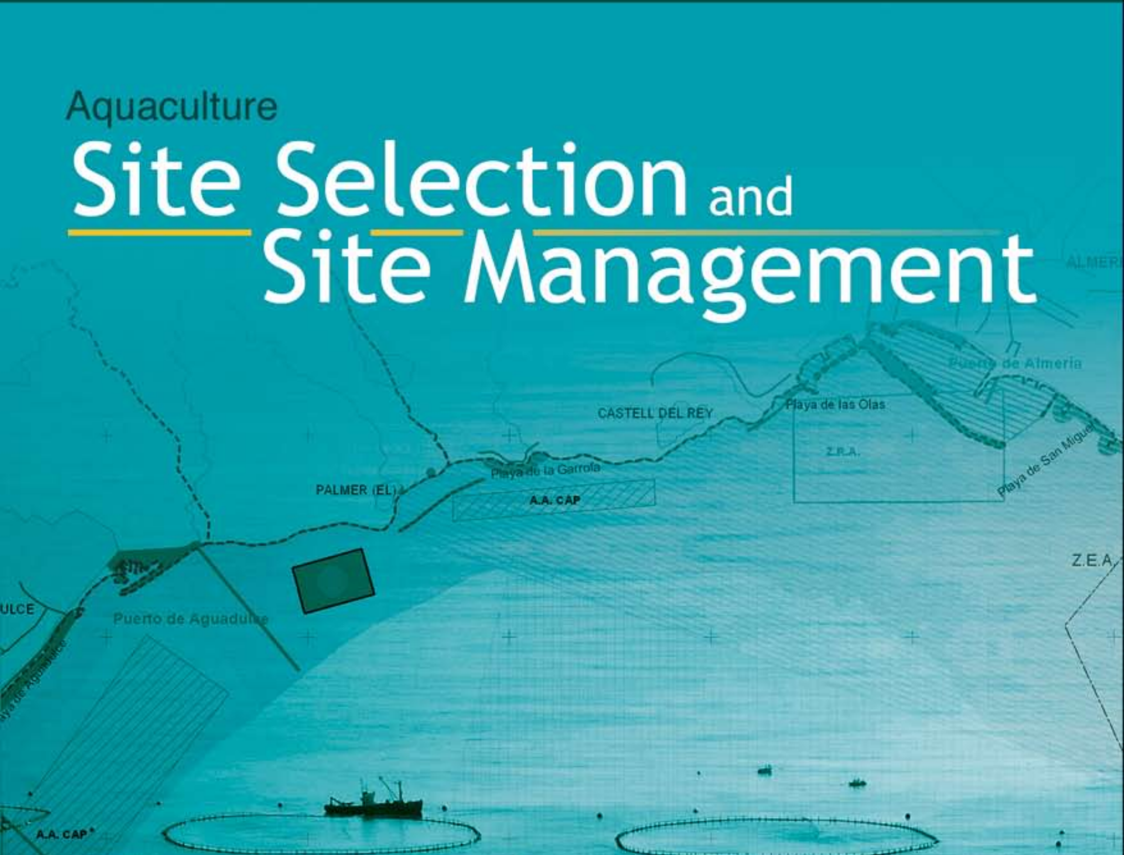
Aquaculture

Site Selection and Site Management



2 Guide for the Sustainable Development of Mediterranean Aquaculture

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Federation of European Aquaculture Producers
GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
SECRETARÍA GENERAL DEL MAR
IUCN

Aquaculture

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2

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Table of contents

Foreword

Aquaculture is currently facing a significant challenge: how to alleviate the pressure on fish stocks exerted by commercial fishing and yet meet the increasing demand for sea products in local and international markets in a sustainable way. As a consequence, aquaculture is expected to develop considerably in the near future in countries all round the Mediterranean.

The availability of suitable areas for aquaculture in the Mediterranean region is becoming a major problem for the development and expansion of the activity. There is a need for sites with appropriate environmental characteristics and good water quality. In addition to these natural limiting factors, the social aspects of interactions with other human activities or conflicts over the use and appropriation of resources in the much-exploited coastal zone are constraints to be considered when aquaculture facilities are set up.

Site selection and site management are among the most important issues for the success of aquaculture and need to be carried out in accordance with sustainability and best practice guidelines. That is the aim of the Marine Programme of the International Union for Conservation of Nature (IUCN). To that end, together with the Federation of European Aquaculture Producers (FEAP) and the Secretariat for Fisheries of the Spanish Ministry of Agriculture, Fisheries and Food (MAPA)[1], IUCN signed an agreement in 2004 to cooperate and generate a series of "Guide for the sustainable development of Mediterranean aquaculture". The first of these devoted to Interactions between aquaculture and the environment, particularly emphasised the fact that most of the potential environmental impacts of aquaculture can be managed and minimized through an understanding of the processes involved, responsible management and the appropriate siting of farms.

The aim of this second guide in the series, "Aquaculture site selection and site management", is to promote the sustainable development of Mediterranean

[1] Currently Ministry of the Environment and Rural and Marine Affairs (MARM).

aquaculture by providing basic guidelines for good practice in site selection and site management. It has been produced by the IUCN/FEAP working group on aquaculture. More than 50 experts in different areas, including socioeconomists, biologists, lawyers, aquaculture farmers, and government and environmental organization representatives from most Mediterranean countries came together in the workshops[2]. The principles and guidelines that follow are the result of extensive debates during these workshops and at later coordination meetings, as well as subsequent work conducted through e-mail exchanges.

All the texts in this guide were drafted by the best Mediterranean experts on each topic. The compilation, revision and structuring of the guides was done by Sandra Simoes Rubiales (IUCN) and Pablo Ávila Zaragozá (D·a·p. Regional Ministry of Agriculture and Fisheries, Government of Andalusia) under the general coordination of François Simard (IUCN) and Javier Ojeda González-Posada (APROMAR/FEAP). The Mediterranean drafting committee is composed of the following experts:

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[2] Istanbul (October 2007), Alicante (February 2008), Split (March 2008). Organized in collaboration with the GFCM and the Mediterranean Action Plan (MAP) Regional Activity Centres (RAC/SPA and PAP/RAC)

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Executive Summary

The shared use of Public Domain areas and the conservation policies for the Mediterranean Sea reduce the availability of sites. At the same time, however, demand for aquaculture products is increasing, especially because industries such as that in the Mediterranean can supply a constant stream of quality products at stable prices. Further efforts are still required to ensure the sustainable development of aquaculture in the Mediterranean; to this end, site selection and site management are important processes that need to be implemented in a sustainable manner.

Most problems stem from the lack of a full appreciation of the essential elements that need to be considered in the site selection and site management processes. Wrong decisions based on incomplete information might jeopardise the sustainable development of aquaculture in the Mediterranean.

This Guide seeks to provide the reader with a full set of parameters and ideas to think about and apply to site selection and site management. Perhaps not all the aspects that might have been treated have been included, but an effort has been made to address those considered relevant within a sustainable framework.

Guide A: The importance of knowledge

Guide B: The participatory approach

Guide C: Social acceptability

Guide D: The precautionary principle

Guide E: The scale approach

Guide F: The adaptive approach

Guide G: Economic aspects

Guide A The importance of knowledge

This guide addresses the bare essentials that must be understood and taken into account in the selection and management of aquaculture sites, so as to further the sustainable development of aquaculture in the Mediterranean.

Principle

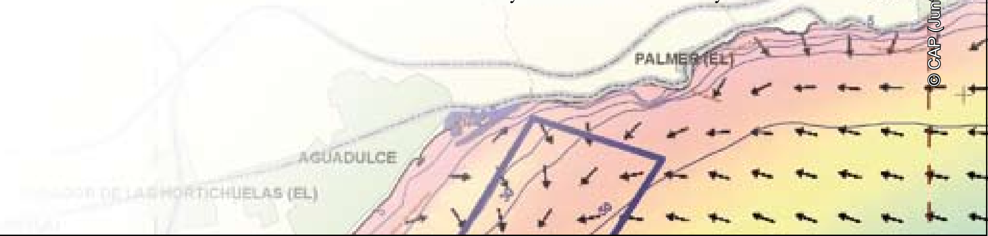
Aquaculture site selection and site management should be based on reliable legal, environmental, technical and socioeconomic knowledge to enhance the viability of the process.

Guidelines

- Information on the legal and environmental aspects of the coastal strip in public ownership should be collected by the authorities and made available to the general public. The collection and dissemination of such information should be the responsibility of the competent authorities, given the public domain nature of most of these areas.
- The development of aquaculture by means of site selection should be based on scientific knowledge complemented by traditional knowledge. Research must be conducted continually in order to improve knowledge on aquaculture, which has to be made available in a way that is understandable by all.

Environmental knowledge

- The study area should be delimited in advance. The study area should be narrowed down without losing vital data, in order to optimize data collection in the field both technically and economically.



Guide A

- Environmental and cultivation conditions should be well enough matched to assure the viability of the project. Depending on the type of aquaculture to be introduced, the most suitable environmental conditions for its development need to be assessed.

Technical knowledge

- Decision makers should be familiar with current production and technological systems to ensure that aquaculture sites are appropriately selected. It is important to know what kinds of aquaculture are suited to the characteristics of a particular area and to use the most up-to-date techniques to achieve the success of the project.
- Only proven technologies should be considered in the selection of sites for aquaculture and their subsequent management, especially in offshore locations or in highly sophisticated systems such as land-based recirculation systems. Both types of aquaculture system are complex. It is therefore essential to be familiar with the most applicable technology in order to manage the high risk of aquaculture.
- Research into the practical implementation of sanitary fallowing of fish farm sites in the Mediterranean should be encouraged. The consolidation of this knowledge could have important future consequences for aquaculture planning and siting, especially in view of the increase in production and site concentration.
- Aquaculture personnel should be provided with lifelong learning. In order to make sure aquaculture ventures run smoothly, it is important to keep personnel abreast of any new technologies or improvements which could improve site selection and site management.

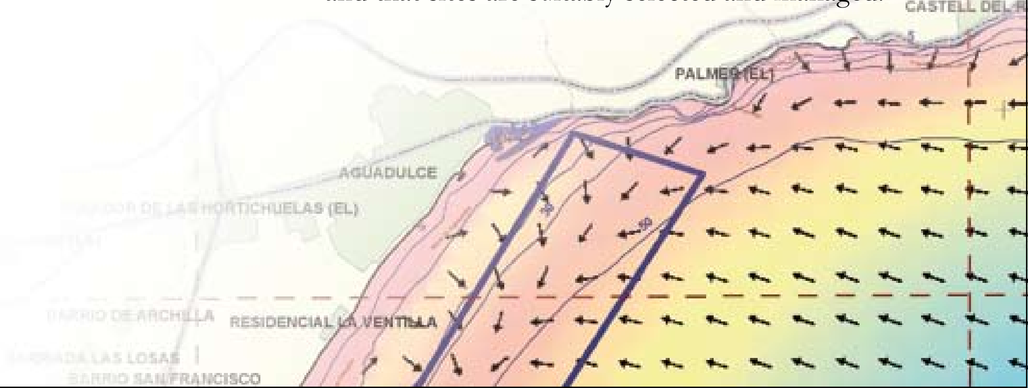
Guide A

Knowledge of the legal system

- Aquaculture farmers and the authorities with jurisdiction over the coast should have clear knowledge of the legislation governing aquaculture and the relevant planning rules. To this end, countries that want to encourage aquaculture development need to have transparent legislation on aquaculture to provide sufficient legal certainty for aquaculture farmers.
- Aquaculture and coastal planning legislation should be familiar and accessible to all stakeholders. In the planning of suitable sites for aquaculture, there should be a clear and comprehensive understanding of the legislation governing all interests affecting the coastline, in order to avoid conflicts of interest.

Socioeconomic knowledge

- The process of aquaculture site selection and site management should take reliable local knowledge into consideration. The views of the people in the area of interest should be taken into account when assessing aquaculture planning within its socioeconomic, political, cultural and legal context.
- Regarding interactions with other activities in the area, synergies and incompatibilities should be taken into consideration. As aquaculture is at present one of the last sectors to arrive in a specific area, it is essential that synergies and incompatibilities with other sectors are emphasised in order to ensure that aquaculture integrates into the local economy and that sites are suitably selected and managed.



Guide B The participatory approach

This guide presents a straightforward concept that is basic in its definition but complex to implement. Its connection with site selection is explained and its importance for the success of the aquaculture project shown. Models and examples are given to guide the implementation of this approach to site selection and site management and the sustainability of aquaculture.

Principle

Site selection and site management processes should involve the participation of all stakeholders that share the same coastal region, in order to achieve the sustainable development of the activity.

Guidelines

- The participatory approach should be considered from the very beginning of the project. It is essential for stakeholders who will be involved in any participatory process to feel involved from the outset, ensuring appropriation and therefore successful site selection for aquaculture.
- The participatory approach should be implemented through a process of co-construction. This process,

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Guide B

based on each stakeholder having an equal right to speak, with decisions being made by majority or consensus, will ensure sustainable objectives and establish common goals that will benefit all the users of a given maritime region.

- The participatory approach should take into account all stakeholders at all levels and identify their roles and abilities. They must be properly represented and their involvement demonstrated according to the degree to which the project may affect them.
- The participatory approach should identify a mediator or steering committee. This person or group – who should be neutral and recognised by all participants – has the task of organizing the process and directing development and implementation.
- The participatory approach should be conducted in a common language. This will ensure that information is shared equally and that all participants can understand it, regardless of their abilities.
- The participatory process should progress according to the 'eddy' model and provide periodic feedback. The continuous evolution to which all processes are subject requires the participatory process to undergo constant revision and restructuring, correcting errors in order to reintroduce the objectives established at the beginning.

Guide C Social acceptability

This guide presents the concept of social acceptability and its direct relevance and importance to site selection and site management. The concept is defined and characterized and the public's perception of it is discussed, together with criteria and tools to assess it and guidelines to achieve it. Social acceptability is considered a key issue to ensure the sustainable development of aquaculture in the Mediterranean.

Principle

Social acceptability should be considered an objective of the site selection and site management process in order to ensure the establishment and permanence of the aquaculture project in the long term.

Guidelines

- Social acceptability is an objective that should be considered from the outset in any aquaculture project. This general rule is particularly relevant in the Mediterranean region, given the annually increasing pressures of coastline occupancy and use.
- Communication, information and transparency should be established to foster a dialogue amongst stakeholders and ensure social acceptability.

Information exchange amongst stakeholders is vital to ensure that the consequences of the acceptance or rejection of a project are properly analysed.

- Cultural parameters are particular to each Mediterranean region and should be considered individually when building social acceptability. The multicultural nature of the Mediterranean adds complexity to the process of achieving social acceptability. These parameters need to be identified, analysed and integrated in the selection and management of aquaculture sites.
- Social acceptability and the consequent sustainability of an aquaculture project should be based on the creation of a 'quality image' for aquaculture. Aquaculture is still unknown to society in general. It is therefore necessary to invest in communication and education to improve people's understanding of site selection and all other aquaculture processes through a quality scheme.

Guide D The precautionary principle

This guide presents the concept of the precautionary principle and its application to the various aspects of site selection and site management. Definitions and methods for the implementation of the concept are given and special attention is paid to the limits between benefits and drawbacks in the application of the precautionary principle.

Principle

The precautionary principle should be applied in the aquaculture site selection and site management processes.

Guidelines

- The precautionary principle should be applied in the decision-making processes for aquaculture site selection and site management, within the framework of the ecosystem approach and in conjunction with the participatory and adaptive approaches. It allows for the taking of decisions even though not all the relevant scientific data may be available, and it helps stakeholders to take a straightforward approach.
- The precautionary principle should be applied within certain limits in order to avoid possible rejection. Precaution has no defined or measurable limits, and these must be established mainly on the basis of the possible effects of any action, without crossing certain thresholds or reaching the point of no action.
- The precautionary principle should take account of all relevant forms of information, such as scientific and traditional knowledge, on an appropriate temporal and spatial scale. The better the decision makers are informed, the more appropriately the site selection process can be planned in view of the risks to be incurred.

Guide E The scale approach

This guide presents the concept of scale as a factor to be considered in the process of aquaculture site selection and site management, where spatial and temporal dimensions influence decision making. A definition of the concept is given and the effect of mismatches among scaling factors on site selection and site management is described.

Principle

Site selection and site management in a context of sustainable development of aquaculture should take the scale approach into account when studying interactions among several systems.

Guidelines

- The scale approach should be applied at each step of the aquaculture site selection and site management process. Continuous attention to sizing and identification of mismatches can help to achieve the success of aquaculture projects in a given area.
- Research should be encouraged to understand and resolve scale mismatches in the process of site selection and site management. The ability to identify, measure, and compare the effects caused

Guide E

by the different scales at which the various systems function can help the process to succeed.

- The potential growth of the aquaculture project should be considered at the outset of the site management process. A long-term view of the possible future development of the aquaculture farm will enable managers to overcome further foreseeable mismatches between the activity and the surrounding systems.
- Tools such as geographical information systems should be used to assess the spatial and temporal scales in the aquaculture site selection and site management process. Powerful tools can help to reveal what is happening in a system at different scales so that the situation can be managed knowingly.
- Site selection and site management should be decentralized to the lowest appropriate level. Government structure and the level of decentralization in Mediterranean countries play an important role in the process. Institutions frequently lack the necessary multi-scale vision and associated flexibility to solve problems that occur at scales that they usually do not consider.

Guide F The adaptive approach

This guide refers to the importance of learning, anticipation and flexibility in the process of site selection and site management in view of the dynamic nature of the ecosystem in which the activity is implemented.

Principle

In aquaculture site selection and site management, the adaptive approach should be implemented to allow the activity to develop in a sustainable manner in a changing environment.

Guidelines

- The adaptive approach should be implemented in evolving processes like aquaculture site selection and site management, on a basis of learning, anticipation and flexibility. Reactive adaptation to change can endanger the sustainability of aquaculture. A long-term strategy is advisable instead.
- Anticipated and unanticipated change involving risk should be addressed at the legal, ecological, socioeconomic or technological level by means of greater flexibility, in order to reduce conflict and achieve the sustainable development of aquaculture.

Guide F

Long-term solutions to mismatches will depend on knowledge and the further development of flexibility to reorganize the activity in response to changes in factors influencing the aquaculture sector.

- Research should be encouraged to allow the aquaculture sector to anticipate change. Anticipatory research can influence and improve past and future studies on the sustainable development of aquaculture as well as help the sector to adapt more easily to a particular change.
- Close partnerships among citizens, managers and scientists as well as cooperation among members of the same aquaculture sector should be encouraged in order to facilitate adaptation to achieve the sustainable development of aquaculture. Through partnership and cooperation, knowledge can be shared and extended, by comparing different strategies used to cope with a given situation. This can speed up learning and adaptation in aquaculture processes.
- Effective and rapid learning, adaptation and flexibility should be taken into consideration to cope with change. Documentation, anticipation, flexibility, comparisons between different approaches and identification of trigger points are essential for the sustainability of aquaculture. Learning and adaptation are processes that always evolve over time.
- Records of successful as well as failed past studies should be accessible to all stakeholders. Much can be gained from the creation of a database of retrospective studies on Mediterranean aquaculture, since the ecoregion is the same.

Guide G Economic aspects

This guide introduces the basic concepts and tools of environmental economics needed for site selection and site management. Economics provides meaningful indicators and decision support tools. It allows analysts, planners and entrepreneurs to compare different activities and their outcomes using a common monetary benchmark. The guide will focus on the application of cost-benefit analysis (CBA) and valuation methods since they are widely recognised and accepted by a range of decision makers, both private and public.

Principle

Economic factors and in particular the economic dimensions of aquacultureecosystem interactions should be considered for effective site selection and site management.

Guidelines

- Economic tools and indicators should be used in conjunction with others (e.g. environmental impact assessments) to enable decision making based on multiple criteria reflecting a range of societal objectives. Decision makers often have insufficient information to reach decisions aimed at avoiding biodiversity loss. This can be overcome through the integrated use of economic and other decision

Guide G

support tools. Economic tools are important because they reflect a range of values using widely accepted and understood monetary measures.

- In order to capture the total economic value (TEV) of a given type of aquaculture at a given site, the application of economic tools of analysis should consider a comprehensive range of non-market and market sources of value, and direct and indirect impacts. Economic tools should be used to value the enterprise and related businesses (e.g. packing, transport and marketing), environmental impacts (e.g. changing water quality and biodiversity), changes in employment, and similar economic aspects. This can be accomplished by using the full range of methods of economic valuation.
- In order to understand trade-offs among candidate users of the same ecosystem, the TEV of aquaculture should be compared to the TEV of other sectors. This will enable decision makers to prioritize activities and assess aquaculture against other uses in relation to its interaction with the ecosystem. Sustainable site selection and management should result in a higher TEV for aquaculture.
- In order to develop appropriate regulatory incentives at the farm level, externalities should be understood and quantified. Fish farming is an economic undertaking. If policy is to encourage or discourage certain activities, farmers must be given appropriate incentives (e.g. fees, fines, subsidies) and these incentives should reflect the externalities caused.

Guide H The importance of governance

This guide deals with the concept of governance and how it should be developed and implemented in connection with aquaculture site selection and site management. From definition to new aspects, characteristics of governance are described which are directly applicable to the sustainable development of aquaculture.

Principle

Good governance practices concerning planning and decision making should be implemented for aquaculture site selection and site management.

Guidelines

- Governance should be flexible, dynamic and adaptive. This ability to react to change and evolve towards greater effectiveness will give decision makers confidence and support.
- Governance should encourage all stakeholders to participate and interact. The inclusion of all actors

and the triggering of linkages within and among them will reinforce governability, increasing success in a shared environment where site selection has to be made.

