PHAROS4MPAS

# SAFEGUARDING MARINE PROTECTED AREAS IN THE GROWING MEDITERRANEAN BLUE ECONOMY

Interreg Mediterranean EUROPEAN UNION PHAROS4MPAs

## RECOMMENDATIONS FOR AQUACULTURE

**Front cover:** Floating cages in an aquaculture farm, Calanques National Park, Marseille, France © Lionel Astruc / Biosphoto


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FISHER CASTING NET OVER FARMED GILTHEAD SEA BREAM (*SPARUS AURATA*), FRIOUL ISLAND, MARSEILLE (FRANCE)

# EXECUTIVE SUMMARY

Aquaculture already accounts for more than half of the Mediterranean's total fishery output, and – in line with global trends – the sector is projected to continue growing. With almost 80% of wild fish stocks in the region at risk of overfishing, aquaculture represents the most effective way of meeting the still-rising demand for fish and shellfish products.

The EU has recognised the importance of aquaculture, and has made it one of its five priority sectors to drive its Blue Growth agenda. But the growth of the aquaculture sector has been mirrored by a growth in marine protected areas, as countries make efforts to meet environmental commitments under the Aichi Targets, the Barcelona Convention and other international treaties.

Since Marine Protected Areas (MPAs), marine Natura 2000 sites and marine aquaculture are all mostly found in coastal and shallow areas of the Mediterranean with good water quality, they have been increasingly overlapping in recent years. And more overlaps are likely to happen in the future. This has brought into focus the environmental impacts of fish and shellfish farming, and raised the question of whether and how far aquaculture should be allowed to take place in such locations.

Just over two-thirds of aquaculture in the Mediterranean is based on finfish farming, with sea bass and sea bream in sea net pens accounting for some 80% of the total. Bluefin tuna are also raised in some locations. Mollusc shellfish farming makes up the other third of production, although a loss of suitable farm sites and other anthropogenic pressures have reduced output levels by about 25% since 2000.

Finfish farms have a range of direct and indirect environmental impacts, from effluent discharges and disease to seafloor damage and the spread of alien species. Shellfish farming, on the other hand, can provide some valuable ecosystem services, although it's also responsible for worrying amounts of marine litter. On both sides, small-scale non-intensive operations perform best in environmental terms.

Aquaculture's environmental effects depend very much on the size of the farms, the production systems and management methods used, and also on the marine habitats in which they're located. Every operation – whether already established or proposed for the future – needs careful scrutiny, and decisions should be made on a case by case basis in the context of detailed and dynamic management plans.

It's clear that some ecologically fragile areas should be kept entirely off limits, but in others it may be possible to support a growing sustainable aquaculture sector without causing irreparable harm to vital ecosystems.

This is where public authorities, MPA and marine Natura 2000 sites managers and the aquaculture industry all have a role to play: with effective collaboration between all stakeholders regulations can be enforced, best practices identified and implemented, environmental impacts avoided or minimized, and a sustainable future created.

# INTRODUCTION

Since the 1970s, the aquaculture sector has been developing rapidly in the countries surrounding the Mediterranean Sea: between 1996 and 2016, the sector more than quadrupled in size. The sector is expected to continue developing and diversifying as demand for fish products for human consumption increases and wild stocks continue to decline [1]. By 2025, it is projected that aquaculture will supply more than half (52%) of all fish used for human food [2].

At the same time, Mediterranean marine protected areas (MPAs) have also grown in number and size to conserve marine ecosystems, which are increasingly suffering from anthropogenic pressures. These MPAs are a key tool for conservation, but their individual effectiveness is highly dependent on how well they integrate with their specific local conditions. Globally, interactions between MPAs and aquaculture have been increasing [3], and the same is true in the Mediterranean.

As the aquaculture sector continues to grow, it has a pressing need for more space for development. Given that good water quality is a prerequisite for aquaculture operations, many MPAs potentially represent appealing new sites. However, the environmental impact of aquaculture is hotly debated, and the growth of the sector, especially in coastal and marine environments, is not without controversy. Aquaculture comes with a number of issues that raise questions over its long-term sustainability, including habitat degradation, biodiversity loss, social conflict and pollution [4].

Whether aquaculture can be successfully practised in MPAs is an important question. Nonetheless, it's important to acknowledge that not all aquaculture activities are damaging, and those linked to the livelihoods of local coastal communities can also be potential mechanisms for generating new revenues within the MPA, both strengthening environmental effectiveness and improving community outcomes.

This report provides a brief but practical reference guide to current thinking on the subject for public authorities, MPA managers and the aquaculture producer sector.

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
- Small-scale fisheries
- Recreational fisheries

FEEDING TUNAS IN CARTAGENA, SPAIN

## PART ONE
## BACKGROUND INFORMATION:

# MARINE AQUACULTURE

# AQUACULTURE represents 47% of the total fish production, that reached about 171 million tonnes in 2016 [1]. In contrast to capture fishery production, which has remained relatively static since the 1980s, aquaculture has shown impressive and continuous growth (Figure 1).

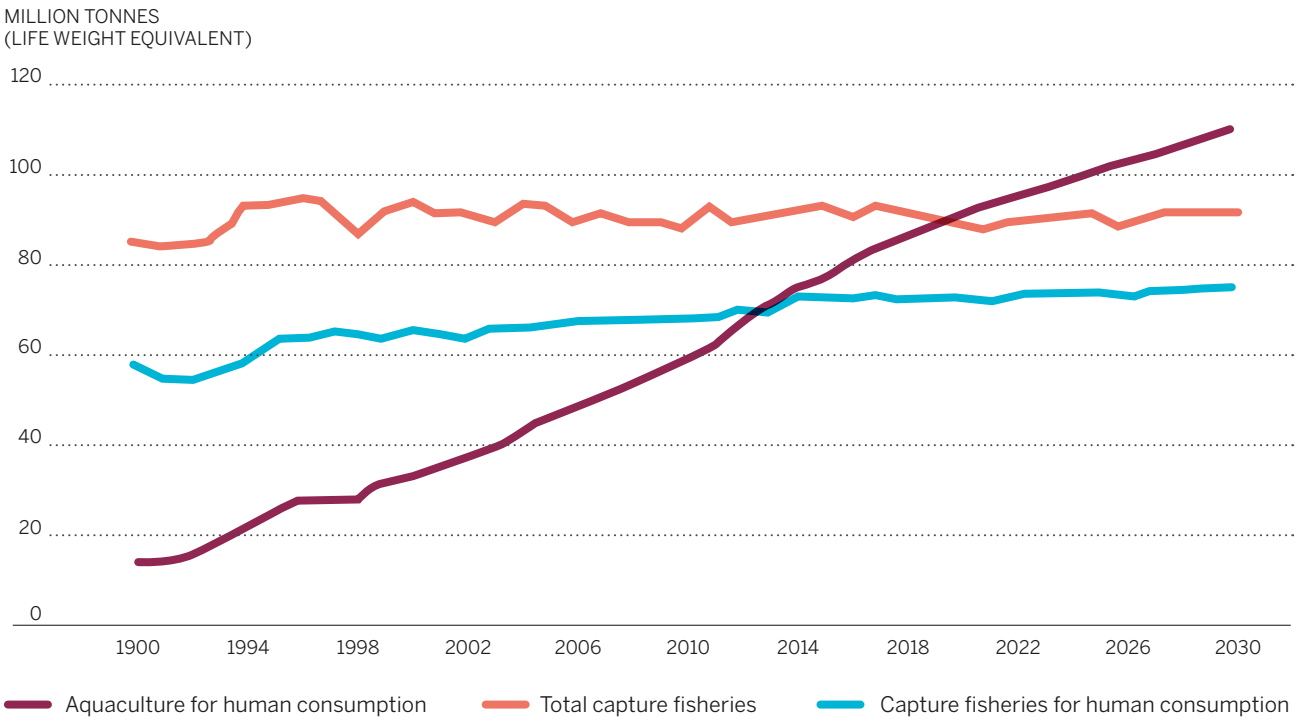



**FIGURE I.** World capture fisheries and aquaculture production (FAO, 2018)

Demand for fish for human consumption is still rapidly growing, and it is widely predicted that aquaculture will continue to expand to meet demand. The World Bank analysis projects that 62% of fish for human consumption will be produced by aquaculture by 2030 [5].

Given the global food landscape, aquaculture represents the most efficient method by which to convert feed to edible protein [6,7]. Aquatic production farming systems appear to be more efficient in reducing externalities and lowering impacts than other livestock production systems (poultry, pig farming, cattle etc). According to the FAO [8], projected increases in the consumption of chicken and aquaculture products in the coming years have a lower environmental footprint than the production of other sources of proteins [9].

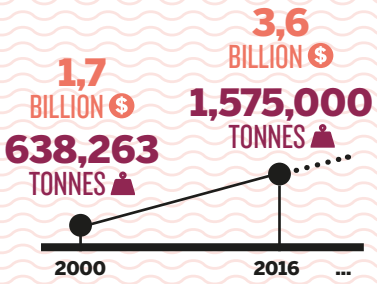
The development of aquaculture in the Mediterranean region mirrors global trends. About 78% of Mediterranean and Black Sea stocks assessed are fished at biologically unsustainable levels [10]. Fishery landings increased until 1994, reaching 1,087,000 tonnes, then declined irregularly to 787,000 in 2013. Algeria, Greece, Italy, Spain, Tunisia, Turkey and Egypt are together responsible for slightly more than 80% of total landings in the Mediterranean.

In parallel, marine and brackish water aquaculture has been growing steadily during the last decades (Figure 2), contributing substantially to meeting rising demand for fishery products.

ccording to the FAO [11], total aquaculture production for the Mediterranean countries (comprising fish, shellfish and crustaceans farmed in marine, brackish waters) increased from 643 thousand tonnes in 2000 to 1,144 thousand

## KEY FACTS

Aquaculture accounts for more than 50% of today's total fishery output at the Mediterranean scale




Marine and brackish aquaculture production ranged from 638,263 tonnes in 2000 to 1,575,000 tonnes in 2016 in the Mediterranean countries, i.e., equivalent to a value ranging from $US 1,7 billion to $US 3,6 billion

**313,000**

Aquaculture sector generates 313,000 direct and indirect employments in the Mediterranean and the Black Sea countries

**2/3** of Mediterranean aquaculture production is based on fish farming with mollusk farming representing the remaining **31%**

Excluding Egypt, Turkey, Greece, Italy and Spain account for some 87% of the total Mediterranean marine and brackish production

SCHOOL OF EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*) IN A MEDITERRANEAN FISH FARM

tonnes in 2010, continuing up to 1,575 thousand tonnes in 2016. The bulk of production (around 1 million tonnes) takes place in brackish inland waters in Egypt for tilapia, cyprinids and mullets. Excluding inland waters, aquaculture in marine and brackish waters reached a total production of more than 480,000 tonnes in 2016 (Figure 2).

Excluding Egypt, four countries account for some 87% of this volume: Turkey (31%), Greece (25%), Italy (24%) and Spain (7%).

A little over two-thirds of Mediterranean aquaculture production is based on fish farming (including bluefin tuna), with mollusc shellfish farming representing the remaining 31%. [11]

In 2016 **Mediterranean marine fish** production reached approximately 334,000 tonnes [11].

The total value of fish aquaculture in the Mediterranean is about US$2 billion, with the same four countries accounting for around 82% of this figure: Turkey receives the highest annual revenues, of about US$670 million.
The main species produced are sea bass (42%) and sea bream (41%).

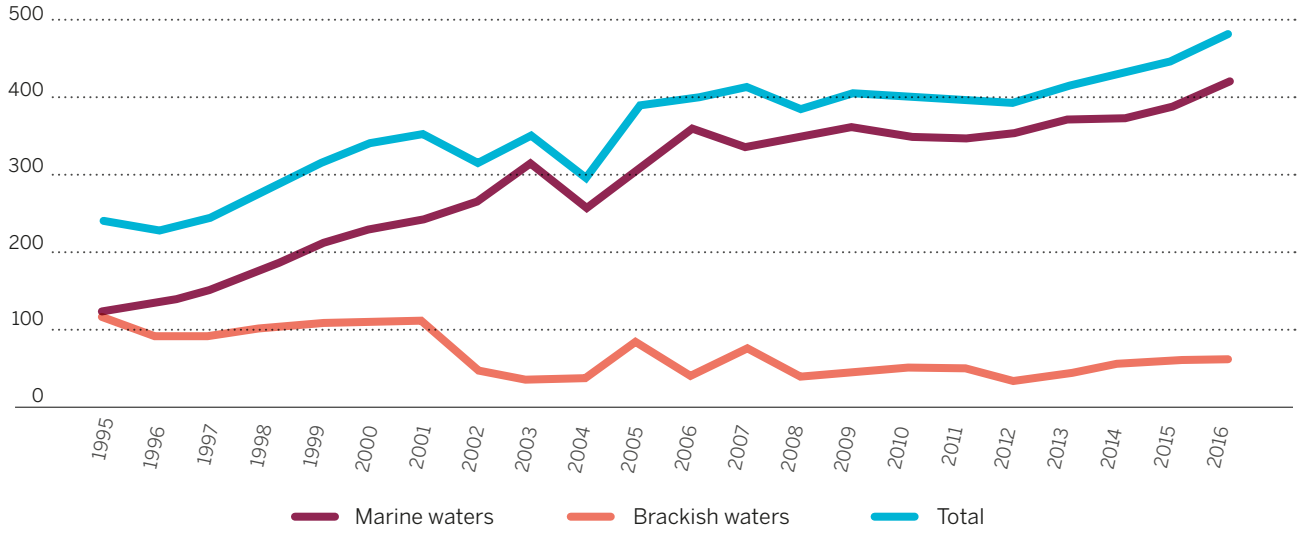



**FIGURE 2.** The evolution of aquaculture production (in thousands of tonnes) for two types of coastal environment – marine and brackish waters between 1995 and 2016 (FAO FISHSTAT, 2018)

