism – in this case a dedicated working group – combined with the legal power of the MPA to oppose the project if its sustainability is not considered sufficient, can help find the best solutions for avoiding and mitigating OWF impacts. It should however be noted that the OWF in question has not yet been constructed, so the effectiveness of the terms agreed has not been tested in real-world operations <sup>[82–84]</sup>.

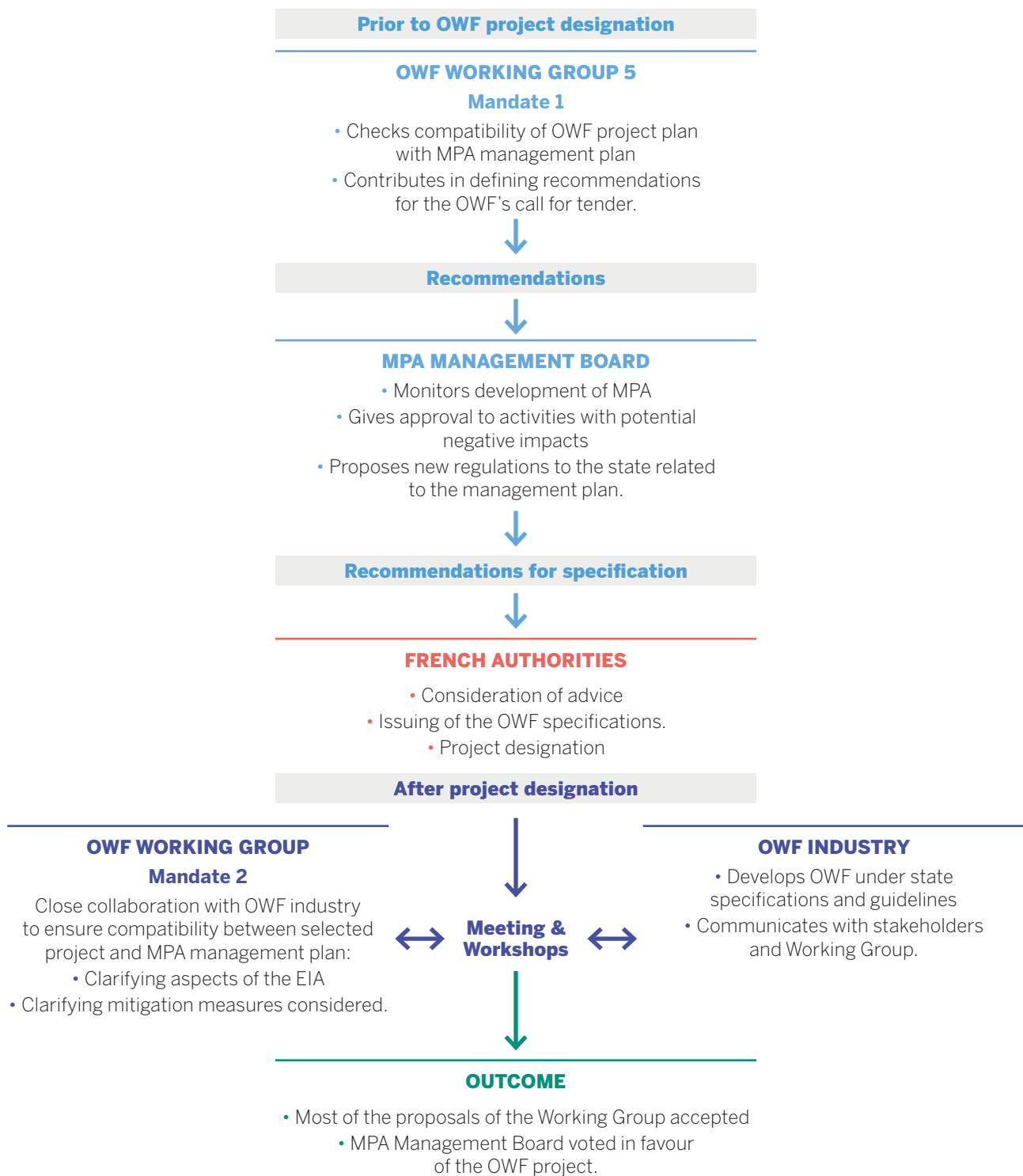
## KEY RECOMMENDATIONS FOR MPA MANAGERS

- Support an ecosystem approach to MSP.
- Share MPA ecological monitoring data to make the EIA as comprehensive as possible.
- Create a working group with all relevant stakeholders as a constructive governance tool.
- Develop recommendations on micro-siting of the turbines.
- Recommend a thorough OWF monitoring programme for operators, including baseline studies prior to construction
- Make recommendations to authorities on how to mitigate OWF impacts
- Balance negative impacts against potential positive effects.



CORMORANT (*PHALACROCORAX CARBO*)  
OFF CAISTER BEACH NEAR SCROBY  
SANDS OWF, NORFOLK, ENGLAND

© STEPHEN WILLIAM ROBINSON / SHUTTERSTOCK



**FIGURE II.** Overview of the decision process for the development of the OWF in the NMPGL. The process consisted of two mandates of the OWF working group prior to and after the designation of the OWF project and resulted in the acceptance of most of the working group's recommendations and an approval of the MPA management board<sup>5</sup>.