- Governance should be applied at all levels. Because globalization is becoming a strong driver of change, new forms of governance should be developed at all scales, from local to global.
- Aquaculture planning should be developed under the best applicable governance. As governance influences the processes of site selection and site management, the rules and their implementation should underline guidelines of sustainability.
- Governance should be considered and implemented on a long-term basis. Unlike fisheries, where daily decisions may be subject to uncertainties, aquaculture planning has a steadier, more long-term course that should be taken into account in governance arrangements.

Guide I The legal framework

This guide offers a series of guidelines for the establishment of appropriate legal frameworks for the practice of aquaculture, particularly with regard to site selection. The aim is to highlight the benefits of adequate regulations for aquaculture. An overview of the current situation is given for the Mediterranean.

Principle

An adequate and favourable legal framework should be in place to ensure appropriate site selection and site management.

Guidelines

- A suitable legal framework should be in place, guaranteeing the rights and stating the obligations of holders of aquaculture licences. That will ensure legal security for both aquaculture operators and the activity itself.
- Coordination and agreements on the legal framework for aquaculture site selection and site management should be built among the various administrative authorities. A lack of clear, concise regulations that specify the division of tasks between administrative authorities may result in the overlap of areas of competence and delays in procedures.
- The legal framework should be available and understandable to all stakeholders. Comprehensive aquaculture legislation will provide guarantees of

success, in terms of both environmental protection and the development of the aquaculture industry. Furthermore, such a legal framework will be a way of informing society about the aquaculture industry.

- The legal framework for aquaculture should establish the basic programmes and conditions necessary for the selection of suitable areas for aquaculture. The designation of appropriate areas for aquaculture in both maritime and coastal areas should be reflected in regulations. This will ensure the legal security of aquaculture activities, their future stability and their success and competitiveness.
- Aquaculture legislation should be integrated with all forms of jurisdiction over the coastal zone. Regulations should be established for the management of coastal areas, covering planning, conservation conditions, protection of coastal resources, and planning of areas to be used for marine aquaculture.
- The legal system should include requirements that ensure compatibility with other uses. To achieve this there must be coordination between the competent administrative authorities and agencies, the industry and the general public, as well as legislative action.
- Aquaculture legislation should address the social and economic aspects of the area in which aquaculture activities take place. A lack of regulation may cause the rejection of aquaculture by society or administrative authorities that prioritize other interests.

Guide J Administrative procedures

This guide gives an overview of the existing administrative procedures in different countries. The main problematic topics of bureaucracy, timing, requirements, rights and duties are explained and possible solutions proposed.

Principle

Adequate administrative procedures should be established in order to facilitate the appropriate selection and management of sites for aquaculture.

Guidelines

- Regulations should be drafted that set out the procedures for granting aquaculture licences. It is important to have regulations that clearly inform aquaculture operators of the requirements for obtaining a licence, the timeframe of the application process, as well as the rights and obligations attached to the licence.
- Instruments should be prepared to coordinate the administrative authorities and agencies involved and the procedures for granting the various authorizations. This will ensure the legal security of both the applicant and the granting authority itself, while also simplifying the aquaculture licensing process.
- Administrative authorities with responsibilities for aquaculture should develop guidelines for the submission of applications, containing legal and

institutional information. These guidelines would be useful for establishing aquaculture policies, not only for the competent administrative authorities, but also for aquaculture operators and society in general. A simple form should be produced, accompanied by a checklist to help the applicant ensure that all documents are submitted.

- The establishment of technical offices that centralize aquaculture procedures in a region or country is recommended. The creation of one-stop shops should be promoted to centralize licence-granting procedures, thus reducing procedure timeframes and requirements.
- Common administrative licensing procedures should be enforced at a Mediterranean level. Efforts should be made to set up a basis for minimum common requirements, to facilitate capital movement within the Mediterranean.
- The criteria used to calculate the aquaculture fee should be reasonable, transparent and uniform for each type of aquaculture, in order to ensure legal certainty. The fee for occupation of an area in the public domain must be proportional to the use thereof, and take into account the specific character of the aquaculture activity in question. Alternatives to purely economic fees should be proposed.
- The capabilities and human resources of the administrative authorities responsible for aquaculture should be increased, backed up by a political commitment to coordinate the institutions and agencies involved in the regulation and management of aquaculture.

Guide K Sectoral planning

This guide presents sectoral planning as a means for achieving the sustainable development of the aquaculture sector and describes the direct links between planning and site selection and site management. A definition of sectoral planning and the components of the sector is given, followed by the role of the authorities and key aspects needed for the development of a sectoral plan. Finally, examples of sectoral planning procedures are described.

Principle

The selection and management of areas for aquaculture should take into account a sectoral approach and sectoral planning.

Guidelines

- The potential for growth of the aquaculture sector in a particular geographical area should be taken into account as the starting point for the selection of sites. The prospect of growth is an essential factor to ensure that the activity appears and/or remains in a specific geographical area.

Guide K

- The growth of the sector should be balanced with respect to other sectors sharing the same public domain areas. It is important to find a balance between the development of aquaculture and other activities that interact with it in public domain areas, which is why the growth of aquaculture must be planned and orderly.
- Sectoral planning should balance the sector's needs and the authorities' objectives. As principal actors in the process, both parties should interact and develop a co-construction process supported by other actors such as associations, research bodies and other organizations.
- Effective sectoral planning should be based on prospective studies. Empirical knowledge is needed to lay the foundations for sectoral plans. This in turn requires sufficient economic, material and human resources to obtain the information needed and make it available to the actors involved in the sector's development.
- Sectoral planning should be carried out with the help of instruments and tools that make appropriate spatial and temporal analysis possible. Geographical information systems are tools that facilitate the reading, representation and analysis of information.

Guide L Private sector organizations

This guide defines professional organizations and associations as organizational structures developed by the private sector. Their roles and commitments are explained as well as their importance in the site selection and site management process. With reference to Mediterranean organizations, the scale factor is considered together with observed trends due to globalization. Finally some examples are given as well as guidelines on how private sector organizations can contribute to the sustainable development of aquaculture.

Principle

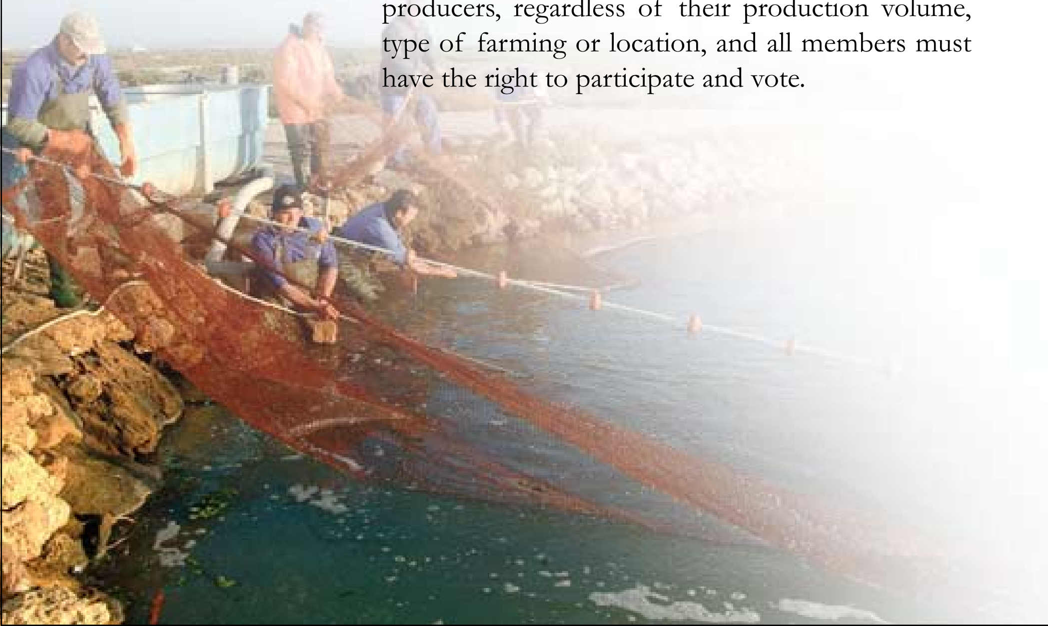
Professional associations and sectoral organizations should be promoted in order to defend the feasibility of private initiatives in the selection and management of aquacultures sites.

Guidelines

- Aquaculture companies and professionals should organize themselves in order to defend common interests. By associating they gain greater social presence and a greater ability to reach top administrative and political levels, which otherwise would remain inaccessible for most companies.

Guide L

- Professional associations should establish and implement codes of conduct and better management practices for all their members. Implementing these initiatives, even if they are voluntary, contributes to improving both productive practices and social acceptability.
- Public authorities should support professional associations. Since the weak spot of structures such as professional associations is usually their limited financial capacity, administrative authorities should have public grants at their disposal.
- Professional associations should be created at a local level, with the intention of joining organizations at a higher level. The creation of a professional association at the local level provides an immediate basis for the identification of common topics and problems. However, there also exist common problems and challenges at higher territorial levels, such as the Mediterranean region, that can only be dealt with effectively through higher-ranking organizations such as federations.
- All producers should have the opportunity to join and participate in an association. Membership of a professional association must be open to all producers, regardless of their production volume, type of farming or location, and all members must have the right to participate and vote.



Guide M Integrated coastal zone management (ICZM)

This guide highlights the need to take all the stakeholders involved in a particular coastal area into consideration in order to ensure that the diverse frameworks and processes occurring in the zone are properly implemented. In this sense, integrated coastal zone management can facilitate aquaculture site selection and site management and its further sustainable development.

Principle

In the process of site selection and site management for aquaculture, Integrated Coastal Zone Management (ICZM) represents a new form of governance that should be implemented.

Guidelines

- A preliminary study exploring each sector's needs in a given area should be implemented. Aquaculture must be seen as one of several activities that use the same marine ecosystem, the development of which requires a search for new sites.
- A thorough understanding of existing and potential interactions that affect the different activities and resources in the area and how they are likely to develop over time is needed in order to integrate aquaculture with the others. Management efforts can no longer be carried out individually by different sectors using the

Guide M

same marine ecosystem. It is necessary to encourage benefits from complementary interactions and to find ways of limiting antagonistic ones.

- The costs and benefits of all activities, including aquaculture, should be identified in order to take into account their beneficial as well as harmful effects on other activities. It is important from an economic point of view to be aware of the direct and/or indirect impacts that may result from such coexistence. Integrated Coastal Zone Management is an adaptive, never-ending process.
- Relevant ICZM elements in the legal framework should be identified and improved. Traditionally, separate legislation may be produced for individual sectors. To integrate the various sectors using the same marine ecosystem as aquaculture, it is necessary to give the existing legal framework a broader outlook to allow them to coexist on a legal basis.
- National experiences with such an experimental process as ICZM applied to aquaculture site selection and site management should be shared globally. This information may be helpful on the one hand to countries whose ICZM capabilities are just emerging and on the other to countries which already apply ICZM yet require further information about the process.
- ICZM activities should be well financed in order to uphold and allow further sustainable development of sectors such as aquaculture. Effective coastal zone management requires regular financing in order to support its ongoing ICZM process, the objective of which is to take all the stakeholders into account, including the aquaculture sector.

Guide N The site selection process

This guide provides a method for site selection, taking into account all the aspects needed to achieve the sustainable development of Mediterranean aquaculture. Key aspects, concepts and terminology are explained and special attention is given to the sequence of the process itself. The guide includes a basic list of parameters to be studied and mapped as well as a practical example from southern Spain.

Principle

A clear and sequential site selection process should be put in place in order to ensure sustainable aquaculture.

Guidelines

- Site selection should depend on the aquaculture activity planned and the existing environmental conditions. In designing a process, all limiting factors or priorities that could interfere with the proposed objective of selecting sites for the sustainable development of aquaculture must be taken into account.
- The scale factor should be applied in order to size the project, taking into account the degree of detail required and the budget available for the process. The material and financial resources required to carry out

a site selection process should be considered in terms of balancing investment against expected results.

- The methodology to be used in a site selection process should begin with a sectoral analysis and the identification of needs. The sectoral analysis must provide information on the type and size of aquaculture planned. This information will be essential in order to identify the best parameters for the study, the agents involved and the project's scope.
- The study methodology should preferably be selective and dynamic. Administrative factors should be addressed first due to possible incompatibilities with other uses and to select and focus, on the environmental factors to study. The process should be dynamic, so that information obtained is progressively interpreted and added to allow for feedback and updating.
- The choice of parameters should directly relate to the statutory context in force for the aquatic activity in the study area. The parameters selected for the study should be the main basis for determining the suitability of the area and should include those that interfere directly or indirectly with the planned activity.
- The site selection method should include the chronological sequence of actions required to carry out the study within the expected timeframe. A schedule should be established for the collection of information, map development, consultation and validation by agents, final results and mapping.
- The results of site selection processes should be mapped at a scale and in a format that can be easily read and interpreted. The information obtained and its interpretation must be represented graphically and be intelligible to the general public.

Guide O The ecosystem approach

This guide promotes the application of the ecosystem approach for managing the impacts of human activities on the ecosystem, with the aim of optimizing its use without damaging it. It would therefore be more accurate to call it an ecosystem-based approach to integrated management (EBM). It is a step-by-step management tool based on the best available scientific, traditional and local knowledge on the ecosystem and complies with the 12 principles recommended by the Conference of the Parties to the Convention on Biological Diversity.

Principle

Site selection and site management should be addressed within an ecosystem-based approach to integrated management.

Guidelines

- In an ecosystem-based approach to integrated management (EBM), site selection and site management should be based on cause-and-effect relationships between stressors, namely the activity, and impacts, so as to provide information on the

Guide O

state of the ecosystem. Assessment tools, such as Pathways of Effects or Cumulative Effects, can help managers to propose mitigation measures or modifications to activities that have a negative impact on the ecosystem conservation objectives.

- EBM is a management tool which should be implemented at all scales, from local to international, without undergoing changes. The ecosystem approach is a space-based strategy taking into consideration environmental and socioeconomic aspects, with the aim of promoting the conservation and sustainable use of the ecosystem in an equitable way.
- Aquaculture site selection and site management should be addressed with EBM, once the top-down process has been carried out. This will secure the ecosystem attributes and objectives relating to biodiversity, productivity, health and resilience and therefore the sustainable development of any activity depending on them.

Guide P — Carrying capacity, indicators and models

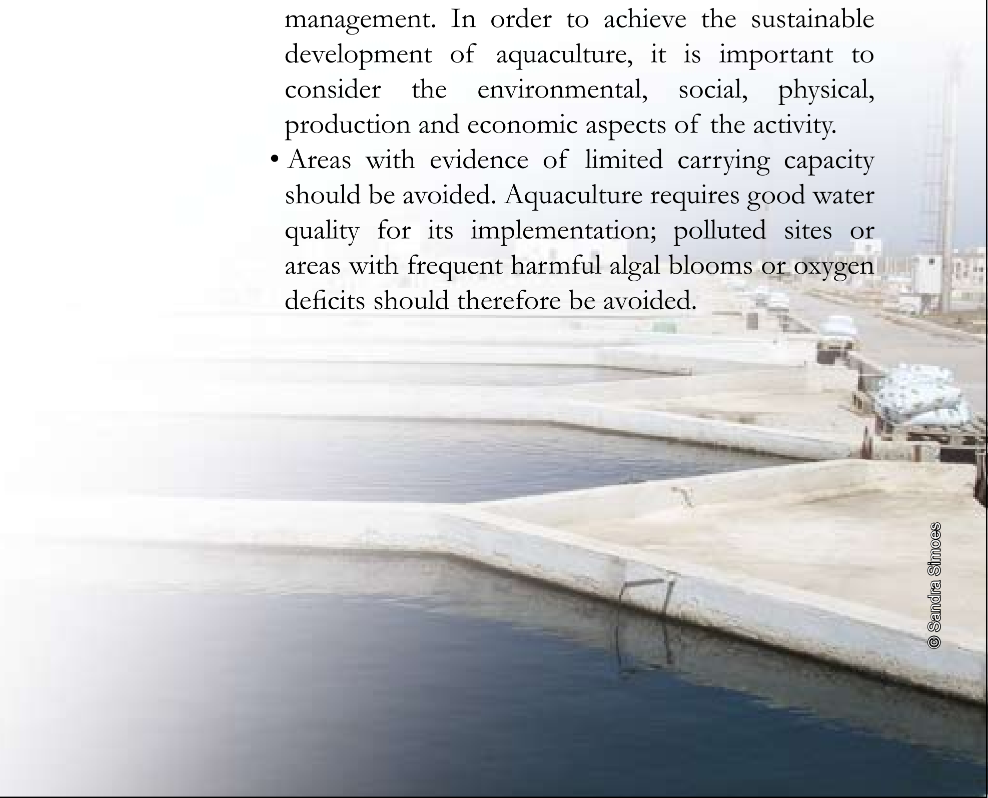
This guide provides definitions and tools for measuring carrying capacity. Different dimensions and meanings of carrying capacity are given, as well as criteria and variables to be used. Examples and models are proposed and guidelines are provided relating to site selection and site management for the sustainability of aquaculture.

Principle

Operational measurements of carrying capacity should be taken into account for aquaculture site selection and site management in order to allow for the sustainable use of marine resources.

Guidelines

- The carrying capacity of all measurable parameters should be considered in site selection and site management. In order to achieve the sustainable development of aquaculture, it is important to consider the environmental, social, physical, production and economic aspects of the activity.
- Areas with evidence of limited carrying capacity should be avoided. Aquaculture requires good water quality for its implementation; polluted sites or areas with frequent harmful algal blooms or oxygen deficits should therefore be avoided.



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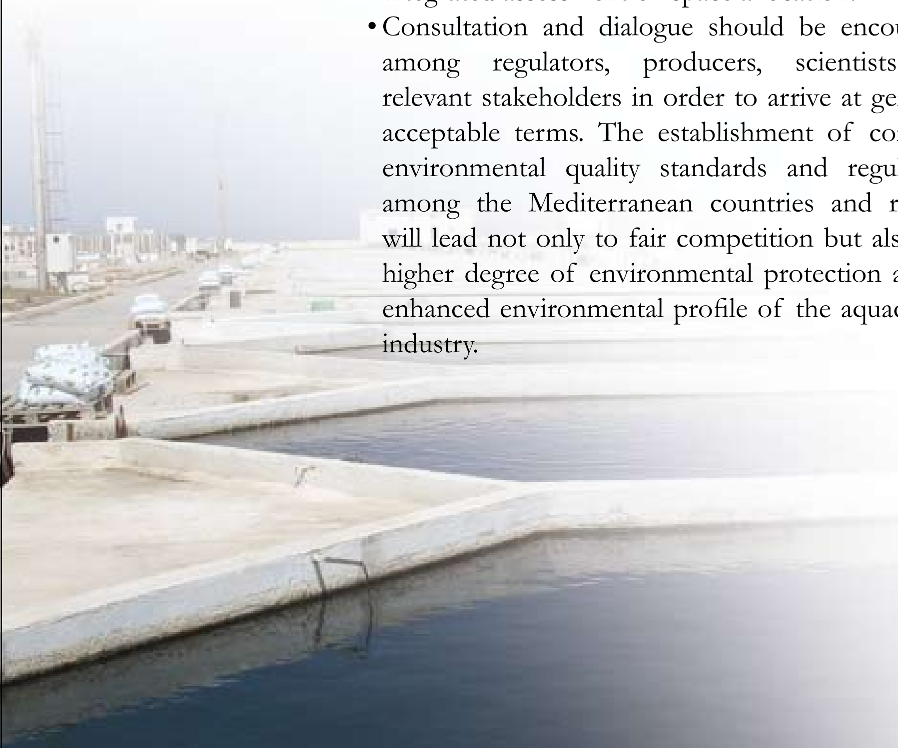
Guide P

- Aquaculture facilities should adjust their production to the carrying capacity of the local environment. Each ecosystem has a different capacity to absorb and assimilate excess loading of organic compounds and nutrients. Therefore production should be low, in shallow, inshore, sheltered areas and higher in deep, offshore, exposed sites.
- Even under the most favourable environmental conditions, an upper limit of production per farm should be established. Any revision of limits should be supported by intensive and regular monitoring, providing sufficient evidence that this maximum production level does not cause irreversible adverse impacts.
- An assessment should be made of the maximal allowable proportion of space that may be used for aquaculture in each water body, taking into account other uses and local wildlife. Ecological and socioeconomic indicators as well as models and standards must be used to obtain the best possible integrated assessment of space allocation.
- Consultation and dialogue should be encouraged among regulators, producers, scientists and relevant stakeholders in order to arrive at generally acceptable terms. The establishment of common environmental quality standards and regulations among the Mediterranean countries and regions will lead not only to fair competition but also to a higher degree of environmental protection and an enhanced environmental profile of the aquaculture industry.



Guide Q Environmental impact assessment (EIA)

This guide outlines the environmental impact assessment as an essential tool to be implemented before a site is approved for aquaculture. It ensures that proper decision-making processes are in place, supported by accurate data on the impacts of the activity, and it takes into account the socio-environmental acceptability of the project. It should be consistent with both sustainability criteria and best practice.

Principle

For appropriate aquaculture site selection and installation, the environmental impact assessment (EIA) procedures should be mandatory and implemented.

Guidelines

- An environmental impact assessment should be mandatory for all projects, including aquaculture site selection, and incorporated in legislation. The sea is an area in the public domain and specific laws should be implemented in order to ensure the appropriate and sustainable use of the ecosystem, thereby promoting the sustainable development of aquaculture. The responsibility for bearing the costs of the EIA should be discussed.
- To facilitate the process of aquaculture site selection, the current environmental impact assessment protocols, standards and models should be simplified and harmonized throughout the Mediterranean and a regular review of the statements should be carried

Guide Q

out. Proper indicators for environmental quality standards (EQS) and impacts must be developed in the Mediterranean for the various types of production (shellfish and finfish).