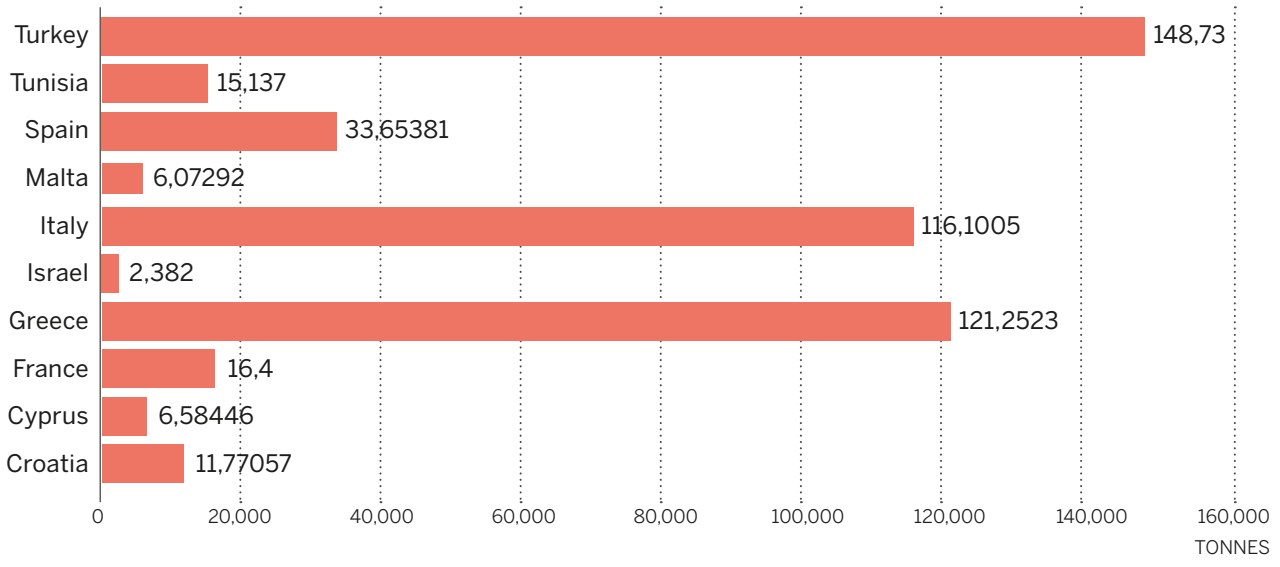



**FIGURE 3.** Annual aquaculture production (*in thousands of tonnes*) in the Mediterranean area by country-producer (FAO FISHSTAT, 2018)

NORTHERN BLUEFIN TUNA (*THUNNUS THYNNUS*) BEING FATTENED FOR THE JAPANESE SUSHI MARKET (SPAIN)



The expansion of the sector in the region has been facilitated by its proximity to viable markets in Europe. The Mediterranean also boasts ideal growth conditions, water temperatures and physiochemical parameters.

As far as **shellfish** are concerned, total production was 190,391 tonnes in 2000 and decreased to 147,101 tonnes in 2010: it then remained largely stable to 2016, reaching 146,051 tonnes [11]. The decrease in production (-23% from 2000) mainly related to the loss of space suitable for shellfish farming, along with important changes in Mediterranean coastal waters on the level of nutrient availability, extreme events, marine pollution and biotoxins. Most of these changes were due to anthropogenic pressures and climate change.

The Mediterranean mussel (*Mytilus galloprovincialis*) is the most commonly produced bivalve, and it's

Bluefin tuna are reared in several locations in the Mediterranean. The main producers are Spain (in the Murcia region), Malta, Turkey and Croatia. Tuna farming is expanding in line with the increased quotas agreed by ICCAT in 2017, which saw Total Allowable Catches (TAC) for bluefin tuna increased by about 20% per year from 28,200 tonnes in 2018 to 36,000 tonnes in 2020 [12]. The output production of the main Mediterranean farming countries accounted in 2018 for about 21,000 tonnes [13].

Mediterranean tuna farming relies on catching fish from wild populations (often juveniles), which are then moved alive to large floating net pens in offshore areas. The fish are kept in these pens for varying periods, ranging from a few months to years, and fed mainly with small pelagics (anchovies, sardines, mackerel, sprat, herrings) until their meat reaches the desired level of fat content for the high-value Japanese market.

It should be noted that tuna is the only species fed on fresh/frozen fish and not on commercial pellets. It has a poor feeding conversion ratio, and its farming puts extra pressure on small pelagic stocks that are already largely overfished in the Mediterranean.

OYSTER PARKS (SHELLFISH RAFTS) IN THE NATURA 2000 SITE OF THE ETANG DE THAU (FRANCE)

© FLICKR / JACQUES DIEGOJACK

farmed mainly in Spain, Italy and France. It's followed by the cupped oyster (*Crassostrea gigas*), produced especially in France; and the Manila clam (*Ruditapes phylippinarum*), of which Italy is the main producer.

Aquaculture practices vary according to a number of important criteria, including the species farmed, the farming environment and the type of water, the type of production system and production intensity used. An understanding of these aspects is key to determining the interactions of aquaculture operations with the environment.

As regards production intensity, it is usually the case that in extensive aquaculture there is no external supply of feed: this type of culture depends entirely on natural processes for production and feed supply. In semi-intensive aquaculture, some supplementary feed may be used to increase fish production. Intensive culture systems depend on the use of external feeds.

The main aquaculture systems practised in the Mediterranean area are described below (modified from the EU's guidance document on aquaculture activities in the context of the Natura 2000 network [14]).

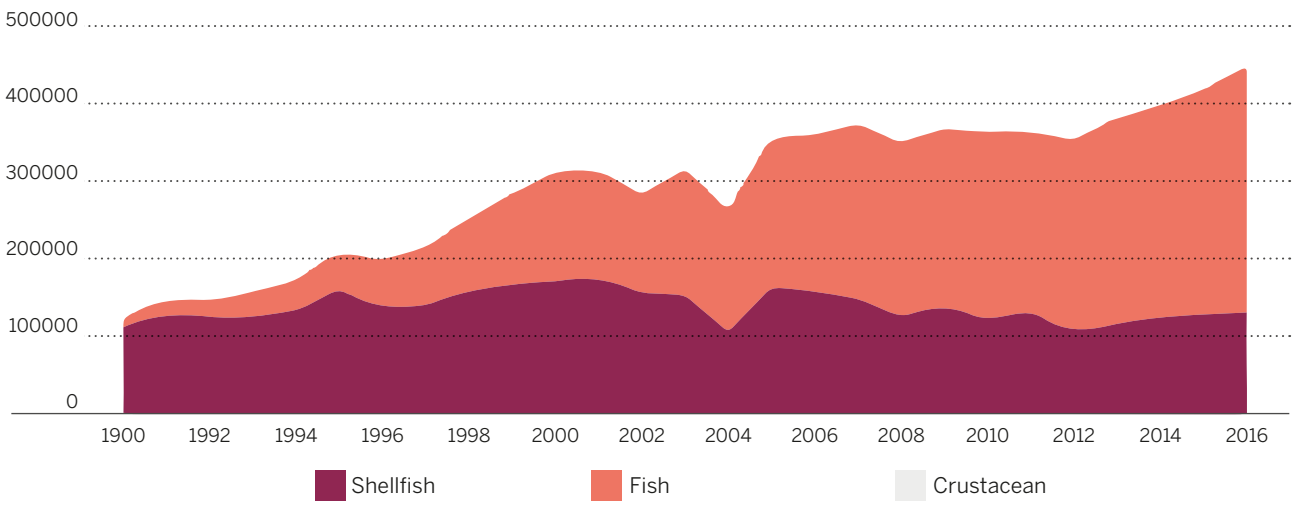



**FIGURE 4.** Total aquaculture production volume in tonnes in the Mediterranean area, 1990-2016. Data are for fish, shellfish and crustaceans farmed in brackish and marine waters. Crustacean production is negligible compared to shellfish and fish production, so cannot be visualised. All Mediterranean countries are included (FAO FISHSTAT, 2018)

# MOLLUSC FARMING

Mollusc farming is usually based on natural seed and spat, with shellfish growth depending on water nutrients provided by the natural environment. Three main types of farming are practised in the EU:

- **Shellfish rafts and longlines.** This form of aquaculture grows mussels and other shellfish in deeper waters, using suspended ropes and longlines from floating rafts. The system relies on natural spat locations, areas of good water quality, and natural nutrient availability for the grow-out phase (eg. Galicia in Spain, and the Italian Adriatic Sea).
- **Intertidal shellfish culture** is one of the older, more traditional forms of aquaculture and is practised extensively in the western part of Europe. It takes place in intertidal zones, thus benefiting from relatively accessible land-based support as well as the hydrodynamic physical environment of the land/water interface.
- **Bottom shellfish culture** takes place in shallow coastal or estuarine areas, where juveniles are seeded on different substrates according to species: mussels and oysters prefer a hard or firm substrate, while clams prefer a softer substrate.

For **oyster culture**, four main methods are used depending on environmental characteristics (tidal range, water depth, etc) and local traditions:

- Off-bottom culture – in mesh bags
- Bottom culture – directly on inter- or subtidal ground
- Deep-water culture – in parks at depths of up to 10 metres
- Suspended culture – on ropes, making it possible to rear them offshore

Methods for oyster seed hatchery production are well established.

**Clam culture** is based on seeds obtained through natural spawning on production sites or in hatcheries. Young clams are seeded in intertidal zones or in lagoons, and managed to ensure regular maintenance of the substrate and appropriate clam density.

# MARINE FISH FARMING

Fish species in the Mediterranean are cultivated ashore and in transitional, coastal and offshore marine waters:

- **Lagoon culture** is a traditional form of extensive fish aquaculture that originated in the Mediterranean, using coastal lagoons, salt ponds and large brackish areas in transitional waters. It relies on natural fry recruitment or controlled seeding of hatchery fingerlings, and management of water in-flow inside channels and barriers of farming areas. Fish are prevented from returning to the sea by complex permanent capture systems and fish barriers. These system are typical of the northern Adriatic Sea (eg. the seasonally-based 'valliculture').
- **Land-based ponds,** mainly shallow earthen basins where modern systems ensure water supply, are used for seabass and seabream in Portugal, southern Spain and Italy. Farms use various levels of intensification and pond size, but in general these are semi-intensive systems covering large areas, with individual ponds ranging from one to several hectares.
- **Land-based tank** systems are an intensive solution for culturing high-value fish. Most systems used for hatchery production are recirculated closed systems (RAS), separated from the external environment by physical filters and drains. These allow the control of water parameters and environmental conditions, which are of paramount importance for rearing eggs, larvae and juveniles. The use of temperature controls frees the activity from local environmental climate constraints. In the Mediterranean, land based tanks are used mainly along Italian coasts and are equipped wih flow-through sea water systems.
- **Sea net pens** is the most common aquaculture system in coastal and open waters. It uses large pocket-shaped nets anchored to the bottom and maintained on the surface by a rectangular or circular floating framework. These net pens are widely used for rearing finfish, such as sea bass and sea bream and to a lesser extent trout, in coastal and open waters. The openness of the farming system makes it vulnerable to external influences (pollution events and physical impacts), as well as exposing marine ecosystems to potential pressures from farming activities (use of chemicals, nutrients and effluent release, spread of pathogens etc).

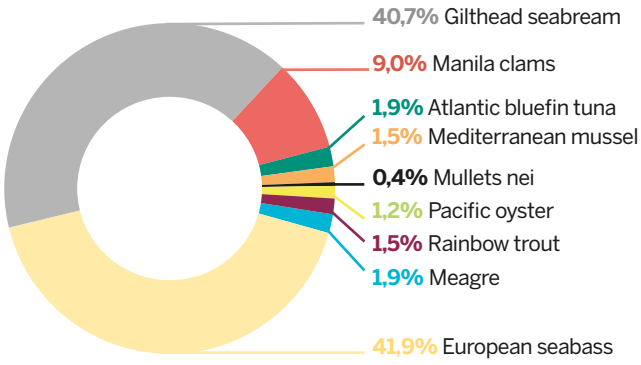



**FIGURE 5.** Main marine and brackish species cultured in Mediterranean Sea in 2016 (FAO FISHSTAT, 2018)

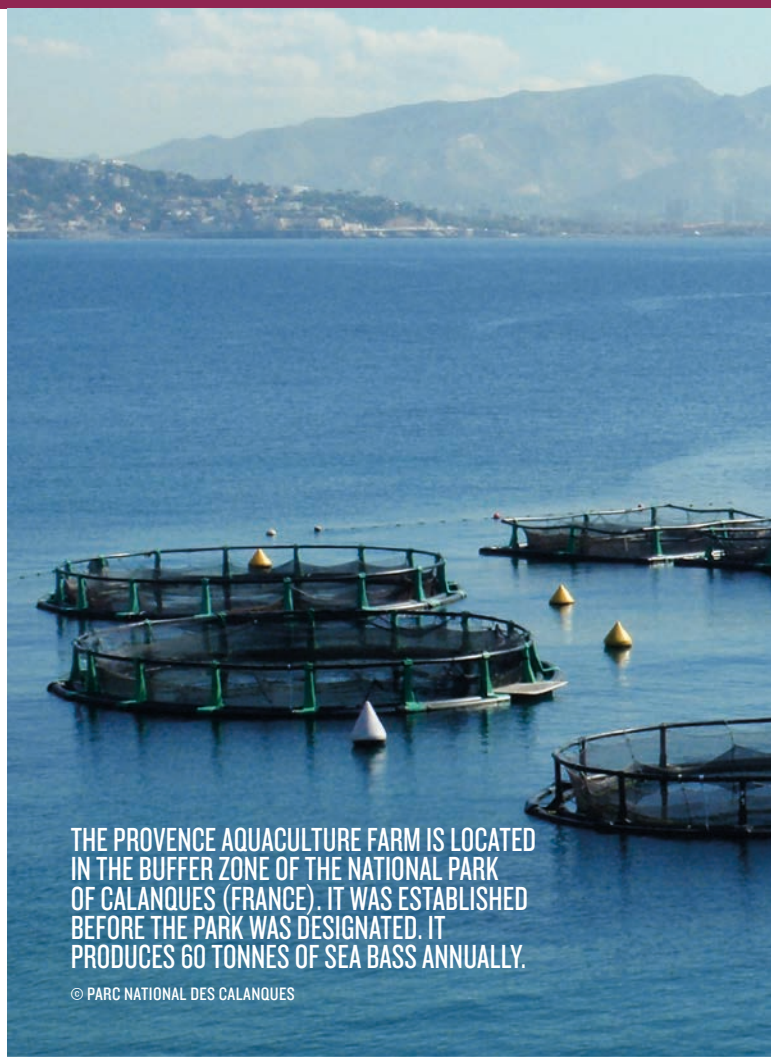
According to the results of the MedAID project (2019), 190 Mediterranean fish farms raise European seabass and gilthead seabream, producing an average of 360 tonnes per year [15]. 62% of these farms are classed as medium to large companies.[1]

In 2015, the General Fisheries Commission for the Mediterranean (GFCM) estimated that there were around 1,000 shellfish farms (mussels and oyster) in the region, generally producing less than 50 tonnes per year per farm [16] through labour-intensive methods. Most of these are family-owned small to medium-sized enterprises (SMEs).

