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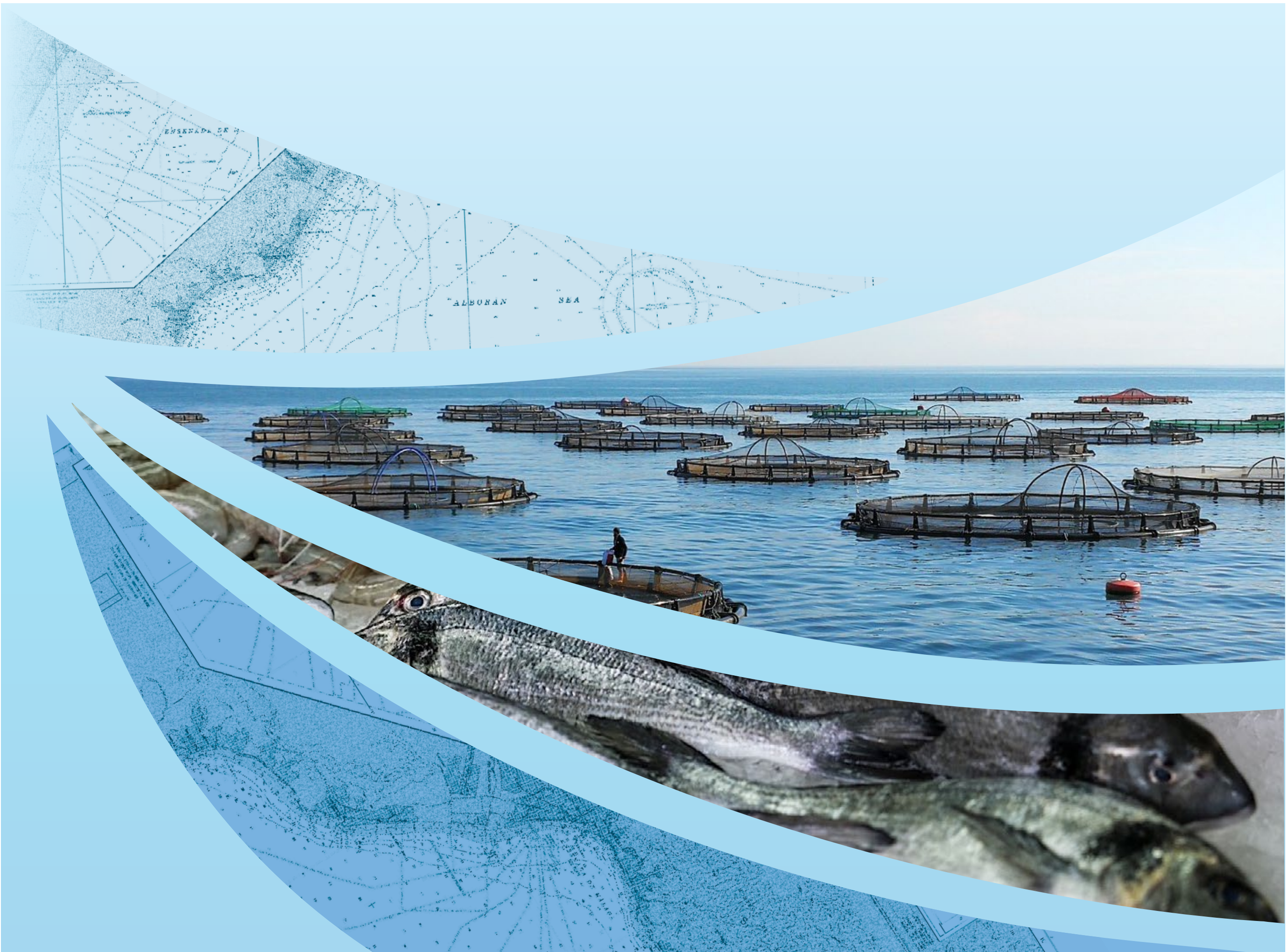
A guide for the establishment of coastal zones dedicated to aquaculture in the Mediterranean and the Black Sea



Cover image and design: Mosaic of aquaculture activities in the Mediterranean and the Black Sea, nautical charts and farmed gilthead seabream (*Sparus aurata*).
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GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

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ALLOCATED ZONES FOR AQUACULTURE

A guide for the establishment of coastal zones dedicated to aquaculture in the Mediterranean and the Black Sea

José Carlos Macias, Pablo Avila Zaragozá, Ioannis Karakassis,
Pablo Sanchez-Jerez, Fabio Massa, Davide Fezzardi, Güzel Yücel Gier,
Vlasta Franičevič, Joseph A. Borg, Rosa María Chapela Pérez,
Paolo Tomassetti, Dror L. Angel, Giovanna Marino, Hassan Nhhala,
Houssam Hamza, Coline Carmignac and Linda Fourdain

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Preparation of this document

This publication is based on the findings of the project Developing site selection and carrying capacity guidelines for Mediterranean aquaculture within aquaculture appropriate areas (SHoCMed), implemented by the Scientific Advisory Committee on Aquaculture (CAQ) of the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) with the support of the European Union (Directorate-General for Maritime Affairs and Fisheries of the European Commission). Concluded in 2016, SHoCMed aimed at developing criteria, standards and guidelines for GFCM contracting parties and cooperating non-contracting parties to improve site selection criteria and set capacity benchmarks and references for aquaculture activities in the Mediterranean.

This guide intends to be a practical tool to facilitate the understanding of site selection and planning for aquaculture and provide information on processes for establishing allocated zones for aquaculture (AZAs) in the Mediterranean and Black Sea region. It is complemented by a toolkit, prepared by the GFCM Secretariat, which gathers a collection of useful documents and information regarding the practical implementation, benefits and management of AZAs in Mediterranean and Black Sea countries.

This document was prepared taking into account the developments related to the AZA concept over the years and based on practical experiences in different countries of the region, as well as an analysis of future development prospects for sustainable aquaculture.

This publication and its contents do not have a legal character and should therefore be used as a guidance document to inform specific local and national policies in relation to aquaculture development.

Abstract

In the Mediterranean and the Black Sea, the future development and expansion of aquaculture will highly depend on the availability of space to develop this activity in a sustainable way. Allocated zones for aquaculture (AZAs) are therefore considered as an essential instrument towards the sustainable development of aquaculture, under a blue growth perspective, and they have a special role to play in marine spatial planning.

This guide is a collection of concepts and practical information aimed at facilitating the establishment of AZAs in the Mediterranean and the Black Sea. It provides detailed information on the process involved in the establishment of an AZA and it is intended as a practical and comprehensive tool to better understand site selection and planning for aquaculture.

This publication first provides a brief overview of the international and regional context, and reviews the institutional and legal framework related to AZAs at various levels. Sequential explanations on the AZA establishment process, as well as suggestions for the main steps are then presented. The step-by-step approach for the establishment of AZAs takes into account a number of specific aspects, such as geographic information system tools, exclusion criteria and stakeholder participation, the main actors to be involved, the role of relevant authorities in charge of geographical and/or marine aquaculture planning, statutory responsibilities, prevention and resolution of possible conflicts, and decision-making. The guide also describes the objectives and contents of AZA management plans and presents the parameters to be used as reference points for the AZA implementation.

The AZA process is supported by a number of tools, such as Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture, and the Guidelines on a harmonized environmental monitoring programme for marine finfish cage farming in the Mediterranean and the Black Sea, which are also briefly outlined here.

This guide is addressed to decision-makers from relevant bodies and administrations, governmental and non-governmental organizations, scientific research institutions, aquaculture producers and fishing communities, as well as other relevant stakeholders involved in aquaculture activities, coastal development, and in the use of the aquatic environment and resources.

It has been developed taking into account the strategic role of marine coastal aquaculture in responding to the growing global demand for seafood and in delivering social and economic benefits to coastal communities. It will hopefully facilitate the integration of aquaculture into coastal areas and contribute to supporting sustainable and responsible aquaculture development in the Mediterranean and the Black Sea.

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Tables, figures, boxes

Abbreviations and acronyms

AMA	aquaculture management area
AquaSpace	Ecosystem Approach to making Space for Aquaculture
AZA	allocated zone for aquaculture
AZE	allowable zone of effect
CAQ	Scientific Advisory Committee on Aquaculture
Chl-a	Chlorophyll a
COFI	Committee on Fisheries
CPCs	contracting parties and cooperating non-contracting parties
DIN	dissolved inorganic nutrients
DO	dissolved oxygen
EAA	ecosystem approach to aquaculture
EIA	environmental impact assessment
EQS	environmental quality standard
EQO	environmental quality objective
EMP	environmental monitoring programme
EU	European Union
ESRI	Environmental Systems Research Institute
FAO	Food and Agriculture Organization of the United Nations
FARM	Farm Aquaculture Resource Management
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GIS	geographic information system
Ha	hectares
ICAM	integrated coastal area management
ICES	International Council for the Exploration of the Sea
ICZM	integrated coastal zone management
IMTA	integrated multi-trophic aquaculture
InDAM	Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean
IOC	Intergovernmental Oceanographic Commission
IUCN	International Union for Conservation of Nature
M	metre
MEU	Ministry of Environment and Urbanization, Turkey
MFAL	Ministry of Food, Agriculture and Livestock, Turkey
MPA	marine protected area
MSP	marine spatial planning
LOI	loss of ignition
PCI	principles-criteria-indicators
POM	particulate organic matter
SHoCMed	Developing site selection and carrying capacity guidelines for Mediterranean aquaculture within aquaculture appropriate areas
SIPAM	Information System for the Promotion of Aquaculture in the Mediterranean
SA	social acceptability
UN Environment	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WGSC	Working Group on Site Selection and Carrying Capacity
WHO	World Health Organization

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1. Introduction

Aquaculture in the Mediterranean and the Black Sea: a rapid growth

At the global level, aquaculture has experienced a continuous growth and reached 80.0 million tonnes of farmed food fish in 2016, with an estimated first-sale value of USD 231.6 billion, consisting of 54.1 million tonnes of finfish (USD 138.5 billion), 17.1 million tonnes of molluscs (USD 29.2 billion), 7.9 million tonnes of crustaceans (USD 57.1 billion) and 938 500 tonnes of other aquatic animals (USD 6.8 billion) (FAO, 2018a).

This surge also occurred in the Mediterranean and Black Sea countries, where aquaculture today represents a crucial contributor to regional fish production. Indeed, considering all the environments and farming technologies used, aquaculture production has increased from 1 million tonnes in 1996 to around 2.65 million tonnes in 2016, while its economic value rose from around USD 2 billion to 6 billion (FAO, 2018b). Moreover, the direct and indirect jobs generated by the regional aquaculture industry are estimated to be more than 400 000[1].

The growing trend in the Mediterranean and the Black Sea for marine species is mainly connected to a booming production of European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*), which increased from around 13 000 tonnes in 1991 to more than 371 000 tonnes in 2016. Such an increase was made possible, among other things, by the improvement of floating cage technology in fish farming. Indeed, starting from the early 1990s, the steady development of floating cages led aquaculture to progressively move further into the open sea. In 2010, marine aquaculture in floating cages represented over 80 percent of the total production of marine finfish farmed species and today is the main production system for European seabass and gilthead seabream (FAO, 2017a). In light of aquaculture development plans in the region, due to the steadily increasing demand for fish and seafood, and constant improvements in farming technology, this trend is expected to continue, thereby highlighting the need for marine and coastal space for aquaculture.

The need for allocated zones for aquaculture

An allocated zone for aquaculture (AZA) is "a marine area where the development of aquaculture has priority over other uses, and therefore will be primarily dedicated to aquaculture. The identification of an AZA will result from zoning processes through participatory spatial planning, whereby administrative bodies legally establish that specific spatial areas within a region have priority for aquaculture development" (Sanchez-Jerez *et al.*, 2016).

The rapid development of aquaculture calls for an integrated coastal zone management (ICZM) approach in order to secure the sustainability of the sector. To this end, the urgent implementation of short-, medium- and long-term measures is required in order to address the challenges currently facing the aquaculture industry, including market competition, environmental issues, allocation of space in coastal areas for aquaculture farms, and competition among the different users of the coastal space and resources. The latter challenge, in particular, represents one of the major sources of concern and has increasingly become a focus of attention.

In light of the increasing pressure on coastal zones, the availability of suitable areas for marine aquaculture is becoming a bottleneck for the further development of the sector in the

1. GFCM application of model developed by Valderrama, Hishamunda and Zhou (2010).

Mediterranean and Black Sea region. This situation calls for the improvement of site selection and the establishment of specific marine spatial planning for aquaculture, with a view to promoting a harmonious integration of aquaculture with other human activities occurring in coastal zones. In this context, establishing AZAs is considered a priority for the sustainable development of aquaculture in the Mediterranean and the Black Sea, as it could facilitate its integration into coastal areas and contribute to improved coordination among the different authorities and actors involved.

The SHoCMed project

In order to further refine the definition of allocation of space and management for aquaculture, and to constitute a body of knowledge, the GFCM implemented the project Developing site selection and carrying capacity for Mediterranean aquaculture within aquaculture appropriate areas (SHoCMed[2]). The specific objectives of the SHoCMed project were to: i) produce site selection criteria in order to enhance the integration of aquaculture into coastal zone management through the use of AZAs and ii) provide a basis for the harmonization of standards, aquaculture policies and legal frameworks across the Mediterranean region to ensure equal terms of competition and minimal environmental impact. This project benefitted from the support of the European Union (EU) and was concluded in 2016.

Within the framework of the SHoCMed project, the following two priorities for aquaculture management were identified (GFCM, 2011):

- AZAs should be defined for the benefit of Mediterranean and Black Sea countries, and their establishment should be supported by relevant national authorities; accordingly, relevant provisions should be enshrined in national legislations and in development plans.
- The implementation of AZAs for the development and management of aquaculture should be considered as a priority for these countries and should be carried out according to a set of proposed guidelines.

2. Further information is also available at http://www.fao.org/gfcm/activities/aquaculture/projects/shocmed/en/

2. Frameworks for AZAs

2.1 International frameworks and mechanisms

The evolution of aquaculture over the last decades has also been reflected in the different legal instruments addressing the sector at the international level. The main milestones that led to the definition of the AZA concept are outlined below.

International frameworks addressing aquaculture: main milestones

The United Nations Convention on the Law of the Sea, adopted in 1982, was the first legal instrument addressing all aspects related to the resources of the seas and the uses of the oceans. Following the nineteenth session of the FAO Committee on Fisheries, held in 1991, which underlined the need for new approaches to fisheries and aquaculture management, based on conservation, environmental, social and economic aspects, the International Conference on Responsible Fishing was held in 1992 in Mexico. This conference stressed the need for aquaculture practices that are not harmful to ecosystems, to resources or to their quality, and called upon FAO to draft an international code of conduct for responsible fishing. As a direct outcome, the Code of Conduct for Responsible Fisheries was unanimously adopted by the 1995 FAO Conference. The Code of Conduct provides a first outline of an international cooperation framework for the sustainable exploitation of marine resources. Its Article 9.1.1, in particular, indicates that "States should establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of responsible aquaculture" (FAO, 1995).

The United Nations have also enshrined the quest for enhanced governance of marine resources in their agenda. In 2015, 17 Sustainable Development Goals (SDGs) were adopted in order to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda. For each SDG, specific targets were defined to be achieved by 2030. In particular, SDG 14 (Conserve and sustainably use the oceans, seas and marine resources) tackles aquaculture development and Target 14.7 aims to "increase [by 2030] the economic benefits to small island developing states and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism".

Within FAO, among the five Strategic Objectives driving its work, Strategic Objective 2 Make agriculture, forestry and fisheries more productive and sustainable acknowledges the need to increase the production of fishery products in order to reduce poverty and achieve food security, in the context of an increasing world population, underlining that increased productivity is to be achieved with an enhanced sustainability, thus reiterating the need for a better management of the aquaculture sector.

In line with the efforts of FAO towards food security and taking into account the principles of its Blue Growth Initiative, promoting the sustainable use and conservation of marine living resources in an economically, socially and environmentally responsible manner is inscribed in the Agreement for the establishment of the General Fisheries Commission for the Mediterranean adopted in 1949. Indeed, Article 5.e reads that the Commission shall "foster, as appropriate, a subregional approach to fisheries management and aquaculture development in order to better address the specificities of the Mediterranean and the Black Sea".

The ecosystem approach to aquaculture (EAA), ICZM and spatial planning are overarching concepts within which AZAs are developed. Since 2006, FAO has been developing a framework for an EAA, which was formalized in 2007, during an expert workshop in Spain, with the following definition: "an ecosystem approach to aquaculture is a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems" (Aguilar-Manjarrez, Kapetsky and Soto, 2008). This definition summarises the ecosystem-based management as proposed by the Convention on Biological Diversity (Rio de Janeiro, 1992) and also takes into account Article 9 of the Code of Conduct for Responsible Fisheries. The EAA has been applied in particular as a practical tool by the Horizon 2020 project Ecosystem Approach to making Space for Aquaculture (AquaSpace) since March 2015, in order to identify key constraints to aquaculture development. The EAA could also be considered as the natural cooperative framework within which AZAs are established at the country level for the development of aquaculture strategic plans.

Within the framework of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, adopted in Barcelona in February 1976 (Barcelona Convention), the Contracting Parties adopted, in 2008, the Protocol on Integrated Coastal Zone Management in the Mediterranean[3], which provides a common framework to promote and implement integrated coastal zone management. This protocol defines, in its Article 2 (f), ICZM as a "dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses, and their impact on both the marine and land parts". The establishment of AZAs is to be considered within the framework of ICZM and against the background of Mediterranean and Black Sea governance, with regulations and/or restrictions assigned to each zone in accordance with their suitability for aquaculture activities and carrying capacity limits, and it should be supported by a multidisciplinary and multi-stakeholder approach, in coherence with the principles of sustainable development.

The concept of spatial planning for aquaculture has been discussed in various fora. The United Nations Educational, Scientific and Cultural Organization (UNESCO), its Intergovernmental Oceanographic Commission (IOC-UNESCO) and the Man and the Biosphere Programme have developed in particular a practical guide to marine spatial planning in 2009 (Ehler and Douvere, 2009). Moreover, FAO within its Regional Commission for Fisheries (RECOFI) published a framework to achieve successful marine spatial planning implementation (Meaden *et al.*, 2016). More recently, FAO and the World Bank have addressed spatial planning and management of aquaculture development within the framework of EAA, using an area management approach, through the establishment of aquaculture management areas (AMAs) (Aguilar-Manjarrez, Soto and Brummett, 2017).

Following the adoption of the Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning, aimed at reducing conflicts, encouraging investments and increasing cross-border cooperation, the European Union (EU) has also developed an integrated planning and management approach called "maritime spatial planning", in line with the EU integrated maritime policy (European Union, 2014). To progress towards an effective management of aquaculture activities in the Mediterranean and the Black Sea, the GFCM adopted, at its thirty-sixth session in 2012 (FAO, 2012), Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture

3. Available at http://web.unep.org/unepmap/8-iczm-protocol

(Appendix 1). This resolution acknowledges that aquaculture activities affect and are affected by other human activities, and considers that the implementation of a regional strategy for the creation of AZAs is an immediate priority for the responsible development and management of aquaculture activities in the Mediterranean and the Black Sea, as it may facilitate their integration into coastal zone areas. The resolution is intended to provide a basic framework to steer GFCM contracting parties and cooperating non-contracting parties (CPCs) in enhancing the integration of aquaculture in coastal areas through the establishment of AZAs. The holistic concept of AZA defined by the resolution has a particular functionality in light of the contribution AZAs can bring to site selection and site management, as well as representing a valuable management tool for preventing conflicts with other coastal zone uses.

The importance of this resolution has been recognized at supranational and international levels. In 2013, the seventh session of the Sub-Committee on Aquaculture of the FAO Committee on Fisheries (FAO, 2014) acknowledged the recent developments and challenges in spatial planning for aquaculture, and recognized the importance of the GFCM resolution on AZAs. Furthermore, the Strategic Guidelines for the sustainable development of the European Union aquaculture, adopted by the European Union, highlight the importance of securing sustainable development and growth of aquaculture through coordinated spatial planning, and refer to the GFCM resolution on AZAs (European Commission, 2013). The resolution was also recalled in a motion for a European Parliament resolution on a fisheries strategy in the Adriatic and Ionian seas (European Parliament, 2012).

The strategy for the sustainable development of Mediterranean and Black Sea aquaculture

In 2014, the Regional Conference on Blue Growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security, organized by the GFCM in Bari, Italy, acknowledged the necessity to support countries in establishing AZAs in order to harmonize the level of development of the process for the allocation of space to aquaculture (FAO, 2017b). The conference also laid the groundwork for the establishment of a GFCM Task Force to develop a strategy for the sustainable development of Mediterranean and Black Sea aquaculture. This Task Force was then established in 2015 at the thirty-ninth session of the GFCM.

As a direct outcome of the wide consultation process launched within the Task Force, the strategy for the sustainable development of Mediterranean and Black Sea aquaculture was adopted in 2017 as Resolution GFCM/41/2017/1. This regional strategy envisages a future where Mediterranean and Black Sea aquaculture will be globally competitive, sustainable, productive, profitable and equitable. It should help Mediterranean and Black Sea coastal countries in formulating harmonized aquaculture activities and action plans, paying special attention to current regional, subregional, national and local aquaculture priorities, as well as to emerging challenges at different levels, while taking into account existing national and supranational strategies and legal requirements (GFCM, 2018).

The overarching objective of the strategy is to unlock the potential of the aquaculture sector in the Mediterranean and Black Sea region. To achieve this, three targets are set, based on the main pillars of sustainable development and in line with SDG 14: 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), and Target 3 (Facilitate market-oriented aquaculture and enhance public perception).

Target 1 specifically addresses the integration of aquaculture in coastal zones and, in particular, the implementation of AZAs. It foresees the development of technical cooperation projects and mechanisms to support the effective implementation of AZAs in the region, including capacity-building and training to support Mediterranean and Black Sea coastal countries, and facilitating proactive planning. It also includes the preparation and dissemination of an AZA toolkit, illustrating the benefits of AZAs and providing information on their implementation and management, in order to maximize existing scientific knowledge on AZAs in the region.

Along with the adoption of the strategy, the GFCM also adopted in 2017 another resolution promoting efficient regulatory and administrative frameworks, as well as participatory policy-making processes. Resolution GFCM/41/2017/2 on guidelines for the streamlining of aquaculture authorization and leasing processes, provides guiding principles and minimum common criteria, based on good practices in administrative and public sector management (FAO, 2018c).

2.2 Legal frameworks in Mediterranean and Black Sea countries

In Mediterranean and Black Sea countries, marine aquaculture takes place in floating cages within coastal and maritime areas of public domain and is regulated by legislative frameworks involving different ministries, departments and authorities, with often no clear hierarchy of responsibility among these bodies. Van Houtte (2001) highlights a series of elements, which are still valid, for effective aquaculture legislation to overcome this difficulty (Box 1).

Mediterranean and Black Sea aquaculture involves different species and technologies, as well as various environments; the sector is hence far from being homogeneous. This diversity is also reflected in the legal and institutional frameworks that regulate these activities across the region. In the Mediterranean and the Black Sea, the legal framework pertaining to aquaculture is very complex; however, despite potential difficulties to access information on site selection for marine aquaculture (Chapela and Ballesteros, 2011), some specific elements can be identified.

Generally speaking, the following can be summarized as the main limiting factors for aquaculture licensing and leasing processes:
- complex and time-consuming administrative procedures for licensing and leasing aquaculture activities in the public domain;
- body of laws, regulations, directives, rules and procedures that the aquaculture investor must comply with; and
- involvement of numerous separate authorities at several levels.

In the Mediterranean and the Black Sea, since the implementation of AZAs and site selection for marine aquaculture take place within the maritime public domain, planning and decision-making should be defined by administrations and policy makers. This calls, *inter alia*, for better and harmonized legal frameworks, in relation to licensing and leasing procedures for aquaculture, in which the zoning process can be facilitated by a participatory process. It is important to promote coordination and agreements between the various administrative authorities participating in the legal framework for aquaculture site selection and site management. In addition, clear regulations are required when the division of tasks among the different administrative bodies needs to be straightforward, in order to avoid unnecessary overlapping competencies and facilitate licensing and leasing procedures (Box 2) (IUCN, 2009; FAO, 2018c).

BOX 1. Main elements for effective aquaculture legislation

Aquaculture-related legislation should be primarily directed towards the development of the sector and conceived for the benefit of the population and communities. To this end, it should:

- recognize, define and assess the activity (practice, facilities and product) and the various agents involved;
- integrate environmental and social values into planning and decision-making processes for allocation of land, water and other natural resources for aquaculture purposes;
- recognize the legitimacy of regulatory instruments such as codes of practice and codes of conduct that reinforce responsible aquaculture practices;
- include effective monitoring, implementation and enforcement mechanisms (economic, administrative and penal) to ensure compliance with the regulatory instruments, including codes of conduct and best management practices; and
- develop and regularly implement performance criteria and indicators that will assess whether the objectives of responsible aquaculture have been achieved by governments and stakeholders.

It is also suggested that particular attention should be devoted to statutory responsibilities, conflicting functions, as well as to the processes involving decision-making and conflict resolution. In addition, it is suggested that an institutional framework for aquaculture, specifically for the establishment of allocated areas, should in particular:

- be geared towards the objectives of an aquaculture policy and legislation, in order to ensure their successful implementation;
- clearly identify the responsibilities of the agency or agencies in relation to the development, operation and management of aquaculture (where several agencies are involved, it should foster and promote the creation of appropriate networks to facilitate the implementation of responsible aquaculture practices);
- in relation to the use of natural resources, open the process of aquaculture management to non-governmental interests, including the private sector, the community, traditional users and aquaculture workers;
- foster a coordinated approach between governmental and non-governmental interests for the efficient enforcement of all laws and regulations applicable to aquaculture; and
- create incentives (financial, educational and others) for responsible aquaculture, geared towards improving existing farming systems, developing and implementing best management practices, supporting implementation of effective environmental controls to maintain and improve requirements for aquaculture, and supporting the maintenance and restoration of the environment.