- The environmental impact assessment should be based on the best and most appropriate scientific knowledge, covering technical, socioeconomic and environmental aspects, as well as on the precautionary principle. Scientific facts, assumptions and expert judgements, and the consequences of the range of error for the assessment have to be discussed. In this context, the precautionary principle or approach is an important element for an EIA.
- The decision-making authorities must keep abreast of innovations affecting environmental impact assessments by means of regular training, while the private sector must also be given easy access to such information. Stakeholders are not always aware of recent developments or reasons for changes. Therefore, regular updating is required to facilitate proper aquaculture site selection.
- Research on current issues, such as cumulative effects or mitigation measures, as well as future topics should be promoted and developed in order to achieve the sustainable development of aquaculture. Innovative techniques, such as those involving distance between cages or limits on diseases, as in examples of prevention from Norway, or any activities that take advantage of the nutrient enrichment of the environment caused by aquaculture have to be more extensively studied and exploited.
- Stronger socioeconomic compensation measures should be introduced in the environmental impact assessment. This would allow for aquaculture projects to be more effectively integrated into the local environment and for synergies to be observed and developed.

Guide R Environmental monitoring programme (EMP)

This guide deals with the environmental monitoring programme (EMP), which has to be consistent with sustainability criteria. This tool, used after the environmental impact assessment (EIA), uses sampling to highlight the extent to which aquaculture management affects the ecosystem over time, by comparing current data collected at various points in time with data obtained before development as well as with other existing data.

Principle

Environmental monitoring programmes should be implemented and should be compulsory for sustainable aquaculture site management.

Guidelines

- A baseline study should be implemented prior to the environmental monitoring programme. Thorough, in-depth knowledge of the surrounding environment and aquaculture practices is needed to define the best possible specific environmental monitoring programme.
- Reliable monitoring should be used to detect environmental responses to changes in the scale of production and to readjust the thresholds of environmental quality standards. Due to the continuous development of the industry, monitoring

must be adaptive to assess the dynamic linkages between aquaculture and the ecosystem within which it operates.

- Standardization and harmonization of EMP should be imposed by law in all Mediterranean countries. Supported by research programmes, the same EMP procedures should be followed, so as to make aquaculture sustainable throughout the Mediterranean.
- The EMP, together with environmental quality standards, should be regularly revised and harmonized by reliable multidisciplinary bodies and the results disseminated in an easily understandable way. A well-conceived EMP is a highly effective method that links environmental changes with activity inputs. However, there are no set ways of monitoring or interpreting the data obtained. These are dependent on the aims of the study, the size (in the case of development), the site characteristics and existing scientific knowledge.
- The sampling frequency used in the EMP should be determined in the environmental impact assessment. Sampling of the sediment and water column should be done at least during the period of greatest impact, in summer. The EMP could be adaptive, so that negative effects would increase the level of monitoring, whereas positive effects would reduce it.
- A regular socioeconomic analysis in the EMP should be developed and revised at least every 5 years. This is in order to monitor the socioeconomic impact and review what was expected in the Environmental Impact Assessment.

Guide S Geographic information systems (GIS)

This guide defines what geographical information systems are and their application to site selection and site management. A brief description of the tool is given, and the features that GIS should have in order to make it useful and effective. An example of a GIS produced in Andalusia (southern Spain) is presented.

Principle

Geographical information systems (GIS) should be used as a tool for site selection and site management.

Guidelines

- Geographical information systems (GIS) should be used as a tool in participatory and co-construction processes. This will help people's understanding and focus the discussion on the real problems, balancing power among all stakeholders.
- The information contained in a GIS should be objective and based on reliable sources. Since these are tools for decision makers, the information must be based on good authority and only be open to question by means of empirical demonstration.
- The information stored in a GIS should be maintained and kept up to date. A GIS should be considered a live system in which the information it contains varies over time; it should therefore prevent decision-making errors resulting from the use of obsolete data.
- Information on the characteristics of the data contained in the GIS (metadata) should be made available. The metadata must conform as far as possible to internationally recognised standards, providing reliability.

Introduction to the Guides

Due to the complexity of the subject and the amount of information treated, the Guide has been structured in four sections:

CONCEPTS

Guides A to G address fundamental concepts to apply, including the importance of knowledge, the participatory approach, social acceptability, the precautionary principle, the scale approach, the adaptive approach and economic aspects. They were chosen to provide a broad overview of the situation.

FRAMEWORKS

Guides H to L mention frameworks that must be taken into account, like the importance of governance, legal issues, administrative procedures, sectoral planning and private sector organizations. They help to establish the aims and guide the process of site selection and site management.

METHODS

Guides M to O cover methods to consider, such as integrated coastal zone management (ICZM), the site selection process, and the ecosystem approach that IUCN has made operational through many initiatives.

TOOLS

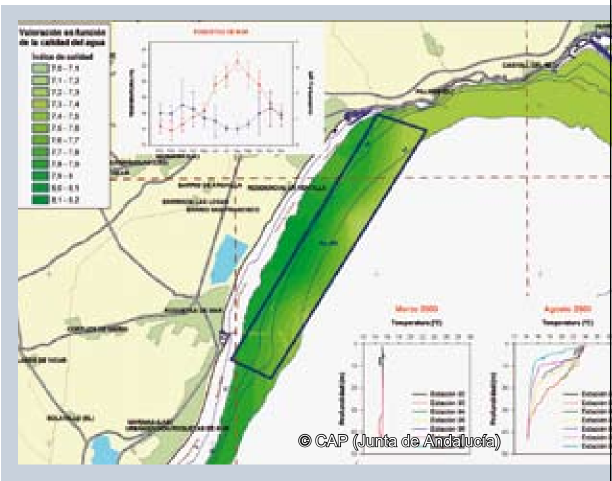
Guides P to S describe tools to use throughout the process, including carrying capacity, indicators and models, the environmental impact assessment (EIA), the environmental monitoring programme (EMP) and geographical information systems (GIS).

Each guide consists of a short summary, definitions, a development of the main theme and a justification, followed by the principle and guidelines. Moreover, a series of Mediterranean examples gives an insight into the current situation in the region.

The importance of knowledge

This guide addresses the bare essentials that must be understood and taken into account in the selection and management of aquaculture sites, so as to further the sustainable development of aquaculture in the Mediterranean.

Any type of industrial activity requires prior knowledge of all the factors that enable it to develop, and with a certain degree of certainty, so that it remains predictable and viable.



In the early years of aquaculture development, biological and production aspects were particularly important due to the newness of the activity and the consequent need for knowledge aimed at its improvement. Nowadays, particular attention is also devoted to site selection and site management processes and these require good knowledge of the most recent developments in coastal or inland aquaculture systems and techniques. But it is not only technical aspects that must be considered when sites are being selected for aquaculture: environmental, legal and socioeconomic aspects are also particularly important with a view to the sustainable development of the activity.

Aquaculture is directly linked to the environment, not only because of the natural conditions that determine whether or not it can be established, but also because it in turn affects the environment on which it depends.

Aquaculture facilities are generally located in areas in the public domain. These are regulated and controlled by the administrative authorities. The multi-user nature of such areas and the pressure on occupation make legal issues increasingly important for aquaculture farmers and authorities, in order to consolidate the activity by guaranteeing their right to occupy the sites.

Knowledge of the regulations, the administrative procedures and the competent authorities that can influence aquaculture site selection and site management can greatly facilitate and simplify these processes. It can smooth the way for aquaculture producers and promote the sustainable development of the activity.

In addition, knowledge of the socioeconomic and cultural characteristics of the area surrounding a potential aquaculture site is becoming more and more relevant, the purpose being to ensure that an aquaculture project is socially acceptable, as society must be involved in the decision-making process for aquaculture site selection and site management.

Environmental knowledge

Environmental knowledge is doubly important for aquaculture site selection and site management. On one hand it is needed to evaluate the suitability of an area for the implementation and development of marine aquaculture with the most appropriate species; on the other it is important for assessing how the activity may affect the surrounding environment.

To begin a study of the natural surroundings with the aim of improving knowledge about the environment, every oceanographic, physical, chemical and biological variable that may affect production and, in turn, may be affected by the activity must be analysed. This is what might be called the environmental characterization of the surroundings, which should be approached from two points of view:

- Environmental suitability for aquaculture: site selection;
- Environmental conditions potentially affected by the activity: environmental monitoring.

In the context of selecting potential sites, it is best to gather environmental knowledge once spatial information on possible conflicting uses has been obtained. Areas can thus be narrowed down and efforts concentrated in places that are ‘free’ or compatible with other uses. Thus, depending on the area where it is intended to locate the project and the type of aquaculture proposed, the most appropriate parameters needed to achieve technical viability can be chosen. In addition, the possible environmental effects on the system should be assessed.

a. Key issues

As stated above, spatially delimiting the study area is important for the technical and financial cost of the work and because spatial variations in the behaviour of environmental variables can introduce large errors when the results obtained are collated.

Consideration of the time scale is also important because of the variability in the natural ecosystems studied. This high variability makes it necessary to extend the environmental study over several production cycles, equivalent to several years, in order to obtain a relatively reliable data series on which cause and effect correlations can be established.

The key aspects to consider when planning work to understand the environmental characteristics of an area where aquaculture facilities can be located are therefore:

- The space time scale, since an area’s environmental conditions may differ or vary over space and time and may impose a limit on the type of aquaculture that can be developed as well on the space needed for its development, e.g. inland areas (estuaries or wetlands), semi-enclosed sea areas (bays or fjords) or open sea areas (inshore or offshore);

- The characteristics of the aquaculture activities to be undertaken, such as species, production levels and area occupied;
- The hydromorphological and geomorphological features of the anchorage area, such as the bathymetry and type of seabed;
- The type of installations planned, e.g. cages, longlines or platforms.

b. Study parameters

The number of parameters and how thoroughly they are studied will depend fundamentally on the area in question, the type of aquaculture to be developed and also the budget available for the work. Broadly speaking, the most relevant parameters, collated into groups, are the following:

- Meteorological data. Meteorological data for the study area are important when analysing the relationship between storms, winds and other natural phenomena and their effects on the marine environment, such as currents and wave patterns.
- Oceanographic conditions. A study of the oceanographic conditions and hydrography of the area provides information on both the natural risks to which the installation will be subject and the properties of currents that will disperse wastes to some extent. Significant wave height (Hs, value and frequency), local currents (prevailing direction and maximum, mean and minimum speeds) and coastal dynamics (local tides and currents) are therefore measured.
- Seabed. In the open sea, the seabed beneath the cultivation facilities will be primarily exposed to the potential effects of the aquaculture activities. Thus, to assess the degree of effect on the seabed, the first step is to conduct a baseline assessment to establish normal values

and to detect whether any particularly sensitive or protected habitats are present. Some of the most important indicator parameters are sediment particle size, redox potential, organic matter, and the benthic faunal community in terms of species abundance and diversity.

- Water quality. The water quality of the marine environment where the installation is situated is fundamental when analysing the biological viability of the species to be farmed. Some of the most significant parameters to be measured are the oxygen profile, salinity, chlorophyll, temperature, suspended solids, nutrients, and other possible contaminants. It is also very important to identify and locate possible external sources of pollution which could affect water quality and therefore the viability of the crop.

When systematically organized, all this becomes a fundamental tool for the selection of aquaculture sites. It is used not only by the authorities as data to support decision making, but also by producers as essential information for successfully making large and risky investments in aquaculture.

Basically, environmental data on the areas is provided by the authorities as general, publicly accessible information that might be useful for any activity, such as tourism, fisheries or aquaculture.

Technical knowledge

Technical aquaculture knowledge comprises all the practical methods, skills and know-how required for aquaculture production. It brings together both empirical and scientific knowledge.

Traditional aquaculture systems, such as marine finfish production in earthen ponds in estuaries like the Italian ‘valli’ or Spanish ‘esteros’, freshwater carp and tench production in ponds and most kinds of mollusc production, are based on empirical knowledge and skills. Such understanding and skills, termed traditional knowledge, are generally transmitted in local ecosystems from generation to generation or gained through working experience.

Generally, they do not change much with time and are not particularly able to adapt to a changing environment.

Nowadays, modern aquaculture systems, such as cage or tank finfish production, are primarily science based. They develop rapidly thanks to constant innovations and the application of technological improvements imported from other fields.

Technical knowledge is applied to many aspects relating to the type of culture and site conditions. Therefore, materials used in the structure, mooring systems, holding capacity, feeding, processing, maintenance, transport and other aquaculture procedures are improved as technical knowledge is obtained and updated. Especially when site conditions are not ideal, technical knowledge can help to reduce risks and improve working conditions.

In the case of aquaculture in cage systems, experience has demonstrated the importance of appropriate site selection and site management to fish health. One of the most important lessons from Norwegian salmon farming is that parasites and diseases have been, still are and perhaps will be among the most serious challenges to worldwide fish farming, and therefore a preventive fish health policy based on technical and scientific knowledge must be applied to control disease.

Fallowing is one of the techniques available for the mitigation of fish diseases. The concept of sanitary fallowing implies that several sites are available for each fish farm in such a way that fish are stocked at each site by year classes and new fingerlings are not stocked at the same site alongside other cages already containing large fish. In the event of a disease outbreak at one site the next juveniles to be stocked will be safe at a different site. Additionally, as a precautionary measure, each site could periodically be left unused for some months in order to break the life cycle of any possible pathogen. When a site is left fallowing, all its floating structures should be removed.

Even though its applicability at present in the Mediterranean is questionable, especially now that environmental and social pressures are leading some of the Mediterranean authorities to concentrate farms, the implementation of fallowing has evident implications for the planning of aquaculture areas and the configuration of the future aquaculture industry. Urgent scientific and administrative knowledge on this issue is therefore needed.

In general terms, technical knowledge needs to be transferred and updated for people directly involved in aquaculture production. This may be achieved through academic training and lifelong learning.

The availability and reliability of technological knowledge is also an important issue to be considered by the administrative authorities and public research bodies. Technological knowledge and the development of know-how should be supported by these bodies, acting on demand from the private sector. This combination of efforts will lead to better and faster development of the activity, which will benefit both sides. Investment in aquaculture technology is highly specific and infrastructures depreciate quickly. All the producers' economic efforts go into their working capital and therefore all the support that the authorities can give will be greatly welcomed by the sector. Moreover, the authorities can direct research towards sustainable development, ensuring compliance with new directives and laws that will apply to aquaculture.

Technical knowledge is a key factor for effective site selection and site management. Improved knowledge will directly increase the number of suitable sites and ensure the sustainable development of the activity.

Knowledge of the legal system

Aquaculture is affected by different regulations depending on the special characteristics of the zones it occupies: onshore, inshore or offshore. Different authorities have jurisdiction over these zones and they may draw up diverse and sometimes disparate regulations.

Planning for site selection should stem from knowledge and experience of all this legislation, both that relating to the substantive and sectoral regulation of aquaculture and that governing the uses of the publicly-owned coastal strip and the activities which take place there, such as shipping, tourism, urban development, ports, fisheries, heritage and defence. This knowledge makes it possible to contextualize the discussion and focus it in the right direction.

Once planning is complete, it must be given legal status either by an *ad hoc* piece of legislation or by new legal provisions produced by the authorities with jurisdiction over the coastline.

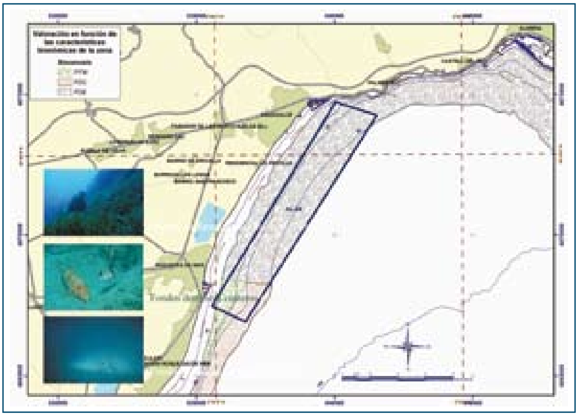
Knowledge of the applicable legislation thus makes the route to site selection and site management easier, through an awareness of which areas are available and who has the power to decide and modify the established management systems. It also provides the legal certainty that aquaculture entrepreneurs need and ensures adaptability to potential changes to the legislation governing area management.

These aspects are fundamental to investors as they not only make it cheaper to find information but also provide them with a firm basis for decision making. As a rule of thumb, the importance that an authority or government attributes to aquaculture can easily be judged from the level of regulation or planning that exists in this field. A country which has not developed any specific rules or clear procedures is not likely to consider aquaculture at present to be a strategic sector for development.

Socioeconomic knowledge

In addition to the environmental, technical and legal knowledge required for good practice in aquaculture site selection and site management, it is important to get to know the whole social and economic background of the area and to understand its culture and traditions, especially the ideas and images locally associated with the practice of aquaculture.

The social fabric, the market, the structure of industry and the availability of services that will be directly or indirectly linked to the aquaculture sector such as storage and transport facilities, processing industries and wholesalers are important aspects to consider. A broad knowledge of these can help in designing the best procedure for site selection and site management, with the aim of gaining social acceptance and other advantages and synergies that will facilitate the sustainability of an aquaculture project.



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The socioeconomic situation of a particular region can also be a decisive factor in selecting aquaculture sites, the type of business plan and even the crop that is chosen for cultivation, in terms of the perceived need for the activity as a source of revenue or even food. In the Mediterranean there are large socioeconomic differences between countries and thus a variety of potential business structures. These range, for example, from multinational companies that own facilities (as in Greece or Spain) to many family businesses that sustain large sections of the population (as in Egypt).

Finally, traditional knowledge that is to say the intrinsic knowledge and experience accumulated by local people and passed down from generation to generation over decades of coexistence in the same environment is also an essential source of information, providing it is reliable, and adds value to the scientific knowledge that can be produced.

Justification

Aquaculture as an economic activity involves large investments and high risk directly related to site selection and site management. Knowledge is needed in the environmental, technical, legal and socioeconomic areas to improve decision making. The more data that is available and the higher its quality, the better the decisions that can be made. Knowledge helps to improve selection criteria for aquaculture sites and makes it possible to draw up management guidelines to help promote the sustainable development of aquaculture in the Mediterranean.

Principle

Aquaculture site selection and site management should be based on reliable legal, environmental, technical and socioeconomic knowledge to enhance the viability of the process.

Guidelines

General

- Information on the legal and environmental aspects of the coastal strip in public ownership should be collected by the authorities and made available to the general public. The collection and dissemination of such information should be the responsibility of the competent authorities, given the public domain nature of most of these areas.

- The development of aquaculture by means of site selection should be based on scientific knowledge complemented by traditional knowledge. Research must be conducted continually in order to improve knowledge on aquaculture, which has to be made available in a way that is understandable by all.

Environmental knowledge

- The study area should be delimited in advance. The study area should be narrowed down without losing vital data, in order to optimize data collection in the field both technically and economically.

- Environmental and cultivation conditions should be well enough matched to assure the viability of the project. Depending on the type of aquaculture to be introduced, the most suitable environmental conditions for its development need to be assessed.

Technical knowledge

- Decision makers should be familiar with current production and technological systems to ensure that aquaculture sites are appropriately selected. It is important to know what kinds of aquaculture are suited to the characteristics of a particular area and to use the most up-to-date techniques to achieve the success of the project.

- Only proven technologies should be considered in the selection of sites for aquaculture and their subsequent management, especially in offshore locations or in highly sophisticated systems such as land-based recirculation systems. Both types of aquaculture system are complex. It is therefore essential to be familiar with the most applicable technology in order to manage the high risk of aquaculture.

- Research into the practical implementation of sanitary fallowing of fish farm sites in the Mediterranean should be encouraged. The consolidation of this knowledge could have important future consequences for aquaculture planning and siting, especially in view of the increase in production and site concentration.

- Aquaculture personnel should be provided with lifelong learning. In order to make sure aquaculture ventures run smoothly, it is important to keep personnel abreast of any new technologies or improvements which could improve site selection and site management.

Knowledge of the legal system

- Aquaculture farmers and the authorities with jurisdiction over the coast should have clear knowledge of the legislation governing aquaculture and the relevant planning rules. To this end, countries that want to encourage aquaculture development need to have transparent legislation on aquaculture to provide sufficient legal certainty for aquaculture farmers.

- Aquaculture and coastal planning legislation should be familiar and accessible to all stakeholders. In the planning of suitable sites for aquaculture, there should be a clear and comprehensive understanding of the legislation governing all interests affecting the coastline, in order to avoid conflicts of interest.

Socioeconomic knowledge

- The process of aquaculture site selection and site management should take reliable local knowledge into consideration. The views of the people in the area of interest should be taken into account when assessing aquaculture planning within its socioeconomic, political, cultural and legal context.

- Regarding interactions with other activities in the area, synergies and incompatibilities should be taken into consideration. As aquaculture is at present one of the last sectors to arrive in a specific area, it is essential that synergies and incompatibilities with other sectors are emphasised in order to ensure that aquaculture integrates into the local economy and that sites are suitably selected and managed.

The participatory approach

This guide presents a straightforward concept that is basic in its definition but complex to implement. Its connection with site selection is explained and its importance for the success of the aquaculture project shown. Models and examples are given to guide the implementation of this approach to site selection and site management and the sustainability of aquaculture.

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Aquaculture shares in the common use of marine areas, where the users of this and other activities come together. All of them will be directly or indirectly affected by aquaculture. The public nature of these marine areas adds complexity to the decision-making process, as a large number of opinion groups have a say in the development of aquaculture. In view of this, what can we do to help public or private stakeholders come to an agreement? This partly explains why the participatory approach is so relevant, because it considers sustainable development a common, shared goal to ensure the long-term feasibility of aquaculture projects.