<sup>5</sup> 20 members: Experts external to the Management Board (8 people), MPA's management body (3 people), State agencies and institutions (4 people), Leisure activity representative (1 person), Recreational fishery representative (1 person), Commercial fishery representatives (3 people), NGOs (2 people), Scientific institution (1 person).

# 4.3.

## OFFSHORE WINDFARM BUSINESS SECTOR

The OWF business sector has a serious responsibility to avoid or minimize its impacts on MPAs. Fast-developing technology and existing expertise and experience can make a significant contribution to the implementation of best management practices.

From an industry perspective, avoiding MPAs and other areas of importance for protected species and habitats will minimize legal risks to their investments: project permits may be denied if the impacts assessment cannot rule out significant impairment of protected areas, habitats or species. Furthermore, corporate commitments to sustainability and environmentally-friendly practices can make a significant positive contribution to a business' public image.

In areas designated as generally suitable for OWFs, project-specific EIAs commissioned by the developer investigate their likely impacts on the environment. The most appropriate solutions tend to be generated through engagement with different stakeholders (e.g. conservation and industry)<sup>[85]</sup>. When common ground can be found then shared goals can be defined (e.g. reducing environmental and social risk), even if stakeholders have different motivations (e.g. environmental vs. economic).

Effective cross-border co-ordination of plans and projects – of environmentally sustainable OWFs as well as efficient MPA networks – is essential with today's growing needs for both renewable energy and increased ocean protection.

### KEY RECOMMENDATIONS FOR OWF BUSINESS SECTOR:

- Respect national legislation restricting industrial development within MPAs.
- Consider alternative locations for OWFs outside the borders of MPAs.
- When performing the EIA required by national authorities, OWF developers should take into account all available scientific knowledge and involve the MPA or marine Natura 2000 site management body in its review.
- Make use of existing data on marine ecosystems from MPA monitoring programmes.
- Share monitoring data with authorities, MPA management boards and other stakeholders in order to develop best practices for future projects.
- Implement mitigation practices targeting environmental and social issues specific to each MPA.
- Apply most recent construction techniques and use environmental friendly alternatives to minimize or avoid further impacts on protected features and the ecosystem in general.

Useful lessons can be learned and methods adapted from existing OWFs<sup>[85]</sup> and the results of extensive research and monitoring programmes conducted in countries including Belgium, Denmark, the UK and Germany<sup>[83,86,87]</sup>. However, all such data comes from northern European seas, and any **hands-on recommendations need to be adapted to Mediterranean conditions and conservation goals.**

Research projects (e.g. the **CoCoNet** project<sup>[81]</sup>) already provide data and recommendations for the Mediterranean Sea on the most suitable sites for OWFs, taking into account both wind conditions and MPA locations. Extensive baseline investigations and monitoring programmes involving scientists and stakeholders from all potentially impacted sectors are essential for the sustainable development of OWFs in general.



A TUG BOAT TOWING A  
CONSTRUCTION BARGE

© DOTI - MATTHIAS IBELER

# ACRONYMS

BACI	Before-After/Control-Impact, a monitoring approach
BSH	Bundesamt für Seeschifffahrt und Hydrographie, Federal Maritime and Shipping Authority, Germany
C-POD	Cetacean-Porpoise Detector
CRM	Collision Risk Models
dB	Decibel, used as a ratio to describe sound pressure level
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EBSA	Ecologically or Biologically Significant Area
ft	feet
HiDef	High-Definition digital flight monitoring surveys
IBA	Important Bird Area
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
MAP	Mediterranean Action Plan
MedPAN	Network of Marine Protected Areas managers in the Mediterranean
MSP	Marine spatial planning
OECMs	Other effective area-based conservation measures
OSPAR	OSlo-PARis Convention
OWF	Offshore Wind Farm
PAM	Passive-Acoustic-Monitoring
pSCI	Proposed Site of Community Importance
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEA	Strategic Environmental Assessment
SPA	Special Protected Area
SPAMIs	Specially Protected Areas of Mediterranean Importance
WWF	World Wide Fund for Nature

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# THE PHAROS4MPAS PROJECT IN NUMBERS

**7.14%** of the Mediterranean Sea is under some form of protection, 1,231 MPAs and OECMs covering **179,798** km<sup>2</sup>

With **€395** bn Gross Marine Product (GMP) the Mediterranean Sea economy is the **5th** largest in the region

**7**  
MARITIME SECTORS

**17** PARTNERS / **10** COUNTRIES



MARITIME TRANSPORT



LEISURE BOATING



RECREATIONAL FISHERIES



CRUISE



OFFSHORE WIND FARMS



AQUACULTURE



SMALL SCALE FISHERIES

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INSTITUTE OF THE REPUBLIC OF SLOVENIA FOR NATURE CONSERVATION



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