Source: Van Houtte (2001).

Appropriate site selection procedures and site concessions for aquaculture activities are widely recognized as one of the most important aspects to facilitate aquaculture development. In this regard, the definition of AZAs at the national level can facilitate the installation of farms and aquaculture activities.

To identify and implement AZAs, various legal frameworks at different levels should be taken into consideration, including those within the framework of the Barcelona Convention and its Protocols.

BOX 2. Main competencies for coastal planning and aquaculture bodies

The designation of a leading agency by law allows for the identification of competencies for coastal planning and aquaculture. The main competencies should be:

- to guarantee the participation of all bodies having competence over issues related to marine coasts. In this regard, a tool to ensure such participation should be provided by law;
- to ensure that coordination tools are in place, which should include specific reference to the methods and tools to coordinate multiple and divergent interests; and
- to ensure that a fisheries or aquaculture agency takes the lead so that the following steps of the process are in place:
  a. development of technical studies: biological (including carrying capacity), oceanographic, environmental, institutional, social, economic and land use;
  b. selection of parameters and criteria, based on technical studies, to determine suitable zones for aquaculture;
  c. mapping suitable zones and areas where aquaculture is forbidden;
  d. information at the governmental level: mandatory reports by agencies having competencies for the implementation and, if applicable, modification of site selection;
  e. meetings with stakeholders (non-governmental organizations, aquaculture and fisheries associations, consumer organizations, entrepreneur associations, etc.) to discuss the aquaculture plan;
  f. public hearing: availability of the preliminary plan to be consulted by the general public;
  g. steering committee with lead agency and involved agencies:
     - analysis of inputs from the public hearing and stakeholders proposals;
     - decision to modify or not the plan (and therefore the zones);
  h. final publication of the aquaculture plan.

Source: Chapela and Ballesteros (2011).

It is worth noting that the distribution of legal competence in this regard varies from one country to another. Some specific cases, such as those from the Spanish region of Andalusia (Box 3), Croatia (Box 4), and Turkey (Box 5) are illustrated below.

BOX 3. Legal framework for aquaculture: the case of Andalusia (southern Spain)

Aquaculture in Spain is regulated at the regional level. The legal framework for aquaculture is adapted to the decentralized model in which regional governments (autonomous communities) have competencies for aquaculture and coastal zone management. The central government, represented by the Ministry of Agriculture and Fisheries, Food and Environment, is only competent for designing general policies for agriculture, fisheries and food, as well as for coordination and representation through the General Secretariat of the Sea (*Secretaría General del Mar*). Autonomous communities can develop their own aquaculture policies, following all legal requirements established at higher levels (i.e. national, European Union, subregional and Mediterranean).

The autonomous region of Andalusia has its own fishing and aquaculture law (Law 1/2002 of 4 April 2002 on the management, promotion and control of maritime fishing, shellfish production and marine aquaculture). This was then developed into a decree (Decree 58/2017 of 18 April 2017, which regulates marine aquaculture in Andalusia), including, among other aspects, the improvement of procedures for obtaining licenses.

BOX 3. Continued

In addition, the region also developed regulations for environmental protection such as Law 7/2007 of 9 July 2007 on the integrated management of environmental quality. The contents of this law are in line with state, community and international laws, and include new precepts that are not adopted in these laws. It is intended to supplement, clarify and update the existing regulatory framework and instruments addressing environmental protection, with a view to improving the quality of citizens' lives in the autonomous community and achieving a high level of environmental protection. In particular, it takes into consideration:

- EU Directive 2003/4/EC of the European Parliament, related to public access to environmental information and public participation, as well as Directive 96/61/EC concerning integrated pollution prevention and control (IPPC);
- EU Directive 85/337/CEE and 97/11/CE on the assessment of the effects of certain public and private projects on the environment; and
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, which established a framework for Community action in the field of water policy; in this sense, it provides a framework for the overall protection of inland and coastal waters, and the transition, following the criteria used in such a Directive.

The concept of "unified environmental authorization" derives from Law 7/2007 and is expressed in Decree 356/2010 of 3 August 2010 (Regional Ministry of the Environment), the main objective of which is to prevent, reduce and control atmospheric, water and soil pollution through an integrated approach and a comprehensive assessment of environmental effects.

This new regional form of environmental intervention integrates environmental impact assessment (EIA), as well as various authorizations and environmental requirements into a single resolution. From a procedural point of view, the authorization for the establishment of aquaculture farms is a mechanism to simplify administrative procedures; it provides what might be called an environmental "single window" (or "one-stop shop") and a "unified environmental response". In this sense, the maximum period for resolving it will be eight months (six for the abbreviated procedure).

On the other hand, this authorization is designed as an instrument with an appropriate nature and scope to enable relevant ministries in the environmental field to follow up and monitor environmental performance.

At the regional level, some regulations were modified and introduced by Decree-Law 3/2015 of 3 March 2015, modifying Law 7/2007 of 9 July 2007 on the integrated management of environmental quality, Law 9/2010 of 30 July on water of Andalusia and Law 1/2014 of 24 June on public transparency.

These modifications were aimed at unifying the environmental evolution of plans, programmes and projects into a single legal text. The state legislator, aware of the legislative diversity that exists in Spain, was committed to creating a common legal framework in the national territory under Article 149.1.23 EC. Finally, Decree-Law 5/2014 of 22 April 2014 on regulatory measures to reduce administrative procedures for companies modified Law 7/2007.

BOX 4. Legal framework for aquaculture: the case of Croatia

In Croatia, the Ministry of Agriculture manages the aquaculture sector and maintains a finfish farmer register containing 35 companies with marine farming facilities, at a total of 63 coastal locations. There are seven administrative regions (counties) on the coastline; however, more than 60 percent of Croatian finfish marine aquaculture is located in Zadar County, where the coastal zone is the most important developing resource. Currently, Zadar County and Šibenik-Knin County are the only two Croatian counties that have defined allocated zones for aquaculture (AZAs) using integrated coastal zone management (ICZM) principles.

Regarding the legal framework, two laws govern the fisheries sector in Croatia: the Marine Fisheries Act, which covers the marine aquaculture sector, and the Freshwater Fisheries Act, which covers the freshwater aquaculture sector. A new law on aquaculture covering all issues related to aquaculture governance entered into force in 2017 and was amended in 2018.

In Croatia, the basic criteria for AZA establishment are defined by the law and related by-laws, whereas AZA implementation, including information on location permits at sea, is defined by physical plans at the county level.

The institutions involved in the marine AZA process in Croatia are the following:

- Ministry of Agriculture for the definition of criteria;
- Ministry of Construction and Physical Planning for the evaluation of physical plans;
- Ministry of Environment and Energy for environmental impact assessment (EIA) procedures; and
- County administration for the development of physical plans.

In Croatia, an EIA is mandatory for:

- finfish farms located in protected coastal areas (within 300 m from the coast), with an annual production of more than 100 tonnes;
- finfish farms located outside of protected coastal areas to a distance of one nautical mile (1852 m), with an annual production of more than 700 tonnes;
- finfish farms located outside protected coastal areas, greater than one nautical mile away from the coast of the island or the mainland, with an annual production of more than 3 500 tonnes;
- shellfish farms in protected coastal areas, with an annual production of more than 400 tonnes; and
- finfish farms located in protected coastal areas with an annual production up to 100 tonnes, and finfish farms located outside protected coastal areas with an annual production of more than 100 tonnes (they have to provide an evaluation of the need for an EIA).

BOX 5. Legal framework for aquaculture: the case of Turkey

In Turkey, finfish farmers must obtain permits from the Ministry of Food, Agriculture and Livestock (MFAL). Finfish farming activities are controlled by a number of specific laws and regulations that are administered mainly through the MFAL and the Ministry of Environment and Urbanization (MEU). The legal, regulatory and institutional frameworks governing site selection, monitoring and environmental impact assessment on aquaculture in Turkey are outlined below.

BOX 5. Continued

Law	Contents
Fishery Law No. 1380, 1971 and its amendments (Fishery Law No. 3288, 1986; Fishery Law No. 4950, 2003).	All fisheries and aquaculture activities are regulated by the Fishery Law. The last revision (2003) introduced important legislative principles and standards for the establishment and management of aquaculture facilities.
Environmental Law No. 2872, 1983 and its amendment (Environmental Law No. 5491, 2006).	Its associated regulations laid the general legal basis and framework for environmental protection similar to that of many other European countries. The last Turkish Environmental Law (2006) forced marine aquaculture facilities to move off-shore within one year.
Regulation	**Contents**
Regulation on aquaculture No. 25507, 2004 (MARA, 2004)*, as amended (MARA, 2005 and 2006).	It addressed major issues related to aquaculture, such as license renewal and development in terms of management, technology and related matters. A minimum capacity of 250 tonnes/year and water quality criteria were fundamental considerations in the proposed licensing requirements for marine aquaculture.
In 1993, detailed EIA regulations were enacted. These regulations were further extended and revised in 1997, 2002, 2003, 2008 and finally in 2013. They accommodated adaptations in accordance with the EU EIA Directives 85 /337 /EC and 97/11/EC.	A major component of this regulation is the need for EIA. This is a process to define the environmental alterations that any developmental project may have and, subsequently, to determine whether a project can be approved, needs to be amended before approval, or must be rejected. EIAs only apply to 1 000 tonnes/year capacity farms.
Regulations for water pollution control (MEF, 2004)** were revised in 2008 (MEF, 2008).	Article 15 of the Regulation for water pollution control provides the general criteria of quality required for marine environments.
In 2007, a regulation (MEF, 2007) was issued to identify the criteria for closed bays and gulfs, which qualified as sensitive areas where fish farms are not allowed.	Fish farms already established in enclosed bays and sensitive areas were to be re-evaluated in accordance with physical and chemical criteria.
Monitoring regulations for fish farms were introduced (MEF, 2009).	This includes sampling techniques and sampling frequencies for sediment and water quality.
Monitoring regulations for fish farms were revised (MEF, 2010).	In addition to macrobenthic flora and fauna species, the distribution of Beggiatoa bacteria in the sediment is addressed.

* The Ministry of Agriculture and Rural Affairs (MARA) became the Ministry of Food, Agriculture and Livestock (MFAL) in 2011;
** The Ministry of Environment and Forestry (MEF) became the Ministry of Environment and Urbanization (MEU) in 2011.

2.3 Concepts and definitions

Zoning, or spatial analysis for aquaculture, is widely requested by the industry and the authorities involved in aquaculture development.

The IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 2001) defined "zoning" as follows:

> Zoning may be used either as a source of information for potential developers (for example by identifying those areas most suited to a particular activity); or as a planning and regulating

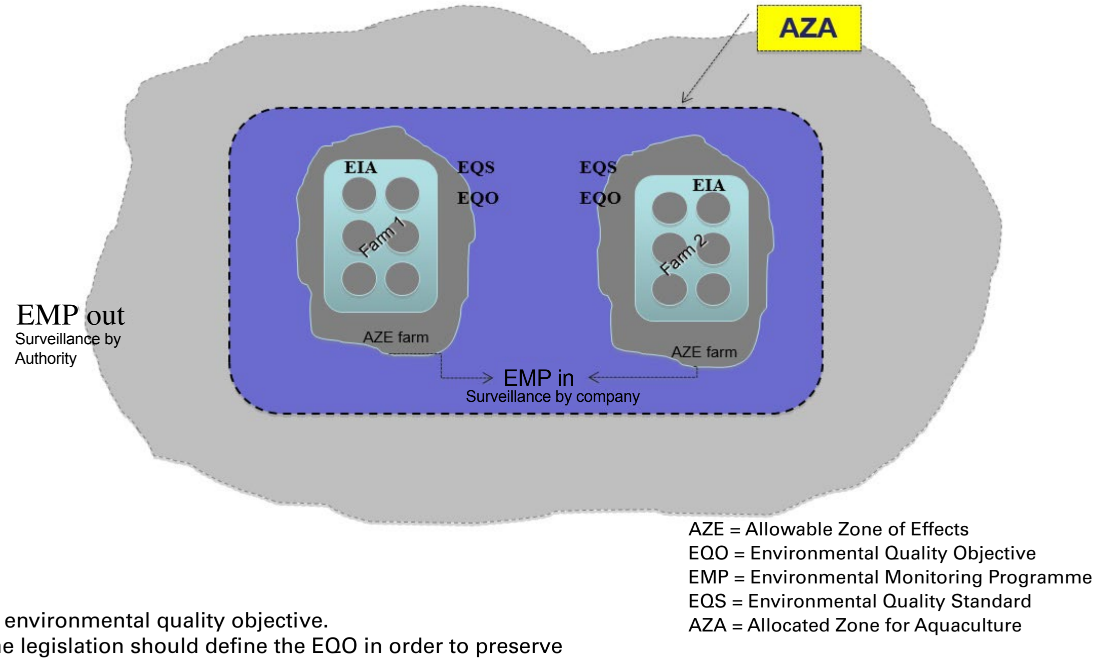
> tool, in which different zones are identified and characterized as meeting certain objectives. Zoning of land (and water) for certain types of aquaculture developments may help in controlling environmental deterioration at the farm level, and in avoiding adverse social and environmental interactions. Conflict between different resource use activities can be avoided. By creating exclusive zones, a sense of ownership and heightened responsibility for environmental management may be created in the user community.

Zoning has also been defined by FAO, as the action of "dividing an area in zones or sections with different characteristics, or reserved for different purposes or uses, or conditions of use such as no take zones or reserves (see marine protected areas [MPAs]), biodiversity corridors, non-trawling areas and areas for exclusive use by small-scale fisheries or aquaculture" (Carocci *et al.*, 2009).

The concept of AZA refers to a system that is enshrined within the wider ecosystem relations and that intrinsically involves the performance of different processes, such as identification, study, selection and spatial analysis in order to obtain an area dedicated to planning, management and best practices in aquaculture (Figure 1).

Furthermore, the concept of AZA is used to refer specifically to a particular area identified within the planning or zoning of a larger and more important area in terms of spatial and temporal scale. AZAs can be considered as a spatial planning system or zoning carried out at the local or national level, and aimed at integrating aquaculture activities into coastal zone areas, where aquaculture should have priority over other activities and uses of marine space and resources, and where negative interferences with these activities and uses are minimized or avoided. It involves coordination among different authorities and is based on a participatory approach.

FIGURE 1
Example of environmental monitoring areas within and outside the allowable zone of effect



EQO: environmental quality objective.
The legislation should define the EQO in order to preserve ecosystem services (Ref. Glossary in Appendix 3).

EQS: environmental quality standard.
The EQS is a value which specifies the maximum permissible concentration of a chemical in the water column and in the sediment (Ref. Glossary in Appendix 3).

Establishing AZAs is key for the development of aquaculture activities in a given area as it allows one to streamline processes, offer suitable sites to companies, prevent or minimise conflicts among different activities and users, increase competitiveness, share costs and services, and secure investments. This process should be based on the best social, economic and environmental information available.

The main aspects to consider for the establishment of AZAs are the type of activities proposed (type of aquaculture) and the geographic location and delimitation of the areas where cage farming would take place.

If the development of aquaculture is declared of priority within AZAs, these zones are not limited to aquaculture. Other uses of the coastal space and resources can be implemented within AZAs and contribute to coastal development, which are also within the framework of the blue growth concept (Box 6 and Box 7).

There is no fixed shape of spatial scope to be respected for the definition and establishment of an AZA. The shape, extent and dimensions can differ depending on the country, space availability, environmental conditions, type of aquaculture and number of companies present. Therefore, an AZA may be a specific area, a polygon, an entire bay, a part thereof, or of any other shape resulting from a zoning process of physical planning in which specific areas are assigned to aquaculture activities.

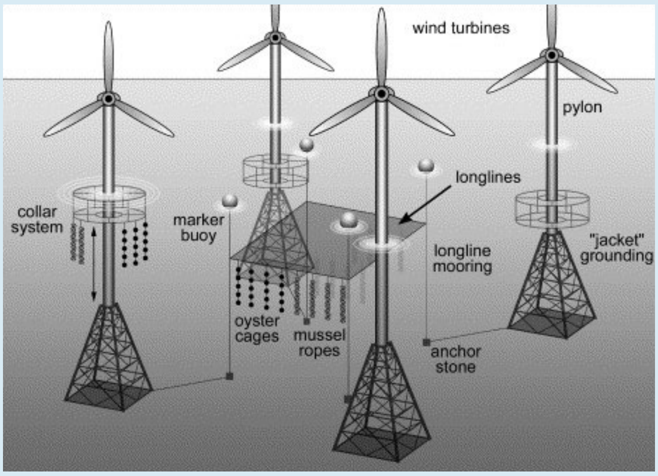
Environmental monitoring should take place outside and inside the allowable zone of effect (AZE). The AZE can be delineated when estimating the environmental carrying capacity and the nutrient flux emanating from the cages. However, when information is not sufficient or available to perform such estimate, the concession area or leased area can be used as an AZE for the purpose of environmental monitoring (Appendix 2).

BOX 6. Blue growth and sustainable aquaculture activities at sea

The concept of blue growth is usually associated with the green and blue economy. Blue growth aims at limiting the degradation of oceans and revitalizing ecosystems, so that the conservation and sustainable management of aquatic resources is balanced with equitable benefits to the coastal communities that depend on them (Massa, Onofri and Fezzardi, 2017). By integrating aquaculture within marine spatial planning, taking into account social, economic and environmental information, AZAs represent a tool that allows the contribution of the aquaculture sector to blue growth to be enhanced. At sea, the amount of productive activities that can be developed is limited. Within a blue growth perspective, aquaculture is an activity that could be complementary and compatible with these activities, thereby fostering local sustainable development, as shown in the cases presented in this box.

In Bremerhaven, northern Germany, the Alfred Wegener Institute carries out research in the Arctic and Antarctic, as well as in the high- and mid-latitude oceans. The institute coordinates German polar research and enables national and international science projects to have access to important infrastructures. The institute has been working on the first offshore aquaculture project as a multifunctional use of offshore wind farms. The outcomes of this project will provide expertise for the feasibility of offshore wind farm areas for the extensive culture of bivalves and seaweed.

BOX 6. Continued



Multifunctional use of offshore wind farms: mussel and oyster farms

Source: Buck, Krause and Rosenthal, 2004.

Aquaculture also needs to be considered for reconciling nature conservation with aquaculture sustainable development. In this context, the establishment of marine protected areas can also be a useful process as both aquaculture and these areas may benefit from each other in striving for global sustainable development (IUCN, 2017).

Another possible use which could be complementary is artificial reefs. Indeed, several types of reefs have been developed over many years, with different locations and functions, such as contributing to minimizing the impact of illegal fishing trawlers in areas of between 30 and 50 m deep, as well as facilitating both finfish farming and shellfish culture, etc. (Fabi and Fiorentini, 1996).

In Spain, a law issued in 2014 fosters both fisheries and aquaculture tourism. This opportunity enables fish farmers to carry out touristic activities linked with their production activities and thus to diversify (Boletín Oficial del Estado, 2014).

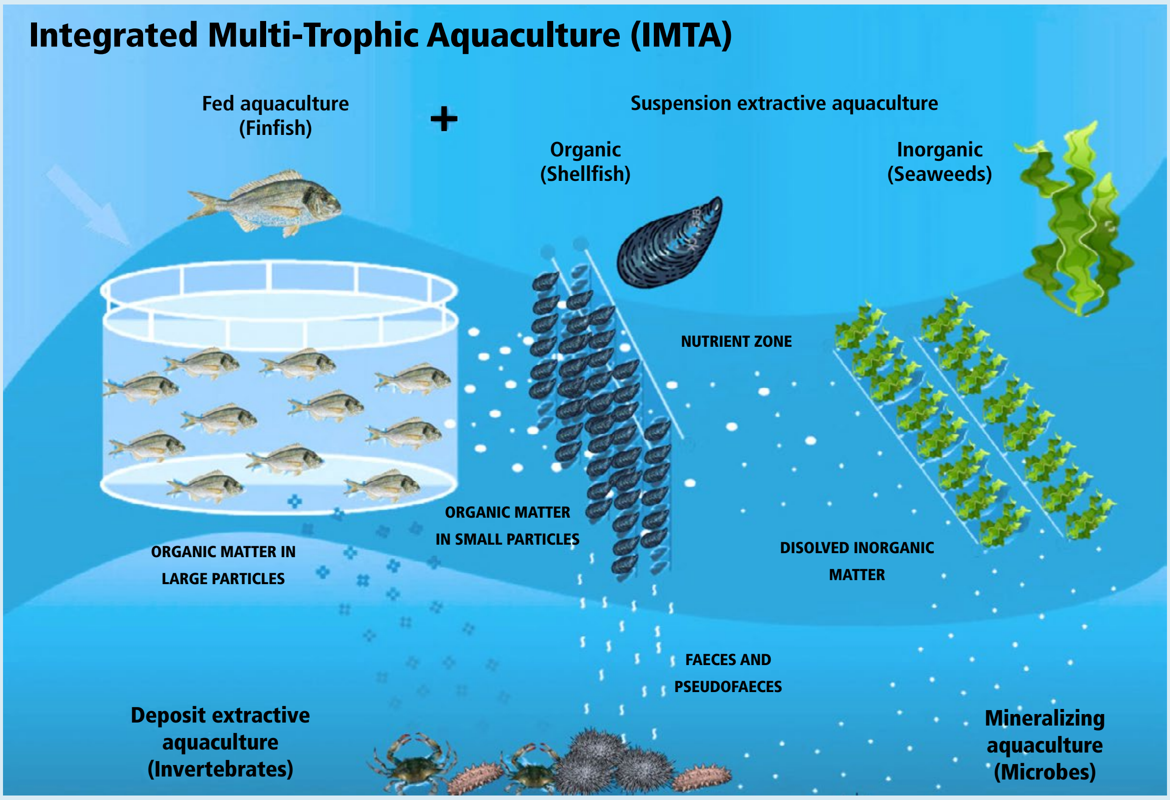
BOX 7. Integrated multi-trophic aquaculture: a better management practice complementing the AZA approach

In the context of AZAs, integrated multi-trophic aquaculture (IMTA) provides several environmental, economic and societal benefits, and can help in the management and governance of aquaculture activities within an integrated coastal area management (ICAM) approach. IMTA combines the cultivation of several species from various trophic levels, while serving complementary ecosystem functions. It is not enough to consider multiple species (as in polyculture); they have to be at multiple trophic levels, based on their complementary functions in the ecosystem, and they should also have an economic value.

The aim is to ecologically engineer systems developed on a balanced ecosystem-based management approach to aquaculture for obtaining increased environmental sustainability, economic stability, and social acceptability. It is important to value the extractive species in IMTA systems not only for their biomass and food trading values, but also for the ecosystem services they provide within a circular economy framework, in which by-products are no longer considered wastes, but co-products that can be valued in other applications. IMTA systems consider different spatial and temporal recapturing strategies to recover the diverse types of nutrients. Accordingly, entire bays/coastal areas/regions should be the units of IMTA management, in agreement with the AZA approach, while appropriate and enabling regulations should be developed based on the recognition of the ecosystem scales at which aquaculture sites operate.

BOX 7. Continued

The IMTA multi-crop diversification approach (fish, seaweeds and invertebrates) could be an economic risk mitigation/management option, particularly in the context of addressing pending climate change and coastal acidification impacts. The value of these ecosystem services should be recognized, accounted for and used as financial and regulatory incentive tools (e.g. nutrient trading credits).



Conceptual diagram of an IMTA operation *Source*: modified from Chopin *et al.*, 2008.

Conceptual diagram of an IMTA operation, including the combination of fed aquaculture (e.g. finfish) with suspension organic extractive aquaculture (e.g. shellfish), taking advantage of the enrichment in small particulate organic matter (POM), while inorganic extractive aquaculture (e.g. seaweeds) benefit from the increased availability of dissolved inorganic nutrients (DIN). Simultaneously, deposit organic extractive aquaculture (e.g. echinoids, holothuroids, decapods and polychaetes), make use of the enrichment in large POM, and faeces and pseudo-faeces (F & PF) from suspension-feeding organisms. The bioturbation and microbial mineralization on the bottom regenerates more DIN, which become available to the seaweeds (Chopin *et al.*, 2008).

BOX 8. An example of direct linkage between sectorial planning, site selection and site management in the Region of Murcia (southeastern Spain)

In 2002, the Ministry of Agriculture and Water of the Region of Murcia decided to create three aquaculture parks as an aquaculture planning and management tool, in order to bring together most of the marine aquaculture companies operating in the region. To this end, laws were issued and definitions laid down, such as:

- Law 2/2007 on Marine Fisheries and Aquaculture of the Region of Murcia, which provides the following definition of a marine aquaculture park: "a set of aquaculture facilities located within a duly demarcated area declared to be suitable for marine aquaculture, which can therefore be subject to specific management rules".
- Article 74 (Areas suitable for marine aquaculture), which states that the responsible regional ministry may declare as suitable for marine aquaculture those areas that are considered appropriate for this type of installation, pursuant to a mandatory, binding report by the government body responsible for areas in the public domain. The bodies responsible for defence, navigation safety, tourism, ports, environment and coastal management, as well as the municipal councils involved, shall also issue reports.

Driven by the aim of conserving the existing seabed of great ecological value, the establishment of these parks sought to benefit both the administrative authorities and the private sector, by facilitating all the administrative procedures and supervision in the former case, and reducing production costs through shared activities in the latter. For the creation of these parks, tenders were invited for the technical projects and the corresponding environmental impact studies, incorporating the following phases:

- Phase 1: development of initial studies to determine appropriate areas for locating the parks;
- Phase 2: preparation of projects to accommodate the target facilities; and
- Phase 3: design and development of environmental impact studies, and the design of a corresponding environmental monitoring plan depending on the results of the study.

The most suitable locations for aquaculture activities were then selected. The obligations and rights of users were laid down, together with the procedures for applying for a site and to be granted an aquaculture licence and a lease. The parks were implemented by means of regulations and laws acting in both directions, i.e. protecting the environment and maritime traffic from the aquaculture operations, while at the same time protecting aquaculture from external activities. In addition, a whole set of regulations on the management of the marine aquaculture parks was issued.