The participation of all stakeholders in the selection and management of aquaculture sites represents a challenge for decision makers and a major commitment for researchers and public authorities, given the system's high level of complexity and fragility. Aquaculture also implies a certain risk to promoters and investors, due to the fact that projects are subject to approval by a number of public delegates, technicians, decision holders and social groups. For this reason, the participatory approach requires balanced objectives and clear procedures for its design and implementation, so as to obtain results that benefit the global community.

From a conceptual perspective, participation applies to an array of highly diverse situations. The first task consists in establishing the various steps needed for participation. The term 'participatory' means taking into account stakeholders' opinions, views and needs at a given stage of the process. For this purpose, it is essential to define each of the elements involved in the participatory process, as well as identifying participants and their roles, the coordination of activities and other steps described below.

Need for and management of local knowledge in the participatory process

The need for 'knowledge' as an essential element in participants' opinions and assessments, especially in the case of aquaculture site selection and management, must be emphasised as it encompasses a wide variety of technical, legal, environmental, social and economic factors on which the project assessment and decision-making process will be based. The researcher plays an essential role in this context, as he or she will identify and demonstrate the elements that contribute to knowledge as well as explaining the processes involved.

Sustainable development and territorial management require that research is organized to ensure participation of non-scientific staff in the research process (Callon *et al.,* 2001). Research programmes should be negotiated with stakeholders, and therefore efforts will be made as a response to stakeholders' demands.

Models of participatory research such as action research lead to the production of applied scientific knowledge through problem-solving by stakeholders (Argyris & Schön, 1996; Avenier & Schmitt, 2007). Therefore, the production of knowledge occurs not only in experimental laboratories but also in the fields of experimentation, and in organizations and businesses.

The entire participatory process should be based on objective information collected in the field and made available in a transparent manner to all stakeholders. The success of the participatory approach depends on the level of participation and is supported by information and knowledge acquired by participants, who should be involved in a process of 'co-construction' towards a common goal. The problem therefore lies in organizing the stakeholders' participation in the research process (David, 2000).

Partnership action research as a participatory model

Having said at, a partnership action research (PAR) (*recherche-action-en partenariat in French*) model is suggested. It was defined by Lindeperg in 1999 as a situation in which a group of stakeholders, such as organizations, institutions or private sector representatives, in collaboration with researchers, assemble human and financial resources in order to work together to achieve common, predefined goals.

PAR is defined as a temporary governance system under the direction of a pilot committee, which should be as neutral as possible. The committee carries out the effective management of activities and ensures that they take place, while defining the necessary adjustments and arbitrating in the event of conflict or tension amongst participants. Governance is thus understood as the way decisions are undertaken and implemented. At the same time, a scientific committee is also needed to oversee the way scientific knowledge is produced and to guarantee quality.

PAR (Girin, 1990; Chia, 2004) is a tool inspired by and based on the results of action research (Liu, 1997), which has a double goal: to solve problems and to produce and spread applied scientific knowledge.

Implementation of the PAR participatory approach should meet a number of conditions:

- It is vital that researchers have the intention to search for solutions and that field stakeholders are willing to change. Only if these two requirements are met will a solution be possible.

- In addition, the 'eddy' model of work should be followed, rather than the traditional 'linear' model (Figure B.1).

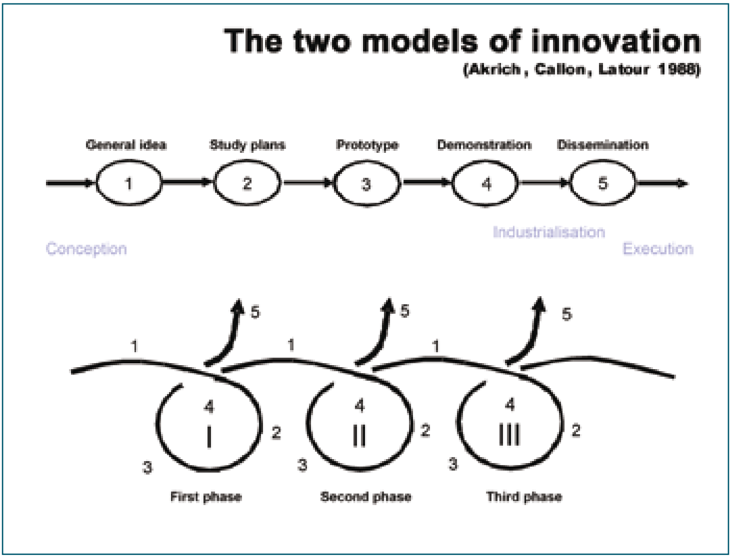


Figure B.1. The linear and eddy models of work.

This eddy model is characterized by its capacity for continuous revision and feedback, whereby it identifies errors, restructures the approaches used, and introduces new aspects into the system to reinforce and validate the process. At the same time, it generates knowledge which can be transferred to the scientific community and society in general.

Implementing partnership action research (PAR) as a model for the participatory approach to aquaculture site selection and site management

- **Analysing the location**
  The selection of aquaculture sites is a complex problem that should take into account technical, social, political, cultural and historical features of the coast.

- **Making a socioeconomic and technical diagnosis**
  A reference document should be generated at the time of implementing a site selection and site management project to identify key stakeholders as well as potential areas and activities

that use the marine ecosystem in a physical or symbolic manner. As an immediate outcome, the following can be identified:

- The local stakeholders, their ways of thinking and their action models;
- Problems and their causes;
- Organizations and levels of organization;
- Innovating and/or learning capacities.

- **Drawing up a common project**

  The outlines of a potential installation project and the design of the aquaculture activities must be established. This work should be carried out by researchers specializing in both the technical and the socioeconomic fields, working in conjunction with the promoters of the aquaculture project to establish a project leading group that can launch the work and activities. This project should be defined again once the group of participating stakeholders has been formed.

- **Specifying the participating stakeholders**

  The stakeholders to mobilize are specified, taking into account all aspects of their involvement with the area and the project, and groups of delegates and spokespersons are identified.

- **Defining a provisional structure**

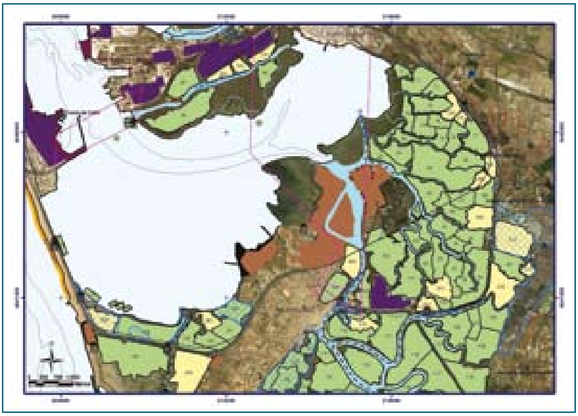
  This is created to manage relationships between researchers and stakeholders. In the case of aquaculture, this structure can be represented by administrative members at local or state level depending on the decentralization of the country.

- **Drafting a collaboration agreement**

  An agreement based on a written or oral ethical framework has to be drawn up, containing project specifications or protocols that specify the terms that will be approved after negotiation. This should ensure two elements of governance: stakeholder training and stakeholder autonomy. The objective is to consolidate the project leading group and establish project specifications which determine the exact terms of the agreement (the stakeholders' commitments and responsibilities, procedures for resolving conflicts or tensions, and the terms in which governance will be defined).

- **Creating a steering committee**
  It is important to create a neutral steering committee to implement the project where there are representatives from different social or stakeholder groups. Subcommittees can also be defined to deal with more specific aspects, depending on the size of the project.

Once these initial stages have been finalized, a review of results is conducted in which the stakeholders, including those considered marginal, are brought together to give their opinions on the results. This feedback is an important and necessary step in order to channel the process and provide stakeholders with a common project and language. These elements are essential to boost their confidence and enable them to contemplate change and innovation. Intermediate objects (Vinck, 1999), such as material representations (graphics, charts or prototypes) to help in reaching agreements, may be used to build a common project or to facilitate successive translations that will consolidate and stabilize the project (Callon *et al.,* 2001).



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The following step is the stage where all aspects are defined when selecting a potential site for aquaculture. In this process, the aim is to define the direction of the project, exploring different possibilities, evaluating difficulties and identifying coactions.

In a process of co-construction, the decision-making procedure is developed by designing simultaneous mechanisms of experimentation as a prior step to the consolidation of the project; the solutions found then lead to a phase of stabilization of the process

Innovation is considered herein to be the result of a co-production process of social and technical elements. The process is consolidated or stabilized (but never finished) when the collective work of revision and rules for the regulation of new practices have been established and approved by consensus among the participants.

Justification

It is important to recognise that the concept of participation generates empathy in the participants whenever they are consulted and their opinions are taken into consideration. It also enables opposing opinions to be channelled towards a common objective, where all stakeholders can benefit through a process of co-construction. The participatory approach, as a well-structured and well-implemented strategy applied to the selection and management of aquaculture sites, offers an opportunity to ensure the acceptance and permanence of any aquaculture project, since it enables all stakeholders to be involved in the definition and implementation of the process. Governance is then reinforced by a process of ownership, emancipation and responsibility of stakeholders, whereby they feel that the project is their own and thus share in its success or its failure.

Principle

Site selection and site management processes should involve the participation of all stakeholders that share the same coastal region, in order to achieve the sustainable development of the activity.

Guidelines

- The participatory approach should be considered from the very beginning of the project. It is essential for stakeholders who will be involved in any participatory process to feel involved from the outset, ensuring appropriation and therefore successful site selection for aquaculture.

- The participatory approach should be implemented through a process of co-construction. This process, based on each stakeholder having an equal right to speak, with decisions being made by majority or consensus, will ensure sustainable objectives and establish common goals that will benefit all the users of a given maritime region.

- The participatory approach should take into account all stakeholders at all levels and identify their roles and abilities. They must be properly represented and their involvement demonstrated according to the degree to which the project may affect them.

- The participatory approach should identify a mediator or steering committee. This person or group – who should be neutral and recognised by all participants – has the task of organizing the process and directing development and implementation.

- The participatory approach should be conducted in a common language. This will ensure that information is shared equally and that all participants can understand it, regardless of their abilities.

- The participatory process should progress according to the 'eddy' model and provide periodic feedback. The continuous evolution to which all processes are subject requires the participatory process to undergo constant revision and restructuring, correcting errors in order to reintroduce the objectives established at the beginning.

Social acceptability

This guide presents the concept of social acceptability and its direct relevance and importance to site selection and site management. The concept is defined and characterized and the public's perception of it is discussed, together with criteria and tools to assess it and guidelines to achieve it. Social acceptability is considered a key issue to ensure the sustainable development of aquaculture in the Mediterranean.

Social acceptability applied to site selection and site management for aquaculture in the Mediterranean is a complex issue and its definition varies. In order to set specific guidelines, positive or negative social acceptability of a particular change is defined hereafter as the reaction of a significant number of people (at a certain scale) to a significant modification of their environment, their activities; or the sense of their work.

This broad definition comprises five major groups of parameters, which include on one hand the geopolitical context, economic factors and scientific data, and on the other the variety of stakeholders and the image of aquaculture seen from a cultural perspective. The first three will not be considered in this analysis because they are highly specific and to some extent objective. They contribute above all to defining the general context of the aquaculture project. The last two groups of parameters, however, play a major role in the final acceptability of the project to society in general.

Guide C

Categories of stakeholders

The different reactions of society to an aquaculture project will at first sight be unpredictable and will depend greatly on the people in question, their relationship with the sea and the activities developed. Additionally, the extent to which they can influence the project will depend upon their organization and their representativeness.

The following categories of stakeholders can be identified:

a. Regarding their location in relation to the sea

The communities living permanently on the coast are the first ones to detect the changes, but they also soon get used to the new landscape and/or directly observe the positive or negative effects of the aquaculture facilities.

Temporary users of the coast, namely tourists, have a more idealized view of the desired scenery that they are paying to enjoy during their leisure time.

The rest of the population will only have a global, subjective view of aquaculture in general, perhaps from the viewpoint of consumers of its products.

b. Regarding their activities

The interests of certain social groups will also play an important role in creating a negative or positive opinion, which will be all the more influential the closer the groups are to the decision-making centres. These groups include:

- Fishermen and other users of the continental shelf, who will be the first to notice the invasion of their traditional working area;
- Water sports enthusiasts and tourists, whose main concerns will be economic and the conservation of the natural surroundings as found and chosen for their activities; they will reject any 'industrialization of the sea', especially if it is visible;
- People involved in industrial (dredging, etc.), military (restricted testing zones, etc.) or trading (harbour transit, etc.) activities, who need space for navigation or extracting resources;

- Those who earn their living from tourism and want to protect their customer base;

- Pressure groups worried about unexpected consequences that might alter the environment;

- Those who will accept certain changes in return for a better supply of sea products;

- Local companies and groups that will see the activity as a source of revenue and employment.

All of them will have their own opinion as to whether a particular aquaculture project should be accepted or rejected, and they will have considerable influence on its development.

The image of aquaculture from a cultural perspective

Generally speaking, the image perceived is one of the main forces that shape public opinion on a particular issue on which there is no specific knowledge. Several studies (on the 'mad cow' crisis, avian influenza, etc.) have shown that acceptability conflicts are more closely linked to the context and the institutions responsible for the issue than to the issue itself (Marris, 2001). On the other hand, in 1998, Szakolczai and Füstös showed in their study on 24 countries that the values defining a person's perceptions depend less on political or economic contexts than on their degree of development and expression, as happens with the conditions to reinforce responsibility at local level. This notion had already been mentioned in the studies coordinated by Gaudin in 1990. Introducing a wrong idea or image can be very costly to rectify.

Public perception in the Mediterranean can vary and can be linked to:

- Cultural diversity. Cultural parameters can support or oppose initiatives to occupy and exploit marine locations to provide food in so far as these initiatives are rooted in the traditions of a particular area.

- Political and administrative diversity. Political strategies and administrative structures can influence social acceptability. The decentralization of a country brings decision making closer to different opinion groups at local level, where the perception of reality becomes stronger with proximity to the issue.

- Differences in development. The level of development and especially of knowledge plays a crucial role in the acceptance or rejection of an aquaculture project. Information and knowledge provide assessment criteria that are different from opinion.

- Differences in needs. Acceptability also depends greatly on the needs of a particular region. The capacity to set priorities is emphasised when those needs are basic.

The sociological work carried out by Jamieson (2005) indicates that the necessary adaptation of humankind to future changes (technological, climate, etc.) should be accompanied by ethics to avoid negative effects.

Furthermore, the World Values Survey characterizes and classifies values in 80 countries every 5 years. In 2006 it published the Inglehart-Welzel Cultural Map of the World, a two-dimensional summary of the results, contrasting survival values with those of self-expression (individualism), and traditional values with those of rational modernity.

The acceptability of aquaculture on the northern shores of the Mediterranean mobilizes mainly values of individualism (companies, market, benefits) and rational modernity (availability of technology). This applies to countries like Spain, Greece, Croatia, Israel, Italy and France, among others. The former communist countries also tend towards rational modernity values but survival values remain important, probably due to their recent history. In the case of southern shore countries, the situation may be different because of the prevalence of collective values and local needs, as in the case of Egypt, Morocco and Algeria, with Turkey in between.

It is clear that multiculturalism in the Mediterranean region results in a more complex picture when it comes to establishing criteria or tools to assess social acceptability.

The simple theoretical solution where there is opposition to an aquaculture project would be to assess the socioeconomic value of those against it (fishermen, for instance) and their compensation (Le Tixerant *et al.,* 2008). But this measure does not provide solutions in the long term and, moreover, it perpetuates the discord between those who oppose the project and those leading it. This situation creates conflicts and a lack of understanding that should be corrected by establishing a debate from the very beginning and involving the main stakeholders from the inception through to the final commitment (Callon *et al.,* 2001; Pesarosos, 2001).

The participation of local communities in the entire planning of the project as well as in its funding might favour social acceptability. The feeling that they are involved in building the project may help to eliminate criticism and even turn it into praise (Breukers & Wolsink, 2007), especially if the stakeholders' opinions are taken into account at an early stage, if the project provides local employment and supports tourism, and if the potential reversibility of the facilities is demonstrated (Gueorguieva-Faye, 2006). With this in mind, achieving the sustainable development and consolidation of aquaculture activities will require an effort to transform negative perceptions into positive ones and disadvantages into potential advantages through synergies.

It is therefore essential to use agreement to enhance social changes, and establish collective rules and organizations. The process can be summarized in four stages: (i) justifications by project stakeholders; (ii) identification of areas of disagreement; (iii) interpretation of opinions, facts and concepts; ending with (iv) the final establishment of an evaluation framework (Beuret, 2006). Throughout the process, the state plays a crucial role as administrator and arbitrator. Mediterranean states are, however, very diverse, which leads to differences in the level of intervention and in their strategies. State intervention ranges from strict enforcement of the legal framework (in Turkey and France) to accompanying measures (in Spain and Cyprus).

Synthesis

A synthesis of the surveys conducted on the reactions by different categories of stakeholders to aquaculture or to similar projects in the sea, for instance wind turbines, shows that social acceptability:

- varies between rejection and agreement depending on the sensitivity of the affected areas, especially during the initial stage;
- is easier to achieve when positive effects are demonstrated (such as aqua tourism, complementary production through artificial reefs, etc.), but less forthcoming when the risks of negative impacts are higher or obvious;
- depends greatly on the initial project management. The main contributing factors are: (i the commitment of all stakeholders from the beginning, including financially, if possible; (ii the possibility of multiple uses through the integrated management of natural resources by different sectors; (iii the increase in local employment levels; and (iv the quality of information and its distribution;
- should be always based on education, training and communication;
- is reinforced by spreading the image of an aquaculture that pays attention to society's opinions on sustainability and product quality. The generalization of international rules could help in this process.

Justification

The shared use and exploitation of marine resources generate very different interests, causing direct or indirect intervention by the various stakeholders affected by a particular activity. The public ownership of Mediterranean coasts adds an element of uncertainty to aquaculture projects, as the decisions made by the administrative authorities could and should take the opinions and potential objections of the various users into account. This is the reason why, in order to select and manage areas of interest for aquaculture, social acceptability should be a key objective to be considered at the very inception of a project. The long-term feasibility and sustainability of the aquaculture activity would thus be made easier.

Principle

Social acceptability should be considered an objective of the site selection and site management process in order to ensure the establishment and permanence of the aquaculture project in the long term.

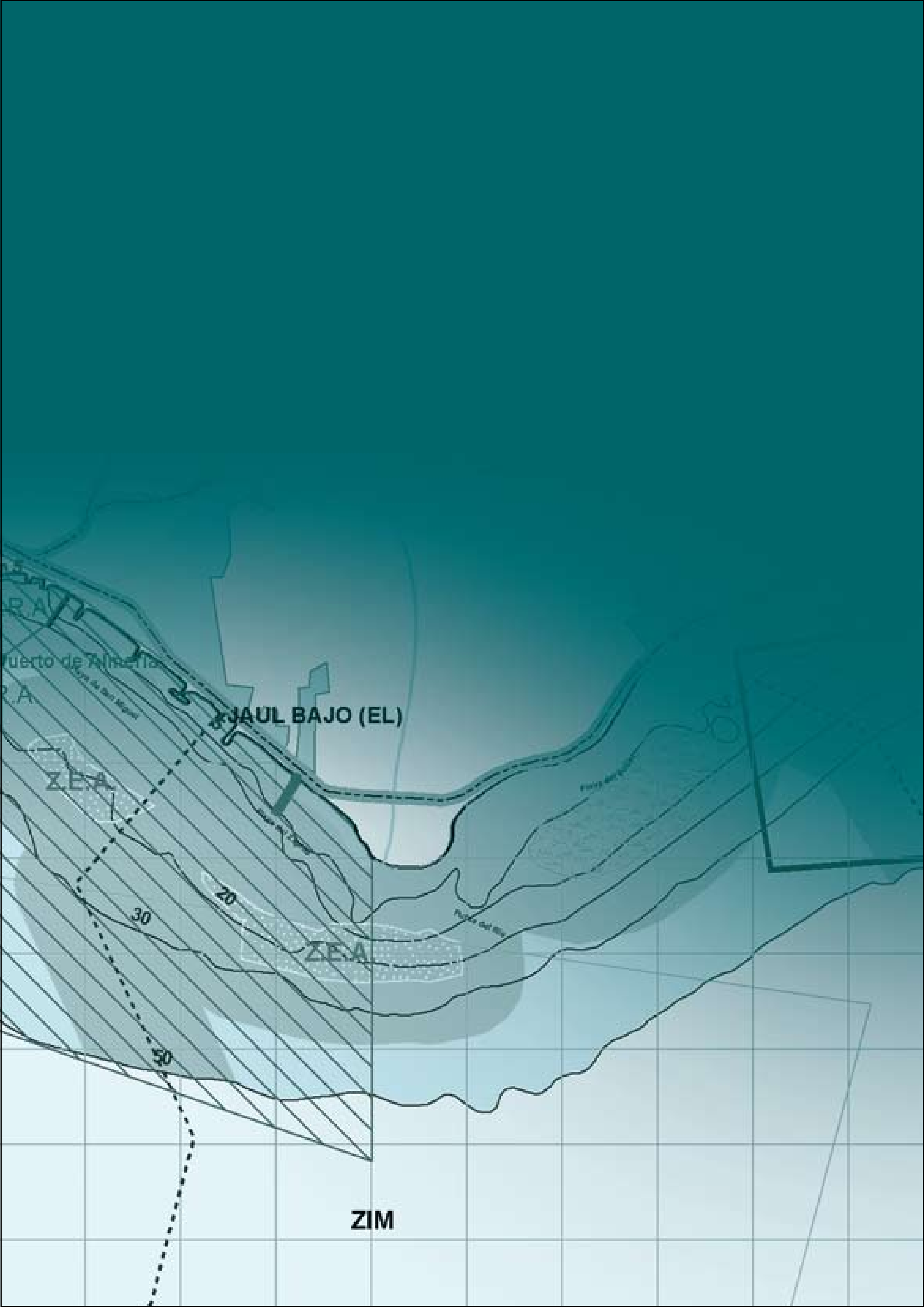
Guidelines

- Social acceptability is an objective that should be considered from the outset in any aquaculture project. This general rule is particularly relevant in the Mediterranean region, given the annually increasing pressures of coastline occupancy and use.