Aquaculture plays an important socioeconomic role in coastal communities. The sector is directly responsible for more than 313,000 jobs in Mediterranean and Black Sea countries [4].

As wild fish stocks continue to decline and demand for seafood continues to increase, aquaculture in the Mediterranean Sea is expected to continue its growth in coming years. The EU has singled out aquaculture as one of the five priority sectors to drive its Blue Growth agenda.

[1] Large companies are those with an annual turnover higher than €10 million, or with more than 150 employees. Medium-sized companies are those with a volume of sales higher than €1 million, or more than 15 employees.



THE PROVENCE AQUACULTURE FARM IS LOCATED IN THE BUFFER ZONE OF THE NATIONAL PARK OF CALANQUES (FRANCE). IT WAS ESTABLISHED BEFORE THE PARK WAS DESIGNATED. IT PRODUCES 60 TONNES OF SEA BASS ANNUALLY.

© PARC NATIONAL DES CALANQUES


NIREUS CONDITIONING FACTORY, CHIOS ISLAND (GREECE)

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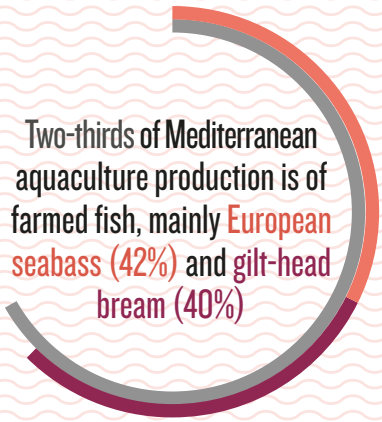
## KEY FACTS

Marine aquaculture shows a continuous growth in the Mediterranean, mainly driven by fish aquaculture



Two-thirds of Mediterranean aquaculture production is of farmed fish, mainly European seabass (42%) and gilt-head bream (40%)

Sea net pens are the most common aquaculture systems used in coastal and open water, especially for tuna, sea bream and sea bass ongrowing

SCHOOL OF GILTHEAD SEA BREAMS
*(SPARUS AURATA)*

PART TWO

# AQUACULTURE: INTERACTIONS WITH MARINE PROTECTED AREAS

The 2016 Status of Marine Protected Areas in the Mediterranean provides a region-wide analysis of the progress of the basin in terms of marine protection [17]. Since the 1950s, Contracting Parties to the Barcelona Convention have established different MPAs and other effective area-based conservation measures (OECMs). Figures from 2016 show there are 1,231 MPAs and OECMs in the Mediterranean Sea covering 179,798 km$^2$: this places a surface of 7.14% under a legal designation (see Figure 6). The Convention on Biological Diversity (CBD) has a 10% marine protection objective by 2020, known as the CBD Aichi target 11.

## MPA: DEFINITION

According to the IUCN, an MPA is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values."

The European Environment Agency (EEA) technical report for spatial analysis of MPA networks in Europe's seas (2015) presents an overview of the subject [18]. MPAs in the Mediterranean can be established under the framework of:

- **The EU nature directives**, i.e. the Habitats and Birds Directives (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; and Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds): MPAs of this kind are known as marine Natura 2000 sites.
- **National designation**, i.e. sites directly designated by the countries in which they are located.
- **Regional Sea Conventions (RSCs)**, which in the Mediterranean means the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean Sea. MPAs of this kind are designated as Specially Protected Areas of Mediterranean Importance (SPAMIs).

**The Marine Strategy Framework Directive (MSFD)** has a wider scope than the marine Natura 2000 network. The MSFD includes the obligation for member states to implement spatial protection measures to achieve 'good environmental status' (GES) of marine waters. Spatial protection measures in MSFD include not only Natura 2000, but also MPAs under other international or regional agreements to which member states are parties.

These sites are established at national level, at regional level (European or Mediterranean scale) or at international level under a wide variety of designations, such as national parks, marine reserves, no-take zones, SPAMIs, etc. [17]

Figure 7 shows the number of MPAs and marine Natura 2000 sites created per year by type of designation (national, regional and international) and cumulative surface area covered from 1950 to 2016.

As aquaculture development occurs mainly in national waters and in coastal areas, the focus of this report is mainly at national level. Using the criteria of the 2016 Status report [17], there are 186 sites designated at national level which cover 1.6% or 40,327 km$^2$ of the Mediterranean Sea. Of these nationally designated sites, 76 have at least one no-go, no-take or no-fishing zone, which between them cover 0.04% of the Mediterranean Sea (976 km$^2$) .

It is worth noting that most MPAs and OECMs are located in coastal and shallow areas of the Mediterranean. Since MPAs and marine aquaculture have both been expanding in these same areas, their interactions have increased over the last decade.

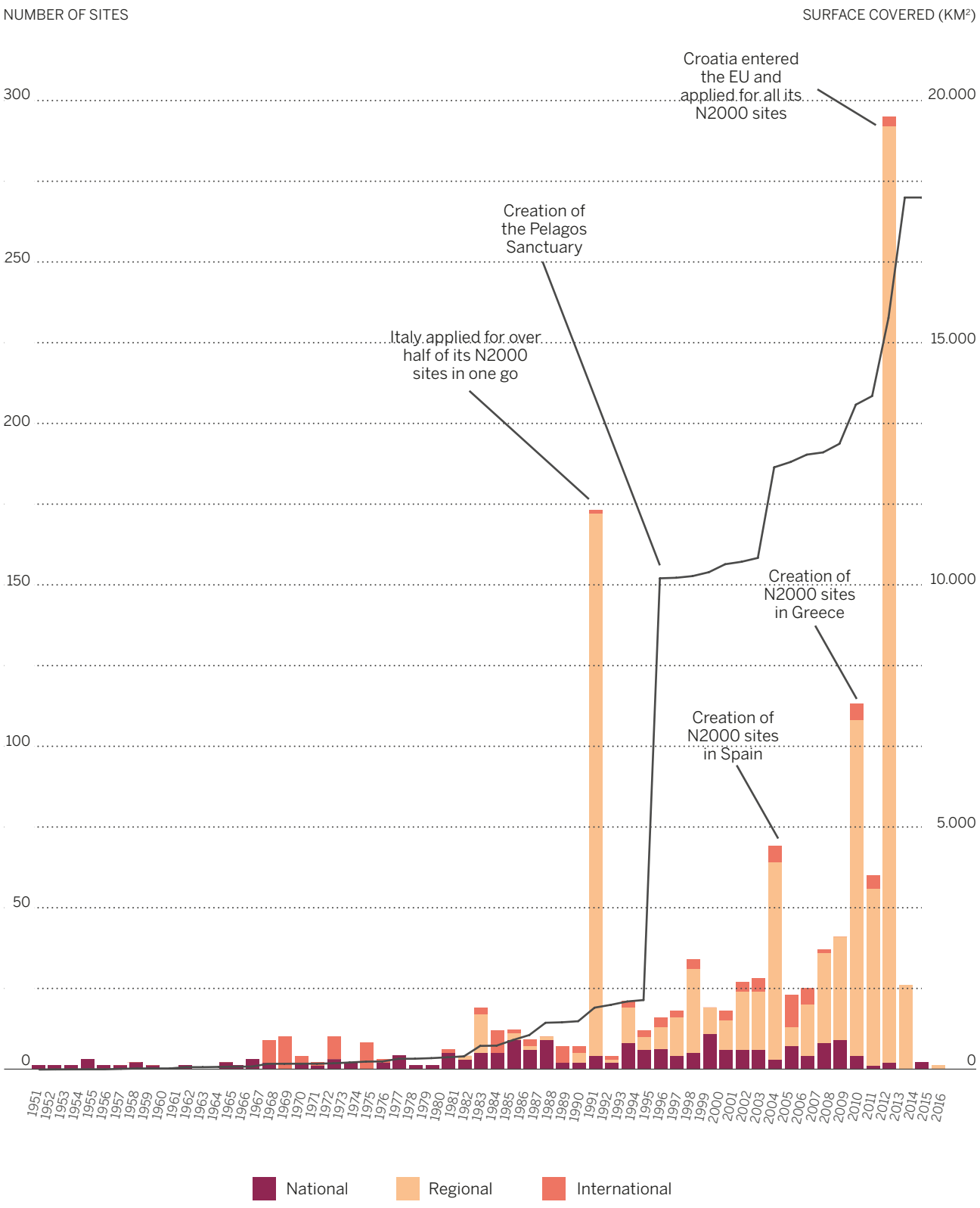



**FIGURE 7.** Number of MPAs and Marine Natura 2000 sites created per year by type of designation (national, regional and international) and cumulative surface areas from 1950 to 2016 (MEDPAN & UN ENVIRONMENT/MAP-SPA/RAC, 2016)

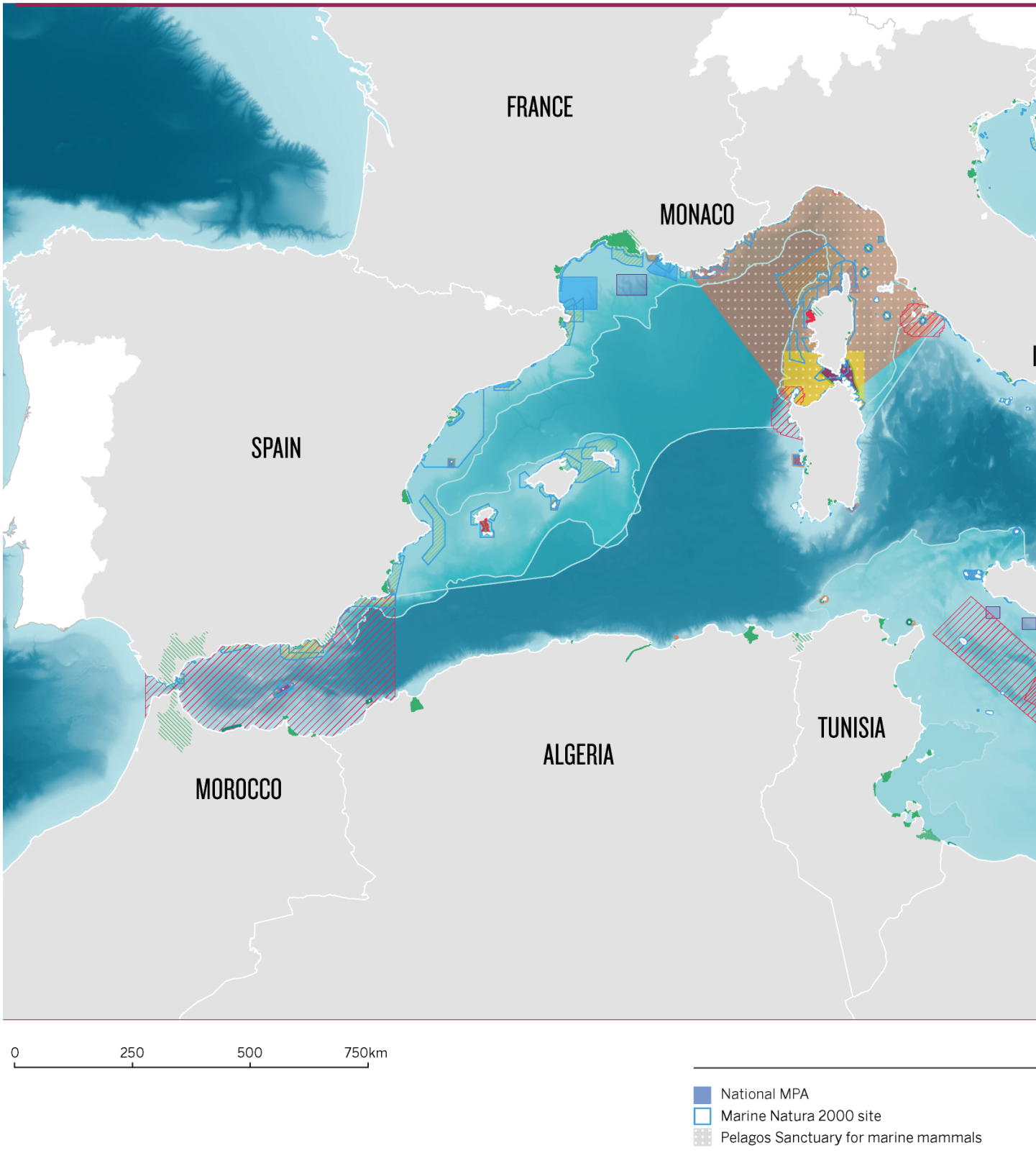
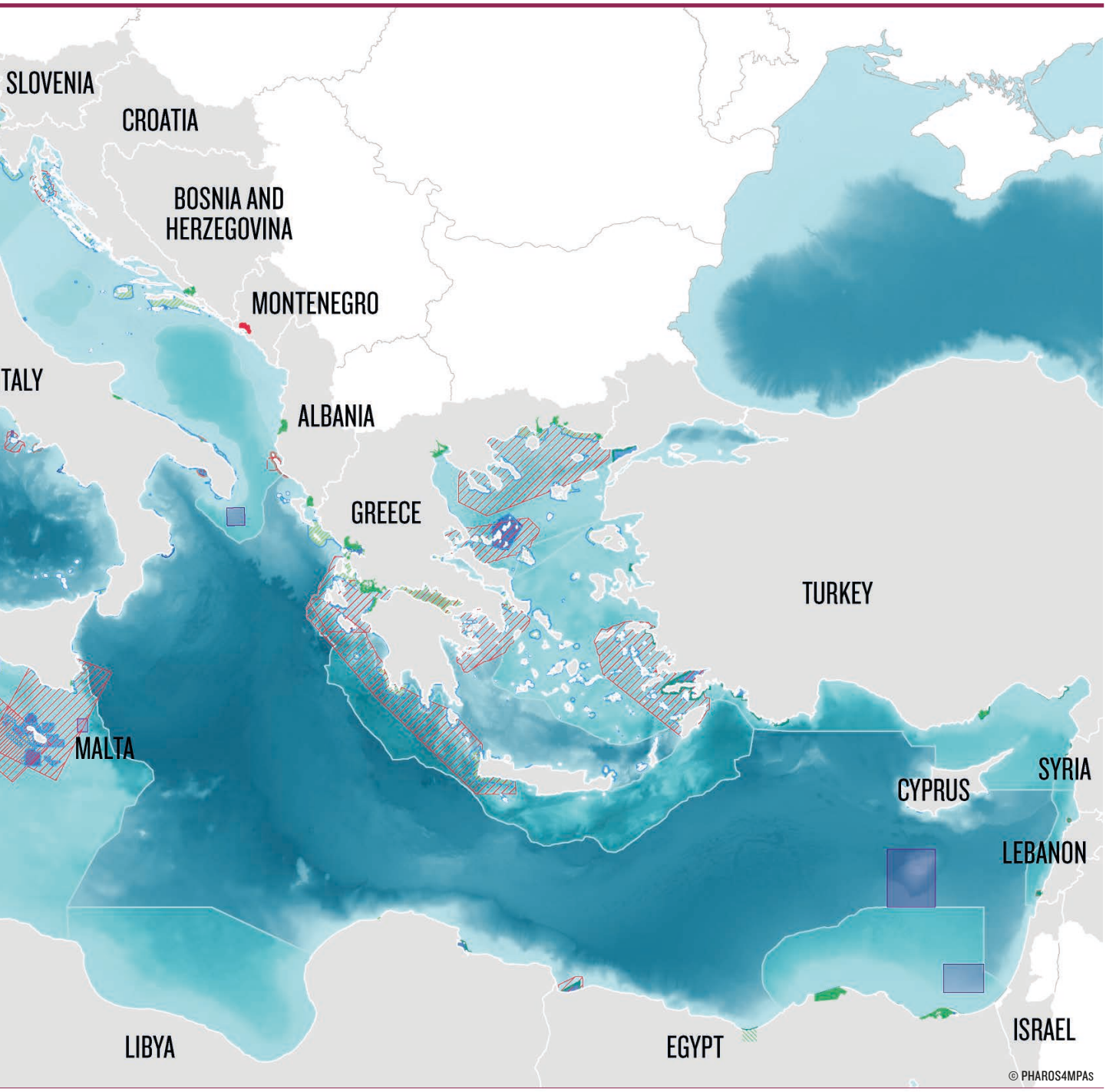