Source: IUCN (2009).

3. Establishment of AZAs

The identification of areas of interest for aquaculture is a process that takes into consideration the principles enshrined in the legal instruments outlined in the previous chapter, as well as other principles such as those outlined below.

Site selection first depends on the existing environmental conditions, and then on the activity planned. In designing a process for the establishment of AZAs, all limiting factors or priorities that could interfere with the proposed objectives of selecting sites for the sustainable development of aquaculture have to be taken into account (IUCN, 2009).

In a given area, the process to establish AZAs should conform to the existing strategic plan(s) for aquaculture and comply with the following principles, among others:

- an AZA should be considered within an EAA perspective, promoting sustainable development, equity and resilience of interlinked social and ecological systems;
- an AZA should be considered within an ICZM approach;
- the AZA establishment process should follow a participatory approach and be transparent;
- the identification of AZAs should be based on the best administrative, social, economic and environmental information available;
- the reliability of the information should be ensured, and the dialogue among stakeholders and all users of the maritime public domain should be facilitated;
- the monitoring of AZAs should be mandatory; an environmental monitoring programme should be defined for each AZA, be flexible and take into account the scale (time and space) approach;
- the preparation of the AZA establishment process should be coordinated by the main authority responsible for marine planning at the local level, and prepared in cooperation with the different authorities and stakeholders involved in aquaculture licensing and leasing procedures and monitoring; and
- AZAs should be regulated by normative frameworks, and included in national or regional legislations.

In addition, AZAs should:

- be perfectly positioned geographically and defined by a coordinate system compatible for integration within spatial planning tools;
- define a management plan in which all aspects are considered (i.e. the performance of the established companies, their interrelation and interactions with the common environment);
- include zones fiscally reserved for aquaculture activities and facilities; and
- be part of the physical plan in which the criteria for their preparation are described in terms of exclusion.

3.1 Aspects to be considered for the establishment of AZAs

The general aspects to be taken into consideration as a starting point for the selection and establishment of AZAs could be summarized as follows:

- Which kind of aquaculture will be developed?
- Type of aquaculture existing in the area (if any)?
- Main activities in the area?
- Legal context in place?
- Environmental conditions in the area?

- Socio-economic context in the area?
- Competent authorities and main stakeholders in the area?
- Market opportunities?

The identification, selection and establishment of AZAs are mainly based on:
- **basic knowledge**: as much information as possible has to be gathered, based on criteria of information utility and costs of collection. A minimum set of parameters should be selected for administrative, environmental and socio-economic aspects, based on scientific and local traditional knowledge;
- **analysis**: the use of geographic information systems (GIS) to select the optimal areas for aquaculture, and an analysis of the data related to the selected parameters are then necessary in order to verify the feasibility of the implementation of AZAs and determine the best applicable options;
- **interpretation**: the interpretation of the analysis results is the intermediary step linking together the analysis of the parameter data and the proposal;
- **agreement and consensus**: the proposal should be agreed among users and stakeholders;
- **establishment of the AZA**: following a participatory approach; and
- **monitoring aquaculture activities**: temporal and spatial control are always necessary to ensure the efficient management and best use of AZAs from an environment-friendly point of view.

The choice of the parameters should constitute the main basis for determining the suitability of the area and be directly related to the regulatory context in force for the aquatic activities in the study area. During the planning process, technical procedures of risk analysis should be applied, in order to identify, assess and treat the risks related to the implementation of the determined areas of aquaculture; they should include social, financial and environmental aspects (Sanchez-Jerez, 2011).

Given the limited information on the marine environment and the high cost of obtaining such information, two types of working lines may be considered:
- **socio-economic and administrative working line**: analyses each of the socio-economic interferences of use that might occur in the area where aquaculture is planned and also identifies the authorities and public bodies that have competencies over the area. This will delimitate the area to be studied and the area of intervention and, therefore, the time and cost of the execution of the following steps;
- **environmental working line**: involves a characterization study of the quality of the water, and of the seabed and different ecosystems, where it is planned to locate aquaculture facilities. This working line can also take into consideration particular environmental conditions characterizing the area (i.e. sensitive areas or environmental constraints).

Both working lines are supported by a previous collection of basic information and data aimed at providing an overall picture of what will be the scope of the effort ahead. The most important parameters to study will depend directly on the characteristics of the pre-selected site, time and cost of information collection, and on the type of aquaculture to be developed. Both working lines require the delimitation of the study areas in order to define both environmental and administrative boundaries of the AZA.

The administrative and environmental parameters, as well as their representation using GIS tools, allow a spatial analysis to be carried out for aquaculture development, which will help the competent authorities define the area. Additional information on the parameters listed hereunder is provided in the guidelines on a harmonized environmental monitoring programme (Appendix 2) and in the glossary (Appendix 3).

Basic parameters

Table 1 provides a summary of the minimum basic information and data needed to establish and to define the study area.

Table 1. Minimum basic parameters and potential authorities involved

Parameter	Description	Potential authorities involved
Bathymetry	"The science of measuring and charting the depths of water bodies to determine the topography of a lake bed or sea floor" (ESRI, 2001). The most appropriate depth for installations at sea will be the one that allows the technical feasibility of facilities on the one hand, and that allows the body of water to flow and thus facilitates oxygenation and dispersion of the inputs on the other hand. It will vary depending on different parameters, including the species, farming method, etc. The distance between the floor of the cages and the sea bottom has to be duly taken into account. Most installations anchored in the Mediterranean countries are located between 20 and 100 m depth.	Regional, national (e.g. Ministry of Infrastructures, geographic institutions), others
Coastline	The coastline is the land along the edge of a coast, forming a boundary between the land and the ocean, sea or lake. The coastline shown on charts represents the line of contact between the land and a selected water elevation, called the coastline contour.	Regional, national (e.g. Ministry of Infrastructures, geographic institutions, environmental authorities), others
Harbour infrastructures	The existence of ports as support for production and the infrastructure, equipment and services in each port. Aquaculture facilities at sea need port facilities for their vessels, which also provide areas for equipment and from where direct daily management operations can be carried out.	Regional, national, local (e.g. Ministry of Infrastructures)
Basic infrastructures of the territory	The basic infrastructures of the territory include the main roads, local ports, airports, etc., and others that may be of interest to a specific culture, particularly with regards to the transport of products. Infrastructure development in the area around the facility determines the advantages of the company in the development of activities (supply and provision of inputs for production, and output of products for sale).	Regional, national (e.g. Ministry of Infrastructures, geographic institutions), others
Territorial entities	Cities, towns, villages and local territorial organizations in the provinces or regions are essential to understand the social and economic context in which AZAs and aquaculture facilities should be placed. The location of these reference points is useful for the study of communications and logistics facilities, and their presence close to an aquaculture facility can support the development of daily activities.	Regional, national (e.g. Ministry of Infrastructures, geographic institutions), others

Administrative and socio-economic parameters

The administrative and socio-economic data and information to be collected refer to the different uses, activities and occupations that occur in the coastal area and that are often related to the limits established by regulations or specific plans of the various governments that have responsibilities in the maritime-terrestrial space (Table 2).

The social structure of a local area and the identification of the main economic activities in place are key issues which will influence the success of the establishment of an AZA. Social structure refers to the distinctive, stable arrangement of institutions, whereby human beings in a society interact and live together. Social structure encompasses elements that collectively define the social macrostructure as a system of coordination for the maintenance and/or acquisition of one or more types of valued resources for the community (Lin, 2002).

New job opportunities can be developed for the local communities; social and economic data are therefore important for the success of AZAs and will help achieve social acceptability and synergies with the existing and planned activities.

Other aspects to be considered from the economic point of view and evaluation methods are indicated below (Freeman, 2003):
– total economic value: aquaculture sites use various ecosystem services that are valuable to the producers and all potential users of the area;
– environmental externalities: interactions and feedback between the production activity and the ecosystem, which could be positive or negative; and
– monetization: values of the ecosystem that can be expressed in monetary terms and be used for assessing the suitability of sites for aquaculture.

Table 2. Administrative and socio-economic parameters and potential authorities involved in data collection

Parameter	Description	Potential authorities involved
Domain areas and port uses	Description, from an administrative point of view, of the existing ports in the area. Ports usually have a Uses and Management Plan that establishes the activities allowed and zones where each type of activity can be run.	National or regional (e.g. ports authority)
Sand deposit areas for regeneration of beaches	Sand areas correspond to sand deposits for the regeneration and/or creation of public beaches. These are areas of the seabed that, due to the dynamic sedimentary sand deposits, have been found suitable for filling and maintenance of beaches. In some countries, where coastal erosion affects the beaches, touristic attractions are regenerated with marine sands; these deposits are of high priority for management bodies. Therefore, in certain countries and regions, aquaculture facilities cannot be on or near large deposits of sand that are used for the regeneration of beaches.	National (e.g. environmental authority)
Protected habitats	Protected habitats, such as nature parks, Ramsar Sites, Sites of Community Importance, marine protected areas, etc. are sea areas that are part of natural areas protected by community law (e.g. some natural habitat proposed for protection under the European Directive 92/40 EEC). Protected areas should have plans of uses that specify which activities may be developed in this space. Aquaculture is often an activity which can be completely integrated into those spaces; MPAs can be an example of reconciling nature conservation and aquaculture sustainable development.	National (e.g. environmental authority)

Table 2. Continued

Parameter	Description	Potential authorities involved
Waste disposal sites	Discharge points located on the coastline and ocean outfalls that discharge to a certain depth; the latter being those that may have some negative effect on the development of productive activities. Aquaculture facilities should be located taking into account these spills or submarine outfalls along the coast, so that the quality of water discharged does not affect the healthiness of production. It is important to recognize the type of discharge (urban, agricultural, industrial, etc.) and activity level.	National (e.g. environmental authority)
Underwater wire exits	Cables and power distribution lines or fuel which flow through the seabed should be taken into account for the location of the moorings of the facilities and, in general, a precautionary distance is usually established between these types of elements and other purposes that share the same space.	National (e.g. infrastructures authority)
Tourist interest zones (beaches)	Due to their strategic location, or unique characteristics, beaches are generally classified according to their use in high-use tourist areas. In some countries of the region, tourism is an important economic activity and the level of interaction with aquaculture should be considered to avoid conflicts in the use of space.	National or regional (e.g. tourism authority)
Marine sports	Due to their location, coastal areas may have the appropriate features for marine sport activities. In some touristic areas, these are also relevant from an economic point of view and could interfere with aquaculture, and therefore conflicts for the use of areas need to be avoided.	National or regional (e.g. appropriate authorities)
Archaeological underwater sites	Archaeological remains may be located on the seabed, leading to the designation of areas of archaeological value. In general, they occupy small areas and for this reason it is important to identify and locate them perfectly in order not to locate aquaculture facilities on archaeological sites. Given the difficulty in locating such remains, positioning studies should be carried out and a precautionary distance established.	National (e.g. culture or heritage authority)
Traditional fishing areas	Traditional fishing areas or fishing grounds are usually areas where artisanal fishing operates daily. Such fishing grounds, and in particular areas of molluscs and shellfish, should be mapped in order not to establish the facility in these localities. Interactions between capture fisheries, especially artisanal, and aquaculture should be analysed. A good knowledge of local fishing patterns will prevent interference with this activity.	National or regional (e.g. fisheries and aquaculture authority)
Artificial reefs	Artificial reefs are composed of modules that populate the ocean floor as a circle of protection, leaving open the layer of water immediately above these structures. The existence of artificial reef areas should be taken into account as they occupy areas of the seabed that could interfere with the anchoring of the aquaculture facilities. Depending on the type of reef, the area where it is located and its purpose, aquaculture could be a complementary activity, strengthening the protection of the water column and the marine environment near the reef.	National or regional (e.g. fisheries and aquaculture authority)
Aquaculture installations	Aquaculture facilities in the area should be taken into account in order to know the types of aquaculture that are already carried out and assess the capacity of the system and other competitors for space, including logistical and environmental interactions and impacts among aquaculture farms. To this end, it is necessary to identify and locate all facilities in the study area.	National or regional (e.g. fisheries and aquaculture authority)

Table 2. Continued

Parameter	Description	Potential authorities involved
Anchoring vessel areas and other installations at sea	Areas in which the anchoring and manoeuvring of ships are carried out must be considered. However, not all of these areas are used by large ships and therefore they do not have the same size or level of use. This means that they may be compatible with other activities. Other industrial installations at sea, such as oil platforms, could also interfere with aquaculture activities due to their large structure.	Ports state authority or/and industrial companies
Military zones	Areas reserved for the national army, designed to carry out military operations, exercises and training activities on land or sea. Depending on the type of activity, aquaculture will be compatible or not. In most cases, compatibility is an issue between the two activities. Depending on the country, military activities are more or less numerous, but it is a common feature in the region.	Army
Fixed fishing gear near the coast	Along the coast of some countries in the region, fixed fishing gear may be found. Depending on the type of fishing and species, aquaculture conducted in close proximity to these types of gear will be compatible or not. For example, facilities should not be located at the entrance of these systems, but if supported, in the vicinity.	National or regional (e.g. fisheries and aquaculture authority)

Environmental parameters

The analysis of administrative parameters offers a short list of areas where there would be no incompatibility of occupation and, therefore, nothing to limit the development of aquaculture. In these pre-selected areas, at this stage and once sufficient information has been obtained regarding the potential interferences of use, it would be possible to demarcate more precisely the area where the aquaculture facilities could be located. At this step, it would be essential to have information on the current environmental conditions, in order to assess the technical and biological feasibility of aquaculture farming.

The number of environmental parameters to be studied and the level of analysis will mainly depend on the area under consideration, type of aquaculture to be carried out and the financial budget available for the study.

The parameters to be considered for the establishment of an AZA can be grouped and defined as follows:

1. Climatology and oceanographic conditions

The better the meteorological conditions in the area, the greater the assurance of technical feasibility of the project. In this respect, a low frequency of heavy storms and the presence of medium intensity winds are elements that contribute to promoting water circulation without compromising the strength of the facilities. Table 3 illustrates the key parameters required to analyse meteorological conditions.

Table 3. Climatological parameters of the study area

Parameter	Description
Temperature	The air temperature indirectly reflects the conditions of the nearest water body. The weather in the area will affect the type of aquaculture to be developed. Temperature is measured in degrees Celsius (°C).
Wind	The wind force and direction provide indirect information of the surface currents and the level of storms that the area is regularly affected by. Wind force is measured in metre per second or knots, while wind direction is indicated using the cardinal points.
Precipitation	All liquid or solid phase aqueous particles that originate in the atmosphere and fall to the earth's surface (American Meteorological Society, 2019). At sea, precipitation is important for helping analyse the frequency of storms that may affect the facility. Precipitation is measured in millimetres per year.
Evaporation	Evaporation is relevant particularly in areas such as bays and semi-enclosed bodies, which can manifest increasing salinity and variation in water quality. Evaporation is measured in millimetres per year.
Significant wave height and return period	Significant wave height is defined as the average wave height, from trough to crest, of the highest one-third of the waves, and this parameter, measured in metres, allows the most appropriate technology to be selected for each area in relation to its technical feasibility. Furthermore, the return period (for example, in which the highest wave of a sea storm has a height exceeding a fixed threshold) could also be assessed in order to have a more in-depth vision of the conditions.
Currents: speed, direction	This parameter will allow the positioning of facilities in the best direction with respect to the currents affecting the water quality. At the same time, sea currents are important for spreading the waste away from cages. Current speed is measured in metres per second, while current direction is defined using the cardinal points.
Hydrodynamic modelling/ particle dispersion	The application and results of these models allow the determination of the extent of particle dispersion generated by the proposed activity, and thus the possible environmental impact. This parameter is measured in metres.

2. Characterization of the seabed

The characterization of the seabed is essential for identifying the most suitable places for installing aquaculture facilities. This allows potential negative impacts to be avoided in sensitive habitats, while providing vital environmental data on the biological and chemical status of the proposed location before installation (Table 4).

Table 4. Parameters used to characterize the seabed

Parameter	Description
Granulometry	The particle size distribution or type of seabed in the area allows the most suitable places for anchoring and the most appropriate type of anchors to be selected. For anchoring, the best sea bottom sediment is sand or muddy sand. Granulometry is measured using particle size analysis.
Organic matter/ nutrients	The level of organic matter/nutrients present in the area will help in understanding the seabed dynamics and set the level of the zero state; this parameter is used as a baseline for establishing the preoperational state. The level of organic matter is measured in percentage.
Special habitats	The presence of habitats of special interest and/or protection, such as sea grass meadows or others listed in the Habitats Directive, must be taken into account in order to establish a precautionary area.
Benthic infauna	The characterization of the principal infaunal families and species in the study area is an important component for evaluating the state of the benthic ecosystem. This parameter is used as a baseline for establishing the preoperational state.

3. Water quality

Water quality is generally obtained from the integration of the values obtained for each of the parameters listed in Table 5.

Table 5. Parameters used to obtain water quality

Parameter	Description
Dissolved oxygen	The dissolved oxygen concentration in the cages or, preferably, at the benthic boundary layer beneath the aquaculture farm, provides an important indication of the ambient conditions in the environment, as well as an alarm for risks that might endanger the production and/or the health of the farmed stock. In the open sea, the dissolved oxygen concentration is not usually a limiting factor for cultivation; however, knowing its value allows the most suitable forms of aquaculture to be established in each area. Dissolved oxygen is measured in milligrams per litre or percentage of saturation.
Temperature	Knowing the ranges of these parameters will help select the most interesting type of aquaculture for each zone and describe the preoperational values for future monitoring. These parameters are measured as follows: – dissolved oxygen (ml/l or % saturation) – temperature (degree Celsius) – salinity: usually expressed in practical salinity units or in parts per thousand (ppt or %) – pH (unit) – redox potential (mV) – chlorophyll a (mg/l) – total suspended matter (mg/l) – water turbidity (m) – nutrients (micromolar)
Salinity	
pH	
Redox potential	
Chlorophyll a	
Total suspended matter	
Water turbidity	
Nutrients (nitrates, nitrites and phosphates)	

3.2 Spatial representation and exclusion criteria

The information and data collected from the parameters listed above have to be combined and analysed in order to obtain an integrated spatial vision of the study area. The spatial representation is essential in the AZA process as it enables an understanding of which areas are suitable for the development of aquaculture.

GIS tools are used to transform the data and information collected into maps. Figure 2 and Figure 3 provide examples of mapping undertaken within the process of establishing an AZA. GIS tools can be defined as follows:

> An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes, that provides a framework for gathering and organizing spatial data and related information, so that it can be displayed and analysed (ESRI, 2001).

The importance of tools such as GIS, remote sensing and mapping applications, for addressing the geographical and spatial aspects involved in marine aquaculture, has been highlighted on many occasions (e.g. Kapetsky and Aguilar-Manjarrez, 2007; Aguilar-Manjarrez, Kapetsky and Soto, 2008), including the location, description, identification and selection of areas of interest for aquaculture. The following excerpt from Aguilar-Manjarrez, Kapetsky and Soto (2008) provides a detailed description of GIS, remote sensing and mapping applications in aquaculture, from an ecosystem viewpoint:

> GIS has been implemented in a very broad variety of ecosystems and scales, as well as in a wide range of culture systems. Spatial analysis experience in terms of addressing issues in the

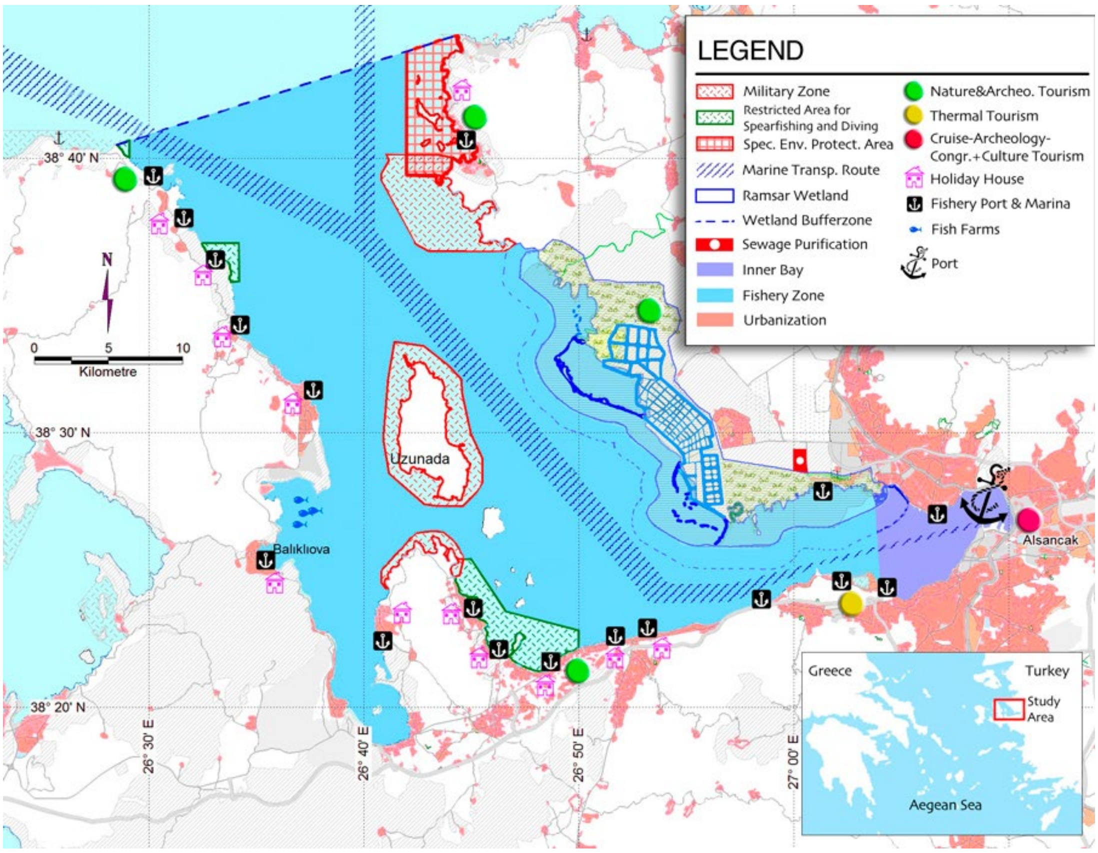
development of aquaculture and in aquaculture practice and management is good overall. Specific gaps in experience (i.e. know-how) are in economics and socio-economics, as well as in multi-sectoral planning for aquaculture. GIS is completely scalable and can include ecosystem, administrative, and social boundaries. The power of GIS is the capability to spatially integrate and analyse the natural and human as components of ecosystems. The most appropriate "scale" for the EAA and for GIS in support of the EAA is defined by the boundaries of the problem, expressed both in ecosystem, economic, social and administrative terms. It is noteworthy that these kinds of spatial boundary differences are easily reconciled by spatial analyses.

The methodology for the selection of aquaculture areas is based on the analysis of a large amount of spatial information processed using GIS. In order to map the information, it is necessary to know the main methodological aspects related to GIS tools, how this system works, its applications and the means that can be provided.

The level of difficulty of the interpretation and construction of the mapping will depend on the level of information provided by the agents involved and in the way the information is provided. Geographical data can be found as follows:
– on paper without geo-referencing: it will need to be geo-referenced and digitized;
– on paper and geo-referenced: it will need to be digitized; and
– in digital format and geo-referenced, as GIS ready layers.

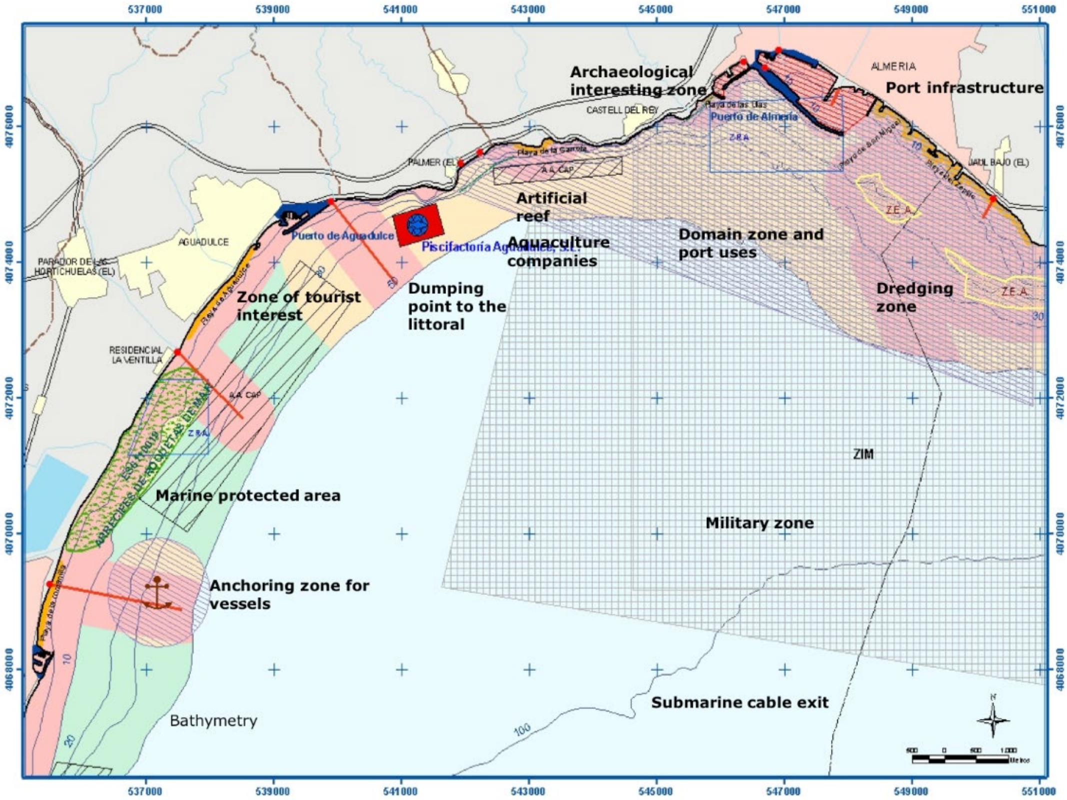
If information or data have to be generated, their collection (ad hoc survey, etc.) and geo-referencing (e.g. coordinate reference system and projection) will have to be defined and planned.