- Communication, information and transparency should be established to foster a dialogue amongst stakeholders and ensure social acceptability. Information exchange amongst stakeholders is vital to ensure that the consequences of the acceptance or rejection of a project are properly analysed.

- Cultural parameters are particular to each Mediterranean region and should be considered individually when building social acceptability. The multicultural nature of the Mediterranean adds complexity to the process of achieving social acceptability. These parameters need to be identified, analysed and integrated in the selection and management of aquaculture sites.

- Social acceptability and the consequent sustainability of an aquaculture project should be based on the creation of a 'quality image' for aquaculture. Aquaculture is still unknown to society in general. It is therefore necessary to invest in communication and education to improve people's understanding of site selection and all other aquaculture processes through a quality scheme.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The precautionary principle

This guide presents the concept of the precautionary principle and its application to the various aspects of site selection and site management. Definitions and methods for the implementation of the concept are given and special attention is paid to the limits between benefits and drawbacks in the application of the precautionary principle.


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The definition of the precautionary principle is: *'Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'* (Principle 15 of the Rio Declaration on Environment and Development–United Nations, 1992). It is a basic principle whereby decisions can be made even though not all the relevant scientific data are available. When used, for example, within the framework of the ecosystem approach, during participatory and adaptive processes, and within the framework of good governance, it represents a strong and efficient principle.

The precautionary principle, or precautionary approach, has emerged over recent decades as an increasingly widely accepted general principle of environmental policy, law, and management. It is an approach to uncertainty, and provides for action to avoid serious or irreversible environmental harm in advance of scientific certainty of such harm (Cooney, 2004). Although it is an important and intuitively sensible principle, the acceptance of the precautionary principle into law and policy and its implementation in practice have been marked by controversy and confusion.

The precautionary principle is used in a variety of ways, and a wide range of formulations exists. The core concept of precaution can be viewed as a mechanism to counter a widespread regulatory presumption in favour of allowing development/economic activity to proceed when there is a lack of clear evidence about its impacts.

Formulations of the precautionary principle vary from weak to strong, and from those that impose obligations to those that empower decision makers to take precautionary action. Features common to most of these formulations include the use of language that limits the operation of the principle to circumstances in which there are threats of serious or irreversible harm, consideration of the cost-effectiveness of precautionary actions, and a shift of the burden of proof to the proponents of activities to demonstrate a lack of harm.

Acceptance of precaution as a governance/management tool is highly inconsistent across biodiversity-related policy sectors, and in general remains contentious. Many countries have incorporated the principle into general environmental, biodiversity or natural resource law and policy. In addition, at a multilateral level, it is very widely incorporated in biodiversity conservation and fisheries management instruments. It appears only a limited form of precaution is provided for under relevant international trade agreements. This poses challenges for coherent environmental policy at both international and national levels.

There are some important features of the biodiversity and natural resources sector that are different from the industrial contexts in which precaution is usually discussed. Uncertainty in natural resources management (NRM) and biodiversity conservation is fundamental and persistent, and surrounds not only underlying natural systems but the socioeconomic and political context or shapes the impact of conservation and resource decisions.

Threats to biodiversity are often posed not by a new, poorly understood technology or process, but by the expansion or intensification of well-understood activities such as harvesting of wild species or aquaculture settlements. Threats often derive from multiple rather than singular sources, with different courses of action each raising potential risks. The costs or burdens of precautionary measures may fall on poor or subsistence natural resource users and communities, rather than industrial interests. However, there are often close linkages between biodiversity conservation and the long-term interests of those resource users whose actions raise threats of harm, and precaution can also support local livelihoods and communities.

Precaution is commonly equated with restrictive, ‘protectionist’ conservation approaches and assumed to be inconsistent with sustainable use. However, determining the precautionary strategy is likely to require assessment of the relative conservation threats and benefits posed by alternative strategies. Such assessments will benefit from taking into account not just scientific knowledge, but traditional and local knowledge, and incorporating an understanding of the social, economic and political contexts that will determine the impact of conservation decisions.

The frequent automatic link made in legislation and policy between biological indicators of threat, such as species status, and specific management responses such as prohibitions on use or trade, often justified on precautionary grounds, should be questioned.

Implementation of precaution involves a political and values-based balance between the interests of biodiversity or resource conservation and other countervailing pressures such as economic or livelihood interests. The more extreme or highly prohibitive versions of precaution-–the ‘when in doubt, don’t’ approach-–are problematic for reasons of both pragmatism and equity, although they may be appropriate in specific circumstances. Many versions of precaution incorporate the concept of proportionality between level of risk and measures adopted, and include some form of analysis of the various costs and benefits involved. Different decision-making instruments, arenas and contexts may demonstrate varying levels of risk averseness, due in part to their different objectives and the varying strength of different interest groups reflected therein. Where the same issue is addressed in different policy or decision-making arenas, this can pose potential conflicts.

Precaution raises significant equity issues in biodiversity conservation and NRM. The livelihood and socioeconomic impacts of the principle can be negative, particularly for those dependent on the utilization of biological resources to support their livelihoods. Highly restrictive or protectionist approaches raise particular problems in this respect. Attention should be paid to which groups bear the burdens of precautionary restrictions, including who bears the burden of proof, and who participates in and influences decision making.

Precaution may be used by various groups in illegitimate ways, and it can be misused to disguise objections to utilization based on, for instance, animal rights concerns.

In the context of aquaculture site selection and site management, the precautionary principle applies to some extent to all aspects of the process. Aquaculture is highly dependent on the environment in which it is installed and is open to outside sources of positive or negative effects. The precautionary principle should therefore be applied to the following aspects of site selection and site management:

- **Environmental aspects**
  There are effects in both directions, from the environment to the activity and vice versa. The initial dimensioning and subsequent development of the activity, together with monitoring, should be based on precaution to avoid causing harm. The precautionary principle should be incorporated in the environmental impact assessment and environmental monitoring programme as well as in the analysis of environmental data collected for the selection of suitable sites for aquaculture.

- **Economic aspects**
  The level of investment and financial risk involved in aquaculture is very high. Economics plays an important role even in the process of site selection and site management, and costs have to be carefully controlled. Precaution is therefore an important issue to be taken into account from the very beginning of the process.

  Investment requirements and risks should be assessed prior to the site selection and site management process itself. Aquaculture as an economic and production activity should grow gradually and in parallel to its adaptation to the environment and to the market. At the same time, the effects and costs of not applying the precautionary principle should be considered.

- **Social aspects**
  Social acceptability is a key aspect in site selection: the potential impact of an aquaculture installation on the surrounding population will influence the failure or success of the project. A precautionary approach provides a better view of the situation,

avoiding possible conflicts with other users and the general public. Broad participation and co-construction as tools of precaution are needed during the process, especially when dealing with activities dependent on the same resources, such as fisheries.

- **Legal aspects**
  Site selection and site management are subject to laws and regulations. Although their impact is more empirical rather than unexpected, laws and regulations can change, especially in publicly owned areas shared and managed by different authorities. Application of the precautionary principle should be supported by a broad, prospective view of other countries or supranational entities such as the EU, which may provide guidelines for future situations.

The precautionary principle is a very wide-reaching concept and should be applied to any aspect in just measure to avoid conflicts over excessive restrictions.

Justification

The precautionary principle raises issues that are central to current international debates around environment, poverty, sustainable development and biodiversity, including the relationship between biodiversity conservation and sustainable development; conservation for biodiversity *vs* conservation for people; protectionist approaches *vs* sustainable use; and regulatory *vs* incentive-based conservation approaches.

The precautionary principle provides guidance for governance and management in responding to uncertainty. It provides for action to avert risks of serious or irreversible harm to the environment or human health in the absence of scientific certainty about that harm. It is now widely and increasingly accepted in sustainable development and environmental policy at multilateral and national levels. The principle represents a formalization of the intuitively attractive idea that delaying action until harm is certain will often mean delaying until it is too late or too costly to avert it. However, the potential for controversy is obvious. Applying precaution will usually involve restrictions on human actions. Such restrictions, by definition, cannot be fully justified by unambiguous scientific evidence, yet may impose substantial costs.

Principle

The precautionary principle should be applied in the aquaculture site selection and site management processes.

Guidelines

- The precautionary principle should be applied in the decision-making processes for aquaculture site selection and site management, within the framework of the ecosystem approach and in conjunction with the participatory and adaptive approaches. It allows for the taking of decisions even though not all the relevant scientific data may be available, and it helps stakeholders to take a straightforward approach.

- The precautionary principle should be applied within certain limits in order to avoid possible rejection. Precaution has no defined or measurable limits, and these must be established mainly on the basis of the possible effects of any action, without crossing certain thresholds or reaching the point of no action.

- The precautionary principle should take account of all relevant forms of information, such as scientific and traditional knowledge, on an appropriate temporal and spatial scale. The better the decision makers are informed, the more appropriately the site selection process can be planned in view of the risks to be incurred.

The scale approach

This guide presents the concept of scale as a factor to be considered in the process of aquaculture site selection and site management, where spatial and temporal dimensions influence decision making. A definition of the concept is given and the effect of mismatches among scaling factors on site selection and site management is described.

Scale refers to any measurable dimension such as space and time. When we consider the cause-and-effect relationship between aquaculture and the environment, or administrative procedures or socioeconomic aspects, on a spatial and temporal scale, we are faced with the problem of understanding how scale influences the number and nature of those interactions, especially when mismatches are found between them.

From the ecosystem point of view, spatial scale is quite variable and usually refers to the boundaries between different ecosystems. The dimensions of the ecosystem usually differ from those of the aquaculture project. However, the interaction between the ecosystem and the activity is evident and therefore both have to be considered, measured, and compared in order to minimize possible mismatches and further undesirable effects.

As ecosystem characteristics determine site selection, scaling is important in terms of the occupation of space by the aquaculture activity. Scaling will help to diminish the costs of collecting ecosystem data, by restricting the study to the smallest possible area that needs to be characterized for a given aquaculture site selection process.

Temporal scale deals with the evolution over time of the aquaculture activity and the dynamics of the ecosystem. Mismatches can appear and should be corrected. Interactions depend on the way in which the activity develops and on the willingness to make the aquaculture project sustainable. It is essential to take a short-, medium- and long-term view of how the activity influences and in turn is influenced by the ecosystem.

Scale is also important with regard to the possible effects that natural events can have on a potential aquaculture site. Within ecological systems there is a relationship between spatial and temporal scales, namely that at a large scale slow changes take place (e.g. climate change), whereas at a small scale fast changes occur (e.g. storms). Environmental changes, foreseeable or not, have direct impacts on the fragile relationship between the ecosystem and the activity, which is still poorly understood and difficult to address. Research in this domain should be encouraged in order to enhance the adaptability of the aquaculture sector in a multiple-use context.

The scale approach should be considered in relation to legal and administrative procedures, since they are closely connected with site selection and site management. The siting of an installation involves the participation of various administrative bodies, to the extent that agreements and decisions are made at different levels. Moreover, mismatches can be found even among authorities within the same country. This complex situation affects aquaculture site selection and site management on a temporal scale. The greater the number of authorities involved in the process, the longer the process will take, which in turn affects the planning of the activity, especially when the final decision comes from central government, which is normally far away from the area of interest. Thus, depending on the complexity of the political structure, the time scale for decision making may be quite lengthy. Scaling is needed so that predictions can be made for investment purposes.

Delegating responsibilities to the lowest appropriate level of administration through government decentralization or administrative 'deconcentration' will encourage the local authorities to take an interest, hence simplifying procedures for aquaculture site selection and site management.

With regard to social aspects, the process of gaining social acceptability in order to achieve sustainability of the aquaculture project will vary in time scale depending on the size of the groups affected by a given site selection process. The organization and representation of the stakeholder groups, whose actions depend on their own perceptions and are conditioned by institutions, is a social issue that takes place within given space and time scales and which has to be taken into account in the site selection process. Therefore, such positive or negative determinants in regard to the social construction as well as the time lag in achieving social acceptability should be assessed in order to avoid possible mismatches.

Scale is also related to the economic value of the investment and the payback period. Since it is an economic activity, all aspects of aquaculture influence its economics in terms of losses, payback period and amortization. Adopting a scale approach to these aspects could help to minimize costs or maximize profits, by adjusting investments to the size of the business or the carrying capacity of the system.

France - Théoule-sur-mer, ©Google

Use of the scale approach in a given marine area is therefore complex. Even if the primary interest is in managing a particular local system like a bay where farming could take place, one needs to understand the ways in which surrounding systems, including their ecological, administrative and socioeconomic aspects, influence the activity and vice versa. Moreover, how the activity itself is influenced by the smaller systems it comprises in terms of nutrient cycling or individual farmers' behaviour has to be taken into consideration. Thus a more complete understanding can be gained by examining different ranges of scales around a given aquaculture activity.

Justification

The scale approach is applicable to any aspect of an activity. In aquaculture, when interactions occur between ecological or social systems, any mismatches on a temporal, spatial or functional scale can affect the success of the interaction and therefore the sustainability of the process. Site selection and site management for aquaculture integrate many different aspects concerning sociology, ecology and economics. The ability to identify mismatches and apply appropriate scale factors should lead to the sustainable development of an aquaculture project.

Principle

Site selection and site management in a context of sustainable development of aquaculture should take the scale approach into account when studying interactions among several systems.

Guidelines

- The scale approach should be applied at each step of the aquaculture site selection and site management process. Continuous attention to sizing and identification of mismatches can help to achieve the success of aquaculture projects in a given area.

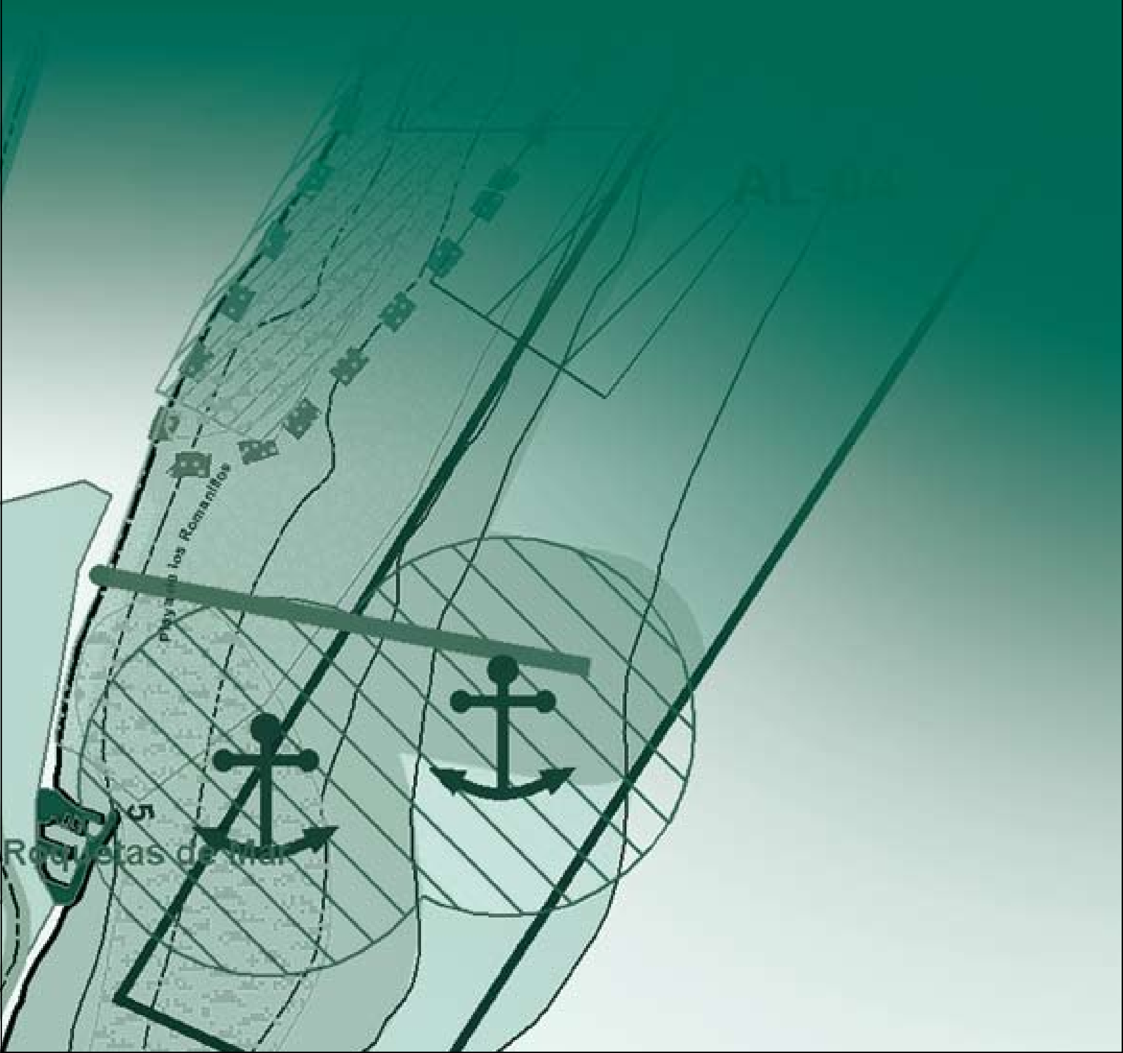
- Research should be encouraged to understand and resolve scale mismatches in the process of site selection and site management.

The ability to identify, measure; and compare the effects caused by the different scales at which the various systems function can help the process to succeed.

- The potential growth of the aquaculture project should be considered at the outset of the site management process. A long-term view of the possible future development of the aquaculture farm will enable managers to overcome further foreseeable mismatches between the activity and the surrounding systems.

- Tools such as geographical information systems should be used to assess the spatial and temporal scales in the aquaculture site selection and site management process. Powerful tools can help to reveal what is happening in a system at different scales so that the situation can be managed knowingly.

- Site selection and site management should be decentralized to the lowest appropriate level. Government structure and the level of decentralization in Mediterranean countries play an important role in the process. Institutions frequently lack the necessary multi-scale vision and associated flexibility to solve problems that occur at scales that they usually do not consider.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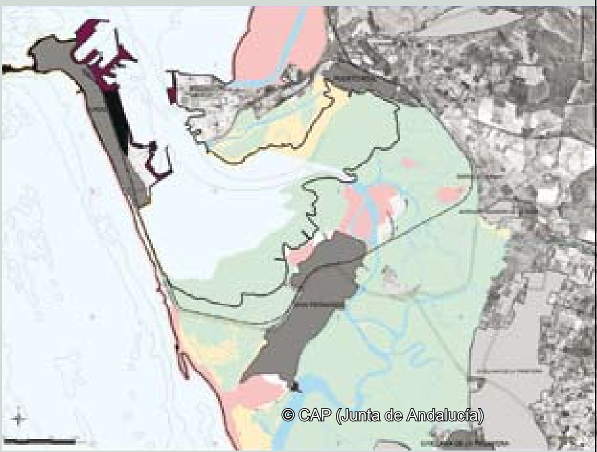
The adaptive approach

This guide refers to the importance of learning, anticipation and flexibility in the process of site selection and site management in view of the dynamic nature of the ecosystem in which the activity is implemented.

In an evolving environment characterized by rapid, profound and often unpredictable change, aquaculture has to develop and maintain long-term strategies in order to adapt and subsist in such a dynamic system. Change may occur both in ecosystems, due to the impacts of rapid world population growth or natural disasters, for instance, and in society, on account of circumstances such as increasing expectations regarding food quality and the global trends in biodiversity protection.



For the aquaculture sector to be sustainable, it must be able to adapt to new situations. Successful adaptation can be defined as positive response to change. It makes it possible to create and maintain sustainable ecosystems that can support human needs in the long term. This requires an understanding of both human and ecological processes as well as their influences over time. Increasing knowledge of societal values and environmental aspects through learning improves the chances that ecosystems can be maintained and sectors such as aquaculture can be sustainable. However, the process of learning and adapting is not an aim in itself but also has to evolve over time.

Guide F

Learning to achieve sustainable development despite change requires a diversity of strategies and a close partnership among managers, citizens and scientists, as well as cooperation among members of the same aquaculture sector, to provide a comprehensive view of expectations and responses to change. In a context where rates of change are increasing, comparing alternative practices adopted to cope with particular situations can lead to faster learning and adaptation. In this way a reliable, long-term strategy can be developed which relies not on reactions to external stimuli but rather on anticipation. Anticipatory research can supply new information that can influence and improve past and future studies on the sustainable development of aquaculture as well as help the sector to adapt more easily to a specific change, reducing management efforts and uncertainties and avoiding reaching a crisis situation that could put the survival of the activity in jeopardy.

In aquaculture as in other sectors, adaptation to change depends on the degree of flexibility, which is the ability to develop strategies in order to maintain the competitiveness and possibly the growth of the activity. There are different types of flexibility to respond to an environmental, social or economic change. For instance, relational flexibility is the ability to develop the activity by means of durable alliances, cooperation or networking, in order to go beyond individual action and favour partnership to better cope with possible changes in the system. Static flexibility refers to the potential of an activity to face predictable changes in a more or less stable environment, while dynamic flexibility is implemented in response to a changing system and is based on anticipation or rapid reaction processes.