**FIGURE 6.** The Mediterranean MPA network in 2016 (MAPAMED, 2017)




**CONSERVATION AREAS**

- International Marine Park of the Bonifacio Strait
- SPAMI
- Fiseheries Restricted Area (FRA)
- World Heritage Site
- UNESCO Biosphere Reserve
- RAMSAR site

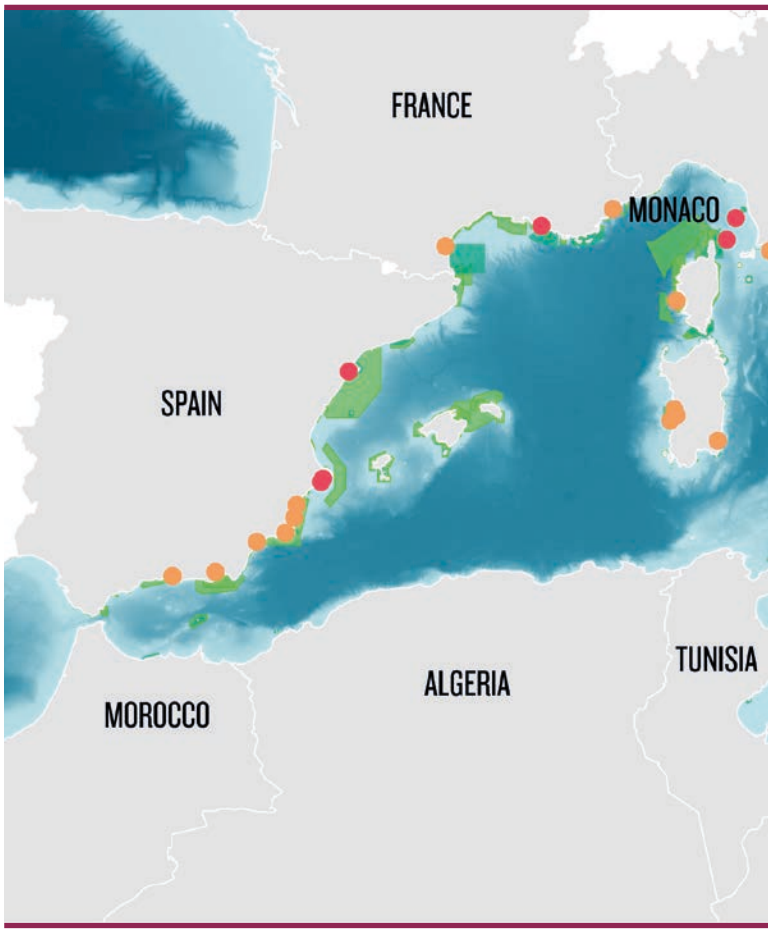
**AREAS OF CONSERVATION INTEREST**

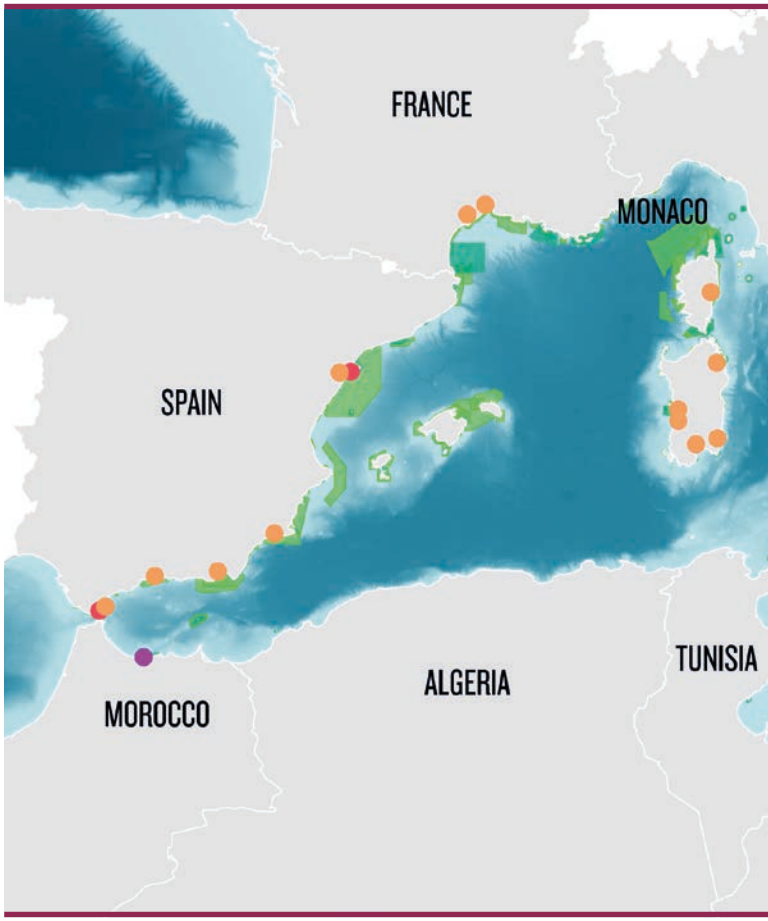
- Particularly Sensitive Sea Area (PSSA)
- EBSA
- Cetacean Critical Habitat (CCH)

# 2.1. SPATIAL INTERACTIONS BETWEEN MEDITERRANEAN MPAs AND MARINE AQUACULTURE

In this report we consider aquaculture in brackish and marine waters, including in estuaries and lagoons with a permanent connection with the sea.

Due to the lack of exhaustive GIS data on aquaculture farms, evidence on spatial interactions is currently scarce in the literature. By using national data sources for Italy, Spain, France and Greece along with WWF sources for Croatia, and overlapping this data with the map of Mediterranean MPAs, we have produced two maps showing MPAs or marine Natura 2000 sites where some fish farms (Figure 8) and shellfish farms (Figure 9) are located.



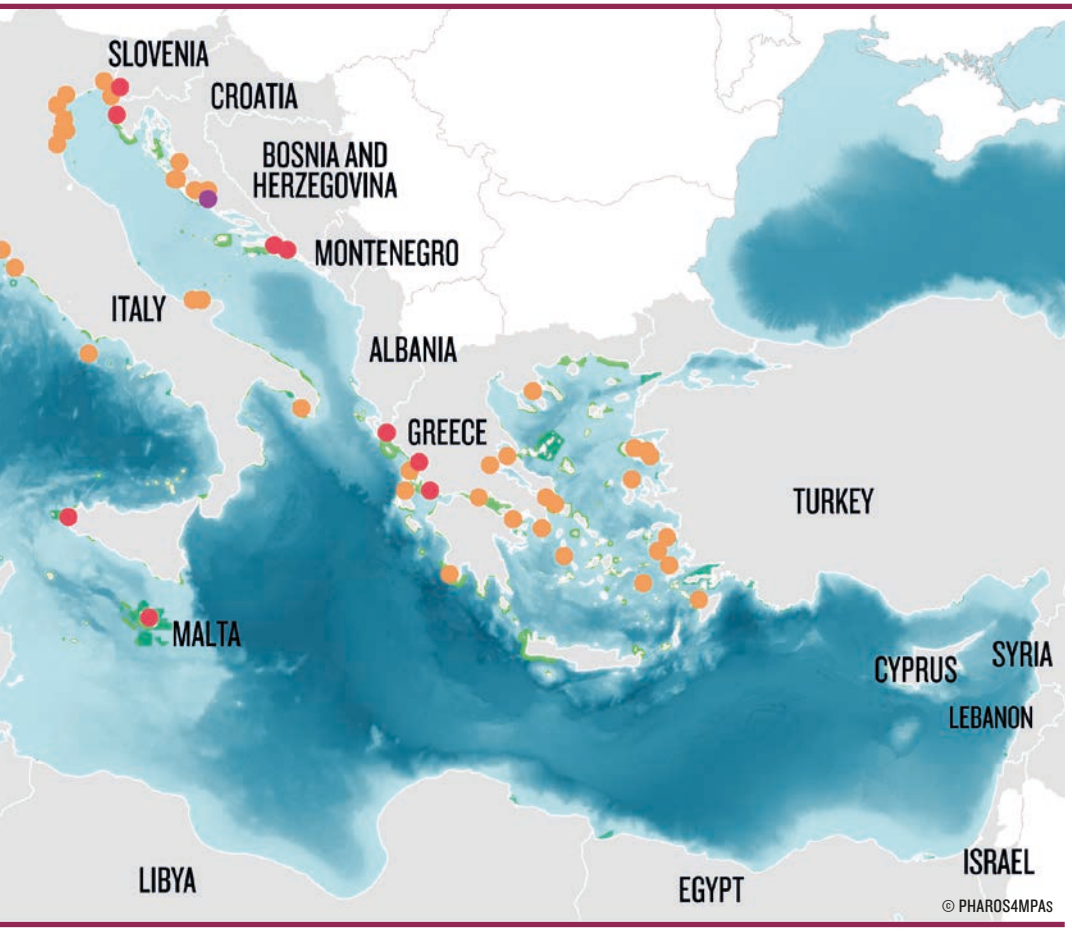



**FIGURE 8.** MPAs (purple dots), Natura 2000 sites (orange dots) and areas where both designations overlap (red dots) in which fish farms are located (WWF, 2019)

Conservation areas
SOURCES: MAPAMED (2017), EAA (2018), EMODnet (2018)
Conservation area in which fish farms are located
SOURCE: WWF (2019)

**CONSERVATION AREA IN WHICH FISH FARMS ARE LOCATED**

- National MPA
- National MPA and Natura 2000
- Natura 2000

**CONSERVATION AREAS**

- National MPA
- Marine Natura 2000 Site


**FIGURE 9.** MPAs (purple dots), Natura 2000 sites (orange dots) and areas where both designations overlap (red dots) in which shellfish farms are located (WWF, 2019)

Conservation areas
SOURCES: MAPAMED (2017), EAA (2018), EMODnet (2018)
Conservation area in which shellfish farms are located
SOURCE: WWF (2019)

**CONSERVATION AREA IN WHICH SHELLFISH FARMS ARE LOCATED**

- National MPA
- National MPA and Natura 2000
- Natura 2000

**CONSERVATION AREAS**

- National MPA
- Marine Natura 2000 Site

# COUNTRIES WITH HIGHEST INTERACTIONS

The PHAROS4MPAs MPAs and Aquaculture Advisory Group performed a 'country census' in order to roughly establish the presence or absence of aquaculture activities in MPAs, including marine Natura 2000 sites, and the related national aquaculture regulations. The aim was not to provide an exhaustive picture of the situation, but only to obtain an initial approximation of how MPAs interact with aquaculture in the Mediterranean Sea. The data was collected based on the personal knowledge or publications of Advisory Group members. It was complemented at country level by data extracted from national datasets when available. Results were obtained from 12 countries, seven of which were EU members (Table 1).

| COUNTRY | MPAs (excl. Natura 2000 sites) | | MARINE NATURA 2000 SITES | |
|---|---|---|---|---|
| | with fish farms | with shellfish farms | with fish farms | with shellfish farms |
| Albania | | | | |
| Algeria | | | | |
| Croatia | 1 | 2 | 5 | 4 |
| France | 1 | 0 | 2 | 3 |
| Greece | 2 | 1 | 15 | 4 |
| Italy | 3 | 1 | 33 | 32 |
| Malta | | | 1 | 0 |
| Morocco | | 1 | | |
| Slovenia | | 2 | 1 | 3 |
| Spain | 1 | | 3 | 6 |
| Tunisia | | | | |
| Turkey | | | | |
| **TOTAL** | **8** | **7** | **60** | **52** |

**TABLE I.** Aquaculture operations inside MPAs and marine Natura 2000 sites (WWF, 2019)

In some countries, legislation forbids any aquaculture operations inside MPAs. This is the case in Turkey and Albania, for instance. However, the country census revealed that some aquaculture farms are located in the close vicinity of MPAs, which raises concerns about their potential environmental impacts.