FIGURE 2
Mapping carried out within the process of establishing an AZA in Izmir Bay, Turkey



Source: Yücel-Gier, Arisoy and Pazi, 2010.

FIGURE 3
Mapping carried out as a preliminary step within the process of establishing an AZA in southern Spain



Source: Del Castillo y Rey and Macias, 2006.

GIS tools enable zones to be excluded that have specific characteristics, based on exclusion criteria obtained from the analysis of the study parameters, their interpretation and the compliance with the regulations and administration competencies which interact in the area. They also help further refine the definition of the zone to be allocated to aquaculture activities.

For land facilities, exclusion criteria can be based on the analysis of: land, soil type, water, meteorological conditions, traditional infrastructure, fish farming infrastructure, markets, government regulations and economic assessments, marine habitat mapping, oceanographic conditions and carrying capacity, interactions with fisheries, and negative impacts from other users (Pillay, 1990; Kővári, 1984). For marine coastal areas, exclusion criteria can be based on the analysis of: organic discharges, chemicals, sensitive habitats, escapes from reared stocks, marine birds and mammals, wild fish and fisheries, spread of benthic pathogens and alien parasites, and risks associated with harmful algal blooms.

For example, in the case of the European Union, exclusion criteria gather the areas of special protection under the Habitats Directive[4] (e.g. seagrass beds) and the military reserve areas of strategic interest for each country. Other possible exclusion criteria include: the existence of important archaeological sites, navigation channels, industrial compounds and active fishing grounds. In each region or location, there are various criteria or parameters to be used during the process of selecting suitable areas for establishing aquaculture.

In this context, GIS can be considered as an authentic management tool that can contribute to enhancing the efficiency of marine spatial planning, particularly as it can delineate features, be used as an indicator

4. Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora.

for the assessment of management performance and effects on given factors, and combine several types of spatial data (European MSP Platform, 2017).

As a result of spatial representation, Macias, Del Castillo and Alamo (2003), defined three main categories to classify the pre-selected zones according to their level of interest: low, medium and high. A similar categorization was made according to the AZA Resolution (Appendix 1). In this case, three zones could be also defined as:

- areas suitable for aquaculture activities: no interference with other uses and good environmental conditions;
- areas for aquaculture activities with particular regulations and/or restrictions, stemming from interactions with other uses, administrative competencies or characteristics of the environment, that will have to be taken into consideration for the establishment and management of AZAs; and
- areas unsuitable for aquaculture activities: administrative and/or environmental incompatibilities.

3.3 Who should establish the AZAs and how?

The decision to establish an AZA depends on the authorities responsible for marine planning. AZAs may be established by decisions regarding the use of available resources, priorities in the productive sectors in the area, level of employment generated by the activity and other influencing variables. It is usually the authority responsible for local geographical and/or marine aquaculture planning that coordinates the preparation of the AZAs. The procedure for the study, selection and establishment of an AZA should be promoted and led by the authorities with competence in aquaculture, either at the local or national level. Coordination and consensus on methods and procedures to be followed should be achieved among the different administrations involved. Indeed, many different authorities are usually involved in the countries of the region.

Once the initial identification for establishing an AZA is available, information should be shared with stakeholders, including producers, aquaculture farmers' organizations and non-governmental organizations, in the context of workshops, meetings and expert panels, in order to foster social acceptability and social license to operate. Local aquaculture multi-stakeholder platforms can also constitute appropriate fora to enable relevant stakeholders to meet and discuss common issues and challenges, thereby contributing efficiently to social acceptability building. Within aquaculture, social acceptability is regarded as an important topic to be considered in order to enable good governance (FAO, 2017b). AZAs can constitute effective aquaculture governance mechanisms by increasing social acceptability and the social licence to operate. Social acceptability is an integral part of sustainability and refers to the social licence and the degree to which, for example, aquaculture activities are accepted by the local community, various interest groups and the wider society (Hishamunda, Ridler and Martone, 2014).

The cohabitation of different producers in an area may not be easy and feedback is therefore necessary to detect possible interactions, as well as the limiting factors that might jeopardize the development of the aquaculture sector in the area. Many aspects could be considered, for example, competition for the same access for space, the risks of spillage of pathogens from one aquaculture farm to another, agreements required between farms in terms of information sharing and adoption of better management practices, etc.

3.4 AZA establishment process

The establishment of an AZA is a tailored process in which various phases should be adjusted according to the study area context, requirements and needs. The implementation of the different phases is reported as following:

Phase 1: Contextualization of the establishment process

1. Analysis of the aquaculture sector in the study area

This analysis takes into consideration, among others, the needs or development goals for establishing an AZA in three types of areas:
- for areas with no existing aquaculture activities, thus finding new areas for the development of the sector;
- for areas where the development of the activity is at an early stage, thus identifying areas for aquaculture; and
- for areas where the sector is already developed and appropriate regulation is still needed for managing the activity.

This analysis describes the aquaculture sector in the study area and identifies the types of aquaculture that are potentially viable. In this sense, it takes inventory of all the licensed aquaculture facilities in the area and addresses other ongoing aquaculture proposals. During this phase, the information is obtained from the administrations that have competencies over granting aquaculture licences and leases. With this information, a series of fact sheets can be produced for each facility, containing digital layers with the geographical location of each installation in the area.

The information to be collected for the study area analysis includes:
- list of existing licences and leases;
- average time for the aquaculture consenting process to obtain a licence and a lease;
- availability of infrastructure facilities;
- aquaculture home ports;
- background information and the state-of-the-art aquaculture activities and facilities;
- main species produced;
- types of existing aquaculture systems;
- record of accidents, crashes or diseases known from facilities of the area;
- industry reports, collected either by the administration or by industry associations;
- authorized production and actual production;
- specific local costs and benefits; and
- any other relevant information or data related to the activity.

2. Analysis of the legal framework

The development of aquaculture should be framed within the current legal and regulatory context specific to each country, concerning in particular:
- aquaculture activities
- space occupation
- environmental protection
- food security
- health monitoring and control

An analysis of the rules directly or indirectly involved in the approval of an aquaculture project has to be performed.

The regulations established for the aquaculture consenting process to grant a licence and a lease should also be differentiated from the regulations that may exist for the development of the activity, such as strategic plans or similar instruments. All the issues affecting the development of the activity need to be analysed from the legal point of view and, if necessary, a revision of the rules could be required in different geographical areas of intervention: at the local, regional, national and supranational levels.

The analysis of the legal framework is focused on the process involved for obtaining a licence and the potential limiting factors that influence licencing processes at the local level. These limiting factors will have to be taken into consideration in a detailed analysis in order to overcome potential difficulties.

3. Spatial analysis and delimitation of the study area

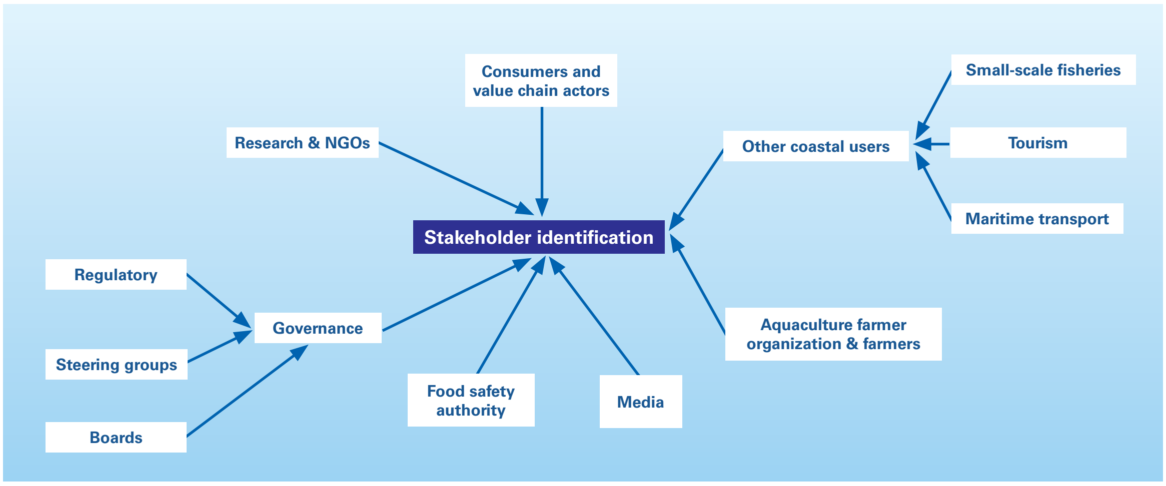
The geographical boundaries of a specific study area can be established once the knowledge on the sector and its regulatory, environmental and socio-economic context is gathered. To support the spatial analysis, different maps or existing charts could be used, such as:
- appropriate scale base mapping;
- digital orthophotography of the area; and
- nautical charts of the area, or other maps.

4. Identification of the agents and other stakeholders that influence the AZA establishment process

At this point of the study, stakeholders that may determine the outcome of the project are identified. They may be public authorities, beneficiaries and/or producers of the activities (Figure 4).

Government agencies are identified, including national and local authorities and other stakeholders, as appropriate, for each topic related to the activity. The stakeholders need to be involved at different levels during the various phases of the process of the identification and implementation of the AZA.

FIGURE 4
Example of potential stakeholders in the establishment of AZAs



Phase 2: Information and data collection

1. <u>Selection of scope and study parameters</u>

The selection of the parameters to be analysed is carried out on the basis of a dual analysis taking into consideration both the administrative and the environmental working lines.

The administrative working line is based on the parameters that might interfere with the development of aquaculture due to incompatible uses from a legal point of view. As an example, in some areas, certain uses are determined by law, such as military uses, fishing grounds, and areas dedicated to maritime traffic. Therefore, the possibility of incompatible uses with aquaculture is quite high in such areas.

The environmental working line refers to the physical, chemical, biological and oceanographic conditions that might directly influence the technical feasibility of the aquaculture system, such as depth or current speed. At the same time, it also refers to parameters that describe the possible influence of the aquaculture system on the environment, such as affecting Posidonia meadows or other critical habitats.

2. <u>Field work and data collection</u>

The collection of information includes the following:
- strategic documents relevant to the study: strategic plans and sector-specific studies, standards and applicable laws, technical studies and projects related to the subject matter, mapping, satellite images and others;
- scientific fieldwork: environmental data and information from grey literature;
- non-scientific fieldwork: technical visits and interviews with stakeholders; and
- other sources.

At this stage of the project and in addition to taking into account all these aspects, it is necessary to consider the creation of a network of people and contact groups who have an interest in the project and may participate, with their proposals and/or recommendations, in subsequent follow-up phases of this work.

Phase 3: Pre-selection of AZA

1. <u>Establishment of criteria for spatial analyses</u>

The establishment of criteria for representation is as important as the technical knowledge of GIS tools, since they will determine the spatial analysis to be performed.

These criteria will be directly related to the information provided by the different administrations, according to the project objectives and the conditioning factors, which are part of the process. They are criteria of both administrative and environmental types.

The criteria established for each constraint need to be addressed, which determine the exclusion or limitation of the development of aquaculture. In many cases, these constraints result from other specific regulations and come from different authorities.

2. <u>Preliminary maps and reports</u>

In parallel with the collection of information and fieldwork (i.e. technical visits, interviews, etc.), a process of integration and mapping of the information and technical reports has to be undertaken. The scale to be chosen depends on the context and would usually be large scale (from 1/10 000 to 1/50 000) or medium scale (from 1/50 000 to 1/500 000).

Phase 4: Consultations and validations of proposed areas

1. Consultations: application of the participative approach

Once data are available and a first approach to the AZA has been prepared, this information (including reporting and mapping) has to be shared with all the stakeholders involved in the process in the context of workshops, multi-stakeholder platforms, meetings and expert panels for analysis, validation and suggestions for improvements, with a view to enhancing social acceptability and avoiding conflicts.

Consensus should be reached among stakeholders and special attention devoted to the production companies which would be the users of AZAs.

The cohabitation of different producers in one area may not be easy, so it would be necessary to know, from the point of view of the company, which would be the limiting factors for sharing an allocated zone with other companies.

2. Thematic cartography and support reports

The cartographical information generated is based on the aquaculture operations, availability of space, uses and activities, legal framework and criteria obtained from the interviews.

Within the process carried out for the establishment of AZAs, a certain number of locations would be identified that can host aquaculture activities, if they comply with the technical and environmental requirements and show no administrative incompatibilities or conflicts with other uses.

Phase 5: Analysis of aquaculture potentiality

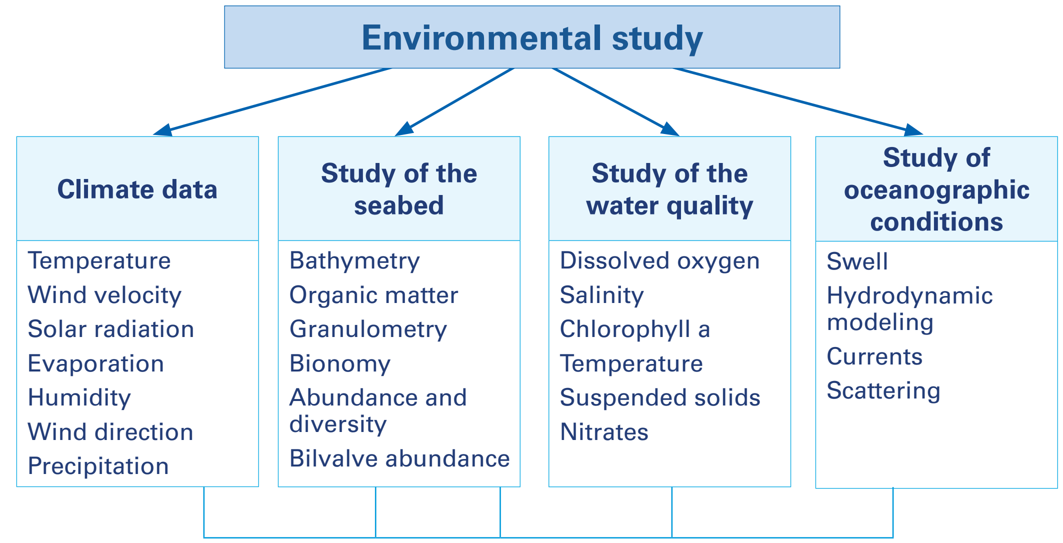
1. Environmental studies: characterization of the area and carrying capacity

The environmental study linked to the process of establishing an AZA has a dual purpose. It aims, first, to find the most suitable conditions for farming and, second, to obtain reference values or record the preoperational state prior to further environmental monitoring in the area (e.g. protected habitats or species).

The environmental characterization of the study areas is also a key aspect to determine the suitability for carrying out different types of aquaculture. Indeed, the promoters and companies interested in developing aquaculture initiatives need to know if the environmental conditions and water quality in the area are suitable for the establishment of an aquaculture operation. A description of the main environmental factors that may contribute to determining the suitability for marine farming include: climate, water quality, hydrology, oceanography and bathymetry. The parameters associated with the environmental study are represented in Figure 5.

This description is done either by using studies already completed in the area by authorities, research bodies and other agencies involved, which can give an input (feasible data) on the environment, or by undertaking new studies. This assessment should be carried out using particular methods and mathematical models, whose results are technically reliable, such as the Farm Aquaculture Resource Management (FARM) and EcoWin modeling tools. However, this part of the process can be quite complex depending on the level of information available, and the type of analysis to be performed.

FIGURE 5
Parameters linked with the environmental study



Modified from Del Castillo y Rey and Macias, 2006.

2. Description of the socio-economic context

An analysis of the socio-economic status of the study area should be undertaken in order to identify the context in which aquaculture is going to take place, including the interrelations and possible effects of other users such as traditional artisanal fisheries.

The description and monitoring of the socio-economic context could be facilitated by the use of indicators of sustainability (Box 9). Useful indicators to be collected can include: number of professional associations, number of workers, production value index, input/output price parity, existence of quality certification schemes by independent bodies for target markets, etc.

BOX 9. Indicators for sustainable aquaculture

The most common way of measuring sustainability in its various dimensions is the use of indicators, which can provide information on any aspect linked to the interplay between the economic, social and environmental facets of a sector or activity. Generally speaking, an indicator is a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions in a given dimension.

The three basic functions of an indicator are: simplification, quantification and communication, and good characteristics include being measurable and achievable. Indicators are only useful if the objectives for measuring them are clear. Indicators should enable answering basic questions. Descriptive indicators would provide answers to queries such as "What is happening in the aquaculture sector?"

BOX 9. Continued

Indicators are usually identified through a co-construction process that uses a principles-criteria-indicators (PCI) approach. Indicators are also associated to standards and reference points, indicating the particular state of the element to be monitored. Indicators of different levels of applicability are available to monitor the sustainable development of aquaculture.

- **Regional indicators** should be considered as appropriate for the whole Mediterranean and Black Sea area, and for the description of aquaculture sustainability at the regional level.
- **National indicators** encompass an entire country and describe the state and trends of aquaculture sustainability in a given nation giving a holistic picture of the aquaculture sector and its environment.
- **Local indicators** are meant for a homogeneous cluster of farms or group of aquaculture operations which, for example, are in close proximity to each other, such as for instance cages in the same bay, municipality, shared resources or infrastructures, county, autonomous region, etc.
- **Farm-level indicators** target single aquaculture operations and their close surroundings. Farms can operate in isolation from other farms or be part of a homogeneous cluster of farms (i.e. polygons). Some indicators are only applicable at the farm level and can provide an operational as well as strictly managerial tool.

Source: Fezzardi *et al*. (2013).

3. Degree of compatibility

Greater depth analysis should be undertaken on the basis of the preliminary maps. Specifically, according to the results of the phase 3 (normally based on administrative incompatibilities of spatial uses) and having integrated all the information obtained during the previous steps, a level of interest should be estimated and introduced into the model. The level of interest[5] could also be defined on the basis of a degree of compatibility (DC) for each area. The DC allows the categorization of the study area into zones with the aim to define the suitability for the development of aquaculture activity. This categorization of zones must be carried out consistently and in line with the variables explained in Box 10 (Del Castillo y Rey and Macias, 2006).

BOX 10. Degree of compatibility estimation: the case of Andalusia

As an example made by Del Castillo y Rey and Macias (2006), the DC could be defined on the basis of the following formula:

$$DC = 100 \times \frac{\sum_i^n K_i \times SI_i}{\sum_i^n K_i}$$

Where:

DC = Degree of compatibility

K = Weighting factor applied to each parameter considered

SI = Suitability index applied in the bay according to the potential influence of each parameter

i = Parameter

n = Number of parameters

5. The term "level of interest" used in Del Castillo y Rey and Macias (2006) is reported as "degree of compatibility" in this publication.

BOX 10. Continued

Specifically:

- The parameters considered during the study will depend on the information available gathered during the previous phases. The parameters used in this phase could be environmental, administrative, socio-economic or oceanographic. Each parameter should have ranges or conditions assigned.
- The suitability index (SI) is assigned for each range of parameter considered in the study. SI can take four different values according to the potential influence of the range considered: -100 (exclusion criteria), -1 (unwise characteristic), 0 (moderately) or 1 (optimum characteristic).
- The weighting factor (K) ranges from 1 to 10 and the value assigned is directly proportional to the reliability and the importance of each parameter. K can vary from one study to another.

Parameters, SI and K values will depend on the socio-economic context and on the specificities of the study area.

Once the variables are determined, the final assessment of the suitability level for each area considered in the study should be undertaken according to the DC estimation (See Section 3.2). An example of the parameters set and related SI, K and the map resulting is illustrated below (Box 11):

BOX 11. Degree of compatibility estimation: the case of Andalusia

The parameters used to calculate the degree of compatibility (DC) in the study carried out in Andalusia (Del Castillo y Rey and Macias, 2006) were classified according to SI and K, and are listed in the following table:

Parameter	Level of interest		Weighting factor K
	Ranges and conditions	SI	
Uses compatibility	Incompatible zone	-100	10
	Limited zone	0	
	Compatible zone	1	
Depth	< 20 m	-1	7
	20 - 50 m	1	
	> 50 m	0	
Medium swell	>3 m	-1	4
	< 1m	0	
	1 – 3 m	1	
Extreme swell	>6 m	-1	
	3 – 6 m	0	
	< 3 m	1	
Average speed of currents (vertical integration)	< 5 cm/s	-1	8
	5 – 15 cm/s	0	
	15 – 60 cm/s	1	
	> 60 cm	-1	
Scattered degree	High	-1	10
	Medium	0	
	Low	1	
Water Quality Index (WQI)*	WQI ≤ 3.33	-1	5
	3.33 < WQI ≤ 6.66	0	
	WQI > 6.66	1	
Bionomic (ecosystem value)	High	-1	6
	Medium	0	
	Low	1	
Seabed	Rock or mud	-1	1
	Rock and sand	0	
	Sand or gravel	1	

* Parameters used in the study to estimate WQI were: dissolved oxygen, temperature, salinity, suspended solids, chlorophyll a and nitrites

According to DC estimation (following the formula in Box 10), the result could be classified and delineated as the following table:

Value	Final assessment
-10000 < DC < -30	Low DC
-30 ≤ DC ≤ 30	Medium DC
30 < DC < 100	High DC

Source: Del Castillo y Rey and Macias (2006).

4. Proposal of aquaculture activities inside the AZA

AZAs are areas in which specific aquaculture projects are located. This could imply the creation and establishment of new companies (producers) that require new licences and leases. These new licences and leases undergo specific and complex administrative processes, in which the proposal of the project is central (GFCM, 2018). Within a defined AZA, one or more aquaculture farms can be implemented as a result of specific aquaculture project(s). Each project is based on a set of technical documents (Box 12).

BOX 12. Technical documents supporting the establishment of an aquaculture farm

Technical project: describes all the technical aspects and elements addressing the installations, mooring systems, security and signaling. It should demonstrate the technical feasibility of the infrastructures.

Biological report or production plan: describes the species to be reared, the production cycle and plan and production capacity. It should demonstrate the biological feasibility of the aquaculture system and species.

EIA and environmental monitoring programme (EMP): describe the characteristics of the environment and production system, linking their possible interactions together. They should demonstrate the lack of irreversible negative effects on the environment.

Economic and financial report: contains the budget, accountancy performance, cost benefit analysis and marketing and financial plans. It should demonstrate the economic feasibility of the aquaculture project.

Once the space available has been determined, an aquaculture project could be proposed, taking into consideration the type of aquaculture, level of production, interaction with the environment and other factors, and assessing the number of aquaculture facilities that may be allocated in the AZA.

All the technical information to be included in an aquaculture project has to be developed and agreed upon by the various stakeholders involved.

That information shall include the following:
- type of aquaculture: cages for finfish, shellfish systems, others;
- species allowed for cultivation;
- maximum volume of production;
- location and size to occupy;
- number of cages and range of dimensions; and
- relevant information on economic aspects, employment, commercialization and marketing of aquaculture products.

Phase 6: Carrying capacity and monitoring plans

1. Design and drafting of management and monitoring plans for AZAs

Management plans have to be designed and implemented in coordination with the users of the AZA. Since a project is developed in the maritime-terrestrial public domain of the coastal areas, the evolution and dynamics of the uses and new uses have to be taken into account. Changes need to be monitored and indicators established for testing the evolution and performance of the system.

The establishment of management plans and monitoring schemes should be supported by laws and regulations adapted to the legal framework of the country. An adaptive approach concerning legal aspects by each location has to be applied and new rules set up for the sustainable development of the aquaculture industry within AZAs.

2. Carrying capacities

An holistic approach to carrying capacity is necessary and has to take into consideration all measurable parameters, including environmental, social, physical, production and economic aspects of the activity (IUCN, 2009). Indeed, "carrying capacity is an important concept for ecosystem-based management, which helps set the upper limits of aquaculture production, given the environmental limits and social acceptability of aquaculture, thus avoiding 'unacceptable change' to both the natural ecosystem and the social functions and structures" (Ross *et al.*, eds, 2013). Four categories of carrying capacity have been defined, i.e. physical, production, ecological and social carrying capacity, as reported by Inglis, Hayden and Ross (2000), and by McKindsey *et al.* (2006) (cited in Ross *et al.*, eds, 2013):

- Physical carrying capacity is based on the suitability for development of a given activity, taking into account the physical factors of the environment and the farming system.
- Production carrying capacity estimates the maximum aquaculture production and is typically considered at the farm scale. For the culture of bivalves, it is the stocking density at which harvests are maximized.
- Ecological carrying capacity is defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, services, species, populations or communities in the environment.
- Social carrying capacity has been defined as the amount of aquaculture that can be developed without adverse social impacts.

A rapid model can be applied to calculate the production carrying capacity, based on parameters such as currents, distance from the coast, etc. (Karakassis *et al.*, 2013). The Greek legislation considers production carrying capacity (Box 13) on the basis of the fish farm's distance from the coast, the water depth under the fish farm, the openness/exposure of the fish farm location or current speed and the area of the farm site or concession.

BOX 13. Measuring production carrying capacity in Greek legislation

The total annual capacity (D) in tonnes of each fish farming park is estimated with the following equation: D=[150+80 * (E-1)] * fa * fb * fk, where:

f_a: fish farm's distance from the coast

f_b: water depth under the fish farm

f_k: openness/exposure of the fish farm location or current speed

E: area of the fish farm site (ha)

The factor values are the following:

Fish farm's distance from the coast[1]	Up to 100 m	101–400 m	401–1000 m	More than 1000 m
f_a	1.0	1.25	1.5	2.0

BOX 10. Continued

Water depth under the fish farm*	Up to 20 m	21–40 m	41–60 m	More than 60 m
f_b	0.9	1.0	1.5	2.0

Openness/exposure of the fish farm location or current speed**	Closed	Open	Very exposed	Flow speed
f_k	1.0	1.5	2.0	2.5

* The fish farm's distance from the coast and water depth under the fish farm are certified by the local coastguard inspection.