For an economic activity such as aquaculture, responses and adaptation to change can occur at the production level by broadening the range of products or not taking on new stock, as well as at the organizational level by implementing improved learning processes or developing partnerships. The aim is for the producer to gradually adapt the operations and structure of the business to an evolving environment in order to achieve as far as possible the established objectives of sustainable development.

Therefore, when faced with a dynamic and often unpredictable system, it is important to learn about a particular situation by comparing different alternative practices, to adapt actively and continuously, to favour partnership and flexibility, and to anticipate outcomes in advance, in order to better cope with uncertainty and facilitate adaptation and further development of the activity.

Croatia - Kali, ©Google

Regarding site selection for aquaculture, the adaptive approach is also essential in all evolving processes. For instance, in governance or the participatory approach, the stakeholders' roles and responsibilities need to be constantly redefined and adapted in order to find common ground and build incentives, so as to achieve development objectives. In relation to legal aspects, adaptability of policies is important in a world where the scrutiny of an increasingly critical citizenry is more and more significant. Laws and regulations as well as administrative procedures should also consider the adaptive approach. Flexibility and the ability to change according to the evolution of the aquaculture sector and society's demands will make legal frameworks a more useful tool for sustainability.

The adaptive approach is also related to aquaculture technology and its ability to adapt to different and new sites for aquaculture. In fact, there is a direct relationship between the availability of new sites and the power of technology to cope with site conditions as well as the capacity for change within occupied sites. A range of possibilities will be opened up if technology applies the adaptive approach and searches for offshore sites, where users are fewer and environmental hazards are reduced.

Justification

The adaptive approach is essential in the process of site selection and in aquaculture management due to the dynamic nature of the system in which the activity is implemented. Change can be rapid and profound and can directly affect the survival of the activity if it is not prepared to adapt to a new environment. Learning based on broad, continuously expanding knowledge, anticipation and flexibility are the main pillars for more effective adaptation.

Principle

In aquaculture site selection and site management, the adaptive approach should be implemented to allow the activity to develop in a sustainable manner in a changing environment.

Guidelines

- The adaptive approach should be implemented in evolving processes like aquaculture site selection and site management, on a basis of learning, anticipation and flexibility. Reactive adaptation to change can endanger the sustainability of aquaculture. A long-term strategy is advisable instead.

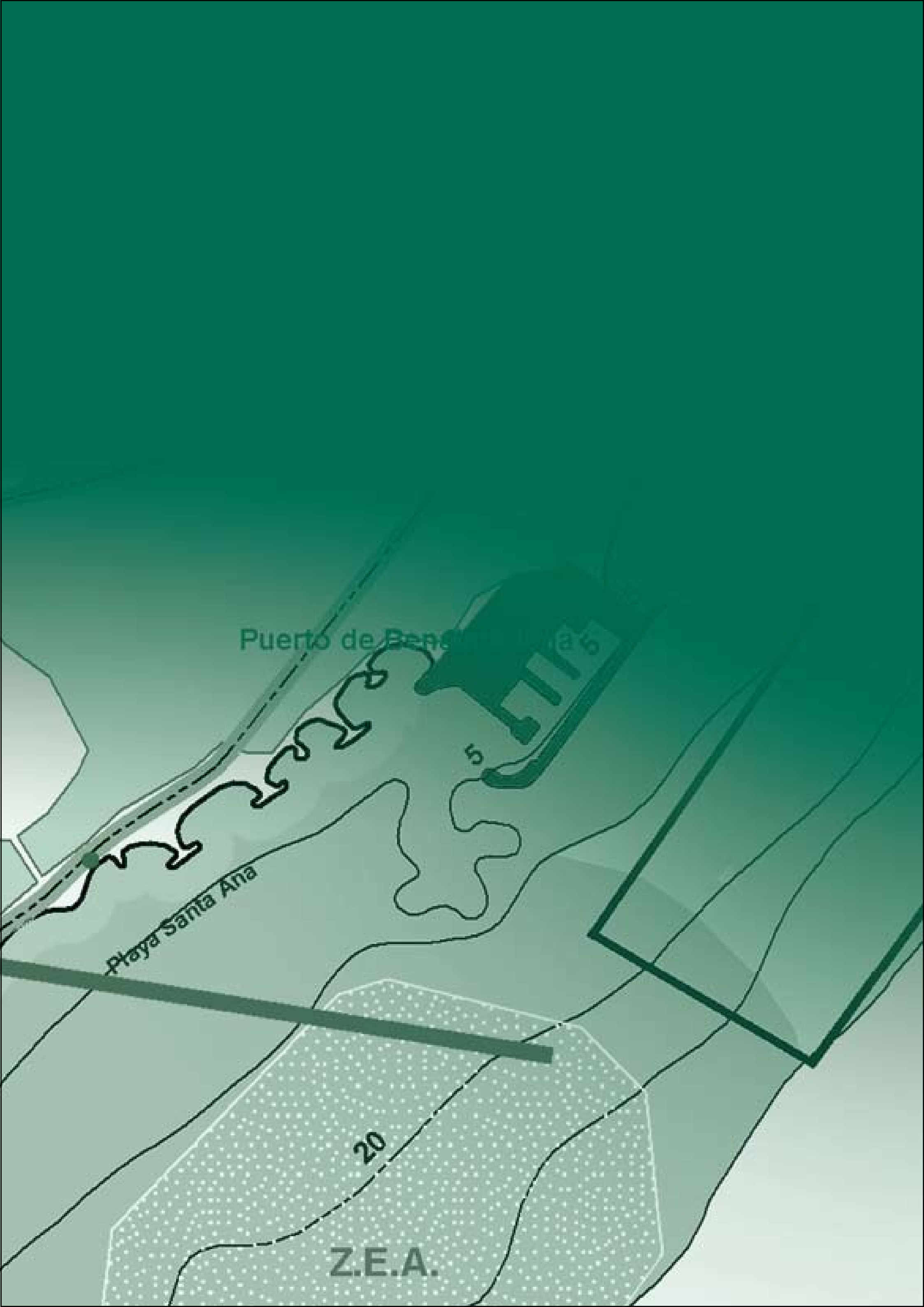
- Anticipated and unanticipated change involving risk should be addressed at the legal, ecological, socioeconomic or technological level by means of greater flexibility, in order to reduce conflict and achieve the sustainable development of aquaculture. Long-term solutions to mismatches will depend on knowledge and the further development of flexibility to reorganize the activity in response to changes in factors influencing the aquaculture sector.

- Research should be encouraged to allow the aquaculture sector to anticipate change. Anticipatory research can influence and improve past and future studies on the sustainable development of aquaculture as well as help the sector to adapt more easily to a particular change.

- Close partnerships among citizens, managers and scientists as well as cooperation among members of the same aquaculture sector should be encouraged in order to facilitate adaptation to achieve the sustainable development of aquaculture. Through partnership and cooperation, knowledge can be shared and extended, by comparing different strategies used to cope with a given situation. This can speed up learning and adaptation in aquaculture processes.

- Effective and rapid learning, adaptation and flexibility should be taken into consideration to cope with change. Documentation, anticipation, flexibility, comparisons between different approaches and identification of trigger points are essential for the sustainability of aquaculture. Learning and adaptation are processes that always evolve over time.

- Records of successful as well as failed past studies should be accessible to all stakeholders. Much can be gained from the creation of a database of retrospective studies on Mediterranean aquaculture, since the ecoregion is the same.



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Economic aspects

This guide introduces the basic concepts and tools of environmental economics needed for site selection and site management. Economics provides meaningful indicators and decision support tools. It allows analysts, planners and entrepreneurs to compare different activities and their outcomes using a common monetary benchmark. The guide will focus on the application of cost-benefit analysis (CBA) and valuation methods since they are widely recognised and accepted by a range of decision makers, both private and public.


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The spectacular growth and development in Mediterranean aquaculture over the past 30 years has largely been driven by market forces. On the demand side, population growth and changing tastes have caused dramatic increases in the demand for fish protein and derivative products. On the supply side, overfishing has stressed many, if not most, wild fish stocks to the point where the viability of capture fisheries is threatened (Andersen, 2002). Farmed fish now provide a complement to increasingly scarce wild stocks, offering a homogeneous and constant supply of good-quality products at fairly stable prices.

This brief history demonstrates the importance of economic factors in the evolution of aquaculture. It also highlights critical links between natural and ecological resource systems and economic

Guide G

impacts (Turner *et al.,* 2001). Economic incentives and poorly defined or enforced property rights led to overfishing and its consequences. This in turn increased the costs of capture fisheries and, coupled with rising demand and prices for fish, transformed aquaculture from a set of backstop technologies[3] to a mainstream and essential production method.

At the same time, the proliferation of aquaculture installations, particularly in coastal areas, has brought the sector into competition with a range of other stakeholders and subjects it to a range of environmental pressures.

Aquaculture's economic prospects cannot be divorced from the ecosystems within which it operates. For this reason, economic factors and the economic dimensions of aquaculture ecosystem interactions in particular must be taken into consideration for effective site selection and site management.

The economic value of a site expresses the benefits of site services in monetary terms. In some cases these values are obtained directly from the market. In other cases, specialized valuation techniques must be used.

Table 1 provides an overview of some of the more significant linkages. Each is a chain joining ecosystem functions, the services or benefits provided by the functions and the economic value associated with the benefit. Functions define the structure and dynamic of a potential site at the ecological and physical level. Services are defined by the human uses made of the site. These can be consumptive (e.g. provision of fish) or non-consumptive (e.g. recreational bathing) and may or may not be exchanged through market mechanisms.

[3] The concept of backstop technology was introduced by Hotelling. In the original conceptualization, it referred to alternative sources for the services from scarce exhaustible natural resources, but it is also applicable to cases in which the demand for a renewable resource such as fish outstrips supply. In general, a backstop technology is an alternative source of supply for the scarce commodity and becomes economically viable when the cost of securing the commodity using conventional means rises to the point at which it equals (or exceeds) the cost of securing the same commodity using the backstop technology. In many cases, aquaculture conforms to this definition: as wildstock biomass falls, the cost of capture fisheries rises and demand outstrips supply, forcing up the market price of fish. The higher price justifies investment in aquaculture, and there is a proliferation as enterprises are attracted by potential profits.

Table G.1. Main impacts and interactions pertinent to Mediterranean mariculture practice. (Main sources: EEA, 2006; FAO, 2007; GESAMP, 1996, 1997, 2001; Naylor et al., 2000; Shang & Tisdell, 1997)

OPERATIONAL ASPECT	NEGATIVE IMPACT	POSITIVE IMPACT	ECONOMIC ASPECT
EFFLUENT *(discharge of organic particulates, dissolved nitrogen and phosphorus, pharmaceutical and other chemicals)*	• Nutrification/eutrophication/turbidity of water column • Benthic changes		• Public health risks • Self-pollution of farm • Impairment of other economic activities that rely on the water body (e.g. tourism, recreation)
INTERACTION BETWEEN WILD FISH STOCKS AND FARM CULTURE *(escapes/pathogen transfer/ juveniles, fish attraction/ manufactured feed)*	• Escapes and potential genetic contamination • Pathogen transfer • Increased pressure on wild stocks from poorly managed capture of fry • Fish attraction to farm structures and food sources leading to uncertain and possibly detrimental changes in local biodiversity • Pressure on wild stocks from demand for manufactured fish feed	• Relief of pressure on stressed wild stocks with properly managed life-cycle (hatchery to mature landing of cultured species) • Fish attraction to farm structures and food sources leading to uncertain yet possibly positive changes in local biodiversity	• Negative impacts potentially add pressure to already stressed wild fish stocks. Economic effects will be at the industry and farm level (e.g. increased scarcity of fry and manufactured feed) outside the aquaculture, in fisheries and other sectors • Positive impacts may improve prospects for capture fisheries and other sectors (e.g. recreational diving and fishing)
INTERACTION WITH BIRDS	• Presence of food in and around farm sites attracts a variety of predatory species		• Fish losses within the farm • Positive effect for recreational bird watching
FOOD SAFETY AND SECURITY	• If poorly managed, risk of pathogen and/or chemical exposure for consumers	• Reliable source of fish protein	• Economic costs of morbidity caused by consumption of contaminated fish • Economic benefits of improved nutrition

OPERATIONAL ASPECT	NEGATIVE IMPACT	POSITIVE IMPACT	ECONOMIC ASPECT
INTERACTION WITH OTHER USERS OF COASTAL AND MARINE RESOURCES *(spillovers among stakeholders)*	• Susceptibility of farms to point and non-point sources of pollution (e.g. sewage, industrial pollution, agricultural runoff, accidental spills) • Physical limitations of a single site in accommodating different activities	• Complementarities between activities at a single site (e.g. integration of cages with artificial reefs to reduce net effluent and enhance opportunities for recreational diving)	• Contamination of cultured fish from non-farm pollution sources • Conflict among existing users possibly leading to difficulty in obtaining permits and licences • Economic benefits from aquaculture plus a complementary activity such as recreation can increase welfare over and above each activity in isolation • Trade-offs between aquaculture and other activities in terms of job creation/ maintenance, investment opportunities, potential for new business opportunities
ENTERPRISE	• Large corporations may export profits • Relatively small number of farm workers; most employment benefits accrue off site	• Potential for local investment • Potentially large employment benefits in farm-related operations (e.g. packing, transport, marketing) with spillovers to the local community • Potential to rejuvenate communities reliant on capture fisheries and other remote communities • Creation of new opportunities (e.g. hatcheries, non-conventional markets)	• Investment revenues • Employment income • Local tax base • Export earnings • Community welfare

Main concepts

Three main concepts underlie decision support tools such as cost-benefit analysis (CBA) and valuation methods. These are: total economic value (TEV), environmental externalities and monetization (Freeman, 2003).

Total economic value (TEV)

Aquaculture sites use a variety of ecosystem services. These services are valuable to the aquaculturist and to all other actual and potential users of the same site. The economic approach to ecosystem functions regards them as providing a flow of goods and services. In some cases, the value derives from direct uses in consumption or production but it may also come from non-consumptive and indirect uses. In some cases ecosystem functions are valued on intrinsic and moral grounds as well. Although many of these benefits are not the result of market activity, techniques of valuation exist and are used to determine the value of ecosystem services in monetary terms (Pearce and Turner, 1990; OECD 2001).

Environmental externality

Many of the interactions and feedbacks between aquaculture and the ecosystem in which it operates are what economists call environmental externalities. Pearce and Turner (1990) define an externality as an activity by one agent that causes a loss/gain to welfare of another agent and the loss/gain is uncompensated. If a fish farm produces unpleasant odours and people living nearby suffer as a result, these odours are a negative externality. Residents' welfare is affected and the disamenity may result in lower real estate prices in affected areas. Similarly, if untreated urban sewage contaminates a fish farm, the lost revenues to the farm are a negative externality stemming from urban activity.

Externalities can operate in two directions. For example, fish farms are both fish-attracting devices and sources of nutrients for migrating species. In some places, the migrating organisms have been shown to both reduce net waste discharges from fish cages and increase fish landings. This is especially true if an artificial reef is placed in proximity to the farm. In this way, fish farms and recreational activities such as diving and fishing may actually complement each other.

Monetization

The economic approach restricts itself to values that can be expressed in monetary terms. The rationalization is that money is a widely accepted and familiar measuring rod for welfare. Not all values can (or should) be expressed in this way. This does not mean that they are unimportant, rather that they are best represented by other indicators and used in conjunction with monetary values in a multi-criterion framework for assessing a site's suitability for aquaculture (Millennium Ecosystem Assessment, 2003).

Cost-benefit analysis (CBA)

Cost-benefit analysis provides a means of determining the net benefit of a specific project and decision-making criteria. This type of accounting was first put forward by Jules Dupuis in 1848 and formalized by Alfred Marshall. It has become the dominant framework used in the assessment of public projects worldwide. The objective is to estimate the TEV of projects in order to select the one with the highest net benefit. In the case of site selection and management it tallies the equivalent money value of all the costs and benefits for a specific type (species cultivated, design and engineering, etc.) and size of farming operation at a particular site. This total includes the economic value of externalities (Randall, 2002). There are three aspects of CBA to consider:

a. Financial

The financial aspect of CBA is widely used at the enterprise level to assess different investment or operational options. In this case the decision maker considers revenues, production and investment costs, all determined by the market. Taxes, subsidies and other transfers between the enterprise and government are also included in the computation. It provides information on contributions in aggregate, such as returns on investment as well as information on employment revenues, contribution to the tax base and foreign exchange.

b. Economic

This aspect reflects concerns of government planning agencies for the net benefits of individual enterprises as well as industries, sectors or geopolitical jurisdictions. The purpose is generally the identification of the combination of activities that yields the highest return in aggregate. It accounts for spillovers among projects as well as aggregate effects in the market. For example, a financial CBA on a single farm would take the price of fish feed as a given, whereas a sectoral analysis of farms would consider the effect of changing aggregate demand for feed on the market price of feed. Similarly, a single farm would not include the changing costs of transport infrastructure in its analysis, whereas a planner considering the expansion of local aquaculture would need to consider the costs of modifying existing roads.

An economic analysis would also consider the opportunity cost of different options if the expansion of aquaculture restricted opportunities for industrial expansion in the same area and vice-versa. The trade-offs between the two must be quantified in order to assess which activity contributes more to overall welfare.

c. Environmental

An environmental CBA extends the economic CBA to include environmental impacts. The issues of concern and the decision maker remain essentially the same, that is, a planner with the objective of maximizing social welfare. The difference is that a range of values not traditionally determined in the market are considered. An environmental CBA would therefore consider the TEV of an aquaculture site, including a comparison over different activities of the economic value of changes in pollution, biodiversity and risk profiles.

Although the environmental CBA is traditionally carried out by a planner, it has clear implications for the enterprise. If the economic value of the environmental impact caused by aquaculture can be transferred to the operator, in the form of a tax or fee, then the firm can and should include these impacts in its financial CBA. In this way, CBA can be used in the implementation of important policy options such as the polluter-pays principle (PPP).

The implications for site selection and management are clear. Firms will internalize the environmental costs of their activities, choosing sites and technologies that are more consistent with the costs they must pay for inappropriate practices.

Valuation of ecosystem services

Because most of the ecosystem services that need to be included in an environmental cost-benefit analysis for a particular site do not have conventional prices, alternative forms of economic valuation are needed (Turner, 2000). Several of the main valuation methods and their relevance to site selection and management are reviewed here.

Direct uses of a site include its potential for aquaculture, urban and industrial expansion, tourism and recreation. Each of these has a market element and can be evaluated in terms of profits, taxes and employment. In addition, there are other categories of value from direct use that do not pass through the market. These include human health effects of environmental pollution and recreational activities in open-access areas such as public beaches. The two main methods of valuation for these types of uses are the travel cost and averting behaviour methods. The first measures the amount that recreational users actually pay in order to make use of the site, including the cost of travel, fees and other expenses incurred at the site together with the opportunity cost of time. The second measures the amount needed to prevent or remediate contamination in order to eliminate threats, such as organic pollution from aquaculture.

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If property prices are affected by the presence of fish farms the effects can be measured by the hedonic price method, which measures the difference in property prices for sites situated near fish farms and similar sites further away.

The production function approach can be used for a number of ecosystem functions such as maintenance of biodiversity. In many cases, the cost of replacing or remediating damage at a site is used as a proxy for the value of environmental change. Most commonly, this type of calculation is used to measure the cost of cleaning up pollution and could include the cost to the firm of enforced fallow periods to allow regeneration of an affected site.

Finally, stated preference methods based on questionnaire surveys can be used to assess the value to stakeholders and the general public of a range of services, including all of the ones mentioned above, as well as the values that people place on preserving ecosystem attributes for future generations and for other reasons unrelated to their own direct use (Heal *et al.,* 2005).

Justification

Aquaculture is primarily an economic activity that interacts with ecosystems. Many, if not most, of the changes at the farm and industry level have economic dimensions. Consideration of these dimensions and the application of tools of economic analysis to site selection and site management are therefore important elements in effective decision making. Used in conjunction with other measures, for example ecological and social acceptability, economic indicators facilitate comparisons between aquaculture and other uses (competing and complementary) of a given site and can be key inputs into the design of tools for environmental protection.

The economic viability of a project is one of the requirements for an aquaculture project licensing application to be accepted for a given site, and at the same time it is one of the three pillars of sustainability. These aspects make economic considerations a key issue, and it is essential for the sustainable development of aquaculture that economic indicators be developed and applied.

Principle

Economic factors and in particular the economic dimensions of aquaculture-ecosystem interactions should be considered for effective site selection and site management.

Guidelines

- Economic tools and indicators should be used in conjunction with others (e.g. environmental impact assessments) to enable decision making based on multiple criteria reflecting a range of societal objectives. Decision makers often have insufficient information to reach decisions aimed at avoiding biodiversity loss.

This can be overcome through the integrated use of economic and other decision support tools. Economic tools are important because they reflect a range of values using widely accepted and understood monetary measures.

- In order to capture the total economic value (TEV) of a given type of aquaculture at a given site, the application of economic tools of analysis should consider a comprehensive range of non-market and market sources of value, and direct and indirect impacts. Economic tools should be used to value the enterprise and related businesses (e.g. packing, transport and marketing), environmental impacts (e.g. changing water quality and biodiversity), changes in employment, and similar economic aspects. This can be accomplished by using the full range of methods of economic valuation.

- In order to understand trade-offs among candidate users of the same ecosystem, the TEV of aquaculture should be compared to the TEV of other sectors. This will enable decision makers to prioritize activities and assess aquaculture against other uses in relation to its interaction with the ecosystem. Sustainable site selection and management should result in a higher TEV for aquaculture.