This is an issue in several regions, for instance near the Cap de Creus MPA in Catalunya, Spain. Vlora Bay, in Albania's Karaburun-Sazan National Park, contains eight fish farms within 10km of the Park; and there's a similar situation around the Kuriates Islands in Tunisia, which are surrounded by nine fish farms. However, more detailed data on these specific cases is needed to draw meaningful conclusions.

The presence of aquaculture farms inside MPAs and marine Natura 2000 sites mainly occurs in EU countries. The countries with the highest level of interactions, shown by the number of MPAs or marine Natura 2000 sites that host aquaculture farms within their boundaries, are Italy, Greece, Croatia and Spain.

However, these figures do not reflect the actual number of aquaculture farms located in the MPAs: in Italy, for instance, 105 fish farms, 462 shellfish farms and 10 crustacean farms aquaculture farms are located in MPAs and marine Natura 2000 sites (pers. comm. G. Marino). In addition, the number of Croatian sites might be underestimated as 21 concessions with farms were found surrounded by a marine Natura 2000 site from which their spatial extent has been excluded (Figure 10).

AQUACULTURE FARMS CLOSE TO KARABURUN-SAZAN NATIONAL PARK (ALBANIA)

© INSTITUTE FOR NATIONAL CONSERVATION OF ALBANIA

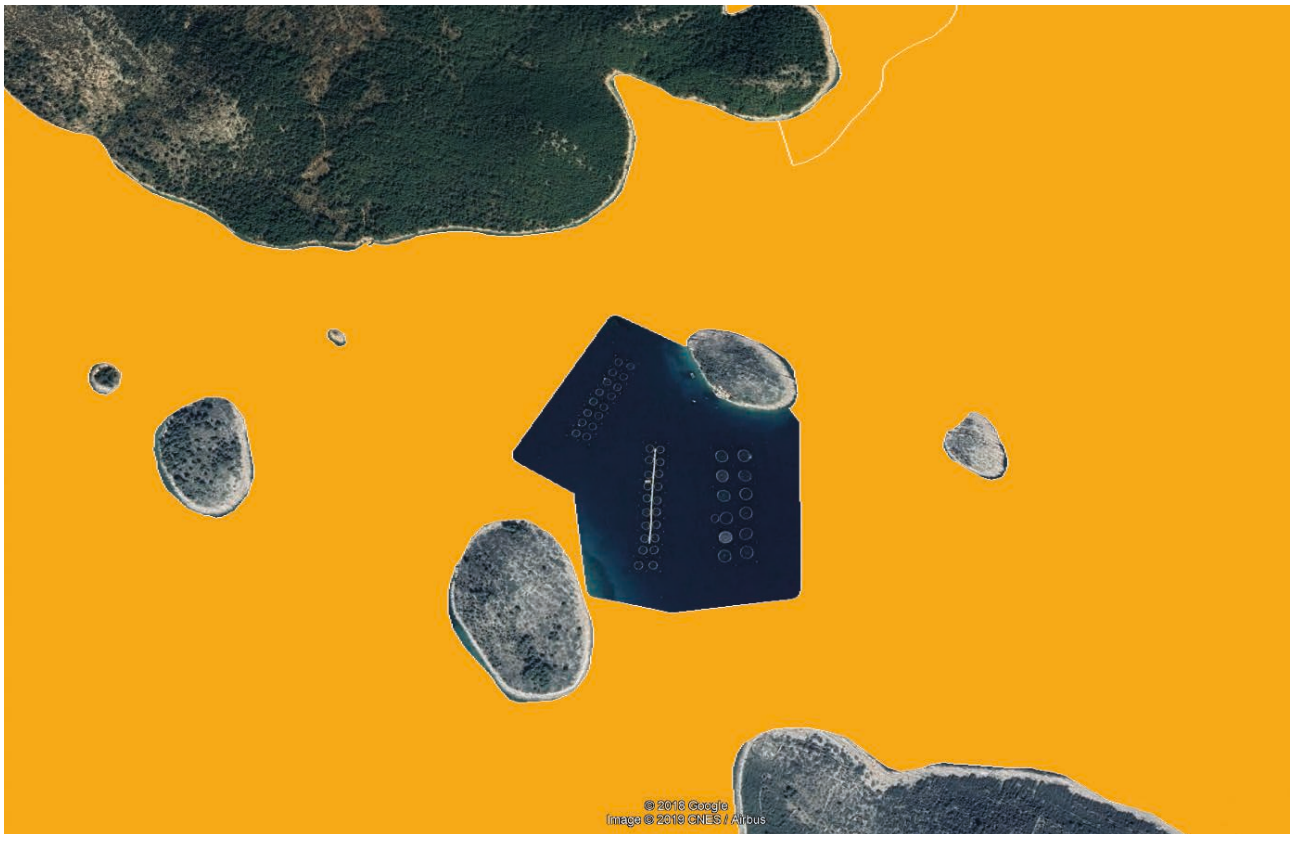



**FIGURE 10.** In Croatia, aquaculture concessions are often carved out from marine Natura 2000 sites, such as this one at Vrgada Island (N2000 site marked in orange). This may not make sense from an ecological perspective (WWF, 2019; GOOGLE EARTH, 2019)

## INCREASING INTERACTIONS

As shown above, future trends include both a development and increase of fish aquaculture production on one hand, and an increase in the number and coverage of MPAs on the other.

World aquaculture production is projected to surpass total wild capture fisheries production (food and non-food uses) in 2020 [19]. At the same time, Aichi Target 11 under the Convention on Biological Diversity requires that 10% of marine waters should be protected by 2020, and current discussions suggest that this target might be increased for the next decade. The IUCN calls for the protection of 30% of the planet's marine waters by 2030.

Interactions between aquaculture and MPAs are thus likely to increase, and the question is how this increase should be dealt with. Whatever the answer, in order to reconcile the human and environmental objectives of sustainable development it is clear that marine aquaculture must be developed based on an ecosystem approach practically applied in real-life situations.

### KEY FACTS

**10** MPAs

**60** NATURA 2000

Approximately 10 MPAs and 60 Natura 2000 sites shelter aquaculture farms in the Mediterranean

Interactions between marine conservation areas and the aquaculture sector will increase in the future

FISH FARM IN A NATURA 2000 SITE ON THE COSTA BLANCA (SPAIN)

© ERNEST ROSE / SHUTTERSTOCK

# 2.2. IMPACTS OF THE AQUACULTURE SECTOR ON MARINE ECOSYSTEMS

As with all human activities, aquaculture inevitably generates environmental and social impacts: the extent to which marine aquaculture is compatible with a healthy marine environment is one of the main questions concerning its sustainability. However, the interaction works both ways: while aquaculture may harm the marine environment, it may at the same time itself be seriously affected by other factors that cause water quality and habitat degradation.

## 2.2.1 IMPACTS OF FISH FARMING

Much of the debate on the impacts of marine aquaculture concerns fish aquaculture in particular (Table 2 and Table 3). The reason is that fish-farming in the Mediterranean has progressively shifted from producing herbivore fish such as grey mullet to producing predatory species such as sea bass. Such 'farming up' the food chain requires a supply of wild-caught fish to use as feed: this is a major issue, since the stocks targeted to produce fish meal are already fully exploited and will not support any further increase in fishing pressure. The aquaculture sector today faces a dual challenge: how can it alleviate the pressure on fish populations while responding to the increasing demand for seafood in local and international markets, without causing additional environmental problems?

### ESCAPES AND INTRODUCTION OF NON-INDIGENOUS SPECIES

At European level, there is a robust legislative framework (Reg.708/2007) for managing non-indigenous species introduced for aquaculture. However, as regulations are not always well managed at country level, such species can compete with native species for food and space if accidentally released into the natural environment; and they could also potentially transfer pathogens and/or parasites, disturbing wild fauna and ecosystem functions in the vicinity of aquaculture sites.

### EXCESSIVE INTAKES OF NUTRIENTS IN THE FOODWEB

Many studies have also pointed at overfeeding in fish farms (which may drift into surrounding foodwebs and favour some organisms over others) as the cause of changes in benthic community structure [20].

### EFFLUENT DISCHARGES

Effluent discharges from aquaculture facilities also pose environmental concerns, as they may contain residues of therapeutic products, antifouling agents or uneaten fish feed. If improperly managed, these discharges can lead to water eutrophication and oxygen depletion [20].

A number of studies have revealed the direct and indirect impacts of aquaculture in the Mediterranean, especially those linked to finfish in sea net pens and sensitive habitats [21,22,23]. Further research has provided information about the impacts on wild biota and habitat changes [24] showing interactions can vary in both qualitative and quantitative terms. Results depend on appropriate assessments, planning, zoning and siting: they may in fact not be negative if the right decisions are made during site selection, and if farmers sharing the same 'aquaculture management area' adopt best management practices (e.g. on biosecurity)[25].

| PRESSURE | ORIGIN |
|---|---|
| Sedimentation | Organic particulate load (faecal material, uneaten feed, detritus from biofouling, decomposing dead organisms); dissolved organic matter load (decomposition of uneaten feed) |
| Changes in biochemical processes | Nitrogen and phosphorus load from waste material; trace elements and micronutrients from faecal material and uneaten feed |
| Interactions with wild species | Accidental escape of farmed fish; involuntary release of gametes/larvae; exchange of parasites and pathogens; release of cultured fish for restoking |
| Use of chemicals | Zinc compounds in faecal material and in uneaten feed; copper compounds in antifouling treatments; disinfectants and drugs for disease treatments (prophylaxis and therapy) |
| Collection of wild organisms | Collection of wild fry, juveniles, sub-adults and adults of various species |
| Diseases spread | Parasites and indigenous pathogens; parasites and exotic pathogens |
| Spread of alien species | Intentional or accidental introduction of exotic species and associated organisms; parasites and exotic pathogens |
| Predator control | Fish-eating birds, marine mammals and other fish |
| Use of fishery resources in feeds (fish meal and oil) | Increasing of fishing pressure on wild stock (small pelagic fish) for fish meal and oil |

**TABLE 2.** Impacts caused by aquaculture and possible origins (MASSA ET AL., 2017, ADAPTED FROM MARINO 2011)

| PRESSURE CATEGORY | | System related Pressure Level | *Reefs: mussel beds* | *Reefs: polychaete* | *Seagrass beds* | *Sand/mudflats* | *Maerl beds* | *Kelps & seaweeds* | *Saltmarshes* | *Sand dunes* | *Shingle* | *Cetaceans* | *Pinnipeds* | *Otters* | *Fish* | *Birds* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sedimentation | Smothering | Medium | | | | | | | | | | | | | | |
| | Turbidity | Medium | | | | | | | | | | | | | | |
| Change in bio-geochemistry | Dissolved $O_2$ | High | | | | | | | | | | | | | | |
| | Nutrients | High | | ? | | | | | | | | | | | | |
| Change in coastal processes | | Negligible | | | | | | | | | | | | | | |
| Infrastructure impacts | | Negligible | | | | | | | | | | | | | | |
| Visual land and seascape modification | | Medium | | | | | | | | | | | | | | |
| Disturbance | | Medium | | | | | | | | | | | | | | |
| Predator control | | High | | | | | | | | | | | | | | |
| Chemical use | | High | | ? | | | ? | ? | | | | | | | | |
| Pathogen transmission | | Medium | | ? | | | | | ? | | ? | | | | | |
| Inter-breeding with wild organisms | | Medium | | | | | | | | | | | | | | |
| Introduction of allien species | | Medium | | | | | | | | | | | | | | |
| Indirect pressures on the ecosystem | | | | | | | | | | | | | | | | |

**TABLE 3.** Sea net pen culture habitat risk matrix: high pressure is shown in red, moderate in orange, low in yellow and negligible in white. The question marks indicate an uncertainty about the pressure (HUNTINGTON ET AL. 2006)

LONGLINE CULTURE (ALSO CALLED ROPE CULTURE) IN A MUSSEL FARM IN THE BAY OF KOTOR (MONTENEGRO)



## 2.2.2. IMPACTS OF SHELLFISH FARMING

In contrast to finfish, shellfish are generally considered as the most environmentally sound animal species to farm. Although they do generate an ecological impact (Table 4 and Table 5), it appears to be limited. This type of farming also minimizes concerns around welfare in captivity.

According to EU legislation (Water Framework Directive 2000), shellfish areas are considered as 'protected areas for farming', and they can also act as 'no-take zones' by permanently occupying a marine space. It is widely recognized that well placed and cleverly managed shellfish farms can provide services to coastal ecosystems such as carbon sequestration, nutrient or phytoplankton biomitigation, and benthic biodiversity restoration [2,26]. These areas also provide biomass for coastal ecosystems with the spillover of spat, or with longline mussels for wild sea bream predation.