** Current speeds are certified by research and academic institutions. The current speeds for each site are estimated as the average of at least three measurements, each of them performed with a five-day interval, during the season 01/06 to 31/08, sampling at 9–11 m water depth.

Distance between two neighbouring fish farming parks or farm units

The distance between two neighbouring fish farming units must be larger than 500 m.

The distance between two neighbouring fish farming parks of the same farm units must be larger than 100 m and smaller than 250 m.

Fish farm size (sea rental)

The total rental marine surface of a floating cage installation (constituted by one or more parks) must not surpass 10 ha, while the surface of each park must not be less than 1 ha.

Source: Joint Circular No 121570/1866/2009 of the Hellenic Ministries of Environment and Rural Development and Food. Regulation of aquaculture issues.

3. Establishment of AZAs and management and monitoring plans

At the end of the process, the authority with competencies in aquaculture, in coordination with other authorities such as the ministries dealing with maritime affairs, transport and environment and other local authorities, should legally establish the AZA and include it into national legislation and regulations, as appropriate.

Phase 7: Integration of AZAs into the legal framework

The results obtained constitute in themselves a planning tool and, as such, have to be integrated into national strategic plans and implemented. Integrating the AZA within the legal framework aims at endowing the selection and establishment of the area with legality and formality.

Sometimes, the publication of studies and reports and their dissemination in the scientific, administrative and private domains can be tools for planning. For each context, the best strategy to be followed has to be coherent with the strategic plan and based on the rules governing aquaculture in that country.

The transposition of the identified and planned AZAs into appropriate normative frameworks is a quite complex process that requires specific regulations or laws and could be materialized by the issuance of:
- national strategic plans, from existing aquaculture acts;
- aquaculture zoning ordinances, from existing statutes;
- aquaculture acts, in order to include areas of development;

- local development plans or marine spatial plans;
- local regulations; and
- other instruments (technical instructions or official announcements, which can also be integrated into secondary law, etc.).

During the process for developing and implementing aquaculture normative information, the issuance of reports and legal documents can be hampered by the administrative burden related to procedures. The most important aspects to consider when developing aquaculture-related legal information are:

- coordinates of the area;
- types of aquaculture and technologies that can be applied;
- specifications for the different facilities;
- volume of production allowance;
- species allowed;
- rights and obligations of the tenderers; and
- monitoring and control plans.

These rules should include a mechanism allowing quick modifications, according to the results obtained in the course of the establishment of aquaculture operations by companies in the selected areas.

4. AZA management

The establishment of an AZA occurs at the governmental level or at the level of agencies that have responsibilities in aquaculture and/or geographical planning, with the consensus of all the stakeholders involved. It is necessary that the attribution of responsibilities between the public and the private sectors be made clear.

4.1 Management plan

In order to ensure its sustainability, an AZA, once established, needs to be accompanied by a management plan. The principal objectives of AZA management plans include:

- ensuring the conservation of a healthy environment and of the ecological services provided by the environment;
- ensuring the conservation and protection of the AZA;
- ensuring social and/or economic benefits for the local communities;
- providing protection for critical or representative habitats, ecosystems and ecological processes;
- avoiding conflicts among different human activities through a participatory approach;
- protecting the natural conditions and/or cultural heritage while allowing a spectrum of reasonable human uses;
- preserving some areas of the AZA in their natural state undisturbed by human activities, except for the purposes of scientific research or education; and
- guaranteeing benefits for the aquaculture farmers.

The authority with competence in aquaculture activities in the area should manage the AZA, working in cooperation with the relevant users and stakeholders involved. It is therefore recommended to create a coordinating body, such as aquaculture multi-stakeholder platforms, that brings together the interests of each party.

Minimum contents

Whatever the type of AZA established, it will be necessary to develop a management plan, which should contain the following key elements at least:

- purpose and scope of the plan, explaining the legislative framework and authority responsible for the plan development;
- targets of development, in the form of a statement of the goals and objectives for the AZA as a whole;
- definition of the area, in the form of a formal statement and geographic description of the boundaries of the AZA;
- description of the environmental resources in the AZA and in its influence zone;
- description of uses in the AZA, which should include social and economic analyses of use;
- description of the aquaculture production activities: facilities, species, annual production, carrying capacity, boats, feeding, etc.;
- environmental monitoring programme (EMP) for the AZA;
- administrative management of the area: processing authorization and licenses;
- management and maintenance of lighting and signage;
- external scientific and technical monitoring and agencies involved;
- animal health surveillance programmes and management, which is a key factor for developing aquaculture in many countries in the world;

– contingency plans to be developed before occurrences of natural diseases or unexpected accidents (e.g. waste spills);
– good practices to be applied in the area;
– assessment and review of the plan effectiveness for evaluation and feedback;
– plan for site management;
– description of relation with local communities, possibly supported by indicators and reference points; and
– other information relevant to good use and management of AZA and sustainability of aquaculture activity.

An AZA management plan should also define, for any kind of activities, the attribution of responsibilities of the different parties involved at the various levels of its management (inspection, administration, farmers, etc.).

Additionally, an AZA management plan may be revised in accordance with the changing conditions (e.g. climate change, market trends).

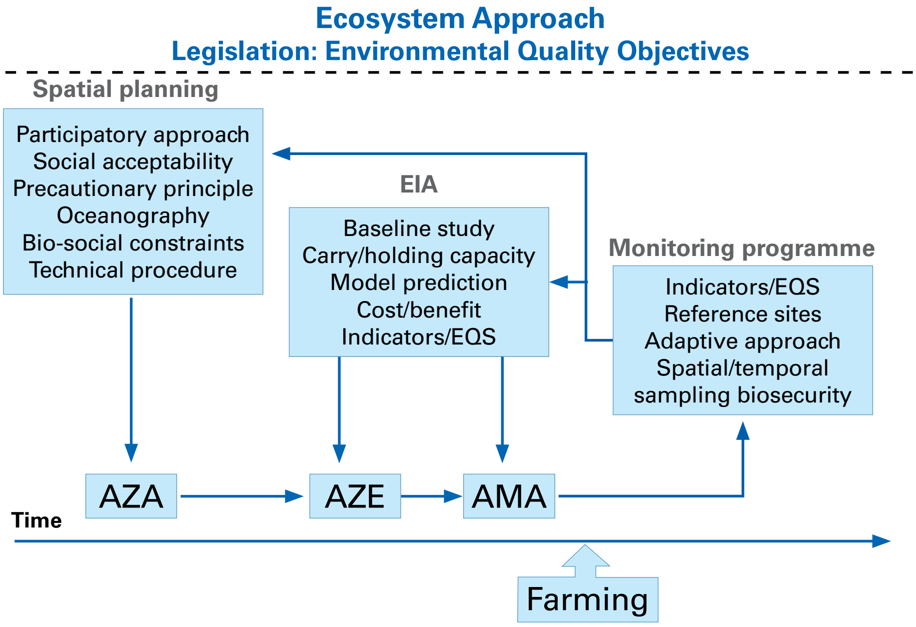
Furthermore, management plans are at the core of the concept of aquaculture management areas (AMAs), which have been considered within the global debate on the allocation of space for marine aquaculture (Box 14 and Figure 6).

BOX 14. Aquaculture management areas (AMAs)

In New Zealand, marine farmers were required to gain consent under the Resource Management Act 1991 to occupy marine space and build onshore and off-shore structures to support marine operations. The 2004 aquaculture reforms attempted to streamline the consenting process by implementing AMAs with the objective of setting aside areas for aquaculture in regional coastal environmental plans. In 2011, legislative changes were implemented to the 2004 reforms and, today, AMAs are intended as a coastal management tool in order to address the effects of aquaculture on the environment, fisheries resources and other uses of the coastal marine area, and to consider their influences on commercial, customary and recreational fishing (Ministry for Primary Industries of New Zealand, 2012; Ministry for the Environment of New Zealand, 2005).

FAO and the World Bank have also addressed AMAs and defined them as “geographical water bodies/areas where all the aquaculture operators agree (coordinate and cooperate) to certain management practices or codes of conduct for the area”. According to this view, AMAs include measures to address the common issues and risks to fish farming, while improving the profitability of the farmers, minimizing impacts on the environment, and ensuring integration with and acceptance by local communities and other users of the water resource (Aguilar-Manjarrez, Soto and Brummett, 2017).

FIGURE 6
Example of procedures for the environmental management of aquaculture*



* Technical procedure for correct full environmental management of aquaculture, which must include the definition of an AZA, an EIA, the definition of an AZE and an AMA and, following the initiation of farming activity, the development of monitoring programmes.

Source: Sanchez-Jerez *et al.*, 2016; modified from Sanchez-Jerez and Karakassis, 2011.

4.2 Rights and responsibilities

Important criteria to consider when establishing an AZA are the rights and responsibilities associated, as the adoption of such areas by the authorities should mean an improvement in the position of companies. These improvements in the form of rights could be related to:
- an easier access to areas of aquaculture;
- an increased legal security of economic activity;
- an improvement of the conditions concerning the occupation of other areas that are not controlled; and
- a greater transparency in communication with local communities, in particular where better management practices are applied.

It is also important to note that the arrival of a company inside an AZA implies that the other companies sharing the area receive new obligations and responsibilities, and that they all respect the environment and controlling authorities. In this context, cooperation among farmers would be mandatory.

The responsibilities of the companies could be related to:
- compliance with the approved management plan for their activity and production;
- adoption and enforcement of good practices agreed for the AZA;
- compliance with safety and risk prevention plans;
- compliance with environmental monitoring plans;
- compliance with the maintenance of facilities and the signalling;
- compliance with sanitary prevention and control of production;

- compliance with other plans, commitments and agreements adopted by the whole aquaculture industry and administration competence in the management of the AZA.

Agreement is also suggested with local communities, relevant stakeholders and non-governmental organizations, as appropriate, in order to prevent any local conflict.

5. General considerations

Since the concept of AZA is interlinked with the wider ecosystem, rather than limited to a mere zoning process, and embraces the pillars of sustainability, the effective implementation of AZAs should be promoted. The application of such an instrument would improve knowledge about the natural environment and its interrelationship with coastal aquaculture production processes. It would also enable impacts to be reduced on the environment, while boosting local economic development, enhancing food security and social acceptability, and increasing institutional capacities for the sustainable development of aquaculture.

In the future, the rise of aquaculture, in terms of the number of facilities and volume of production, will depend on the availability of space to develop the activity in a sustainable way – that is to say on AZAs. Indeed, AZAs can be considered as a full-fledged management tool supporting countries in the holistic development of aquaculture, linking together the pillars of sustainability, the EAA and regulation, monitoring and feedback processes, within a blue growth and marine spatial planning context.

This guide should be considered as a flexible and living document, to be enriched with knowledge acquisition, and which will evolve, as the AZA concept itself will, in response to future technological developments enabling aquaculture to move further offshore and in relation to climate change.

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Appendix 1

Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture[6]

The General Fisheries Commission for the Mediterranean (GFCM),

RECOGNIZING that aquaculture plays an important role in terms of its contribution to economic development and that it represents an important source of food and employment for coastal communities of contracting parties and cooperating non-contracting parties (CPCs);

CONSISTENT WITH the Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations, in particular Article 9 which calls upon states, *inter alia*, to produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities;

TAKING INTO ACCOUNT relevant provisions in the 2002 Johannesburg Declaration on Sustainable Development and the 1995 Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean (Barcelona Convention) and its protocols as amended, in particular, the Protocol on Integrated Coastal Zone Management in the Mediterranean;

NOTING that aquaculture activities are rapidly expanding in the GFCM area of application, thus calling for an integrated coastal zone management, consistent planning and management at the regional level;

ACKNOWLEDGING that aquaculture activities affect and are affected by other human activities to the extent that their relative contribution to environmental degradation needs to be controlled and that adverse social and environmental interactions with aquaculture activities have to be reduced;

CONSIDERING the implementation of a regional strategy for the creation of allocated zones for aquaculture (AZAs) as an immediate priority for the responsible development and management of aquaculture activities in the Mediterranean and the Black Sea;

FURTHER CONSIDERING that the creation of AZAs may facilitate the integration of aquaculture activities into coastal zone areas exploited by other users and contribute to the enhancement of coordination between the different public agencies involved in aquaculture licensing and monitoring processes;

ACKNOWLEDGING conflicts between aquaculture activities and other users of the coastal zones, in addition to the main variables and factors affecting the development of aquaculture activities;

STRESSING IN PARTICULAR the need for the definition of common criteria for the selection of sites for aquaculture activities;

BEARING IN MIND that the sustainable development of aquaculture can be significantly facilitated by a clear vision of AZAs;

6. To cite this document: GFCM. 2012. Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture. (Also available at: http://151.1.154.86/GfcmWebSite/docs/RecRes/GFCM_2012_RecRes_en.pdf)

DESIRING to promote in the GFCM area of application the establishment of AZAs as a management tool for marine spatial planning;

ADOPTS, in conformity with Articles 5 and 8 of the Agreement for the establishment of the General Fisheries Commission for the Mediterranean, the following resolution:

1. CPCs should include in their national marine spatial planning, a strategy for aquaculture development and management schemes for the identification and allocation of specific zones reserved to aquaculture activities.
2. AZAs should comprise specific areas dedicated to aquaculture activities. Any future development thereof, and their identification, should be based on the best social, economic and environmental information available, in order to prevent conflicts among different users for increased competitiveness, sharing costs and services, and to assure investments.
3. AZAs should be established within the remit of local or national aquaculture plans of CPCs, with the aim of ensuring the sustainability of aquaculture development and of promoting equity and resilience of interlinked social and ecological systems.
4. AZAs should be established within the framework of integrated coastal zone management, with regulations and/or restrictions being assigned to each zone in accordance with their degree of suitability for aquaculture activities and carrying capacity limit.
5. The zoning process for the establishment of AZAs should follow a participatory approach, be transparent, coordinated by the main authority responsible for marine planning at the local level and carried out in cooperation with the different authorities involved in aquaculture licensing and leasing procedures and monitoring. The coordination of competencies among the different public authorities involved in aquaculture licensing and leasing procedures and monitoring should be ensured at the national level.
6. Zones to be allocated to aquaculture activities may be classified, *inter alia*, as, "areas suitable for aquaculture activities", "areas unsuitable for aquaculture activities" and "areas for aquaculture activities with particular regulations and/or restrictions". Guidelines should be developed to this end.
7. Once established, AZAs should be based on legal and regulatory provisions, integrated into the national legislation or other adequate national administration level, as well as on interministerial coordination in order to ensure their effective implementation.
8. For every AZA, an allowable zone of effect of aquaculture activities may be defined in the close vicinity of each farm. The definition of such zones should be accompanied by an environmental monitoring programme.
9. The environmental monitoring programme should be flexible and adaptable, taking into account a scale (time and space) approach, and monitoring should be mandatory.

Appendix 2

Guidelines on a harmonized environmental monitoring programme for marine finfish cage farming in the Mediterranean and the Black Sea[7]

Definition, scope and principles, criteria, and objectives of the environmental monitoring programme (EMP)

EMP definition

The implementation of an EMP system dedicated to marine aquaculture should be decided at the beginning of the AZA identification process. AZA remains the key condition to implement an EMP and to develop aquaculture.

The EMP for marine cage finfish farming is a prerequisite and a first step towards mitigation of negative impacts of fish farming. The EMP is defined as a functional tool at the disposal of the authorities and the aquaculture industry (e.g. farmers) for aquaculture management practices in order to ensure the sustainability of the sector itself.

The EMP is also intended as a record-keeping system for documenting series of information and values of environmental parameters relevant to aquaculture activities, which will be used to perform periodic environmental assessments and monitoring.

The EMP record-keeping system should be based on the best scientific knowledge available in relation to marine aquaculture environmental monitoring and should be adaptable to the aquaculture conditions of the Mediterranean Sea and the Black Sea.

The EMP is also intended as a functional procedure to be adapted to the local sustainable reference system for aquaculture and should be adjusted at the local or at the country level, without prejudice to more detailed and appropriate existing regulations. The functionality of the EMP should be periodically monitored and adapted and/or revised as necessary according to the quality of the identified environmental objectives.

The EMP is therefore an essential means for evaluating the effectiveness of any management measure taken to reduce environmental impact.

EMP scope and principles

The purposes of the EMP at the regional level are to enable the different counterparts to meet safe environmental objectives, to ensure long-term sustainability of marine living resources, sustainable development of aquaculture and protection of sensitive habitats. At the national level, the main purpose is to adopt a harmonized regulated framework so as to ensure adequate measures for the conservation of the water quality status surrounding finfish farms at sea.

7. The guidelines were developed within the project Developing siting and carrying capacity guidelines for Mediterranean aquaculture within aquaculture appropriate areas (SHoCMed), supported by the European Union under Grant Agreement SI2.695897, and within the activities of the CAQ. Key elements for guidelines were endorsed at the ninth session of the CAQ (Morocco, February 2015). In order to grant them enhanced efficiency, the guidelines were then adjusted based on the results of a regional assessment of their feasibility at the national level and of a calibration exercise, carried out in November-December 2015 and February-June 2016, respectively.

The EMP shall be implemented systematically and permanently to avoid any potential harmful effects on the marine environment at the local and regional levels, and to respect the shared ecological services provided by ecosystems.

Implementing AZEs, including reaching a consensus on its definition, is essential in order to identify the source and level of impact of aquaculture on the environment and/or vice versa.

Addressing properly and in an integrated manner the responsibility over aquaculture and other related issues requires the cooperation of, *inter alia*, the authorities in charge of environmental monitoring and authorities in charge of aquaculture management.

The participation of aquaculture farmers in EMP collection and dissemination activities with competent authorities should be fostered to enhance responsibility sharing and stewardship.

The data and results of EMP activities should be easily accessible to the general public for the sake of transparency and in order to strengthen the image of aquaculture and aquaculture products in the society at large; addressing transparency in aquaculture would increase the social acceptability and responsibility of aquaculture itself.

More specifically, the information provided by the EMP will be useful to:
- minimize the global impact of aquaculture;
- respect the ecological services provided by ecosystems;
- minimize local impacts on the environment and biodiversity;
- ensure compliance with regulations and the achievement of environmental objectives and contribute to the protection of biodiversity;
- ensure the long-term sustainability of finfish culture;
- help identify actions to be taken to improve farm management practices;
- evaluate the achievement of quality objectives of the measures adopted to protect the environment and of bringing the results to the attention of the civil society and the public; and
- ensure fish health and welfare and product quality.

EMP functionality

The EMP is aimed at identifying how aquaculture activities could affect the surrounding environment, on the basis of measuring specific environmental variables. The EMP also provides feedback on any potential adverse environmental impacts through assessment of the recorded monitoring results, and comparison with defined values for environmental attributes and objectives.

The monitoring requirements should comprise a minimum scheme that can be applied in any type of marine environment, as well as additional requirements that can be adapted according to the different scales of farming activities and depending on the sensitivity of the receiving environment.

EMP reporting system and contents

If not properly managed, marine aquaculture can result in a variety of adverse environmental impacts that are mainly determined by the release of organic matter and nutrients, for example, those originating from fecal waste and uneaten fish feed. Further potential sources of impacts include the use of chemicals, farmed fish escape events and disease outbreaks.

Following the establishment of an AZA for marine aquaculture activities, a specific EMP should be established by the authorities in charge of granting the maritime concession, and of monitoring the environment and ensuring nature protection, in order to protect the environment and aquaculture itself, and to avoid any potential irreversible impact by the finfish farm on the marine ecosystem. The EMP shall describe the sampling process and activities that are required to define the quality of the environment.

The EMP shall be flexible and adaptable, and take into account the scale approach (time and space), as well as the type of facility, farming system and production levels.

The EMP requires data on the "zero state" for all indicators and on the defined limits of tolerance.

The EMP requires the collection of a series of information on the particular area, and of data considered as most appropriate to describe the environmental conditions of the water and sediment. These should be registered in a logbook that will be referred to as the record-keeping system, which is intended to record physical, chemical and biological information collected within the monitored areas, including the area located in the immediate vicinity of a finfish farm and termed "allowable zone of effect" (AZE).

The logbook should include the frequency of sampling, the physical and chemical variables and other attributes to be monitored, as well as the number and locations of the sampling stations relative to the locations of the fish cages.

The record-keeping system should comprise two logbook types: Logbook 1 (Lb1) and Logbook 2 (Lb2). The first refers to the AZA and the farm(s) within the AZA, while the second refers to the monitoring activities undertaken within the zone surrounding the farm/farms, and which may possibly experience an adverse environmental impact.

Logbook 1 should contain at least the following information:
- Maps with locations of the fish farm, fish cages and monitoring stations;
- Water depth (minimum, maximum, mean);
- Mean sea current speed (with the definition of length and period of measurement);
- Sediment grain size or percentage of silt-clay;
- Information on the benthic community;
- Information on sensitive habitats, if any;
- Information on the finfish farm(s): cage farming system and characteristics; cultured species and cycles; production capacity; estimated feed conversion ratio (FCR); potential maximum cultured biomass per year; potential maximum feed quantity used per year.

Logbook 2 should contain information that will be recorded during the monitoring activities. This information should be collected according to a typology classification that is based on the production category and the mean sea current speed.

Ideally, the sampling should be carried out twice a year, during two opposite seasons; however, the sampling can also be annual and undertaken during the period when there is maximum biomass in the cages.

The number of sampling stations[8] could be as follows:

8. The sampling station layout design shall be reported separately.

Outside the AZE:
- 1 control station located up-current from the cages
- 1 control station located down-current from the cages

Inside the AZE:
- 1 station under the cages;
- 1 station located up-current from the cages, near to the limit of the AZE;
- 1 station located down-current from the cages, between the cages and the limit of the AZE;
- 1 station located down-current from the cages, near the limit of the AZE.

The distance between the stations and the cages will depend on the characteristics of each site.

For each station, the samples related to water monitoring variables should be collected in three different layers (surface, intermediate, and deep).

The variables to be recorded in Logbook 2 should at least include the following physical, chemical and biological attributes:

Water monitoring*	Sediment monitoring
Temperature (°C)	Macro-benthic community
Salinity (psu)	Visual inspection
Turbidity (m)	Redox potential (Eh, mV)**
Dissolved oxygen (% saturation; mg/l)	Sulphide (µM)
Chlorophyll a (mg/l)***	Organic matter (LOI, %)
pH (unit)	pH (unit)
TSM - Total Suspended Matter (mg/l)	Total Organic Carbon (TOC, %)****
POM - Particulate Organic Matter (mg/l)	Total Nitrogen (mg/g)
	Total Phosphorous (mg/g)
	Gas bubbles (Outgassing)
	Litter present on the seabed in the vicinity of the farm

* After a second survey and expert consultation, some variables (Ammonium ($N\text{-}NH_4$, µM), Nitrite ($N\text{-}NO_2$, µM), Nitrate ($N\text{-}NO_3$, µM) and Phosphate ($P\text{-}PO_4$, µM)) have been removed because of their volatility and rapid change in time, also in relation to the daily feeding and oxidation process.

** Possibly at sediment surface and at 4 cm below sediment surface.

*** Nutrients and chlorophyll-a are quite variable over time. Maximum values are found around noon and depend on the feeding time. There is evidence that the maximal change in chlorophyll-a is found at an intermediate distance (Tsagaraki *et al.*, 2013).

**** Either this or LOI.

In Logbook 2, there should also be some space dedicated to recording:
- Escape incidents (species, size, number)
- Disease incidents (type of disease; species at risk; number of outbreaks; medical treatment used)
- Disasters and weather-related events (e.g. presence of jellyfish; mortalities caused by exogenous pollution; storm events, etc.)

EMP design of sampling stations

The EMP should be accompanied by a sampling plan and design. The design should indicate the exact locations of the stations where the data/samples will be collected in relation to the layout of the finfish farm facilities.

The EMP sampling design should be based on transects located within the AZE (EMP-in), while control stations should be located outside the AZE (EMP-out). Sampling designs are usually of two types: i) use of transects that follow the direction of the main sea current (Figure 1); and ii) random stratified sampling (Figure 2).

Sampling stations should be located in such a way that consideration is given to the potentially impacted zone surrounding the farm, while the sampling protocol should be site-specific. In the case of uncertainty, sampling stations should be located 50 m away from the farm operations. Reference data should include data collected before deployment of the finfish cages. The use of BACI (Before-After-Control-Impact) or M-BACI (multiple controls) designs are considered as the most appropriate.

FIGURE 1
Examples of monitoring programmes based on transects laid across the AZE

A) Simple design using a single transect following the direction of the main current.

B) Two transects that intersect at the centre of the AZE.

C) Several transects laid perpendicular to the AZE, with the aim of applying spatial statistics such as the Kriging technique. At each sampling site, one or several samples can be collected.