- In order to develop appropriate regulatory incentives at the farm level, externalities should be understood and quantified. Fish farming is an economic undertaking. If policy is to encourage or discourage certain activities, farmers must be given appropriate incentives (e.g. fees, fines, subsidies) and these incentives should reflect the externalities caused.

The importance of governance

This guide deals with the concept of governance and how it should be developed and implemented in connection with aquaculture site selection and site management. From definition to new aspects, characteristics of governance are described which are directly applicable to the sustainable development of aquaculture.

Governance in general terms refers to the quality, efficacy and purpose of the activities of the governing structures, giving legitimacy to their actions. Governance also refers to the values, policies, laws and institutions by which sets of issues are addressed.

Good governance supports the fundamental goals and the institutional processes and structures that are the basis for planning and decision making. Management, in contrast, is the process by which human and material resources are harnessed to achieve a known goal within a known institutional structure (Olsen, 2003). Governance sets the stage within which management occurs.

Governance thus encompasses the formal and informal arrangements that structure and influence topics such as how resources or an ecosystem are utilized, how problems and opportunities are analysed and evaluated, what behaviour is deemed acceptable or forbidden, and what rules and sanctions are applied to affect the pattern of use.

Governance implies finding solutions to problems, creating opportunities and guiding the development of sectors towards specific goals. Governance is considered to be the most inclusive term, covering policy, public administration and management. It addresses long-term societal trends and needs.

Governance is a key issue in site selection and site management. Aquaculture development involves the administrative authorities directly, since it occupies and uses areas in the public domain. Licensing, site management, interference with other uses, rights and obligations, policies that apply to it, economic interests, and its close relation to the environment and its preservation all form part of an overall, changeable system that needs to be managed and on which decisions have to be made. Governance has to deal with all these aspects and must therefore apply new concepts and characteristics in order to address sustainability criteria.

Aquaculture systems are complex and dynamic, as are the activities that take place around them, particularly when new aspects and concerns, such as ecosystem health, social justice, food security, food safety and employment, have to be taken into account. Governance has to adapt to continuous changes in these aspects.

This adaptability of governance has to be built on learning, through feedback gained from observation, perception and understanding of the nature of problems. Governance has to deal with real problems in real time and be aware of what is happening in the field. Usually private sectors develop rapidly and the reaction of the authorities comes afterwards. Aquaculture is an example, and the rapid growth of the activity means that decision makers must react quickly to the process of site selection and site management, increasing the risk of poor decisions that might damage the sustainable development of the activity.

In view of this, another definition of governance could be: Governance is the set of public and private interactions that are initiated to solve societal problems and create societal opportunities.

This definition leads to a new concept of an 'interactive governance approach' in which diversity is addressed through inclusiveness, complexity through rational, holistic and integrative approaches, and dynamics through an interactive and adaptive framework (Bavinck, 2005). This approach combines several aspects that help governance to keep up with developments and respond promptly to real situations, although it introduces complexity at first sight due to the participation of many stakeholders or actors. Actors are any social group that has the power of action; in the case of site selection and site management, many stakeholders would be involved in the governance system, including producers' associations, social groups, other users of the publicly owned areas, other administrative bodies and so on. The solution, however, is not to reduce such participation, but to find ways to bring participants together in an equitable, just and workable manner.

Governance also needs instruments that can be used and applied to achieve goals and means. For aquaculture, it is clear that aquaculture management plans are the most powerful instrument for drawing actors into a commonly accepted system. Aquaculture plans alone are not enough, however. For site selection and management, other system-wide instruments are needed since aquaculture shares space; therefore, coastal zone planning needs to be included in governance. In any case, and coming back to the previously mentioned aspects of interactive and participatory governance, the identified actors must be informed and involved in the development or selection of aquaculture plans in order to ensure the effectiveness of governance.

Other elements relating to governance are the actions that have to be taken to implement the rules and policies. Laws can be enforced directly, although it is a relatively difficult procedure, so other means to achieve the same goals in a sustainable manner should be considered, such as participation of the sector in the drafting and implementation of laws.

Scale is another aspect to be considered in the governance process. Governance can be implemented at any level depending on the country's administrative structure. From national to local levels, competences are shared and feedback processes can help to adapt governance. Because of globalization, however, the ability of local actors to cope with situations is more limited. This may be the case in the Mediterranean, where a global outlook is gaining strength especially in terms of ecosystems, so governance should aim for a global scale as well.

Egypt - Dumyat © Google

Justification

Site selection and site management depend on areas in the public domain, where the occupation and sharing of space by a variety of stakeholders make governance a key issue. Governance as a concept is not new but in its application and the way it operates nowadays it is taking new paths. It is evolving towards better practice based on co-construction and participation, and adapting new visions and implementation methods. These, among others, are issues that provide governance with tools to achieve sustainability. As an example, a good understanding between the aquaculture sector and governments concerning site selection and site management is part of good governance, and thus contributes to the sustainable development of aquaculture in the Mediterranean.

Principle

Good governance practices concerning planning and decision making should be implemented for aquaculture site selection and site management.

Guidelines

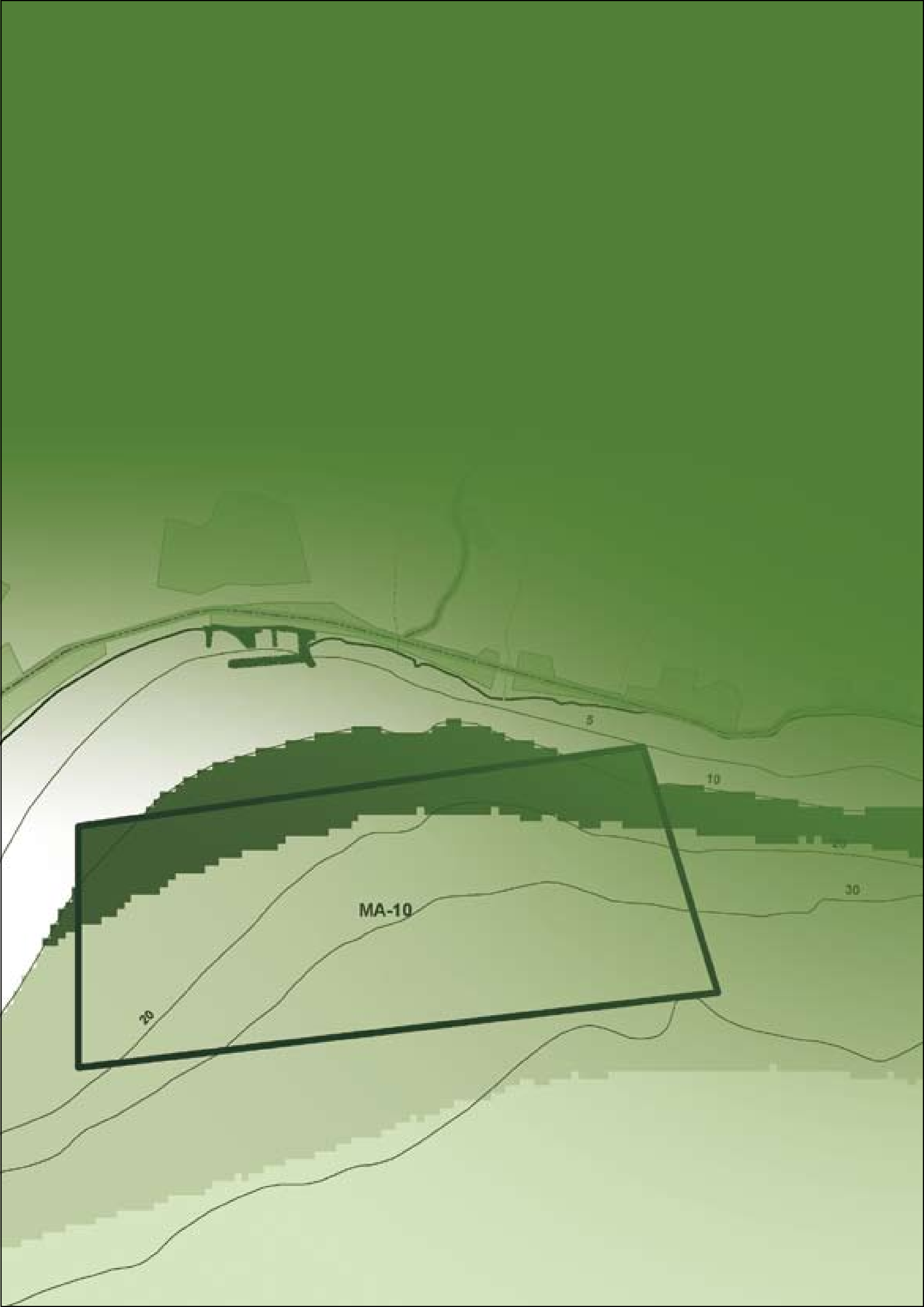
- Governance should be flexible, dynamic and adaptive. This ability to react to change and evolve towards greater effectiveness will give decision makers confidence and support.

- Governance should encourage all stakeholders to participate and interact. The inclusion of all actors and the triggering of linkages within and among them will reinforce governability, increasing success in a shared environment where site selection has to be made.

- Governance should be applied at all levels. Because globalization is becoming a strong driver of change, new forms of governance should be developed at all scales, from local to global.

- Aquaculture planning should be developed under the best applicable governance. As governance influences the processes of site selection and site management, the rules and their implementation should underline guidelines of sustainability.

- Governance should be considered and implemented on a long-term basis. Unlike fisheries, where daily decisions may be subject to uncertainties, aquaculture planning has a steadier, more long-term course that should be taken into account in governance arrangements.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The legal framework

This guide offers a series of guidelines for the establishment of appropriate legal frameworks for the practice of aquaculture, particularly with regard to site selection. The aim is to highlight the benefits of adequate regulations for aquaculture. An overview of the current situation is given for the Mediterranean.

Current situation

Once the main technical problems related to aquaculture production have been overcome, one of the factors that may jeopardise the development of aquaculture in a given country is the lack of an appropriate legal framework that promotes the aquaculture industry.


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Some of the legal aspects that currently have a great impact on the development of marine aquaculture in the Mediterranean are:

- The large amount of diverse and, in some cases, disparate legislation applicable to procedures for setting up and managing aquaculture facilities;

- The involvement of so many different authorities at different levels;

- The long and sometimes confusing procedures for the granting of aquaculture licences.

Added to these aspects are the extent of the influence and intervention of administrative authorities, depending on the degree of decentralization and the impact of various regulations at different administrative levels: local, regional, European and, in some cases, international.

Aquaculture is an economic operation that entails risk and requires high levels of investment. Aquaculture operators must be informed of and clearly understand the legal requirements and associated costs, and be fully informed about matters relating to appropriate places for setting up aquaculture establishments. This information includes: the conditions and requirements that will be demanded; the agencies involved and which of them have decision-making powers; the criteria used to calculate the taxes and fees, and the sums that operators can expect to pay; the environmental protection measures required; and ,finally, the rights that operators will acquire and the guarantees in place to protect those rights against third parties.

Not all the countries of the Mediterranean have aquaculture legislation. The legal situation is very heterogeneous, with regard to both the existence of regulations for aquaculture and the content of those regulations.

Most Mediterranean countries, however, have developed a complex legal framework for aquaculture. Some, such as Spain, Algeria and Egypt, have a specific aquaculture act, although the majority (Malta, Turkey, Croatia, Greece, Morocco and many of Spain's Autonomous Communities) regulate fishing and aquaculture jointly. Finally, other countries, like France, regulate aquaculture through lower-level regulations such as decrees.

Nearly all of these regulations contain numerous gaps, and it is widely agreed that there is overlap and a lack of coordination among administrative authorities, resulting in over-bureaucratization. Therefore, it is necessary to find mechanisms for coordination among them, as the absence of such mechanisms could have negative consequences on the development of aquaculture.

There are no homogeneous or common criteria that make it possible to perform a single legal analysis for the whole of the Mediterranean; on the contrary, the legislation of each country is primarily based on local criteria, depending on the type of aquaculture, the country's legal tradition and the greater or lesser importance of aquaculture there.

Areas of regulation

The legal framework for aquaculture is not just limited to the sectoral regulation of this activity, i.e. the conditions and characteristics of access to the activity in the form of licences and permits, validity periods, the rights and duties of establishment operators, the characteristics of aquaculture facilities and their production systems, etc. In addition, many more extremely important rules must be added that, although not issued by the administrative authority responsible for aquaculture, directly affect the development of this industry.

Here we are referring to important, wide-ranging legislation on the occupation and exploitation of the marine public domain or coastal public domain, which are described by different names depending on the country. This legislation covers state-owned coastal areas that must be leased for the practice of aquaculture. This applies to the majority of Mediterranean aquaculture regulations (in Spain, Greece, France, Italy, Egypt, Algeria, Turkey, etc.), which are normally issued by a different administrative authority to that which grants aquaculture licences.

In addition to these aspects, there are other areas of regulation that also affect the industry, particularly legislation on heath, environmental impact and management, marketing in the field of aquaculture, and so on. In fact at EU level there are more than 300 rules that affect this industry. However, for the purposes of this guide, we will focus on legislation concerning licence, and the spatial planning and use of areas in the public domain, which has the greatest influence on site selection.

Improvement mechanisms within the legal framework

Of interest in this respect are aquaculture laws that establish criteria for determining suitable sites for aquaculture or that require aquaculture activities to be grouped together and concentrated in sea farming centres or areas. This is the case of the autonomous regional governments in Spain. For example, in Galicia, Law 6/1993 on fishing in Galicia and its implementing regulations provide for the organization of mussel farming facilities in specially designated centres and the development of mussel beds in areas delimited by the regional government (Articles 58 and 62 of the Galician Fishing Act).

Also in Galicia, Decree 406/1996 on aquaculture provides for the management of designated sea farming areas within the framework of the integral planning of coastal uses (Article 20), and the Galician Aquaculture Plan, as a sectoral territorial plan, will be the legislation that regulates the areas delimited for practising aquaculture in coastal terrestrial areas. Law 2/2007 on fishing and aquaculture in Murcia regulates designated sea farming sites, which it defines as areas suitable for anchoring floating cages within zones declared as being of interest for aquaculture by the regional government, 'after assessment of their environmental impact'. This law adds that the rules establishing such designated sites must specify both their maximum production capacity and the species that may be farmed (Article 75).

Other regulations, instead of imposing mandatory rules on planning and management, simply recommend 'areas of interest for marine aquaculture', which are most appropriate for aquaculture operations. This is the case of the Spanish Aquaculture Act and the laws of the Autonomous Communities (Galicia, Murcia, Asturias, etc.).

The importance of an adequate legal framework was highlighted in the 10-Year Plan for Marine Aquaculture, published by the NOAA in the United States in October 2007. Its main objective is to establish a legal and administrative framework to encourage the sustainable development of aquaculture. On the basis of this plan, the National Offshore Aquaculture Act of 2007 and other legislation has been approved, thus promoting a type of aquaculture that had previously been paralysed due to the lack of a legal framework within which to develop. The plan proposes the implementation of regulations to coordinate licence-granting procedures, environmental impact statements (EIS), the zoning of areas suitable for offshore aquaculture and the establishment of consultations between government bodies and the general public as part of the legislative process.

The Norwegian legal system is another good example of how the legislative process has contributed to the development of aquaculture. Through the new Aquaculture Act of 17 June 2005, Norway has resolved problems generated by the previous act, in force for 20 years, which hindered the development of aquaculture. The new act increases the legal security and competitive advantage of Norwegian aquaculture operators. The main changes introduced by the new act concern simplification of the licensing procedure and the administrative authorities involved. The act is based on four fundamental areas:

- Growth of the industry;
- Simplification of procedures for industry and the administrative authorities, increasing the efficiency and familiarity of said procedures;
- A more modern and comprehensive environmental management system;
- Efficient use of the coast, attempting to reconcile coastal interests.

All these principles can be summed up by the mandate established by law of improving coordination and administrative efficiency.

In Chile, the Aquaculture Concession and Licence Regulations of 28 May 1993 represented a firm commitment from the Chilean Government to develop aquaculture in the country. Other countries that have been keen to establish a legal framework for the development of aquaculture and guarantee the legal security of aquaculture operators include Canada, with the

Aquaculture Act of 1988, and the USA, with the National Aquaculture Act of 1980.

In Europe there have been commendable efforts to establish a synthesis between existing legislation and best practice guidelines for the regulation of aquaculture through the MARAQUA project (Monitoring and Regulation of Marine Aquaculture in Europe) and based on other documents of interest (Cullinan & van Houtte, 1997; Pickering, 1998). The FAO, meanwhile, has prepared a report entitled 'Aquaculture policy, administration and legislation', in the document about Article 9 of the FAO Code of Conduct (FAO, 1999), as well as other legal content in different documents, and the National Legislation Overview prepared by the FAO Legal Department, which contains legal information about a large number of countries. However, the harmonization of legislation is a complex task that is beyond the remit of the EU, insofar as it affects the competence of the Member States. This guide may serve therefore to stimulate debate about seeking solutions and proposals for common guidelines with a view to preparing European aquaculture regulations.

The legislation regulating aquaculture should include a definition of the activity and a minimum level of content: the various aquaculture systems, the areas in which aquaculture may be carried out, plans or areas of interest for aquaculture and characteristics for the establishment of aquaculture facilities; the authorities responsible for the development of aquaculture regulations, environmental protection criteria, EIA management systems, EMASs, etc.; rights and duties, concession procedure; the authorities involved in the granting of permits and mechanisms for coordination among them, licences and granting systems; land use, registration of licences, transfer, inheritance, licence mortgages; control and sanction mechanisms; causes of revocation, expiry and cancellation; fees and charges.

In any event, the legal structure must regulate aquaculture within a framework of sustainability, balance among the various uses, protection of the environment and resources, and regulations that, in short, make society aware of the economic and social importance of this industry.

Justification

The development of aquaculture in a given country directly depends on the degree of effectiveness and simplification of its regulation, and how much that regulation favours the development of aquaculture in coastal areas, over other activities that share its space. Restrictive legislation may act as a brake on the development of aquaculture, whereas the flexibility, effectiveness and simplicity of legislation will be translated into the development of the aquaculture industry in the country in question.

The existence of an effective, simplified legislative framework for aquaculture is also key to determining suitable sites and managing this activity. Work is needed to establish a legislative structure that coordinates all the administrative authorities with coastal responsibilities. It will therefore have powers in the planning of such areas through the issuance of reports on the viability and acceptability of aquaculture as an activity that is compatible with other activities, as well as through spatial planning.

The preparation of appropriate legislation for aquaculture will give it greater legal security, consolidating it as an industry and securing its place when it comes to planning coastal uses.

Principle

An adequate and favourable legal framework should be in place to ensure appropriate site selection and site management.

Guidelines

- A suitable legal framework should be in place, guaranteeing the rights and stating the obligations of holders of aquaculture licences. That will ensure legal security for both aquaculture operators and the activity itself.

- Coordination and agreements on the legal framework for aquaculture site selection and site management should be built among the various administrative authorities. A lack of clear, concise regulations that specify the division of tasks between administrative authorities may result in the overlap of areas of competence and delays in procedures.

- The legal framework should be available and understandable to all stakeholders. Comprehensive aquaculture legislation will provide guarantees of success, in terms of both environmental protection and the development of the aquaculture industry. Furthermore, such a legal framework will be a way of informing society about the aquaculture industry.

- The legal framework for aquaculture should establish the basic programmes and conditions necessary for the selection of suitable areas for aquaculture. The designation of appropriate areas for aquaculture in both maritime and coastal areas should be reflected in regulations. This will ensure the legal security of aquaculture activities, their future stability and their success and competitiveness.

- Aquaculture legislation should be integrated with all forms of jurisdiction over the coastal zone. Regulations should be established for the management of coastal areas, covering planning, conservation conditions, protection of coastal resources, and planning of areas to be used for marine aquaculture.

- The legal system should include requirements that ensure compatibility with other uses. To achieve this there must be coordination between the competent administrative authorities and agencies, the industry and the general public, as well as legislative action.

- Aquaculture legislation should address the social and economic aspects of the area in which aquaculture activities take place. A lack of regulation may cause the rejection of aquaculture by society or administrative authorities that prioritize other interests.

Administrative procedures

This guide gives an overview of the existing administrative procedures in different countries. The main problematic topics of bureaucracy, timing, requirements, rights and duties are explained and possible solutions proposed.

The selection of sites for the establishment of aquaculture activities is closely linked to mandatory administrative procedures, as the areas to be occupied are public. More precisely, as these areas are defined as 'marine public domain', their occupation must be authorized by the competent administrative authorities.

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The licensing system is a control procedure that allows the authorities to verify the viability of the installation site and the potential environmental impact of the operation in question. Licences establish aquaculture sites, the conditions and operating period, environmental requirements and the carrying capacity of each aquaculture facility, i.e. the conditions that affect the specific area where aquaculture will be practised.

There are various types of licences, depending on the type of activity or the legal status of the aquatic resource used. They have different names, such as authorization, concession, licence, permit or lease. In nearly all countries, the mostly commonly used terms are licence, referring to the activity, and concession, referring to the occupation of an area in the public domain.

Current procedures in the Mediterranean region

As mentioned above, the legislation of most countries provides for two types of authorization for aquaculture: the operating licence and the concession to occupy an area in the public domain.

In the case of Spain, the regional government departments responsible for aquaculture grant the operating licences. In addition to these licences, however, potential operators must also obtain a concession or a binding report on the occupation of the marine public domain, which must be granted or issued by the Ministry of the Environment.