Less positively, there's a growing concern in several areas of the Mediterranean, particularly in the Adriatic and Ionian Seas, over the use and disposal of plastic socks for mussel culture. According to recent data [27], these plastic nets make up the seventh most common category of litter recorded on beaches and the third most common category on the seafloor. In bottom trawl surveys in the Adriatic Sea, mussel nets accounted for 8.4% of the total marine litter gathered.

Similarly, a study conducted in the central and northern Adriatic [28] on the spatial distribution and typology of marine litter showed that aquaculture litter, mainly from shellfish farming, accounted for 17% of the plastic litter found in the area. The widespread use of these plastic nets is expected to lead to their accumulation in the marine environment and greater exposure risk for wild organisms and human populations over time – and that may have a long-lasting impact on the marine environment. Marine litter is an emerging issue not addressed in previous analysis [27,28].

PLASTIC SOCKS FROM MUSSEL FARMING LANDED BY A TRAWLER IN ANCONA, ITALY

© FABIO GRATI

| PRESSURE CATEGORY | | System related Pressure Level | Reefs: mussel beds | Reefs: polychaete | Seagrass beds | Sand/mudflats | Maerl beds | Kelps & seaweeds | Saltmarshes | Sand dunes | Shingle | Cetaceans | Pinnipeds | Otters | Fish | Birds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sedimentation | Smothering | Medium | | | | | | | | | | | | | | |
| | Turbidity | Medium | | | | | | | | | | | | | | |
| Change in bio-geochemistry | Dissolved $O_2$ | Medium | | | | | | | | | | | | | | |
| | Nutrients | Medium | | ? | | | | | | | | | | | | |
| Change in coastal processes | | Negligible | | | | | | | | | | | | | | |
| Infrastructure impacts | | Negligible | | | | | | | | | | | | | | |
| Visual land and seascape modification | | Medium | | | | | | | | | | | | | | |
| Disturbance | | Medium | | | | | | | | | | | | | | |
| Predator control | | Low | | | | | | | | | | | | | | |
| Chemical use | | Negligible | | | | | | | | | | | | | | |
| Pathogen transmission | | Negligible | | | | | | | | | | | | | | |
| Inter-breeding with wild organisms | | Negligible | | | | | | | | | | | | | | |
| Introduction of allien species | | Low | | | | | | | | | | | | | | |
| Indirect pressures on the ecosystem | | | | | | | | | | | | | | | | |

**TABLE 4.** Shellfish rafts and longline habitat risk matrix: high pressure is shown in red, moderate in orange, low in yellow and negligible in white. The question mark indicates an uncertainty about the pressure (HUNTINGTON ET AL. 2006)

JAPANESE CARPET SHELLS
(*RUDITAPES PHILIPPINARUM*)
© ISPRA

| PRESSURE CATEGORY | | System related Pressure Level | Reefs: mussel beds | Reefs: polychaete | Seagrass beds | Sand/mudflats | Maerl beds | Kelps & seaweeds | Saltmarshes | Sand dunes | Shingle | Cetaceans | Pinnipeds | Otters | Fish | Birds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sedimentation | Smothering | Low | | | | | | | | | | | | | | |
| | Turbidity | Low | | | | | | | | | | | | | | |
| Change in bio-geochemistry | Dissolved $O_2$ | Negligible | | | | | | | | | | | | | | |
| | Nutrients | Negligible | | | | | | | | | | | | | | |
| Change in coastal processes | | Negligible | | | | | | | | | | | | | | |
| Infrastructure impacts | | Low | | | | | | | | | | | | | | |
| Visual land and seascape modification | | Negligible | | | | | | | | | | | | | | |
| Disturbance | | Low | | | | | | | | | | | | | | |
| Predator control | | Low | | | | | | | | | | | | | | |
| Chemical use | | Negligible | | | | | | | | | | | | | | |
| Pathogen transmission | | Low | | ? | | | | | ? | | ? | | | | | |
| Inter-breeding with wild organisms | | Negligible | | | | | | | | | | | | | | |
| Introduction of allien species | | Medium | | | | | | | | | | | | | | |
| Indirect pressures on the ecosystem | | Negligible | | | | | | | | | | | | | | |

**TABLE 5.** Bottom shellfish culture habitat risk matrix: high pressure is shown in red, moderate in orange, low in yellow and negligible in white. The question marks indicate an uncertainty about the pressure (HUNTINGTON ET AL. 2006)

# DIFFERENT TYPES OF PRODUCTION = DIFFERENT LEVELS OF PRESSURE

The types and levels of pressures associated with aquaculture depend on the production system used. Table 6 compares the different types and the environmental pressures to which they give rise.

Compared to other types of marine aquaculture, net pens aquaculture holds the highest potential risks for several sensitive habitats, communities and species. In the Mediterranean, this relates mainly to the farming of seabream, seabass, meager and tuna.

| Environmental Pressures/Category | ECOLOGICAL CLASSIFICATION |
|---|---|
| | **Traditionnal classification (type and intensity of production)** |
| Sedimentation | Organic load |
| | Turbidity |
| Change in geochemical processes | Disolved $O_2$ |
| | Nutrients |
| Spread of alien species | |
| Interaction with wild species | |
| Use of chemical products | |
| Collection of wild forms | |
| Control of predators | |
| Disease spread | |
| Use of fishery resrouces in feeds (fish meal/oil) | |

A FISH FARM IN A PELOPONNESE BAY, GREECE

| | Open systems | | | Semi-open systems | | | | Closed Systems |
|---|---|---|---|---|---|---|---|---|
| | Intensive | Semi-intensive | Solar | Intensive | | Semi intensive | Extensive | Intensive |
| | Mollusc long lines | Mollusc bottom | Ranching | Fish (net pens) | Fish (tanks) | Fish (ponds) | Fish (valli, lagoons) | Fish (RAS)* |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**TABLE 6.** Key pressures and their links to aquaculture production systems: high pressure is shown in red, moderate in orange, low in yellow and negligible in white (ISPRA, 2011 ADAPTED FROM HUNTINGTON ET AL. 2006)

* Recirculating aquaculture system

In environmental terms for the Mediterranean:

- Sea net pen aquaculture is not compatible with reefs, seagrass, sand/mudflats, maerl beds or seaweeds (high or medium risk of impact); and its impacts need to be carefully evaluated for other habitats, communities and species.
- Shellfish rafts and longline aquaculture are not compatible with reefs, seagrass, sand/mudflats, maerl beds or seaweeds (high or medium risk of impact).
- Intertidal shellfish culture is not compatible with seagrass, sand/mudflats, maerl beds or seaweeds (high or medium risk of impact); and it needs to be carefully evaluated for other habitats, communities and species.
- Bottom shellfish culture is not compatible with seagrass, maerl beds or seaweeds (high or medium risk of impact); and it needs to be carefully evaluated for other habitats, communities and species.
- Only 'extractive species' (which absorb nutrients), such as bivalves or seaweed, can be farmed in waters which are already nutrient-rich.

The impact of the aquaculture will however be variable and is related to:

- Production system
- Site characteristics
- Farmed species
- Sensitivity of the receiving ecosystem

Thus, the effects should be estimated and monitored on a case-by-case basis, and any impact assessment should be specific in terms of site characteristics and production system used [30].

## KEY FACTS

Compared to other types of marine aquaculture, sea net pen aquaculture has the highest risk of impact on several sensitive habitats, communities and species.

# 2.3. COEXISTENCE: HOW FAR CAN THE AQUACULTURE SECTOR INTERACT WITH DIFFERENT TYPES OF MPAs?

The IUCN definition of a protected area is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".

Based on that definition, the IUCN identified six categories of protected areas depending on their primary conservation objectives.

| | |
|---|---|
| **Ia** | Strict Nature Reserve |
| **Ib** | Wilderness Area |
| **II** | National Park |
| **III** | Natural Monument |
| **IV** | Habitat / Species Manag. Area |
| **V** | Protected Landscape / Seascape |
| **VI** | Managed Resource Protected Area |

In an analysis performed in 2017, the IUCN suggests that some categories of protected areas could potentially accommodate aquaculture activities [2]:

- **Category IV,** aimed at protection of particular species or habitats (e.g. sanctuaries for marine mammals), often including active management to limit the impacts of human activities
- **Category V,** aimed at seascape protection, typically in coastal areas with a focus on the interaction of people and nature
- **Category VI,** aimed at sustainable use of natural resources, where social and economic benefits for local communities are included among secondary objectives.

| CATEGORIES | Ia | Ib | II | III | IV | V | VI |
|---|---|---|---|---|---|---|---|
| High density fish cage culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✳ | ✳ |
| High density on-land close system fish culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✳ | ✓ |
| Medium density on-land curculating system fish pond, culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✓ | ✓ |
| High density shell fish culture (table, long-lines) | ✗ | ✗ | ✗ | ✗ | ✳ | ✳ | ✓ |
| Low density pond/lagoon fish culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✓ | ✓ |
| High density seaweed culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✳ | ✓ |
| Low density shellfish culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✓ | ✓ |
| Medium density invertebrate (e.g. cucumber) culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✓ | ✓ |
| Integrated multi-trophic culture | ✗ | ✗ | ✗ | ✗ | ✳ | ✓ | ✓ |
| Restoration purpose aquaculture | ✳ | ✳ | ✳ | ✳ | ✳ | ✓ | ✓ |

✗ No ✓ Yes ✳ Variable, depends on whether the activity can be managed in such a way that it is compatible with the MPA's objectives.

**TABLE 7.** Illustrative example of a matrix of aquaculture systems and MPA categories. (Any actual version would need to be developed through extensive dialogue, so the table should not be taken to reflect the formal view of the IUCN or its Commissions (LE GOUVELLO ET AL., 2017))

FISH FARM IN A NATURA 2000 SITE, CORSICA (FRANCE)

© GLORIA MARIS

Defining what type of aquaculture could be appropriate for a MPA category is a key issue, and their interactions need to be carefully evaluated.

Table 7 is an illustrative example of a matrix of aquaculture systems and MPA categories proposed by IUCN[3].

In the Mediterranean specifically, it's important to note that IUCN categories have not been assigned to MPAs in most countries. It is hence difficult to make decisions based solely on IUCN criteria, but they nonetheless provide a framework for reflection.

# MPAs AND EXISTING AQUACULTURE ACTIVITIES

The aquaculture sector interacts widely with marine Natura 2000 sites, especially in Italy, Greece, Croatia and Spain – dozens of sites host aquaculture farms within their boundaries. In the case of national MPAs, 13 have aquaculture farms within their boundaries.

| Country | MPA | Fish farming | Shellfish farming |
|---|---|---|---|
| Croatia | Mali Ston Bay | | ✓ |
| | Lim Bay | ✓ | ✓ |
| France | Calanques National Park | ✓ | |
| Greece | Messolonghi-Aetoliko lagoons, estuaries of Acheloos, Evinos and Echinades islands | ✓ | |
| | Amvrakikos Wetlands National Park | ✓ | |
| | Axios Delta National Park | | ✓ |
| Italy | Parco Nazionale Arcipelago Toscano (Capraia island, Gorgona island) | ✓ ✗ | |
| | Parco Nazionale Arcipelago Pontino (Ponza island) | ✗ | |
| | Parco Nazionale sommerso di Baia (Baia, Bacoli, Campi Flegrei, Pozzuoli) | ✓ | ✓ |
| Morocco | Al Hoceima National Park | | ✓ |
| Slovenia | Strunjan Natural Reserve | | ✓ |
| | Debeli Rtic Natura Monument | | ✓ |
| Spain | Natura Park of the Ebro Delta | | ✓ |

**TABLE 8.** List of Mediterranean MPAs identified with ✓ aquaculture farm operating within the MPA boundary and ✗ farm inactive in 2019 (WWF, 2019)

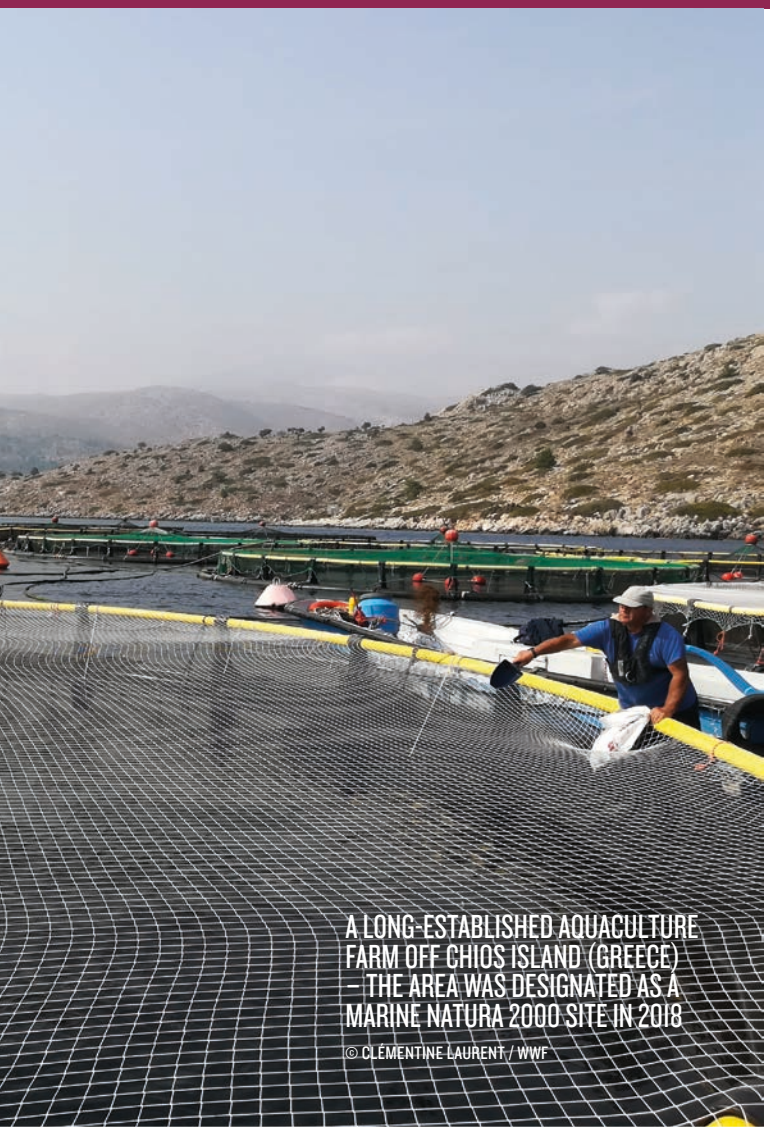
# INTERACTIONS: DIFFERENT CONTEXTS

## CASE I: AQUACULTURE FARM WAS ALREADY OPERATING BEFORE THE DESIGNATION OF THE PROTECTED AREA

This seems to be a common situation in the Mediterranean, and it needs to be remembered in discussions about area management: many aquaculture farms were established before the waters surrounding them were listed as marine Natura 2000 sites or other MPA designations (Figure 7). Aquaculture producers have by no means all been supportive of the new designations, since associated regulations could potentially lead to the relocation of farms and to increased environmental controls.