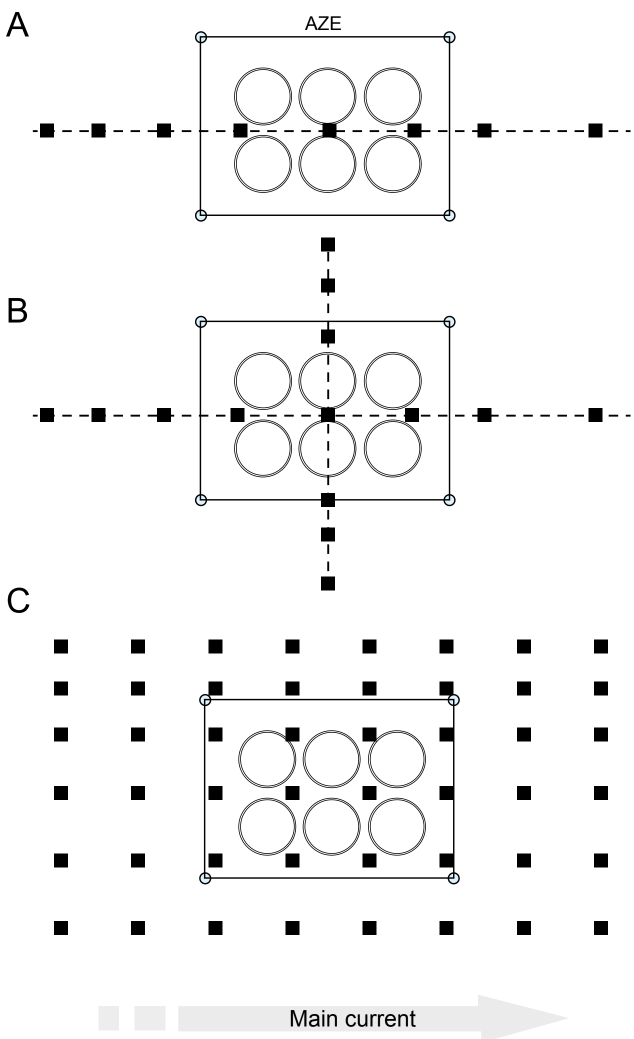
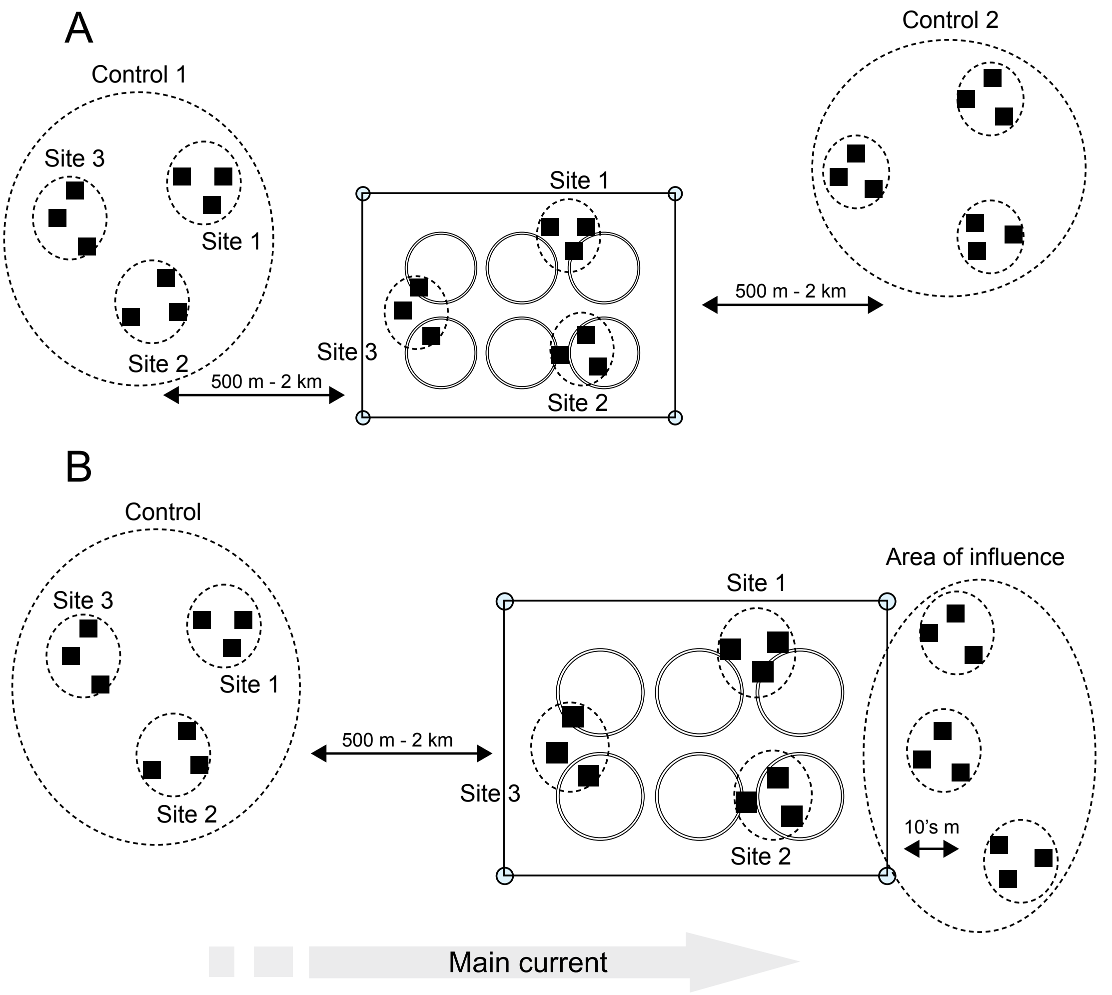


FIGURE 2
Example of random stratified sampling, considering (A) an impact zone (AZE) with two control zones that are sufficiently distant from the aquaculture facilities, and (B) three zones: impact zone (AZE), area of influence and one or several controls. Inside each zone, several sites are randomly selected, with three samples collected, for example, using a Van Veen grab



EMP responsibility

The responsibility for the EMP and data recording should be:

- within the AZE: aquaculture farms should record the data for the EMP. Alternatively, data collection will be under the responsibility of the competent authorities;
- outside the AZE: data recording should be under the responsibility of the authorities in charge of granting maritime concessions and/or of environmental/nature protection.

Data recorded within and outside the AZE should be analysed by the authorities in charge of granting maritime concessions and/or environmental/nature protection.

The data and results from the EMP should be recorded and stored in a way that is easy to understand and which would be easily accessible for the sake of transparency, in order to strengthen the image of aquaculture products with society at large.

Appendix 3

Glossary

Term	Definition	Reference
Adaptive approach	It is a term that is often associated with management, which focuses on an experience- and feedback-based learning process. Adaptive management strategies, often used in the natural sciences, may also employ intervention to test the response of the system to manipulations.	**Blackhart, K., Stanton, D.G. & Shimada, A.M.** 2006. NOAA Fisheries Glossary. NOAA Technical Memorandum NMFS-F/SPO-69, 71 pp. **Johnson, F.A., Williams, B.K., Nichols, J.D., Hines, J.E., Kendall, W.L., Smith, G.W. & Caithamer, D.F.** 1993. Developing an adaptive management strategy for harvesting waterfowl in North America. *Transactions of the North American Wildlife and Natural Resources Conference*, 58:565–583. **Walters, C.J.** 1986. *Adaptive management of natural resources*. New York, MacMillan. 374 pp.
Allocated zone for aquaculture	A marine area where the development of aquaculture has priority over other uses, and therefore will be primarily dedicated to aquaculture. Identification of an AZA will result from zoning processes through participatory spatial planning, whereby administrative bodies legally establish that specific spatial areas within a region have priority for aquaculture development.	**Sanchez-Jerez, P., Karakassis, I., Massa, F., Fezzardi, D., Aguilar-Manjarrez, J., Soto, D., Chapela, R., Avila, P., Macias, J.C., Tomassetti, P., Marino, G., Borg, J.A., Franičević, V., Yücel-Gier, G., Fleming, I.A., Biao, X., Nhhala, H., Hamza, H., Forcada, A. & Dempster, T.** 2016. Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefits of Allocated Zones for Aquaculture (AZAs) to avoid conflict and promote sustainability. *Aquaculture Environment Interactions*, 8: 41–54.
Allowable zone of effect	An allowable zone of effect (AZE) is an area of seabed or volume of the receiving water body in which a competent authority allows the use of specific environment quality standards (EQS) for aquaculture, without irreversibly compromising basic environmental services provided by the ecosystem.	**GFCM.** 2011. *Report of the Workshop on the definition and environmental monitoring within Allowable Zone of Effect (AZE) of aquaculture activities within the Mediterranean countries (WGSC-SHoCMed)*. 34 pp.

Term	Definition	Reference
Aquaculture	Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans, other invertebrates, crocodiles, alligators, turtles, amphibians and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquaculture production is defined as an increment of biomass and/or an increment in the number of individual organisms produced during the period of farming. Therefore, in order to measure aquatic production, both inputs to and outputs from the farming environment are needed.	**GFCM.** 2009. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM).* Trabzon, Turkey, 9–10 December 2009. 19 pp.
Aquaculture farmer organization	Any formal membership organization formed by aquaculture farmers/producers to promote their interests through advocacy, economic and/or technical services.	**Rad, F., Massa, F., Afanasjeva, A., De Rossi, F. & Fezzardi, D.** 2014. A preliminary survey on aquaculture farmers' organizations in the Mediterranean and Black Sea. *Journal of Academic Documents for Fisheries and Aquaculture*, 2: 55–62.
Area of interest	In site selection for aquaculture, it refers to coastal and maritime areas, which are free of incompatibilities or interference of use from an administrative point of view and are selected by governments to encourage the development of aquaculture.	**IUCN.** 2009. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management*. IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp.
Artificial reef	Artificial reefs are underwater structures constructed by humans for a variety of purposes, including recreational diving, erosion control, trawl exclusion and other types of fishing, enhancement of commercial or recreational marine species (e.g. lobsters or finfish), etc.	**Clark, S. & Edwards, A.J.** 1999. An evaluation of artificial reef structures as tools for marine habitat rehabilitation in the Maldives. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 9:5-21. **Qiu, J.W., Thiyagarajan, V., Leung, A.W.Y. & Qian, P.Y.** 2003. Development of a marine subtidal epibiotic community in Hong Kong: implications for deployment of artificial reefs. *Biofouling*, 19: 37–46.
Bathymetry	The science of measuring and charting the depths of water bodies to determine the topography of a lake bed or sea floor.	**Folger, P.** 2011. *Geospatial Information and Geographic Information Systems (GIS): An overview for Congress*. Congressional Research Service (CRS). (also available at https://fas.org/sgp/crs/misc/R41825.pdf).

Term	Definition	Reference
***Beggiatoa*-type mats**	*Beggiatoa* is a group of filamentous sulfide-oxidizing bacteria that are often found in organically-enriched environments and appear on the interface between anoxic, sulphate-oxidizing surfaces and oxygenated seawater. *Beggiatoa* spp. form distinctive white mats, especially in polluted marine environments and have been used as visual indicators of impacted seafloors under net cage fish farms. Their presence indicates that the sediment is fully reduced, i.e. anoxic, with not even a few mm of surface mixed oxic sediment. The presence/absence of *Beggiatoa*-type mats is relatively easy to measure by means of divers, Remotely Operated Vehicles (ROVs) or even sediment profiling imagery (SPI) devices.	**Grant J. & Bathman U.V.** 1987. Swept away: resuspension of bacterial mats regulates benthic-pelagic exchange of sulfur. *Science*, 236: 1472–1474. **Fenchel T. & Bernard C.** 1995. Mats of colourless sulphur bacteria. I. Major microbial processes. *Marine Ecology Progress Series*, 178: 161–170. **Karakassis, I., Tsapakis, M., Smith, C.J. & Rumohr, H.** 2002. Fish farming impacts in the Mediterranean studied through sediment profiling imagery. *Marine Ecology Progress Series*, 227: 125-133.
Benthos	Organisms that live on or in the sediment in aquatic environments.	**Crespi, V. & Coche, A. (comps).** 2008. Glossary of aquaculture/ Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese).
Better management practices	Better management practices (BMPs) are management practices aimed at improving the quantity, safety, and quality of products, taking into consideration animal health and welfare, food safety, and environmental and socio-economic sustainability. BMP implementation is generally voluntary; they are not a standard for certification. The aquaculture sector can and should be able to improve on production through the adoption of BMPs.	**Umesh, N.R., Chandra Mohan, A.B., Ravibabu, G., Padiyar, P.A., Phillips, M.J., Mohan, C.V. & Vishnu Bhat, B.** 2009. Shrimp farmers in India: empowering small-scale farmers through a cluster-based approach. In: De Silva, S.S. & Davy, F.B., eds. *Success Stories in Asian Aquaculture*. 2009. Springer.
Biodiversity (biological diversity)	The variability among living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems.	**CBD.** 1994. Convention on biological diversity. Text and annexes. Chatelaine, Switzerland, Interim Secretariat for the Convention on Biological Diversity. **Welcomme, R.L. (comp.).** 2001. *Inland fisheries. Ecology and management.* Oxford, UK, FAO/ Fishing News Books. 358 pp. **Fagetti, E., Privett, D.W., & Sears, J.R.L. (comps.) & Hudson, J. (rev.).** 2000. *Aquatic sciences and fisheries thesaurus. Descriptors used in the Aquatic Sciences and Fisheries Information System*. Rome, FAO, ASFIS Reference Series, (6, Rev.2): 335 pp. **Crespi, V. & Coche, A. (comps.).** 2008. *Glossary of aquaculture/ Glossaire d'aquaculture/Glosario de acuicultura*. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese).

Term	Definition	Reference
Biosecurity	Biosecurity is defined as a strategic and integrated approach that encompasses the policy and regulatory frameworks for analysing and managing relevant risks of the sectors dealing with: human life and health (including food safety); animal life and health (including fish); plant life and health; environment.	**FAO**. 2009. *Report of the FAO Workshop on the Development of an Aquatic Biosecurity Framework for Southern Africa. Lilongwe, Malawi, 22– 24 April 2008*. FAO Fisheries and Aquaculture Report. No. 906. Rome, FAO. 55 pp.
Blue Growth Initiative	The Blue Growth Initiative (BGI) is based on the principles enshrined in its Code of Conduct for Responsible Fisheries, a key programme embedded in FAO's Strategic Objectives. FAO defines the BGI as "Sustainable growth and development emanating from economic activities in the oceans, wetlands and coastal zones that minimize environmental degradation, biodiversity loss and unsustainable use of living aquatic resources, and maximize economic and social profits".	**FAO.** 2014. Global Blue Growth Initiative and Small Island Developing States (SIDS). Fisheries and Aquaculture Resources Use and Conservation Division (FIR). (also available at http://www.fao.org/3/a-i3958e.pdf). **FAO**. 2015. FAO's Blue Growth Initiative and aquaculture document prepared for the Eighth Session of the Committee on Fisheries, Sub-Committee on Aquaculture, Brasilia, 5–9 October 2015. (also available at http://www.fao.org/cofi/30795-045b188b4c734e56986ed853cfb667a88.pdf).
Brackish water aquaculture	Brackish water aquaculture is the cultivation of aquatic organisms where the end product is raised in waters of fluctuating salinity in a range between 0.5‰ and full strength seawater. Aquaculture utilizing relatively high salinity water originating from inland water bodies should be considered as brackish water aquaculture. If these conditions do not exist or have no effect on aquaculture practices, production should be recorded under either "freshwater aquaculture" or "mariculture". Earlier stages of the life cycle of these aquatic organisms may be spent in fresh or marine waters.	**GFCM.** 2009. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM).* Trabzon, Turkey, 9–10 December 2009. 19 pp. (also available at http://www.fao.org/docrep/012/ak805e/ak805e00.pdf).

Term	Definition	Reference
Carrying capacity	The amount of a given activity that can be accommodated within the environmental capacity of a defined area. In aquaculture, it is usually considered to be the maximum quantity of fish that any particular body of water can support over a long period without negative effects to the fish and to the environment. Carrying capacity is now also being described by the following four definitions commonly applied to both bivalve farming and finfish cage aquaculture: Physical carrying capacity is defined as the total area of marine farms that can be accommodated in the available physical space; Production carrying capacity is defined as the maximum sustainable yield of cultured organisms that can be produced within an area; Ecological carrying capacity is defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, species, populations, or communities in the environment; Social carrying capacity is defined as the amount of aquaculture that can be developed without adverse social impacts.	**McKindsey, C.W., Thetmeyer, H., Landry, T. & Silvert, W.** 2006. Review of recent carrying capacity models for bivalve culture and recommendations for research and management. *Aquaculture*, 261:451–462. **Byron, C.J. & Costa-Pierce, B.A.** 2013. Carrying capacity tools for use in the implementation of an ecosystems approach to aquaculture. *In* Ross, L.G., Telfer, T.C., Falconer, L., Soto, D. & Aguilar-Manjarrez, J. eds. *Site selection and carrying capacities for inland and coastal aquaculture*. 87–101 pp. (also available at http://www.fao.org/3/a-i3322e.pdf)
Certification	Procedure by which a certification body or entity gives written or equivalent assurance that a product, process or service conforms to specified requirements. Certification may be, as appropriate, based on a range of audit activities that include continuous auditing in the production chain. (Modified from ISO Guide 2, 15.1.2; Principles for Food Import and Export Certification and Inspection, CAC/GL 20; Ecolabelling Guidelines). Credible aquaculture certification schemes consist of three main components: (i) standards; (ii) accreditation; and (iii) certification. The FAO Technical Guidelines on Aquaculture Certification cover: standard setting processes required to develop and review certification standards; accreditation systems needed to provide formal recognition to a qualified body to carry out certification; certification bodies required to verify compliance with certification standards.	**FAO. 2011.** *Technical Guidelines on Aquaculture Certification. Directives techniques relatives à la certification en aquaculture. Directrices técnicas para la certificación en la acuicultura*. Rome/Roma, FAO. 2011. 122 pp. (also available at http://www.fao.org/3/a-i2296t.pdf).

Term	Definition	Reference
Chlorophyll a	The concentration of Chl-a in the water column provides a measure of the phytoplankton biomass which is likely to be affected by various factors such as nutrient input from the fish farms, but also from other uses of the coastal environment, discharges from rivers, agricultural runoff, etc. The monitoring of this variable could provide some information regarding the trophic status of the farming site and the risk for diel oxygen fluctuations. The method used for the analysis of Chl-a content in marine water samples is of relatively low cost and the results may be obtained rather quickly.	**Pitta, P., Karakassis, I., Tsapakis, M. & Zivanovic, S.** 1999. Natural vs. mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. *Hydrobiologia*, 391: 181-194. **Pitta, P., Tsapakis, M., Apostolaki, E.T., Tsagaraki, T., Holmer, M. & Karakassis, I.** 2009. 'Ghost nutrients' from fish farms are transferred up the food web by phytoplankton grazers. *Marine Ecology Progress Series*, 374: 1-6. **Soto, D. & Norambuena, F.** 2004. Evaluation of salmon farming effects on marine systems in the inner seas of southern Chile: a large-scale mensurative experiment. *Journal of Applied Ichthyology*, 20:493–501. **Yentsch, C.S. & Menzel, D.W.** 1963. A method for the determination of phytoplankton chlorophyll and phaeophytin by fluorescence. *Deep Sea Research*, 10:221-231.
Coastal aquaculture	Coastal aquaculture; off-the-coast aquaculture and offshore aquaculture can be defined according to "operational criteria", based on the distance from the coast and water depths, thus underlining the degree of exposure, but also according to fish-farm operational requirements and accessibility.	**Lovatelli, A., Aguilar-Manjarrez, J. & Soto, D., eds.** 2013. *Expanding mariculture farther offshore: technical, environmental, spatial and governance challenges*. FAO Technical Workshop, 22–25 March 2010, Orbetello, Italy. FAO Fisheries and Aquaculture Proceedings No. 24. Rome, FAO. 73 pp. (also available at http://www.fao.org/docrep/018/i3092e/i3092e.pdf).
Coastal zone	Coastal zone means the geomorphologic area either side of the seashore, in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems, made up of biotic and abiotic components, coexisting and interacting with human communities and relevant socio-economic activities.	**UN Environment/PAP/RAC.** 2008. *Protocol on Integrated Coastal Zone Management in the Mediterranean*. 89 pp.
Coastline	The coastline is the land along the edge of a coast, forming a boundary between the land and the ocean, sea or a lake. The coastline shown on charts represents the line of contact between the land and a selected water elevation, called the coastline contour.	**Silver Spring, M.D.** 2000. *Tide and Current Glossary*. NOAA, National Ocean Service. 33 pp. (also available at https://tidesandcurrents.noaa.gov/publications/glossary2.pdf).
Co-construction approach	The co-construction approach is a joint approach to building indicators which is procedural, adaptive and participatory, and aims to promote collective learning in order to implement a sustainable aquaculture.	**Rey-Valette, H., Clément, O., Aubin, J., Mathé, S., Chia, E., Legendre, M., Caruso, D., Mikolasek, O., Blancheton, J.P., Slembrouck, J., Baruthio, A., René, F., Levang, P., Morrissens, P. & Lazard, J.** 2008. *Guide to the co-construction of sustainable development indicators in aquaculture*. Montpellier, Cirad, Ifremer, INRA, IRD, Université Montpellier 1. 144 pp.

Term	Definition	Reference
Code of conduct	Principles, values, standards, or rules of behaviour that guide the decisions, procedures and systems of an organization in a way that (a) contributes to the welfare of its stakeholders, and (b) respects the rights of all constituents affected by its operations.	**International Federation of Accountants (IFAC).** 2008. *International Good Practice Guidance. Defining and Developing an Effective Code of Conduct for Organizations*. (also available at https://www.hkicpa.org.hk/-/media/HKICPA-Website/HKICPA/section4_cpd/Continuing-Professinoal-Development-Programme-(CPD)/IFAC_corporatecode_Dec08-Eng.pdf?la=en&hash=F239E388D1075B-D2A52EBC927CBF72BD).
Code of Conduct for Responsible Fisheries	The Code of Conduct for Responsible Fisheries (CCRF) of FAO is an internationally accepted code of conduct for fisheries and aquaculture that was unanimously adopted on 31 October 1995 by the FAO Conference. It establishes principles and standards of behaviour for responsible practices, with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognizes the nutritional, economic, social, environmental and cultural importance of fisheries and the interests of all stakeholders of the fishing and aquaculture industries.	**FAO.** 1995. *Code of Conduct for Responsible Fisheries*. Rome, FAO. 1995. 41 pp. (also available at http://www.fao.org/3/a-v9878e.pdf).
Code of practice	A code of practice (CoP) is usually a "lower level" document that provides guidance on management or other practices to be adopted in implementing the principles of the codes of conduct. Some examples are: (1) The Global Aquaculture Alliance (GAA) Codes of Practice for Responsible Shrimp Farming; (2) The International Council for the Exploration of the Sea (ICES) Code of Practice on the Introductions and Transfers of Aquatic Organisms.	**FAO/NACA/UN Environment/WB/WWF.** 2006. *International Principles for Responsible Shrimp Farming*. ENACA Publications. Draft Principles for consideration by the Governing Council of the Network of aquaculture Centres in Asia-Pacific. (also available at http://library.enaca.org/Shrimp/Publications/International_Principles_for_responsible_shrimp_farming_Draft_25Jan2006.pdf).
Consumer perception	The response of persons when they see a product or a "brand" (a name or symbol that distinguishes the products or services of one seller from others) and their attitudes (not necessarily involving a reaction) regarding the specific product or service.	**Schiffman, L.G. & Kanuk, L.L.** 2000. *Consumer behaviour*. 7th edition. London, Prentice Hall.

Term	Definition	Reference
Cost Benefit Analysis (CBA)	A decision-support framework that compares the costs and benefits of a project or an action. Generally, cost-benefit analyses are comparative, that is, they are used to compare alternative project proposals on the basis of their net benefit. The cost-benefit decision rule is that no project with a net benefit of less than zero should be implemented and the project with the highest net benefit of all candidate projects should be accepted. Various types of cost-benefit analyses are recognized. These include financial, socio-economic and environmental variants.	**IUCN.** 2009. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management*, IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp. (also available at portals.iucn.org/library/sites/library/files/documents/2009-032.pdf).
Criteria	Within a principles-criteria-indicators methodology, criteria break down each principle into several specific themes or homogeneous elements and specify the issue(s) to be addressed through the relevant variables to be monitored. Criteria should be formulated expressing the degree or state of the variable, e.g. "level of", "control of", "existence of", "access to", "capacity of", as in "level of input efficiency".	**GFCM.** 2011. *Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.
Decision-makers	Decision-makers are referred to as those who are responsible for making strategic decisions regarding the fisheries sector. Thus, they are concerned with the formulation of policies for the sector and the development of strategies for its management, which will then be implemented by a range of "managers", working at different levels and within different institutions and agencies.	**Townsley, P.** 1998. *Social issues in fisheries*. FAO Fisheries Technical Paper. No. 375. Rome, FAO. 1998. 93 pp.
Diagenesis of organic matter	Organic matter is decomposed in sediments by an array of aerobic and anaerobic microbial processes with a concurrent release of inorganic nutrients. Decay rates depend on the composition of the organic matter, its age, temperature, sediment conditions, etc.	**Kristensen, E.** 2000. Organic matter diagenesis at the oxic/anoxic interface in coastal marine sediments, with emphasis on the role of burrowing animals. *Hydrobiologia*, 426:1-24.
Dissolved organic matter	Dissolved organic matter (DOM) is the soluble organic material derived from the partial decomposition of organic materials (including soil organic matter, plant residues, and soluble particles, such as bacteria and algae). This parameter plays an important role in nutrient sequestration and supply in aquatic ecosystems.	**Wright, A.L. & Reddy, K.R.** 2015. *Dissolved Organic Matter in Wetlands.* Soil and Water Science Department. SL 294. Original publication date June 2009. Reviewed January 2015 (also available at http://edis.ifas.ufl.edu/pdffiles/SS/SS50700.pdf).

Term	Definition	Reference
Dissolved oxygen	The dissolved oxygen (DO) concentration in the cages or, preferably, at the benthic boundary layer, beneath the farm provides a serious indication of the ambient conditions in the farming environment, but also an alarm for risks that might endanger the production and/or the health of the farmed stock. According to the ECASA toolbox (www.ecasatoolbox.org.uk), eutrophication effects in an inshore area could result in increased DO consumption in the basin water. The measurement of DO could be straightforward by using a water sampling bottle and a portable oxygen meter, although it would be advisable to calibrate it regularly using the Winkler titration method.	**Ehrhardt, M., Grasshoff, K., Kremling, K. & Almgren, T.** 1983. *Methods of Seawater analysis*. Verlag Chemie. 419 pp. **Erlandsson, C.P., Stigebrandt, A. & Arneborg, L.** 2006. The sensitivity of minimum oxygen concentrations in a fjord to changes in biotic and abiotic external forcing. *Limnology and Oceanography*, 51: 631-638. **IUCN**. 2007. *Guide for the Sustainable Development of Mediterranean Aquaculture. Interaction between Aquaculture and the Environment*. IUCN Gland, Switzerland and Malaga, Spain. 107 pp. (also available at https://cmsdata.iucn.org/downloads/acua_en_final.pdf). **Stigebrandt, A.** 2001. Physical Oceanography of the Baltic Sea. Chapter 2, p. 19-74. *In*: Wulff, F.V., Rahm, L. & Larsson, P., eds. 2001. *A Systems Analysis of the Baltic Sea*. Springer Verlag.
Ecosystem	A natural entity (or a system) with distinct structures and relationships that link biotic communities (of plants and animals) to each other and to their abiotic environment. The study of an ecosystem provides a methodological basis to understand the complex synthesis between organisms and their environment.	**GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UN Environment Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection)**. 2001. *Planning and management for sustainable coastal aquaculture development*. GESAMP Reports and Studies, No. 68. Rome, GESAMP. 90 pp. (also available at www.fao.org/3/a-y1818e.pdf).
Ecosystem services	Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services, such as food and water; regulating services, including flood and disease control; non-material services, such as spiritual and cultural benefits; and supporting services, including nutrient cycling or waste degradation, that maintain the conditions for life on earth.	**Alcamo, J., Ash, N.J., Butler, C.D. *et al.***, 2003. *Ecosystem and human well-being. A framework for assessment*. Millennium Ecosystem Assessment. Washington, DC, Island Press. 245 pp.
Ecosystem approach to aquaculture	An ecosystem approach to aquaculture is a strategy for the integration of an activity within the wider ecosystem, so that it promotes sustainable development, equity, and the resilience of interlinked social-ecological systems.	**FAO**. 2010. *Aquaculture development. 4. Ecosystem approach to aquaculture*. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. Rome, FAO. 53 pp. (also available at http://www.fao.org/3/a-i1750e.pdf).
Environmental impact	The change in well-being of ecosystems, resulting from a process set in motion or accelerated by human actions.	**Fagetti, E., Privett, D.W. & Sears, J.R.L., comps. & Hudson, J., rev.** 2000. *Aquatic sciences and fisheries thesaurus. Descriptors used in the Aquatic Sciences and Fisheries Information System*. Rome, FAO, ASFIS Reference Series, (6, Rev. 2) 335 pp.

Term	Definition	Reference
Environmental impact assessment (EIA)	A set of activities designed to identify and predict the impacts of a proposed action on the biogeophysical environment and on human health and wellbeing, and to interpret and communicate information about the impacts, including mitigation measures that are likely to eliminate the risks. In many countries, organizations planning new projects are required by law to conduct an EIA. Usually it is carried out by three parties: the developer, the public authorities and the planning authorities.	**Scialabba, N.** ed. 1998. *Integrated coastal area management and agriculture, forestry and fisheries*. FAO Guidelines. Environment and Natural Resources Service, Rome, FAO, 256 pp.
Environmental monitoring programme for marine finfish cage farming	Environmental Monitoring Programme (EMP) for marine finfish cage farming is defined as a flexible and adaptable functional tool at the disposal of the authorities and the aquaculture industry (e.g. farmers) for aquaculture management practices to ensure the sustainability of the sector itself. The EMP is also intended as a record-keeping system for documenting series of information and values of environmental parameters relevant to aquaculture activities, which will be used to perform periodic environmental assessment and monitoring.	**GFCM.** 2016. Key elements for guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and the Black Sea. 10 pp.
Environmental quality objective	Documented limits and tolerances on the measured ratios and levels of pollutants allowed in water. Stated as water quality, a tested body of water must be within a certain range of tolerance to be labelled as usable as intended. Under the umbrella of an ecosystem approach, national and/or regional legislation should define the EQOs, which ensure the safeguarding of ecosystem services.	**Sanchez-Jerez, P., Karakassis, I., Massa, F., Fezzardi, D., Aguilar-Manjarrez, J., Soto, D., Chapela, R., Avila, P., Macias, J.C., Tomassetti, P., Marino, G., Borg, J.A., Franičevič, V., Yücel-Gier, G., Fleming, I.A., Biao, X., Nhhala, H., Hamza, H., Forcada, A. & Dempster, T.** 2016. Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefits of Allocated Zones for Aquaculture (AZAs) to avoid conflict and promote sustainability. *Aquaculture Environment Interactions*, 8: 41–54
Environmental quality standard	An environmental quality standard (EQS) is a value, generally defined by regulation, which specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water. Sediments were also included by the former CAQ Working Group on Site Selection and Carrying Capacity (WGSC).	**GESAMP.** 2012. Environmental Quality Standards - Web Site. In: The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). UK. (also available at http://www.gesamp.org/work- programme/eqs).
Equity	Equity is a principle of stewardship. In fisheries and environmental management, equity relates to fairness, justice, impartiality and freedom from bias or favouritism (e.g. in the allocation of rights or determination of claims). It requires that similar options be available to all parties. It is an important factor of compliance.	**Garcia, S.M. & Boncoeur, J.** 2007. Allocation and conservation of ocean fishery resources: Connecting rights and responsibilities. American Fisheries Society Symposium. American Fisheries Society, Bethesda, Maryland, USA. 28 pp.

Term	Definition	Reference
Escapes from aquaculture	Escapes of fish from sea-cage aquaculture have typically been thought of as referring to juvenile and adult fish. Such escapes have been reported for almost all species presently cultured around the world. Recently, a second form of escape has come into focus, involving the escape of viable, fertilized eggs spawned by farmed individuals from sea-cage facilities, or so-called "escape through spawning".	**Jensen, Ø., Dempster, T., Thorstad, E.B., Uglem, I. & Fredheim A.** 2010. Escapes of fishes from Norwegian sea-cage aquaculture: causes, consequences and prevention. *Aquaculture Environment Interactions*, 1:71-83. (also available at http://www.int-res.com/articles/aei2010/1/q001p071.pdf)
Eutrophication	Over enrichment of a water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen concentration (1). Natural or artificial nutrient enrichment in a body of water, associated with extensive plankton blooms and subsequent reduction of dissolved oxygen (2).	**Lincoln, R.J., Boxshall, G.A. & Clark, P.F.** 1986. *A Dictionary of Ecology, Evolution and Systematics*. Cambridge University Press. 306 pp. **Scialabba, N. ed.** 1998. *Integrated coastal area management and agriculture, forestry and fisheries*. FAO Guidelines. Environment and Natural Resources Service, Rome, FAO, 256 pp.
Externalities	Externalities refers to situations when the effect of production or consumption of goods and services imposes costs or benefits on others, which are not reflected in the prices charged for the goods and services being provided. Externalities may be positive or negative.	**Organization for Economic Co-operation and Development.** 2007. *Glossary of statistical terms*. (also available at https://ec.europa.eu/eurostat/ramon/coded_files/OECD_glossary_stat_terms.pdf).
Food security	Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food security is a flexible concept as reflected in the many attempts at definition in research and policy usage. Even a decade ago, there were about 200 definitions in published writings. Whenever the concept is introduced in the title of a study or its objectives, it is necessary to look closely to establish the explicit or implied definition	**Clay, E.** 2002. Food Security: Concepts and Measurement, Paper for FAO Expert Consultation on Trade and Food Security: Conceptualising the Linkages, Rome, 11-12 July 2002. Published as Chapter 2 of Trade Reforms and Food Security: Conceptualising the Linkages. Rome. FAO, 2003. **Maxwell, S. & Smith, M.** 1992. Household food security; a conceptual review. *In* Maxwell, S. & Frankenberger, T.R., eds. *Household Food Security: Concepts, Indicators, Measurements: A Technical Review*. New York and Rome: UNICEF and IFAD. **Maxwell, S.** 1996. Food security: a post-modern perspective. *Food Policy*, 21 (2): 155-170. **World Food Summit.** 1996. Rome. *Declaration on World Food Security*. Rome, Italy. 13-17 November 1996.
Food safety	Assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use.	**FAO & WHO.** 1997. Codex Alimentarius. Food Hygiene Basic Texts. Joint FAO/WHO Food Standards Programme, Codex Alimentarius Commission. (also available at https://www.nutfruit.org/files/multimedia/1488439104_gap-5_4487.pdf).

Term	Definition	Reference
Freshwater aquaculture	Freshwater aquaculture is the cultivation of aquatic organisms where the end product is raised in freshwater, such as ponds, reservoirs, rivers, lakes, canals, etc., in which the salinity does not normally exceed 0.5‰. Earlier stages of the life cycle of these aquatic organisms may be spent in brackish or marine waters.	**GFCM.** 2009. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM).* Trabzon, Turkey, 9–10 December 2009. 19 pp.
Gas bubbles	Gas bubbles or outgassing i.e. the release of gas (H_2S or even CH_4) from the bottom sediments is a clear sign of anaerobic processes in the benthic environment, occasionally found beneath the cages, mainly during the warm seasons of the year. It is an easy to observe environmental characteristic. The release of H_2S is considered as a risk for the farmed stock due to the toxicity of H_2S to most marine fish. However, it is worth noting that H_2S is rapidly oxidized in the seawater (around 90% of it is removed from the bubbles after ascending 20 m from the sediment surface).	**Karakassis, I., Tsapakis, M., Smith, C.J. & Rumohr, H.** 2002. Fish farming impacts in the Mediterranean studied through sediment profiling imagery. *Marine Ecology Progress Series*, 227: 125-133.
Geographic Information System (GIS)	An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information, so that it can be displayed and analysed.	**ESRI.** 2001. *The ESRI Press dictionary of GIS terminology*. Environmental Systems Research Institute, Inc. Redlands, California, USA.
Governance	A systemic concept relating to the exercise of economic, political and administrative authority. It encompasses: (i) the guiding principles and goals of the sector, both conceptual and operational; (ii) the ways and means of organization and coordination of the action; (iii) the infrastructure of socio-political, economic and legal instruments; (iv) the nature and modus operandi of the processes; and (v) the policies, plans and measures.	**Garcia, S.M.** 2009. Governance, Science and Society. *In* Quentin Grafton, R., Hilborn, R., Squires, D., Tait, M. & Williams, M., eds. *Handbook of Marine Fisheries Conservation and Management*. Oxford University Press: 87-98.
Growth rate	(1.) The increase in weight of a fish per year (or season), divided by the initial weight. (2.) In fish, this is often measured in terms of the parameter K of the von Bertalanffy curve for the mean size (length or weight) as a function of age.	**Cooke, J.G.** 1984. Glossary of technical terms. *In* May, R.M., ed. *Exploitation of Marine Communities*, Springer-Verlag. In FAO glossary. **Ricker, W.E.** 1975. Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada*, 191: 2-6.
Habitat	The locality, site and particular type of local environment occupied by an organism or communities; local environment.	**Lincoln, R.J., Boxshall, G.A. & Clark, P.F.** 1982. *A Dictionary of Ecology, Evolution and Systematics.* Cambridge University Press.

Term	Definition	Reference
Indicator	Within a principles-criteria-indicators (PCI) methodology, indicators are a simple way to express the information related to the criteria. They are communication tools identified at farm, local, national and regional levels, which serve to quantify and simplify information in order to make it understandable to a target audience. Indicators provide benchmarks to assist in monitoring, evaluating, forecasting and decision-making. An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria.	**FAO.** 1999. *Indicators for sustainable development of marine capture fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 8. Rome, FAO. 68 pp. **GFCM.** 2011. *Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp. **Madec, P.** 2003. *Les indicateurs de développement durable*. INRA-University of Montpellier II. 118 pp.
Infauna	Aquatic animals that live within the sediment, i.e. the bottom substrate of a body of water, especially in soft sediments.	**Waldbusser, G.G., Marinelli, R.L., Whitlatch, R.B. & Visscher, P.T.** 2004. The effects of infaunal biodiversity on biogeochemistry of coastal marine sediments. *Limnology and Oceanography*, 49: 1482-1492
Integrated coastal zone management	Integrated coastal zone management (ICZM) means a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses, and their impact on both the marine and land parts.	**UN Environment/PAP/RAC.** 2008. *Protocol on Integrated Coastal Zone Management in the Mediterranean*. 89 pp.
Integrated multi-trophic aquaculture	Integrated multi-trophic aquaculture (IMTA) is the practice which combines, in the appropriate proportions, the cultivation of fed aquaculture species (e.g. finfish/shrimp) with organic extractive aquaculture species (e.g. shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweed) to create balanced systems for environmental sustainability (biomitigation), economic stability (product diversification and risk reduction), and social acceptability (better management practices).	**Barrington, K., Chopin, T. & Robinson, S.** 2009. Integrated multi-trophic aquaculture (IMTA) in marine temperate waters. *In* Soto, D., ed. *Integrated mariculture: a global review*. FAO Fisheries and Aquaculture Technical Paper. No. 529, Rome. FAO. pp. 7–46. (also available at http://www.fao.org/docrep/012/i1092e/i1092e00.htm).
Labelling	Labelling includes any written, printed or graphic matter that is present on the label, accompanies the food, or is displayed near the food, including that for the purpose of promoting its sale or disposal.	**FAO & WHO.** 2001. Codex Alimentarius. Food Labelling. Complete Texts. Joint FAO/WHO Food Standards Programme, Codex Alimentarius Commission.

Term	Definition	Reference
License for aquaculture	A license in an aquaculture context is a legal document giving official authorization to carry out aquaculture. This kind of permit may take different forms: an aquaculture permit, allowing the activity itself to take place, or an authorization or concession, allowing occupation of an area in the public domain, so long as the applicant complies with the environmental and aquaculture regulations.	**IUCN.** 2009. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management*. IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp.
Litter in the surrounding area	The presence of litter in the vicinity of the fish farms is probably among the environmental effects most visible to the public. Although the presence of litter normally would not have any toxic effect on the farmed stock and/or the consumers, it is likely to attract negative publicity and to result in local conflicts with other users of the coastal zone. Litter can also cause losses to aquaculture operations due to damage or entanglements.	**Cheshire, A.C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B. & Westphalen, G.** 2009. *UN Environment/IOC Guidelines on Survey and Monitoring of Marine Litter*. UN Environment Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83: xii + 120 pp.
Livelihood	A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain and enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.	**Carney D., ed.** 1998. *Sustainable rural livelihoods: What contribution can we make?* UK Department for International Development (DFID). In FAO glossary.
Macrofauna	This is a large group of aquatic (marine, estuarine or freshwater) invertebrates that live on or in sediments, or attached to hard substrates and are usually collected using 0.5 or 1 mm mesh screens. The macrofauna generally include representatives from the gastropods, crustaceans, bivalves, worms and tunicates. Macrofauna serve as important indicators of the status (health) of aquatic systems and help maintain good water and sediment quality.	**Eleftheriou, A. & Moore, D.C.** 2005. Macrofauna Techniques. *In* Eleftheriou, A. & McIntyre, A. eds. *Methods for the Study of Marine Benthos*. 3rd Edition. Blackwell Scientific, Oxford, London.
Macrofaunal biomass	The total macrofaunal biomass (expressed in g/m^2) represents one of the macrobenthos elements of the benthic components. The macrofaunal biomass is an indicator for cautionary and critical conditions related to marine sediments, located under fish farms. Both the abundance and biomass of macrofaunal species are significantly modified along organic enrichment gradients. The determination of biomass requires quantitative sampling of macrofauna, sorting of samples to separate benthic animals from the sediment, and weighing the wet or dried mass of the specimens.	**GFCM.** 2011. *Site selection and carrying capacity in Mediterranean marine aquaculture: Key issues (WGSC-SHoCMed)*. 54-70 pp. **Pearson, T. & Rosenberg, R.** 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review*, 16: 229-311.

Term	Definition	Reference
Map	Graphic representation of the physical features (natural, artificial, or both) of a part or the whole of the Earth's surface, by means of signs and symbols or photographic imagery, at an established scale, on a specified projection, and with the means of orientation indicated.	**Andrews, J.H.** 1996. What Was a Map? The Lexicographers Reply. *Cartographica*, vol 33, Chepstow, Wales, UK. (available at https://edisciplinas.usp.br/pluginfile.php/1825017/mod_resource/content/2/what%20was%20a%20map%3F.pdf)
Mariculture	Mariculture is the cultivation of the end product which takes place in seawater, such as fjords, inshore and open waters and inland seas, where salinity is generally high and is not subject to significant daily or seasonal variations. Earlier stages in the life cycle of these aquatic organisms may be spent in brackish or fresh water.	**GFCM.** 2009. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM).* Trabzon, Turkey, 9–10 December 2009. 19 pp.
Marine protected area (MPA)	A protected marine intertidal or sub tidal area, within territorial waters, exclusive economic zones (EEZs) or in the high seas, set aside by law or other effective means, together with the overlying water and associated flora, fauna, historical and cultural features. It provides degrees of preservation and protection for important marine biodiversity and resources; a particular habitat (e.g. a mangrove or a reef) or species, or sub-population (e.g. spawners or juveniles) depending on the degree of use permitted. The use of MPAs for scientific, educational, recreational, extractive and other purposes, including fishing, is strictly regulated and could be prohibited.	**FAO.** 2003. *Fisheries management. 2. The ecosystem approach to fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2. Rome, FAO. 112 pp.
Marine spatial planning (MSP)	Marine spatial planning is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process. Characteristics of marine spatial planning include ecosystem-based, area-based, integrated, adaptive, strategic and participatory. It is a practical way to create and establish a more rational use of marine space and the interactions between its uses, to balance demands for development with the need to protect the environment, and to achieve social and economic objectives in an open and planned way.	**Ehler, C. & Douvere, F.** 2009. *Marine Spatial Planning: A Step-by-Step Approach Toward Ecosystem-Based Management*. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No 53, ICAM Dossier No.6. Paris: UNESCO.
Maritime spatial planning	Maritime spatial planning is a cross-cutting policy tool enabling public authorities and stakeholders to apply a coordinated, integrated and trans-boundary approach. Maritime spatial planning contributes to the effective management of marine activities and the sustainable use of marine and coastal resources, by creating a framework for consistent, transparent, sustainable and evidence based decision-making.	**EU.** 2014. Directive 2014/89/EU of the European Parliament and of the Council on establishing a framework for maritime spatial planning, 2014 O.J. L 257/135 (also available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0089&from=EN).

Term	Definition	Reference
Monitoring	Systematic recording and periodic analysis of information over time.	**Clark, J.R.** 1996. *Coastal Zone Management Handbook*. New York, Lewis Publishers. 694 pp.
Number of macrofaunal species	The decrease in the number of macrofaunal species indicates the level of degradation of the seabed, since it is one of the variables which are significantly linked with macrofaunal succession along gradients of organic enrichment (Pearson & Rosenberg, 1978). On the other hand, the number of macrobenthic species provides a measure of the potential of the benthic communities to provide ecological services, such as the mineralization of the settling organic material.	**Pearson, T. & Rosenberg, R.** 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review*, 16: 229-311.
Outgassing	Release of a gas that was dissolved, or otherwise contained within a substrate, such as marine sediments or a liquid, e.g. seawater. This release occurs as a result of physical disruption, including bioturbation, sediment resuspension or after the concentration of the gas exceeds its dissolution limits.	**Samuelsen, O.B., Ervik, A. & Solheim, E.** 1988. A qualitative and quantitative analysis of the sediment gas and diethylether extract of the sediment from salmon farms. *Aquaculture*, 74: 277-285.
Oxygen saturation	Oxygen saturation is a ratio of the concentration of dissolved oxygen in the water to the maximum amount of oxygen that will dissolve in the water at that temperature and pressure under stable equilibrium. Well-aerated water (such as a fast-moving stream) without oxygen producers or consumers is 100% saturated.	**Yellow Springs Incorporated (YSI).** 2005. Environmental Dissolved Oxygen Values Above 100% Air Saturation. YSI Environmental.
Participatory approach	This approach assigns considerable weight to the opinions and perspectives of residents and local populations (stakeholders) in the decision-making process, regarding a wide range of issues, such as aquaculture site selection and management. This is a “bottom-up” process, whereby stakeholders are involved in all aspects, e.g. from decisions on how to go about evaluating the potential sites, who carries out the evaluation process, and how the site will be monitored. It is a participatory approach because it invites participation of all relevant sectors, and not only the decision-makers.	**Holland, J. & Blackburn, J.** 1998. Whose Voice? Participatory research and policy change. *Intermediate Technology Publications*. London.
Particulate organic matter	Particulate organic matter (POM) is the particulate material of biological origin that is suspended in water	**Lee, C., Wakeham, S. & Arnosti, C.** 2004. Particulate organic matter in the Sea: the composition conundrum. Royal Swedish Academy of Sciences. Springer, *Ambio*, 33(8): 565-575 pp.

Term	Definition	Reference
Percentage of silt/clay in sediments	The silt and clay content of the sediment is an important variable for the characterization of the seabed since it describes a rather easy way to understand one of the most determining features of the benthic environment. The sediment contains silt and clay from natural sources, but also there is an increase due to sedimentation of suspended solids in the vicinity of the sea cages.	**Buchanan, J.B.** 1984. Sediment analysis. *In* Holme, N.A. & McIntyre, A.D., eds. *Methods for the Study of Marine Benthos*. Blackwell Science, Oxford: 41-65. **Chou, C.L., Haya, K., Paon, L.A. & Moffatt, J.D.** 2004. A regression model using sediment chemistry for the evaluation of marine environmental impacts associated with salmon aquaculture cage wastes. *Marine Pollution Bulletin*, 49:465-472. **Shepard, F.P.** 1954. Nomenclature based on sand, silt, clay ratios. *Journal of Sedimentary Petrology*, 24: 151-158.
Polygons	These are specially designated areas (also known as allocated zones for aquaculture) for cages in mariculture, as well as in land-based aquaculture. The Spanish Ministry of Environment has, for example, established a polygon in consultation with the administrations for defence, marine navigation, tourism, ports, local authorities and coastal planning.	**Chapela-Perez, R.** 2009. Cage Aquaculture Development in the RECOFI Region. Regional technical workshop on sustainable marine cage aquaculture development. Draft Review document on cage aquaculture licensing procedures: Case Studies in Spain, Chile, Greece, USA and Norway. Centro Tecnológico del Mar Fundación CETMAR, Vigo, Spain.
Posidonia oceanica	This species of seagrass (higher marine plant) occurs only in the Mediterranean Sea and provides a variety of ecosystem and ecological services. It forms thick and often extensive seagrass beds that occur in a fairly wide range of depths; protects the seabed against erosion and provides a unique habitat to numerous vertebrate and invertebrate species. The seagrass grows slowly and some *P. oceanica* meadows are thought to be thousands of years old. Moreover, this plant is quite sensitive to changes in water quality, such as those exerted by trawl fishing, anchors, sedimentation and aquaculture. As such, it has been designated conservation/protection status by the EU Habitats Directive (Dir 92/43/CEE) and there is an attempt to limit activities that may jeopardize the health and integrity of the seagrass beds.	**Holmer, M., Argyrou, M., Dalsgaard, T., Danovaro, R., Diaz-Almela, E., Duarte, C.M., Frederiksen, M., Grau, A., Karakassis, I., Marba, N., Mirto, S., Perez, M., Pusceddu, A. & Tsapakis, M.** 2008. Effects of fish farm waste on *Posidonia oceanica* meadows: Synthesis and provision of monitoring and management tools. *Marine Pollution Bulletin*, 56:1618-1629. **Ruiz, J.M., Perez, M. & Romero, J.** 2001. Effects of fish farm loadings on seagrass (*Posidonia oceanica*) distribution, growth and photosynthesis. *Marine Pollution Bulletin*, 42:749-760.
Principle	Principles are associated to the dimensions of sustainable aquaculture. Within a principles-criteria-indicators (PCI) methodology, they are the high-level goals to address an issue and determine the criteria and indicators to be selected. Principles should be formulated as short statements, with action verbs originating from management vocabulary, such as: contribute, ensure, adapt, strengthen, minimize, etc. For example, "Minimize the impact of aquaculture on the environment".	**GFCM.** 2011. *Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.

Term	Definition	Reference
Pseudofeces	Many filter-feeding organisms, e.g. mollusca are selective feeders and they eliminate undesirable food particles by wrapping these in mucus sheaths that are eliminated from the body without passing through the digestive tract. The release of large fluxes of pseudofeces may cover the seafloor, especially under shellfish aquaculture sites where animal abundances are high, thereby smothering the underlying seafloor and causing negative impacts.	**Beninger, P.G., Veniot, A. & Poussart, Y.** 1999. Principles of pseudofeces rejection on the bivalve mantle: integration in particle processing. *Marine Ecology Progress Series*, 178, 259–269.
Public domain (maritime and terrestrial zones)	These areas are public property, which are managed by the state and in general are available for public use. The state determines the particular uses of each of these areas, and may offer concessions or authorizations to private or public organizations for exclusive uses.	**IUCN.** 2009. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management*. IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp.
Redox potential	The reduction/oxidation (redox) potential (also known as Eh) is a chemical expression (in volts or millivolts) of the tendency of a given compound to attain electrons and become chemically "reduced". In aquaculture, redox potential is often measured in sediments to examine the sediment "quality", insofar as the suitability (or inhospitality) of chemical conditions for the presence of natural fauna/flora. Organically-enriched, anoxic and sulfidic (impacted) sediments are often characterized by highly negative redox potential values, whereas 'healthy' sediments have positive redox potential values. The redox state of sediment is the result of the combined effect of biological and chemical processes of a reversible and/or irreversible nature. Redox potential is measured by profiling an electrode down a sediment core to as deep as is necessary to detect the redox discontinuity layer (RPD): the point at which redox values change abruptly from highly negative values to either less negative, or to positive values.	**Hinchey, E.K. & L. C. Schaffner.** 2005. An evaluation of electrode insertion techniques for measurement of sediment redox potential in estuarine sediments. *Chemosphere*, 59:703-710. **Pearson T.H. & Black K.D.** 2001. The environmental impacts of marine fish cage culture. *In* Black, K.D., ed., *Environmental Impacts of Aquaculture*, Academic Press, Sheffield, UK, 1- 27. **Zobell, C.E.** 1946. Studies on redox potential of marine sediments. *Bulletin of the American Association of Petroleum Geologists*, 30, 477-511.
Reference point	For a given indicator, a reference point or standard is a specific value against which the data are measured and classified. Once an indicator is associated with its reference point, it is possible to assess the particular state of the broad issue to be monitored. The value (whether qualitative or quantitative) of a reference point should be validated by international literature, and/or be agreed upon between experts through common opinion or by driven discussions (for example Delphi), and/or endorsed through a multi-stakeholder consensus.	**GFCM.** 2011. *Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.