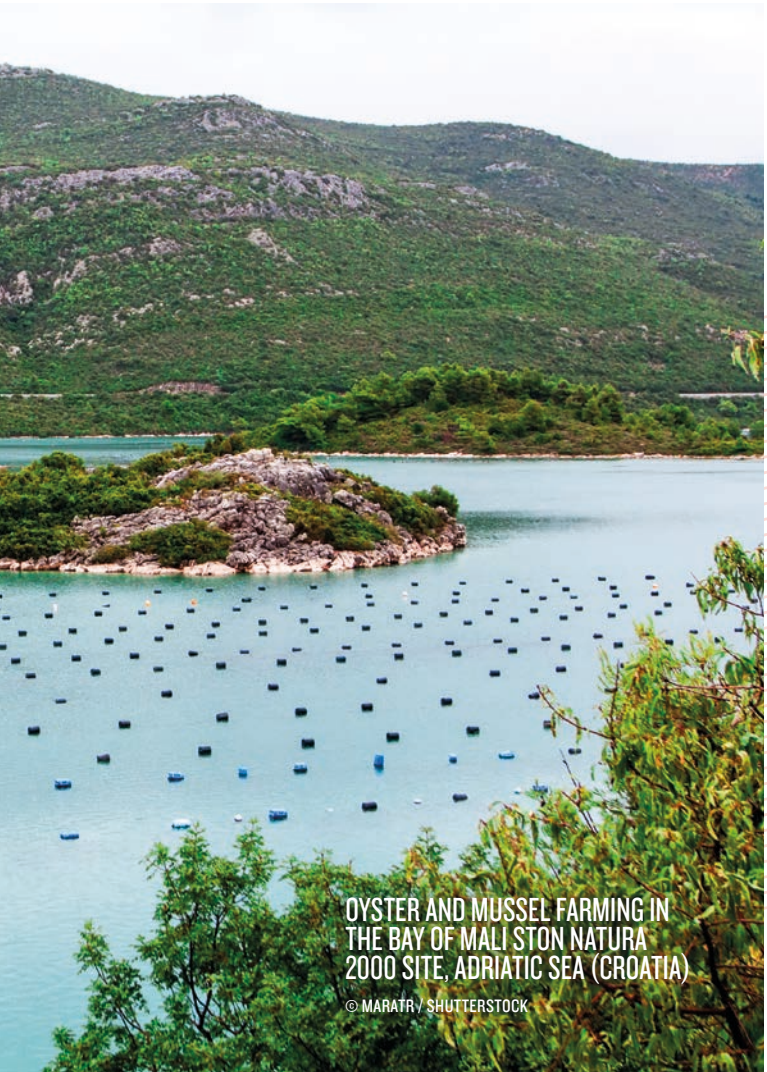
At EU level, a previous analysis [14] using the Natura 2000 dataset showed that more than 5% of the sites reported hosting aquaculture activities at the time of their designation, which equates to more than 1,200 special protection areas (SPAs) and sites of community importance (SCIs). The report states that aquaculture has traditionally been practised in many of those sites, and is considered compatible or has adapted its operations to the conservation needs of the sites [14].

However, in some cases, an MPA has been deliberately designated to benefit aquaculture production. Notably this is true for the Bay of Mali Ston, the highest shellfish production area in the eastern Adriatic, where an MPA was established to protect the mariculture. The tradition of collecting and cultivating the European oyster (*Ostrea edulis*) goes back a couple of centuries in this area, and the Mediterranean black mussel (*Mytilus galloprovincialis*) is also farmed here.



A LONG-ESTABLISHED AQUACULTURE FARM OFF CHIOS ISLAND (GREECE) – THE AREA WAS DESIGNATED AS A MARINE NATURA 2000 SITE IN 2018

© CLÉMENTINE LAURENT / WWF



OYSTER AND MUSSEL FARMING IN THE BAY OF MALI STON NATURA 2000 SITE, ADRIATIC SEA (CROATIA)

© MARATR / SHUTTERSTOCK

# CASE 2: AQUACULTURE DEVELOPMENT OCCURRED AFTER THE ESTABLISHMENT OF THE PROTECTED AREA

Cases of this kind may occur in the course of the development of national aquaculture strategies.

In Greece, for instance, the Law 4282/2014 'Development of aquaculture and other issues' (Law number 182/A /29-08-2014) regulates aquaculture permits and operations. There is also a Special Spatial Plan for Aquacultures which has identified marine areas suitable for further aquaculture development. Some of these areas overlap with protected areas. The Plan states that "sustainable aquaculture can be compatible and even beneficial for the management of Natura 2000 sites if allowed by the conservation targets and the management plans of these areas," but this has been criticized by environmental NGOs.

In one Mediterranean location, mariculture development has been allowed as a compensation for the loss of fisheries in an MPA, following the designation of a no-take zone. In Morocco's Al Hoceima National Park, a small area of approximately 200m x 200m at the edge of the park was granted to the artisanal fisher collective to practise mussel farming, in return for them respecting the areas forbidden to fishing within the Park.

## KEY FACTS

Many aquaculture farms are established in locations that later were designated as conservation areas. Traditional aquaculture practices are most compatible with these protected zones.

For aquaculture development occurring after the establishment of the protected area, high levels of sustainability should be respected.

PART THREE

# RECOMMENDATIONS FOR MEDITERRANEAN STAKEHOLDERS: PREVENT OR MINIMIZE IMPACTS OF AQUACULTURE ON MPAs

FOOD DISTRIBUTION AT A SEABASS AND SEABREAM FARM CLOSE TO PAKOSTANE ISLAND, ADRIATIC SEA (CROATIA)

This section gives an overview of recommendations for dealing with interactions between MPAs and aquaculture in the Mediterranean Sea. However, it's important to note these are general points: individual real-world examples should be carefully assessed on a case by case basis.

We also give specific recommendations addressing different stakeholder groups:

- Public authorities
- MPA managers
- Aquaculture producers

An understanding of coastal and marine ecosystem services and processes, together with responsible management and practices, can help reduce the environmental impacts of the aquaculture sector. Therefore, sustainable management guidelines for the aquaculture sector are essential tools for policymakers, administrators, aquaculture producers and other stakeholders.

# 3.1. PUBLIC AUTHORITIES

The FAO, GFCM, the EU, IUCN and a number of research institutions have developed guidelines to support public authorities at a national and regional level in making decisions concerning aquaculture in general and its interaction with MPAs in particular.

## RELEVANT REGULATORY FRAMEWORKS

The main relevant regulatory frameworks, as well as key guidelines and recommendations, are listed below:

- **Policy and governance in aquaculture: lessons learned and way forward (FAO Fisheries and Aquaculture Technical Paper No. 577):** this report aims to help countries improve governance of aquaculture activities within their jurisdiction [32].
- **The General Fisheries Commission for the Mediterranean:** the GFCM actively promotes an ecosystem approach to aquaculture (EAA). EAA is a strategy to integrate aquaculture within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems [33].
- **The Water Framework Directive (WFD 2000/60/EC)** addresses pollution and biodiversity concerns in inland, coastal and transitional waters (e.g. estuaries and fjords). It establishes a framework to prevent further deterioration of aquatic ecosystems and introduces the consideration of the biological community, as well as the natural structure and functions of the aquatic ecosystem, as a quality element in the assessment of surface water status.
- **The Marine Strategy Framework Directive (MSFD 2008/56/EC)** applies to marine waters which include the coastal waters covered by the WFD but extends to those waters which are under sovereignty of Member States (mainly EEZs). It requires EU Member States to achieve 'Good Environmental Status' for their marine waters by 2020, on a regional scale, as judged against a range of 11 so-called 'descriptors'.
- **The Mediterranean strategy for sustainable development (MSSD) 2016-2025** provides a strategic policy framework for securing a sustainable future for the Mediterranean region consistent with the Sustainable Development Goals. Adopted by the Barcelona Convention COP 19, it aims to harmonize the interactions between socio-economic and environmental goals, adapt international commitments to regional conditions, guide national strategies for sustainable development, and stimulate

regional cooperation between stakeholders in the implementation of sustainable development.

- **The strategy for the sustainable development of Mediterranean and Black Sea aquaculture,** adopted by FAO GFCM Resolution GFCM/41/2017/1, has been developed as part of an extensive consultation process. It envisages a future for Mediterranean and Black Sea aquaculture where a level playing field is achieved and the promotion of the sector is ensured so that it is more competitive, sustainable, productive, profitable and equitable. It is based on three targets and associated outputs and activities:
  - **Target 1:** Build an efficient regulatory and administrative framework to secure sustainable aquaculture development
  - **Target 2:** Enhance interactions between aquaculture and the environment while ensuring animal health and welfare
  - **Target 3:** Facilitate market-oriented aquaculture and enhance public perception.

Although it is not regulatory, the strategy is expected to help Mediterranean and Black Sea riparian countries in formulating harmonized aquaculture activities and action plans, paying special attention to current priorities and specificities at the local, national, subregional and regional level.

**National aquaculture strategies** must ensure sustainable development and growth, avoiding potential negative impacts in terms of non-indigenous species, eutrophication, seafloor integrity, concentrations of contaminants (both in the water generally and in seafood specifically), populations of commercial fish, and marine litter.

A majority of Mediterranean countries have adopted a strategy or plan for the development of their aquaculture sector (Figure 11). In 2016, this was the case for 62% of countries in the region.

**National public authorities** are the most influential actors in minimizing the impacts of aquaculture development on the marine environment. The rapid expansion of aquaculture in the Mediterranean has

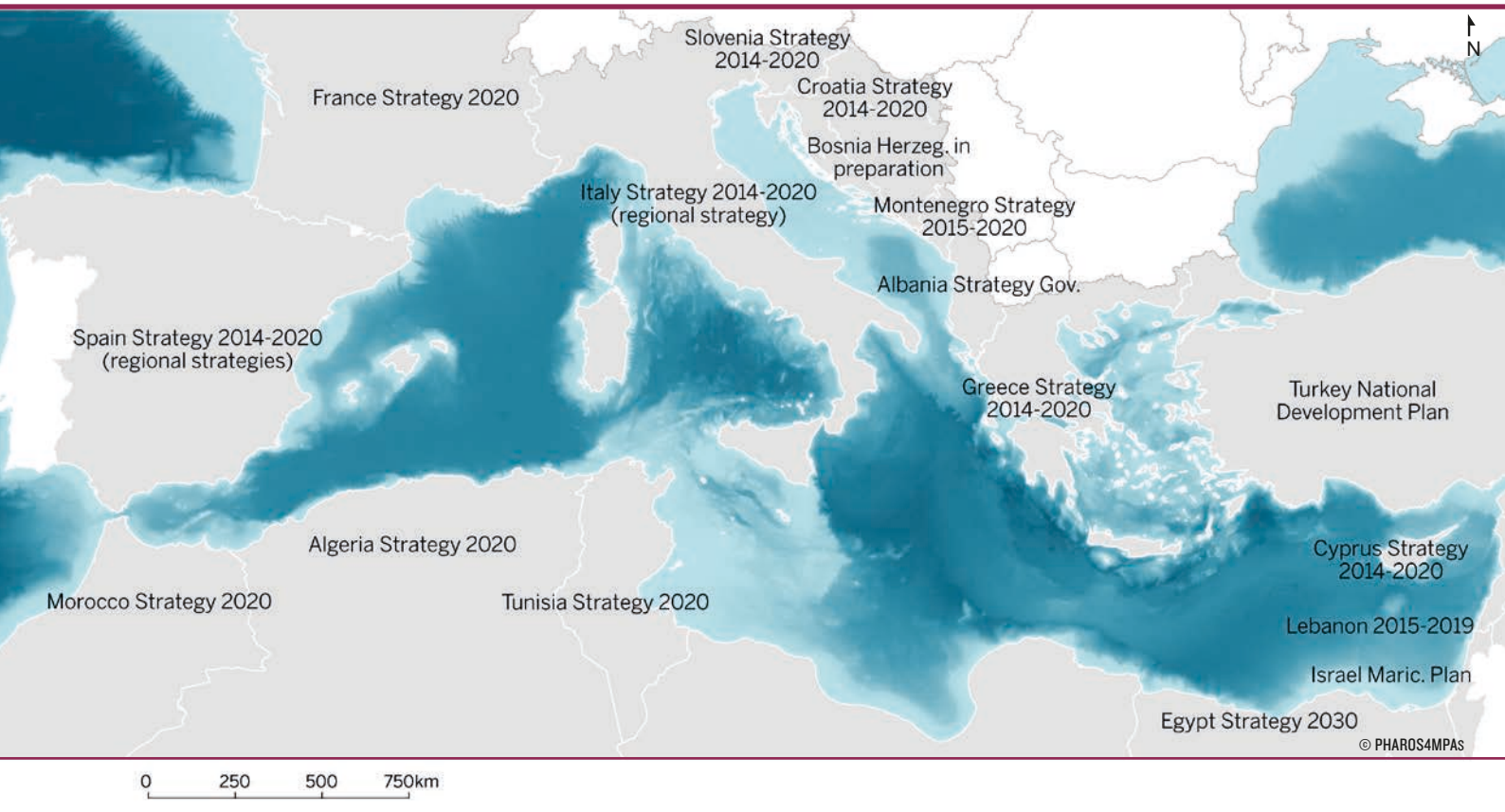



**FIGURE 11.** Regional aquaculture strategies and plans (MASSA, 2018)

intensified the competition for the use of coastal zones, and as such there is a pressing need to integrate aquaculture into marine spatial planning processes. **Without coordinated spatial planning, it will be impossible to move towards sustainable development for the sector: the process is a key European Commission aim, and member states are encouraged to ensure that it takes place** (COM 229 Final 2013; Common Fisheries Policy, 2013; EU Directive on Maritime Spatial Planning, 2014). Likewise, taking an ecosystem approach to aquaculture means it's necessary to assess the carrying capacity of the marine environment, to identify suitable boundaries for aquaculture production within ecological limits.