Term	Definition	Reference
Regulatory tools	Regulation is the mechanism by which society gives its members rights and allocates responsibilities. Regulatory tools are the means employed to ensure that regulation takes place, e.g. laws that are enforced by authorities, with a penal system for violators.	**CEC.** 1993. Council Regulation (EC) No 3699/93 of 21.12.1993 - Laying down the criteria and arrangements regarding Community structural assistance in the fisheries and aquaculture sector and the processing and marketing of its products. Official Journal, L 346, 31 December.
Remote sensing	Collecting and interpreting information about the environment and the surface of the earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote-sensing methods include aerial photography, radar, and satellite imaging.	**ESRI.** 2001. *The ESRI Press Dictionary of GIS Terminology*. Environmental Systems Research Institute, Inc. Redlands, California, USA. **University of Nebraska-Lincoln.** 2005. Virtual Nebraska Glossary. Remote Sensing Glossary. Reference Information for Virtual Nebraska.
Risk analysis	Risk analysis is: i) a detailed examination, including risk assessment, risk evaluation and risk management alternatives, performed to understand the nature of unwanted, negative consequences to human life, health, property or the environment; ii) an analytical process to provide information regarding undesirable events; iii) the process of quantification of the probabilities and expected consequences for identified risks.	**Bondad-Reantaso, M.G., Arthur, J.R., Subasinghe, R.P., eds.** 2008. *Understanding and applying risk analysis in aquaculture*. FAO Fisheries and Aquaculture Technical Paper. No. 519. Rome, FAO. 2008. 304 pp. (also available http://www.fao.org/docrep/011/i0490e/i0490e00.htm).
Scale	The ratio or relationship between a distance and area on a map and the corresponding distance or area on the ground, commonly expressed as a fraction or ratio. A map scale of 1/100 000 or 1:100 000 means that one unit of measure on the map equals 100 000 of the same unit on the earth.	**ESRI.** 2001. *The ESRI Press Dictionary of GIS Terminology*. Environmental Systems Research Institute, Inc. Redlands, California. USA.
Seabed	This is the bottom of the sea and is also known as the "seafloor". It may be composed of soft (e.g. sand or mud) or hard (e.g. rock) substrates, and the biotic community that lives in or on the seafloor is called "benthos".	**Hiscock, K., Langmead, O., Warwick, R. & Smith, A.** 2005. *Identification of seabed indicator species to support implementation of the EU Habitats and Water Framework Directives*. Second edition. Report to the Joint Nature Conservation Committee and the Environment Agency from the Marine Biological Association. Plymouth: Marine Biological Association. JNCC Contract F90-01-705. 77 pp.

Term	Definition	Reference
Seagrass (meadows)	Seagrasses are "higher" plants that belong to a rather small number of angiosperm species and occur on the seafloor in many parts of the world. Seagrasses form either monospecific or multispecies meadows that are very productive (on average 400 g C m^{-2} yr^{-1}) ecosystems that play essential roles in the sea. Seagrasses are essential components of the marine environment and are protected by legislation. Seagrasses are sensitive to various environmental impacts, and the combined flux of particulate organic matter and shading, caused by net-cage fish farms, weaken the seagrasses and exclude them from the region around this activity.	**Duarte, C.M., Middelburg, J. & Caraco, N.** 2005. Major role of marine vegetation on the oceanic carbon cycle. *Biogeosciences*, 2: 1–8. **Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L. Jr., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Olyarnik, S., Short, F.T., Waycott, M. & Williams, S.L.** 2006. A global crisis for seagrass ecosystems. *Bioscience*, 56: 987-996.
Sectoral planning	The strategic planning for a specific industry or sector, which is generally the responsibility of the government, but should also include participation of the private sector. In order to succeed, the plan should consider issues such as: a) the current status of the sector and the desired situation (aspirations); b) how the desired situation may be attained; c) the resources needed to accomplish the desired status; d) the obstacles that may hinder the plans and; e) a contingency plan to deal with the obstacles.	**ADB (Asian Development Bank).** 2000. *Handbook for the Economic Analysis of Health Sector Projects*. Manila, Philippines, ADB. 156 pp.
Sediment grain size (granulometry)	Grain size distribution is one of the basic and characteristic properties of a particular sediment, which may change as a result of various processes, such as runoff, bioturbation, eutrophication, etc. Grain size analysis consists of measurements of particle sizes and/or their hydraulic equivalents, and a summary of the size data yields a frequency distribution.	**Barth, N.G.** 1984. *Modern methods of particle size analysis*. John Wiley and Sons, 309 pp. **Friedman, G.M. & Sanders, J.E.** 1978. *Principles of Sedimentology*. New York (Wiley).
Sediment resuspension	This is a process that involves singular or multiple events of redistribution of benthic sediment particles into the water column. Resuspension may be motivated by physical (e.g. waves, currents) or biological (e.g. bioturbation, activities of demersal animals or burrowing fishes) processes. The extent of physical resuspension depends largely on the depth, the energy of the driving forces, bathymetry, sediment composition, etc. Resuspension may release nutrients, resting cells and toxins into the overlying water and may make the water column turbid.	**Bloesch, J. 1994**. A review of methods used to measure sediment resuspension. *Hydrobiologia*, 284: 13-18.
Semi-intensive aquaculture	It is a method of aquaculture whereby the cultured stock is provided a part of the nutrition required externally, mostly through supplementary feeding.	**GFCM.** 2009. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM).* Trabzon, Turkey, 9–10 December 2009. 19 pp.

Term	Definition	Reference
Sensitive habitat	A sensitive habitat is: essential to the ecological and biological requirements of at least one of the life stages of the species; crucial for the recovery and/or the long term sustainability of the marine biological resources and the assemblages to which the priority species belongs; of high biodiversity importance, but potentially impacted by fisheries activities; of high biodiversity importance, but potentially impacted by climate change.	**GFCM.** 2008. *Criteria for the identification of sensitive habitats of relevance for the management of priority species*. GFCM: SAC11/2008/Inf.20.
Site selection	The success of aquaculture projects relies heavily on the proper selection of the site for this activity, regardless of whether the site considered is on land or at sea. In addition to the actual geographic location, consideration must be given to physical, chemical and biological/ecological factors, as well as to the socio-economic aspects of the proposed venture. The optimal situation is where the aquaculture activity is deemed environmentally, socially and economically sustainable. This involves planning with respect to the specific aquaculture systems and the species to be cultivated, and requires foresight regarding the impacts of aquaculture on the environment, as well as the effects of surrounding activities and the environment on the enterprise.	**FAO.** 1987. *Site selection for aquaculture: Introduction, technical and non-technical considerations in site selection*. Lectures presented at ARAC for the Senior Aquaculturists course. Project Report AC 170, ARAC/87/WP/12-1&2, 9 pp. **IUCN.** 2009. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management*. Gland, Switzerland and Malaga, Spain, IUCN. 303 pp.
Social acceptability (SA)	Social acceptability is an integral part of sustainability and refers to social licence and the degree to which aquaculture activities are accepted by the local community, various interest groups and the wider society.	**Hishamunda, N., Ridler, N. & Martone, E.** 2014. *Policy and governance in aquaculture: lessons learned and way forward*. FAO Fisheries and Aquaculture Technical Paper No. 577. Rome, FAO. 59 pp. (also available at http://www.fao.org/3/a-i3156e.pdf).
Social license to operate	A social license to operate (SLO) is a community's perceptions of the acceptability of a company and its local operations.	**Thomson, I. & Boutilier, R.G.** 2011. Social license to operate. *In* P. Darling, ed., *SME Mining Engineering Handbook* (pp. 1779-1796). Littleton, CO: Society for Mining, Metallurgy and Exploration.

Term	Definition	Reference
Spatial planning for aquaculture	Spatial planning is a process that should consider the social, economic, environmental and governance objectives of sustainable development, in order to aim at an integrated management of land, water and living resources for the development of aquaculture and expansion of the sector in a sustainable and equitable way, including mitigation measures for changing climatic conditions	**FAO**. 2013. *Applying Spatial Planning For Promoting Future Aquaculture Growth. Seventh Session of the Sub-Committee on Aquaculture (SCA) of the FAO Committee on Fisheries (COFI). St. Petersburg, Russian Federation, 7–11 October 2013*. (also available at http://www.fao.org/fi/static-media/MeetingDocuments/COFI_AQ/2013/6e.pdf). **FAO**. 2014. *Report of the seventh session of the Sub-Committee on Aquaculture. St Petersburg, Russian Federation, 7-11 October 2013*. FAO Fisheries and Aquaculture Report. No. 1064. Rome, FAO. 53 pp. (also available at http://www.fao.org/3/a-i3647t.pdf).
Spillovers	Spillover effects are the outcomes of activities that influence those that are not directly involved. The visual impact of net-cage fish farms that affects the property value of coastal homeowners is an example of a negative spillover effect on the stakeholders; conversely, the increased employment provided by the farms is a positive spillover effect upon the local residents.	**Tisdell, C.A.** 2004. Aquaculture, environmental spillovers and sustainable development: links and policy choices, 249-268 pp. *In* Quaddus, M.A. & Siddique, M.A.B., eds. *Handbook of sustainable development planning: studies in modelling and decision support*. 1st Edition. Cheltenham, UK, Edward Elgar Publishing, 360 pp.
Stakeholder	A large group of individuals and groups of individuals (including governmental and non-governmental institutions, traditional communities, universities, research institutions, development agencies and banks, donors, etc.) with an interest or claim (whether stated or implied), which has the potential of being impacted by or having an impact on a given project and its objectives. Stakeholder groups that have a direct or indirect "stake" can be at the household, community, local, regional, national, or international level.	**Choudhury K. & Jansen, L.J.M.** 1999. *Terminology for Integrated Resources Planning and Management*. FAO, Rome, Italy: 69 pp. In FAO glossary. **FAO**. 1997. *Fisheries management*. FAO Technical Guidelines for Responsible Fisheries, 4: 82 pp.
Standard	See "reference point"	
Stocking	The practice of placing aquatic organisms into natural or modified water bodies. Stocked material may originate from aquaculture facilities or translocations from the wild.	**FAO**. 2014. *Report of the seventh session of the Sub-Committee on Aquaculture. St Petersburg, Russian Federation, 7-11 October 2013*. FAO Fisheries and Aquaculture Report. No. 1064. Rome, FAO. 53 pp. (available at http://www.fao.org/3/a-i3647t.pdf).

Term	Definition	Reference
Sulphide	The pathways of sulphide oxidation in marine sediments involve complex interactions of chemical reactions and microbial metabolism, where sulphide becomes partly oxidized and bound by Fe (III), and the resulting iron-sulphur minerals are transported toward the oxic sediment-water interface by bioturbating and irrigating fauna. Established relationships between organic enrichment processes and the concentration of sulphide within the sediment pore water are given in Wildish *et al.* (2004).	**Blackburn, T.H. & Kleiber, P.** 1975. Photosynthetic sulphide oxidation in marine sediments. *Nordic Society Oikos*, 26:103-108. **Brooks, K.M. & Mahnken, C.V.W.** 2003. Interactions of Atlantic salmon in the Pacific northwest environment II. Organic wastes. *Fisheries Research*, 62: 255-293. **Heijs, S.K., Jonkers, H.M., van Gemerden, H., Schaub, B.E.M. & Stal, L.J.** 1999. The buffering capacity towards free sulphide in sediments of a coastal lagoon (Bassin d'Arcachon, France) – the relative importance of chemical and biological processes. *Estuarine, Coastal and Shelf Science,* 49:21-35. **Jørgensen, B.B. & Nelson, D.C.** 2004. Sulfide oxidation in marine sediments: Geochemistry meets microbiology. *Geological Society of America Special Papers*, 379:63-81. **Wildish, D.J., Dowd, D., Sutherland, T.F. & Levings, C.D.** 2004. A scientific review of the potential environmental effects of aquaculture in aquatic ecosystems, vol. III, Near-field organic enrichment from marine finfish aquaculture. *Canadian Technical Report Fisheries and Aquatic Sciences*, 2450, 117 pp.
Sustainable development	Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable.	**FAO.** 1989. *Sustainable development and natural resources management.* Twenty-fifth Conference. C 89/2 – Suppl. 2. August. Rome, FAO. 54 pp.
Thresholds for environmental change	In an ecological, economic or other system, thresholds are the critical values beyond which the system goes through a substantial change. Small changes in crucial variables (e.g. a slight rise in seawater temperature) can lead to large responses in the system (e.g. a large drop in reproductive success of a keystone marine species).	**Groffman, P., Baron, J., Blett, T., Gold, A., Goodman, I., Gunderson, L., Levinson, B., Palmer, M., Paerl, H., Peterson, G., LeRoy Poff, N., Rejeski, D., Reynolds, J., Turner, M., Weathers, K., & Wiens, J.** 2006. Ecological thresholds: the key to successful environmental management or an important concept with no practical application? *Ecosystems*, 9:1–13. **Muradian, R.** 2001. Ecological Thresholds: a survey. *Ecological Economics*, 38:7–24.

Term	Definition	Reference
Total nitrogen in sediments	Total nitrogen (TN) is defined as the sum of organic nitrogen, nitrate, nitrite, and ammonia. The nitrogen levels are elevated under fish farms as a result of diagenesis of the organic material settling on the seafloor. Although nitrate and nitrite are not released by the stocked organisms, and are not toxic to most marine organisms, they may help in determining the risk of eutrophication at a given site (GFCM, 2011). Total nitrogen concentrations are expressed as % of N in sediment.	**GFCM. 2011.** *Site Selection and Carrying Capacity in Mediterranean Marine Aquaculture: Key Issues (WGSC- SHoCMed).* Draft March 2011 - GFCM:CAQVII/2011/Dma.4 rev 2. **Hedges, J.I. & Stern, J.H.** 1984. Carbon and nitrogen determination of carbonate containing solids. *Limnology and Oceanography*, 29: 657-663.
Total organic carbon	Total organic carbon (TOC) is the amount of carbon bound in an organic compound and material derived from decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals. As in the case of organic matter, it is related to the sedimentation of fish feces and unused fish feed in the vicinity of the farms, but also to natural sedimentation of organic material, e.g. from primary production in the water column. It is determined in sediment samples using a CHN Elemental Analyzer according to the procedure described by Hedges & Stern (1984).	**Hedges, J.I. & Stern, J.H.** 1984. Carbon and nitrogen determination of carbonate containing solids. *Limnology and Oceanography*, 29: 657-663.
Total organic matter in sediments	Total organic matter provides an estimate of the organic content in the sediments beneath the aquaculture installation. For coastal aquaculture, major concerns are the discharge of wastes in the form of uneaten food and fish excretions, which will have an effect on the benthos and species that are particularly sensitive to an increase in input of organic matter. Organic matter input is closely dependent on species, production, aquaculture method, hydrography, feed type and management. The organic material (or loss on ignition, LOI) is determined as the weight loss of the dried sample after combustion for 6 h at 550°C; regarding the units, 1% is equal to 10 mg/g sediment.	**Kristensen, E. & Andersen, F.O.** 1987. Determination of organic carbon in marine sediments: a comparison of two CHN analyzer methods. *Journal of Experimental Marine Biology Ecology*, 109:15-23. **Wu, R.S.S.** 1995. The environmental impact of marine fish culture: towards a sustainable future. *Marine Pollution Bulletin*, 31: 159–166.

Term	Definition	Reference
Total phosphorus	As in the case of organic carbon or organic material in total, P is released in particulate form (fish feces and unused feed) and precipitates beneath and close to fish farms. High sedimentation rates of P have been measured around fish farms and discernible distribution patterns have been found in profiles and transects. P has been suggested as a useful indicator of fish farm waste loading and also been proposed as an indicator of fish farm impact on *Posidonia oceanica* habitats. Total phosphorus is determined in the dried sediment samples, which were homogenized by grinding and digested with a mixture of perchloric and nitric acid. The concentration of P is determined colorimetrically as molybdate reactive phosphorus.	**Apostolaki, E., Tsagaraki, T., Tsapakis, M. & Karakassis, I.** 2007. Fish farming impact on sediments and macrofauna associated with seagrass meadows in the Mediterranean. *Estuarine, Coastal and Shelf Science*, 75: 408-416. **Holmer, M., Argyrou, M., Dalsgaard, T., Danovaro, R., Diaz-Almela, E., Carlos, M.D.E., Frederiksen, M., Grau, A., Karakassis, I., Marba, N., Mirto, S., Perez, M., Pusceddu, A. & Tsapakis, M.** 2008. Effects of fish farm waste on *Posidonia oceanica* meadows: Synthesis and provision of monitoring and management tools. *Marine Pollution Bulletin*, 56:1618-1629. **Karakassis, I., Tsapakis, M., Hatziyanni, E., Papadopoulou, K.N. & Plaiti, W.** 2000. Impact of cage farming of fish on the seabed in three Mediterranean coastal areas. *ICES Journal of Marine Science*, 57: 1462-1471. **Pergent-Martini, C., Boudouresque, C.F., Pasqualini, V. & Pergent, G.** 2006. Impact of fish farming facilities on *Posidonia oceanica* meadows: a review. *Marine Ecology-An Evolutionary Perspective*, 27:310-319. **Strickland, J.D.H. & Parsons, T.W.** 1972. *A Practical Handbook of Seawater Analysis*. Fisheries Research Board of Canada, Bulletin 167, Ottawa, Canada, 2nd edition, 310 pp.

Term	Definition	Reference
Traceability	Defined by the International Organization for Standardization (ISO 8402:1994) as the "ability to trace the history, application or location of an entity by means of recorded identification". The enforcement of traceability implies the development of systems giving information on the entire life cycle of food products, "from the farm -or the sea- to the fork". The ability to follow the movement of a food through specified stage(s) of production, processing and distribution. A good traceability system provides accurate information on the origin, sex, age, breed, movements, and records the veterinarian treatments an animal receives. Traceability systems are important tools to prevent the spread of animal diseases and to enhance biosecurity in general. Animal identification and livestock/meat traceability are not themselves food safety, animal disease prevention or quality assurance programmes, but they facilitate public health, veterinary public health and animal health interventions. FAO through its contribution to the Codex Alimentarius commission is involved in inclusion of traceability within international standards.	**Bondad-Reantaso, M.G., McGladdery, S.E., East, I. & Subasinghe, R.P.** 2001. The Asia diagnostic guide to aquatic animal diseases. FAO Fisheries Technical Paper No. 402/2, 237 pp. **FAO & WHO.** 2006. Codex Alimentarius - Codex Procedural Manual. Principles and Guidelines for National Food Control Systems. CAC/GL 60-2006.

Term	Definition	Reference
Turbidity	Turbidity may be easily measured by means of a Secchi disk. The Secchi depth (i.e. the maximum depth at which the Secchi disk is visible from the surface) has significance in deep stratified waters, where the amount of matter resuspended from the bottom sediment is minor (see ECASA toolbox at the site: www.ecasatoolbox.org.uk). The significance is less in shallow waters where the amount of suspended matter might be quite large. The Secchi depth can be calibrated to estimate the concentration of particulate organic matter (POM) or equivalently Chlorophyll a (Chl-a) in the surface layers. After local calibration, it can also account for coloured matter supplied by freshwater runoff in coastal and inshore waters if synoptic vertical profiles of salinity are measured. Secchi depth is obviously of great relevance to farmers of filter feeders and to authorities interested in the environmental effects of fish farming. Secchi depth observations often can replace Chl-a measurements at sites where Chl-a is used as an indicator of eutrophication. As Chl-a fluctuates during the season so does the Secchi depth and therefore measurements need to be carried out regularly. Particulates or solids from feed and fish waste are two primary sources of turbidity associated with cage culture.	**Preisendorfer, R.W.** 1986. Secchi Disk science: visual optics of natural waters. *Limnology and Oceanography*, 31: 909-926. **IUCN**. 2007. *Guide for the Sustainable Development of Mediterranean Aquaculture. Interaction between Aquaculture and the Environment*. IUCN Gland, Switzerland and Malaga, Spain. 107 pp. (available at https://cmsdata.iucn.org/downloads/acua_en_final.pdf)
Water column	This is the body of water that extends from the sea surface to the seafloor. The water column is also referred to as the "pelagic zone", which may be divided into different depth zones, with characteristic conditions and biota. The water column is often referred to in the environmental context with respect to "water quality" (see also item 2482 in FAO Glossary of Aquaculture); the various physico-chemical properties make it suitable or unsuitable for aquatic life.	**Connor, D.W., Gilliland, P.M., Golding, N., Robinson, P., Todd, D. & E. Verling.** 2006. *UK SeaMap: the mapping of seabed and water column features of UK seas*. Joint Nature Conservation Committee Report, Peterborough.
Water quality	This term encompasses the chemical, physical, and biological characteristics of water with respect to its suitability for a specific purpose, e.g. drinking, bathing, and aquaculture. Water quality is a subjective term and "good" versus "poor" quality is defined by the properties (e.g. clarity or pH) and the levels (e.g. chemical concentration or salinity) of these properties that are set for the chosen purpose. In aquaculture, the water quality variables determined must be monitored to safeguard both the cultivated organisms and the surrounding environment.	**American Public Health Association (APHA).** 1992. *Standard Methods for the Examination of Water and Wastewater*. 18th Edition. American Public Health Association, Washington, DC. **Boyd, C.E.** 2000. *Water Quality. An Introduction*. Kluwer Academic Publishers. Boston, Dordrecht, London. 325 pp. **Zweig, R.D., Morton, J.D., & Stewart, M.M.** 1999. *Source water quality for aquaculture: A guide for assessment*. Washington, D.C: World Bank Publication, 62 pp.

Term	Definition	Reference
Zoning	Dividing an area into zones or sections with different characteristics, or reserved for different purposes or uses, or conditions of use such as no-take zones or reserves (see MPAs), biodiversity corridors, non-trawling areas and areas for exclusive use by small-scale fisheries or aquaculture. Ocean zoning is an element of marine spatial planning.	**Carocci, F., Bianchi, G., Eastwood, P. & Meaden, G.** 2009. *Geographic information systems to support the ecosystem approach to fisheries: status, opportunities and challenges*. FAO Fisheries and Aquaculture Technical Paper. No. 532. Rome, FAO. 101 pp.

ALLOCATED ZONES FOR AQUACULTURE

A guide for the establishment of coastal zones dedicated to aquaculture in the Mediterranean and the Black Sea

In the Mediterranean and the Black Sea, the future development and expansion of aquaculture will highly depend on the availability of space to develop this activity in a sustainable way. Allocated zones for aquaculture (AZAs) are therefore considered as an essential instrument towards the sustainable development of aquaculture, under a blue growth perspective, and they have a special role to play in marine spatial planning.

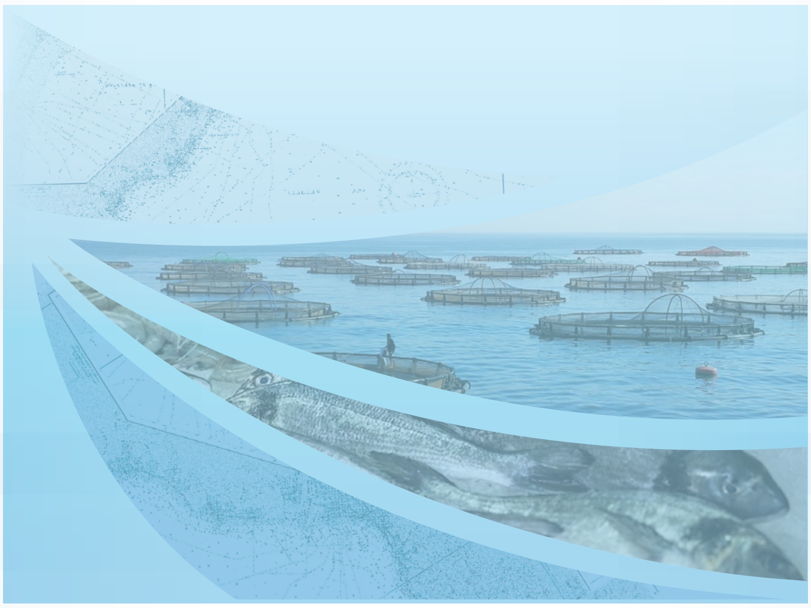
This guide is a collection of concepts and practical information aimed at facilitating the establishment of AZAs in the Mediterranean and the Black Sea. It provides detailed information on the process involved in the establishment of an AZA and it is intended as a practical and comprehensive tool to better understand site selection and planning for aquaculture.

This publication first provides a brief overview of the international and regional context, and reviews the institutional and legal framework related to AZAs at various levels. Sequential explanations on the AZA establishment process, as well as suggestions for the main steps are then presented. The step-by-step approach for the establishment of AZAs takes into account a number of specific aspects, such as geographic information system tools, exclusion criteria and stakeholder participation, the main actors to be involved, the role of relevant authorities in charge of geographical and/or marine aquaculture planning, statutory responsibilities, prevention and resolution of possible conflicts, and decision-making. The guide also describes the objectives and contents of AZA management plans and presents the parameters to be used as reference points for the AZA implementation.

The AZA process is supported by a number of tools, such as Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture, and the Guidelines on a harmonized environmental monitoring programme for marine finfish cage farming in the Mediterranean and the Black Sea, which are also briefly outlined here.

This guide is addressed to decision-makers from relevant bodies and administrations, governmental and non-governmental organizations, scientific research institutions, aquaculture producers and fishing communities, as well as other relevant stakeholders involved in aquaculture activities, coastal development, and in the use of the aquatic environment and resources.

It has been developed taking into account the strategic role of marine coastal aquaculture in responding to the growing global demand for seafood and in delivering social and economic benefits to coastal communities. It will hopefully facilitate the integration of aquaculture into coastal areas and contribute to supporting sustainable and responsible aquaculture development in the Mediterranean and the Black Sea.



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