**Spatial planning for the sector in the Mediterranean is based on the establishment of allocation zones for aquaculture (AZA).**

## AZA: DEFINITION

An AZA is a marine area where the development of aquaculture is prior to other uses and which is dedicated to aquaculture, recognized by physical or spatial planning authorities that would be considered as a priority for local aquaculture development [34].

**The priority is to select sites with minimum impact on the environment.** Adopting AZAs can also improve the integration of aquaculture with other coastal activities, thus reducing conflicts among stakeholders on the use of the marine resources.

## GUIDANCE DOCUMENTS

There are a number of guidance documents to support the decision-making process:

- Marine Spatial Planning for Enhanced Fisheries and Aquaculture Sustainability. FAO Fisheries and Aquaculture Technical Paper - T604, 2016. [35]
- Ecosystem approach to aquaculture. Aquaculture development. 4. FAO Technical Guidelines for Responsible Fisheries. FAO 2010 No. 5, Suppl. 4 [36].
- Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. FAO. 2017 [25].
- Guidance on Aquaculture and Natura 2000. European Commission. 2012 [14].
- The Future Brief on Sustainable Aquaculture. European Commission. 2015 [37].

In addition to these technical guidelines, geographic information system (GIS) tools which include multiple criteria for MSP have been developed for aquaculture siting. For instance, AquaSpace is a GIS tool which allows integrated assessment and mapping of 30 indicators reflecting economic, environmental, inter-sectorial and socio-cultural risks and opportunities for proposed aquaculture systems in a marine environment. The outputs comprise detailed reports and graphics allowing key stakeholders such as planners or licensing authorities to evaluate and communicate alternative planning scenarios and to take more informed decisions [38].

It is also important to consider the complex cumulative effects on the marine environment of aquaculture along with other anthropogenic activities. Some EU countries are making progress on this issue, which is considered as very important in implementing the Marine Strategy Framework Directive and the achievement of Good Environmental Status of marine waters by 2020.

## RECOMMENDATIONS TO PUBLIC AUTHORITIES ON INTERACTIONS BETWEEN MPAs AND AQUACULTURE:

- Only marine aquaculture farms with no detrimental effect on the designated protected areas should be permitted in MPAs, and this should be decided on a case-by-case basis.
- Fish farms with sea net pens settlements in areas with significant seagrass meadows and coralligenous formations and/or important fish habitats, spawning grounds and nursery areas should not be allowed. In general, habitats sensitive to the discharge of organic matter are not appropriate for fish or shellfish aquaculture.
- In general, fish farms with sea net pens settlements inside or in the close vicinity of MPAs should be avoided. Buffer zones should be maintained between sea net pens settlements and protected areas, according to the type of aquaculture and the conservation objectives of the protected area.
- The farming of exotic species should be avoided in MPAs.
- Industrialized intensive fish production should be avoided in MPAs.

OYSTER BEDS IN THE THAU LAGOON NATURA 2000 SITE, FRANCE

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## RECOMMENDATIONS TO PUBLIC AUTHORITIES ON INTERACTIONS BETWEEN MARINE NATURA 2000 SITES AND AQUACULTURE:

**The EU Commission Guidelines on Aquaculture and Natura 2000 offer clear advice on this subject [14].** Only marine aquaculture farms without a detrimental effect on the habitats and species protected under the Birds and Habitats Directive should be permitted in marine Natura 2000 areas, and these should be assessed on a case-by-case basis.


To provide a solid basis for implementing these recommendations both in MPAs and marine Natura 2000 areas, national public authorities should put in place environmental monitoring programmes for marine aquaculture. While such monitoring is usually made mandatory in national regulatory frameworks, in some countries stakeholders mention that this monitoring is left to the aquaculture producers themselves, without any public oversight. Beside, it makes sense that public research on sustainable aquaculture should be encouraged to support businesses in progressively enhancing production efficiency and sustainability.

# 3.2. MPA MANAGERS

MPAs are promoted globally as a tool for managing fisheries, conserving species and habitats, maintaining ecosystem functioning and resilience, preserving biodiversity, and protecting countless human values associated with the ocean. Ecologically, MPAs have been shown to be effective at protecting or reducing degradation of habitats and ecosystems and increasing biomass and species diversity, richness, and numbers. However, while the principal mandate of MPAs is conservation of marine resources and biodiversity, they can also lead to beneficial local development outcomes which increase community support.

In a multi-use MPA, management objectives are usually defined by a legal text: this may clarify whether aquaculture development within some zones of the MPA is legal, and thus possible or not.

## RECOMMENDATIONS TO MPA MANAGERS ON INTERACTIONS BETWEEN MPAs AND AQUACULTURE:

- In MPAs, when allowed, aquaculture should follow current best practice. Sustainability criteria must be established in collaboration with the relevant authorities.
- When unsustainable aquaculture practices are identified as a threat to an MPA, actions to mitigate them should be included in the MPA management plan.
- Once key action points have been prioritized, a list of possible strategies to address them should be developed. These may include a wide range of conservation actions such as territory protection, policy change, education or habitat restoration.

## CASE 1: AQUACULTURE ALREADY OPERATING IN THE MPA

The first step in establishing sustainable aquaculture within an MPA is to gain a clear baseline understanding of its effects, through an environmental and social diagnosis of the current operation. Each production cycle should be monitored and include sediment monitoring based on benthic macrofauna and physical-chemical parameters of granulometry, total organic matter, pH, redox potential and temperature. It is also necessary to define the allowable zone of effect (AZE), determine the acceptability limits, and ascertain if marine biodiversity is being affected or not (unsustainable practices can lead to anaerobic conditions).

Once this information has been gathered, tools that promote environmental commitments must be identified and agreements reached with companies regarding the implementation of good aquaculture practices. The strategy should also include the implementation of follow-up mechanisms through participatory environmental monitoring in which the companies play an active role.

All actions recommended here should be discussed and agreed with the aquaculture companies involved.

| STRATEGY | | |
|---|---|---|
| **Responsible aquaculture in the MPA** | | |
| **GOALS** | **RESULTS ASSOCIATED** | **INDICATOR** |
| Management plan includes a responsible aquaculture strategy and 100% of environmental quality indicators have a baseline | Environmental and social diagnosis of the current aquaculture operation | Percentage of environmental quality indicators with a baseline |
| Within two years of the strategy's approval, the farm has begun the process of implementing impact reduction | Voluntary agreements formally adopted by company | Number of farms with impact mitigation tools in place |
| Within three years of the strategy's approval 50% of impact mitigation measures are implemented | Environmental mitigation measures in place | Percentage of mitigation measures implemented |

**TABLE 9.** Example of a strategy to achieve sustainable aquaculture in an MPA (WWF, 2019)

## CASE 2: AQUACULTURE DEVELOPMENT PLANNED IN THE MPA

The recommendations above apply here too. Baseline data on the state of the marine environment is needed before any new aquaculture development begins within the boundaries of the MPA, so impacts can be monitored and the evolution of the marine environment compared against a solid baseline. In general, MPAs should favour community-driven small-scale aquaculture developments.

**For both existing and future developments, best aquaculture practices should be officially agreed by all stakeholders. For MPA managers in particular:**

- Get to know the aquaculture producer, its operations, its difficulties and constraints. Involve the producer in all relevant consultation processes led by the MPA.
- Educate the MPA management team about the ins and outs of the marine aquaculture sector.
- Make sure relevant monitoring data collected by public authorities is made available to the MPA. This may require a confidentiality clause, but it is essential data for the management of the MPA.
- Ensure that the environmental standards required from aquaculture operations are respected, and include these in the management plan of the MPA.

# VOLUNTARY AGREEMENTS, MARKET TOOLS AND INCENTIVES FOR ENVIRONMENTAL COMMITMENTS

Agreed environmental quality standards should be a priority for aquaculture operations in protected areas, based on environmental certifications and similar tools. Best practices can be publicized and shared through the adoption of codes of conduct promoted by national producers' associations, as well as certification schemes.


ORGANIC STANDARD LABELS IN A CRATE OF SEA BREAM READY FOR MARKET

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EXAMPLE OF CERTIFIED AQUACULTURE: SEA BASS AND SEA BREAM GROWN IN SEA NET PENS IN THE AJACCIO BAY NATURA 2000 SITE, CORSICA, FRANCE

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However, existing standards such as organic or ASC (Aquaculture Stewardship Council)[2] may not address all the objectives of an MPA or a marine Natura 2000 site. New certification standards could be created (e.g. 'certified MPA-friendly') [2]. As a real-world example, France's Calanques National Park is currently developing its own quality standard, 'Label Parc', for marine aquaculture. Beside, eco-management systems, like EMAS, may enable aquaculture operations to be controlled and continuously improved.

[2] The ASC's Seabass, Seabream and Meagre Standard has been developed jointly by Nireus, the leading fish producer in Greece and the Mediterranean, in partnership with WWF-Greece. The standard was launched in Septembre 2018 and is applicable to all species in the genera Dicentrarcus, Sparus, Pagrus and Argyrosomus and in all regions (e.g. in the Mediterranean Sea and Pacific) where these fish are cultured in sea net pens, from hatchery to grow-out stages.

## THE SMALL SCALE AND MULTI-STANDARD STRATEGY OF AN AQUACULTURE PRODUCER

The Gloria Maris group is a French company which focuses on small-scale high-quality production (1,000 tonnes) at two fish farms (sea bass, sea bream and meagre) located in Corsica, France. They are engaged in different certification processes, such as the **French organic standard.**

One of the farms is located within the Ajaccio Bay marine Natura 2000 site, and there is a continuous dialogue between the company, the management body of the site and the public French Biodiversity Agency. The site is certified **Friends of the Sea.** The meagre is certified **'Label Rouge'.** Research is ongoing on integrated multi-trophic aquaculture.

# 3.3 AQUACULTURE BUSINESS SECTOR

Aquaculture companies have a responsibility to minimize the impacts of unsustainable practices on MPAs: current expertise and fast-developing technology can both contribute significantly to this aim. Furthermore, a visible commitment to sustainability provides real corporate image benefits in a market where environmentally-friendly practices and eco-responsibility agreements are becoming increasingly important.

## RECOMMENDATIONS TO BUSINESS SECTOR:

- **Adhere to the legal framework.** Respect national legislation imposing restrictions on the establishment of extractive activities within the MPA.
- **When performing the environment impact assessment (EIA) required by national authorities, take into account all the available scientific knowledge** and involve the site management body in the review of the EIA. Use this as a baseline to demonstrate that operations are not having a significant adverse impact on the numbers or distribution of designated species, such as overwintering bird populations, subject to natural change.
- **Implement best management practices to deal with environmental and social issues specific to each MPA and aquaculture site:**
  - — Implement an environmental monitoring plan
  - — Create a dialogue with the MPA manager and local communities.
  - — Make all monitoring data available to the management body of the MPA or marine Natura 2000 site
  - — Adopt the best possible sustainable practices: this often means going beyond national regulations
  - — Sustainability standards might be an option, and should be carefully investigated. Different sustainability standards are available for marine aquaculture including both global standards and national standards: organic aquaculture standards, local standards, Aquaculture Stewardship Council, Friends of the Sea etc...
- **Comply with the following conditions for waste management:**
  - — Adopt measures to prevent the dumping of solid and liquid waste from aquaculture activities, including mortalities, blood compounds, chemicals, sludge and other materials and substances of any origin which may affect the seabed and water column
  - — The accumulation, transfer and disposal of such wastes and residues should be done in airtight containers that prevent runoff residue/waste
  - — Maintain the cleanliness of beaches and beach grounds in the vicinity of the farm, by removing any solid residue generated by aquaculture
  - — At the end of the farm's activities, remove all non-degradable or slow-degradable supports that have been used as a bottom fixing system, with the exception of concrete structures, bolts and anchors (inert material like this has very limited effects on the environment, and may sometimes create a positive 'reef effect' when left in place).
- Promote the replacement of fish meal and fish oil with alternative feed products such as algae or insect-based raw materials
- Whenever possible, contribute to scientific research on sustainable aquaculture.

# ACRONYMS

| | |
|---|---|
| AZA | Allocation Zones for Aquaculture |
| AZE | Allowable Zone of Effect |
| CBD | Convention on Biological Diversity |
| EAA | Ecosystem Approach to Aquaculture |
| EEA | European Environment Agency |
| EEZ | Exclusive Economic Zone |
| EIA | Environment Impact Assessment |
| EU | European Union |
| FAO | Food and Agriculture Organisation |
| FM | Fish Meal |
| FO | Fish Oil |
| GES | Good Environmental Status |
| GFCM | General Fisheries Commission for the Mediterranean |
| GIS | Geographic Information System |
| ICCAT | International Commission for the Conservation of Atlantic Tunas |
| MPA | Marine Protected Area |
| MSFD | Marine Strategy Framework Directive |
| MSSD | Mediterranean Strategy for Sustainable Development |
| NGO | Non-Governmental Organization |
| OECM | Other Effective Area-Based Conservation Measures |
| RAS | Recirculating Aquaculture System |
| SCI | Sites of Community Importance |
| SME | Small or Medium Enterprise |
| SPA | Special Protection Areas |
| TAC | Total Allowable Catches |
| WFD | Water Framework Directive |

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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** km²

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

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- LEISURE BOATING
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