In France, there is a similar system based on two separate forms of authorization: a mariculture licence (*autorisation d'exploitation des cultures marines*) granted by the Maritime Affairs Office, and a declaration required for facilities producing more than five tonnes per year, or a licence for those producing more than 20 tonnes per year, which are considered 'installations classified for the protection of the environment (ICPE)'; applications for licences are dealt with by the Veterinary Department[4].

In Malta, for offshore aquaculture, two permits are required: an operational permit granted by the Fisheries Conservation and Control Division, and an occupancy permit granted by the Malta Environment and Planning Authority.

Similarly, Algeria also has an operating licence granted by the territorial authority in charge of fishing and, if the activity involves occupation of the public domain, a public concession agreement. In accordance with the Decree of 21 November 2004, a committee is formed to assess the granting of this concession. Various administrative authorities are represented on this committee: the Fisheries Agency, Public Domain Management, Aquatic Resources Agency, Agricultural Services, Tourism, Transport and Forest Conservation Authorities, Environment Agency and Public Works Authority.

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[4] Facilities producing more than 5 t/yr require a 'declaration' while those producing more than 20 t/yr must apply for a 'licence', the application being dealt with by the Veterinary Department.

A similar dual system is in place in Morocco: an operating licence (authorization of exploitation) granted by the Marine Fisheries Department, and a permit for temporary occupation of the public domain, granted by the Ministry of Public Works.

Two forms of authorization are also required in Turkey: a fish farmer certificate, granted by the Ministry of Agriculture and Rural Affairs for a period of three years, and permission to occupy the maritime area or maritime space for the aquaculture facility, which is granted by the provincial authorities. This occupancy permit is the main permit for practising aquaculture in Turkey, and is associated with important aspects of legal insecurity that complicate aquaculture licence-granting procedures: for example, its uncertain duration—permits may be granted for 3 years or even 15 years—and the lack of unambiguous criteria.

In short, in addition to any other bodies involved in the procedure, the concurrence of two main administrative authorities is required: one that is responsible for the actual activity of aquaculture and grants the licence to begin operations, and another that manages the marine and coastal public domain and authorizes the occupation of a public area for a specified time. It is the granting of this second authorization that generates most problems.

Often, these two main agencies belong to different departments or ministries, which means that they must liaise with each other in order to speed up the process. This makes institutional coordination and cooperation all the more necessary. A step forward in this direction has been the recent integration in Spain of responsibility for management of the coasts (public domain) and the bodies that represent Spanish marine aquaculture, through the creation of the Ministry of the Environment and Rural and Marine Affairs. However, power to authorize aquaculture operations remains in the hands of the regional governments, which makes the system more complex.

This analysis of the current state of play shows that the main problems affecting aquaculture in practically all Mediterranean countries tend to stem from:

- The lack of simplification and clarity in administrative procedures for the granting of aquaculture licences;

- The numerous authorities involved in said procedures;
- The resulting over-bureaucratization and lengthiness of licence-granting procedures.

The involvement of other administrative authorities

The procedure becomes even more complicated when other permits, licences and reports are required from other authorities with responsibilities for coastal and maritime areas. This is another source of difficulty, due to the large number of agencies and authorities involved and, in the majority of cases, the lack of a real plan for coordination among them.

All this is due to the fact that marine aquaculture is carried out in the special, fragile area that is the coast: an area where numerous powers and economic interests are at play, and a special environmental protection area. Consequently, each of the various administrative authorities has to issue an opinion regarding the location of new facilities to ensure that they do not harm or negatively affect the interests that each authority defends or represents.

In Spain, the procedures vary from one Autonomous Community to the next, although in nearly all of them it is the administrative authority responsible for aquaculture that receives the application and gathers all the reports from the authorities with coastal responsibilities: Regional Planning, Defence, Tourism, Environment (the regional governments), Navigation, Ports, Culture and Heritage, and local councils. Once all the reports have been obtained, the application is publicly announced and the corresponding environmental impact assessment is requested from the Environment Agency. Finally, the application is forwarded to the central government agency that manages areas in the public domain, which must issue a binding report or a concession for occupation of the public domain.

In Greece, the competent administrative authorities are the Ministry of Agriculture, Merchant Shipping Ministry, Ministry of Development, and Ministry of the Environment, Physical Planning and Public Works.

When the use of marine waters is concerned, however, the intervention of the Ministry of Culture, Ministry of National Defence, and Ministry of Health and Welfare is required in addition to that of the aforementioned ministries. In Turkey, licences are granted by the Ministry of Agriculture, with input from other administrative authorities: Tourism, Navigation, Health, Ministry of the Environment, and local and provincial authorities. In the end, the use of maritime areas must be authorized by the provincial authority.

If an area in the public domain is to be occupied, a greater number of administrative authorities are involved in the process (in Spain, Greece, Turkey, Morocco, Algeria, etc.), precisely because of the special nature and specific protection requirements of maritime and coastal areas.

Duration of the procedures

The involvement of so many agencies and authorities results in lengthy procedures that may take between two and three years, as is the case in Greece, some Autonomous Communities in Spain, and Turkey. The timeframe varies from six months to three years in Algeria, and can take up to four years in Egypt, where a particularly high number of administrative authorities are involved, making it sometimes necessary to acquire as many as 12 licences from different Egyptian agencies.

In Greece and some Spanish Autonomous Communities, the number of documents and copies of those documents required can exceed eight copies for the Ministry of Fisheries and Agriculture, three copies for the Land Use Planning Office of the Ministry of the Environment, plus a third application with three copies for the environmental impact assessment.

In Spain, the timeframe for aquaculture procedures varies substantially depending on whether the facility occupies the maritime public domain managed by the Directorate-General of Coasts of the Ministry of the Environment, or the port public domain managed by the Ministry of Development. In the first case, the duration of the procedure also depends on the Autonomous Communities, and ranges from six months to two years. In the case of aquaculture in a port area, the average timeframe is around six months. The heterogeneous and case-specific nature of licence-granting procedures in Mediterranean countries is clear.

Possible procedural improvements

Procedural timeframes can be reduced by enhancing coordination among the authorities and agencies involved in said procedures.

In the case of Norway, alternative models that improve the coordination and efficiency of procedures among all the administrative authorities involved have been sought through the new Aquaculture Act of 17 June 2005. The result has been the simplification of procedures and a dramatic reduction in timeframes, from the 20 months prior to the Act to less than six months now. One of the most interesting measures that contributed to achieving these results was the introduction of much shorter timeframes at every phase of the procedure, by giving each agency a short deadline within which to issue its reports. Another important new feature is the central place given to the creation of an agency that leads the procedure within the Directorate of Fisheries, increasing its resources and powers in the assessment of applications.

Another possible route for improving the coordination of agencies and administrative authorities is the creation of inter-institutional agencies or ‘one-stop shops’ that centralize, coordinate and process all the permits, licences and reports from the various agencies and authorities that have responsibilities for aquaculture, acting as the sole authority. Although the majority of European countries have not completely resolved their coordination problems, countries such as the USA and Canada have opted for the creation of such inter-institutional coordination offices or agencies.

In its 10-Year Plan for Marine Aquaculture (2007), one of the NOAA’s priorities is to coordinate procedures for aquaculture licences in coastal areas, ensuring both internal coordination and coordination with other federal agencies. This will make the NOAA responsible for granting licences for aquaculture in federal waters and coordinating the actions of other agencies that grant aquaculture licences.

In the State of Florida, an Aquaculture Division has been created to act as a one-stop shop for marine and continental aquaculture, centralizing all legislative activities and issuing the Aquaculture Certificate of Registration. Moreover, in this state, an Aquaculture Interagency

Coordinating Council has been created, which serves as a forum for the discussion of aquaculture policies and coordinates the five departments involved in the aquaculture sector, preparing proposals to foster the development of aquaculture. Florida producers have agreed to adopt a document setting out Best Management Practices (BMP) for Aquaculture, designed to eliminate overlap between the agencies and authorities involved, duplication of licences, etc.

The State of Maine, meanwhile, has set up an Aquaculture Policy Ombudsman in the Department of Marine Resources, the duties, of which include coordinating state policies on aquaculture and coordinating the Interagency Committee on Aquaculture.

The development of aquaculture in Canada is the responsibility of the Aquaculture Task Group, whose objective is to create a one-stop shop for the development of aquaculture. In addition, the Interdepartmental Committee on Aquaculture (ICA) seeks to harmonize the activities of all federal agencies by holding periodic federal inter-agency meetings to enhance communication and cooperation among federal departments, improve inspection and develop harmonized policies and regulatory frameworks. For its part, the Nova Scotia Aquaculture Development Committee coordinates the agencies with competence in aquaculture, in a coordinated effort to enhance the promotion and development of aquaculture.

In the Mediterranean, the most similar case of a coordination body is perhaps the Spanish Mariculture Advisory Board (JACUMAR): a coordination and consultation body made up of representatives of all the regional governments with competences in aquaculture and the Ministry of the Environment and Rural and Marine Affairs.

In any case, the regulatory framework of the procedure should stipulate procedural timeframes that are binding on the administrative authorities. The main body responsible for managing and coordinating the procedure must set the deadlines for information and responses from the other agencies or authorities that must issue opinions on different aspects: navigation, tourism, cultural heritage, ports, the environment, etc. Similarly, it must specify the legal consequences of failing to issue the permit or report by the set deadline, in order to avoid the indefinite paralysis of procedures.

Legislation should establish the validity period of licences. This will ensure the legal security of aquaculture and the sustainability of aquaculture businesses. Periods may vary according to the legislation of each country and depending on whether or not the aquaculture facility occupies the public domain.

At the same time, coordination policies should be developed by setting up inter-agency task groups charged with harmonizing and coordinating all aquaculture-related competences held and regulated by the various agencies or administrative authorities. The mandate of such groups will cover not only licences and their procedures, but also issues linked to product health, aquaculture research, environmental aspects and impact management, coastal planning, etc. Likewise, it should act as an office for the promotion of aquaculture, in the style of the bodies set up in Canada and the USA.

Another factor that contributes to simplifying and shortening administrative procedures is the prior establishment of suitable sites for aquaculture. To achieve this, a process of information gathering, analysis and consensus among administrative authorities must be carried out, based on rules of use and coordination. If the aquaculture operator and the administrative authority know in advance what documentation is required for that site, the licences will be granted within a reasonable timeframe and there will be fewer requirements.

A similar improvement has been made with another important element of the aquaculture licence, the environmental impact assessment, which can now be issued just once, when the aquaculture sites are declared, and not each time an individual application is submitted. This considerably reduces administrative paperwork.

In short, a lack of definition or delimitation of aquaculture sites can lead to an increase in the number of requirements, licences or reports, with a resulting delay in administrative procedures and, therefore, the start of investment.

Other requirements

a. Environmental impact assessment (EIA)

In general, applications for aquaculture projects are submitted with a technical study, a biological study and other required documents such as the environmental impact assessment. For aquaculture licences, the EIA is an important element for supervising protection of the environment in which the aquaculture activity will take place.

It is here that the regulations of the various countries differ in terms of their content and the standards required. Although Community rules have attempted to harmonize the legislation of the EU Member States, EIA requirements still differ from one Mediterranean country to the next. While in EU countries the EIA criteria are based on production, in other countries, like Egypt, they are based on the site where the facility will be located (for example, if it is in a protected area).

b. Operator selection criteria

Some legislations, such as those of the Spanish Autonomous Communities, establish operator selection criteria, based on a series of indicators, to determine the advisability of granting aquaculture licences that involve occupation of areas in the public domain. These criteria include:

- The socioeconomic importance of the project;
- Experience in aquaculture;
- The introduction of new technologies and limited environmental impact;
- Job creation, especially for fishermen and women;
- The food contribution to European markets;
- Preferences over groups related to traditional fishing activities, such as fishermen's associations.

Elsewhere, as in Croatia, the evaluation criteria include the concession fee offered, the total investment, social criteria such as the number of jobs created, and environmental aspects such as the amount invested in environmental protection.

Rights and obligations of aquaculture licence holders

Aquaculture licences grant their holders rights and obligations, especially in the case of concessions that confer the right to occupy areas in the public domain.

a. Rights

Very briefly, licences grant exclusive exploitation rights and a right to occupy an area in the public domain, which cannot be violated by third parties or administrative authorities, which would have to indemnify the concession holder were they to revoke the licences in question. Licences are granted for limited, though relatively long, periods of time, which range from 10 to 30 years, depending on the country.

The occupation rights contained in a concession are usually transferable and may be covered by a mortgage, thus strengthening the legal and economic security of concessions. In any case, regulations must guarantee that the new licence holder fulfils the capacity requirements demanded of the previous licence holder, as well as the operating conditions.

b. Obligations: payment of fees and charges

Aquaculture licences are usually linked to the payment of fees or charges, either for occupation of a public domain area or for performing the actual aquaculture activity. Payment of the fee to occupy the public domain is viewed as a pecuniary consideration that the state receives in return for the private or special use of property in the public domain.
The payment of charges and fees also means that aquaculture will contribute to covering costs linked to the monitoring and inspection of aquaculture establishments, environmental monitoring and water quality assessments, as well as any costs related to carrying capacity and the restoration of the public domain area to its original state, if necessary. These types of fees are usually paid annually and are calculated based on criteria adopted by each country, generally combining the surface area or volume of water occupied with the annual production of the facility.

An example of the calculation of occupation fees according to clear and fair criteria has resulted from the negotiations begun by the Spanish association of mariculture operators, APROMAR, in 2004, with the Spanish Ministry of the Environment. The changes came about with the approval of Law 42/2007 on Natural Heritage and Biodiversity. Flat-rate calculation criteria have been set for all types of aquaculture, with a single annual charge of eight percent of the taxable amount consisting of the value of the land in the public domain, and a variable coefficient on the anticipated revenue generated from the occupation of the public domain. In addition, as a new feature intended to 'encourage better environmental practice in the aquaculture sector', the new law provides for the fee to be reduced by 40 percent for concession holders that join the EMAS Eco-Management and Audit Scheme, and by 25 percent for those that become ISO 14001 certified.

The situation is very different on the Mediterranean coast in countries like Turkey, where the issue of calculating fees has yet to be resolved: there are no standard rates or common criteria for their calculation, and prices and charges are very high.

In any event, in order to ensure legal certainty for operators, the criteria used must be reasonable, transparent and uniform for each type of aquaculture.

Justification

Given the public nature of the space to be occupied in the selection and management of aquaculture sites, and in view of the hindrances caused by the administrative procedures for licensing aquaculture activities and authorizing occupation of the public domain, such procedures need to be revised for the Mediterranean as a whole, so that they contribute to the proper selection and management of areas and, therefore, the sustainable development of the industry.

Principle

Adequate administrative procedures should be established in order to facilitate the appropriate selection and management of sites for aquaculture.

Guidelines

- Regulations should be drafted that set out the procedures for granting aquaculture licences. It is important to have regulations that clearly inform aquaculture operators of the requirements for obtaining a licence, the timeframe of the application process, as well as the rights and obligations attached to the licence.

- Instruments should be prepared to coordinate the administrative authorities and agencies involved and the procedures for granting the various authorizations. This will ensure the legal security of both the applicant and the granting authority itself, while also simplifying the aquaculture licensing process.

- Administrative authorities with responsibilities for aquaculture should develop guidelines for the submission of applications, containing legal and institutional information. These guidelines would be useful for establishing aquaculture policies, not only for the competent administrative authorities, but also for aquaculture operators and society in general. A simple form should be produced, accompanied by a checklist to help the applicant ensure that all documents are submitted.

- The establishment of technical offices that centralize aquaculture procedures in a region or country is recommended. The creation of one-stop shops should be promoted to centralize licence-granting procedures, thus reducing procedure timeframes and requirements.

- Common administrative licensing procedures should be enforced at a Mediterranean level. Efforts should be made to set up a basis for minimum common requirements, to facilitate capital movement within the Mediterranean.

- The criteria used to calculate the aquaculture fee should be reasonable, transparent and uniform for each type of aquaculture, in order to ensure legal certainty. The fee for occupation of an area in the public domain must be proportional to the use thereof, and take into account the specific character of the aquaculture activity in question. Alternatives to purely economic fees should be proposed.

- The capabilities and human resources of the administrative authorities responsible for aquaculture should be increased, backed up by a political commitment to coordinate the institutions and agencies involved in the regulation and management of aquaculture.

Specific examples of legal frameworks and administrative procedures in the Mediterranean

a. Turkey

In Turkey the aquaculture sector is still experiencing a time of rapid growth. Over the last decade the volume of aquaculture production has increased by 250%, reaching 128,943 tonnes in 2006. This corresponds to 22% of the total fisheries production. Currently, there are 1,470 fish farms, 1,159 of which are freshwater and 311 marine. The Turkish aquaculture sector has a large number of family-operated, small- and medium-scale units (Turkish Fisheries, 2007). Most marine aquaculture—92 percent—takes place in the Aegean, including 63 percent in the Muğla area, 23 percent in İzmir Province and 5 percent in the Province of Aydın (Candan *et al.,* 2007).

Aquaculture legislation: licensing and site selection

Fisheries Law No 1380 of 1971, as amended by Laws 3288 of 1986 and 4950 of 2003, is the framework law for all fisheries and aquaculture. The basic authority responsible for aquaculture is the Ministry of Agriculture and Rural Affairs (MARA). These laws provide the basic instrument for regulation. Circulars are issued from time to time under the authority of the Minister. These are also used to regulate aquaculture. Aquaculture is further managed through the Implementing Regulation of Aquaculture of 2004, as revised in 2005 and 2007 (Regulation on Aquaculture No: 25507, 2007). The regulations cover:

- Site selection for inland and marine farms;
- Project approval and licensing;

- Monitoring and control of farming activities;
- Improving production, closing down farms, site changes and farm sales.

All aquaculture producers must have an aquaculture registration licence from MARA. Figure J.1 shows the leasing procedures for marine fish farms. The entrepreneur can then prepare the full project documentation, which includes a feasibility report and an environmental impact assessment (EIA) report, given by the Ministry of Environment and Forestry. Approval is also needed from other relevant institutions such as the Ministry of Culture and Tourism, the Authority for Specially Protected Areas, the Coast Guard Command and the Ministry of Transport.

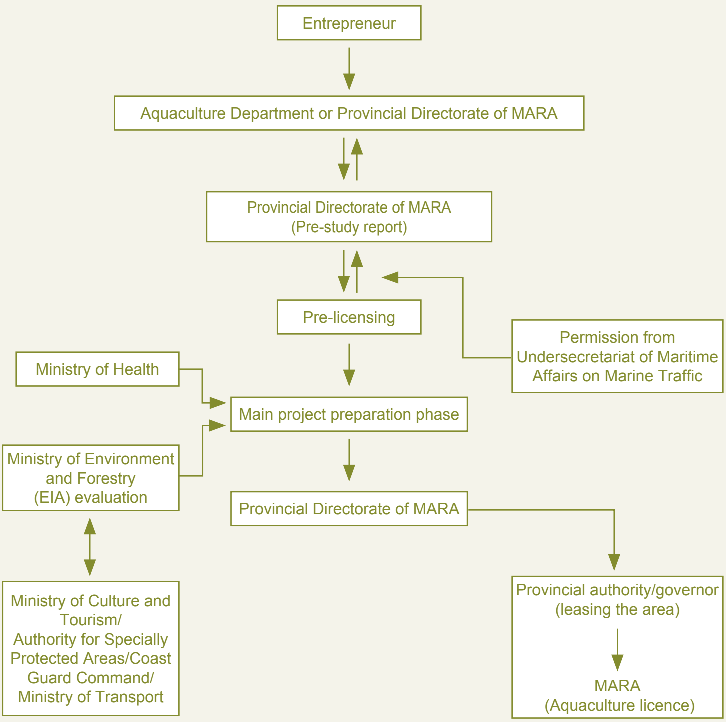


Figure J.1. Licensing and leasing procedures for marine fish farms in Turkey

In 2006 Environmental Law 2872 of 1983 was further amended as Law 5491. According to this, 'fish farms in the seas can not be established in such enclosed bays or gulfs as are sensitive natural or archaeological sites'. The enforcement of this law is the responsibility of the Ministry of Environment and Forestry. According to a further amendment of this law, farms in contravention of these new criteria must relocate within the years 2007–2008.

b. Croatia

The main legal basis for spatial (or physical) planning in Croatia is provided by the Physical Planning Act, under the responsibility of the Ministry of Environmental Protection, Physical Planning and Construction (MEPPPC). This basic document provides the main elements of the planning procedure and sets out guidelines for all activities that may be actually performed in a given area. The act draws on the general guidelines set forth in the Physical Planning Strategy, and calls for detailed plans at county level. There are 21 counties in Croatia, seven of which are coastal and of potential interest to the marine aquaculture industry. All coastal counties have drafted their physical plans, but since the general provisions allow for rather broad definitions, most plans do not contain direct allocations of space for marine aquaculture.

Another important basic document is the Ports and Maritime Estate Act, under the responsibility of the Ministry of Sea, Transportation and Infrastructure (MSTI). This act provides for the concession procedure, and detailed implementing regulations have been adopted pursuant to this act. Further legal basis is given by the Environmental Protection Act, again under the responsibility of the MEPPPC. This document provides the basis for environmental issues, in particular the environmental impact assessment requirements and procedures. All food safety and animal health and welfare issues are governed by relevant provisions of the food and veterinary laws, under the responsibility of the Ministry of Agriculture, Fishery and Rural Development (MAFRD).

Finally, the basic instrument for the actual commercial activity is the Marine Fisheries Act, under the responsibility of the MAFRD, which stipulates the conditions under which an aquaculture licence may be granted to a physical or legal person. Detailed implementing regulations governing the requirements for marine aquaculture have been adopted pursuant to this act, including issues of data collection, the contents of the licence, environmental requirements from the point of view of best farming conditions and so forth.

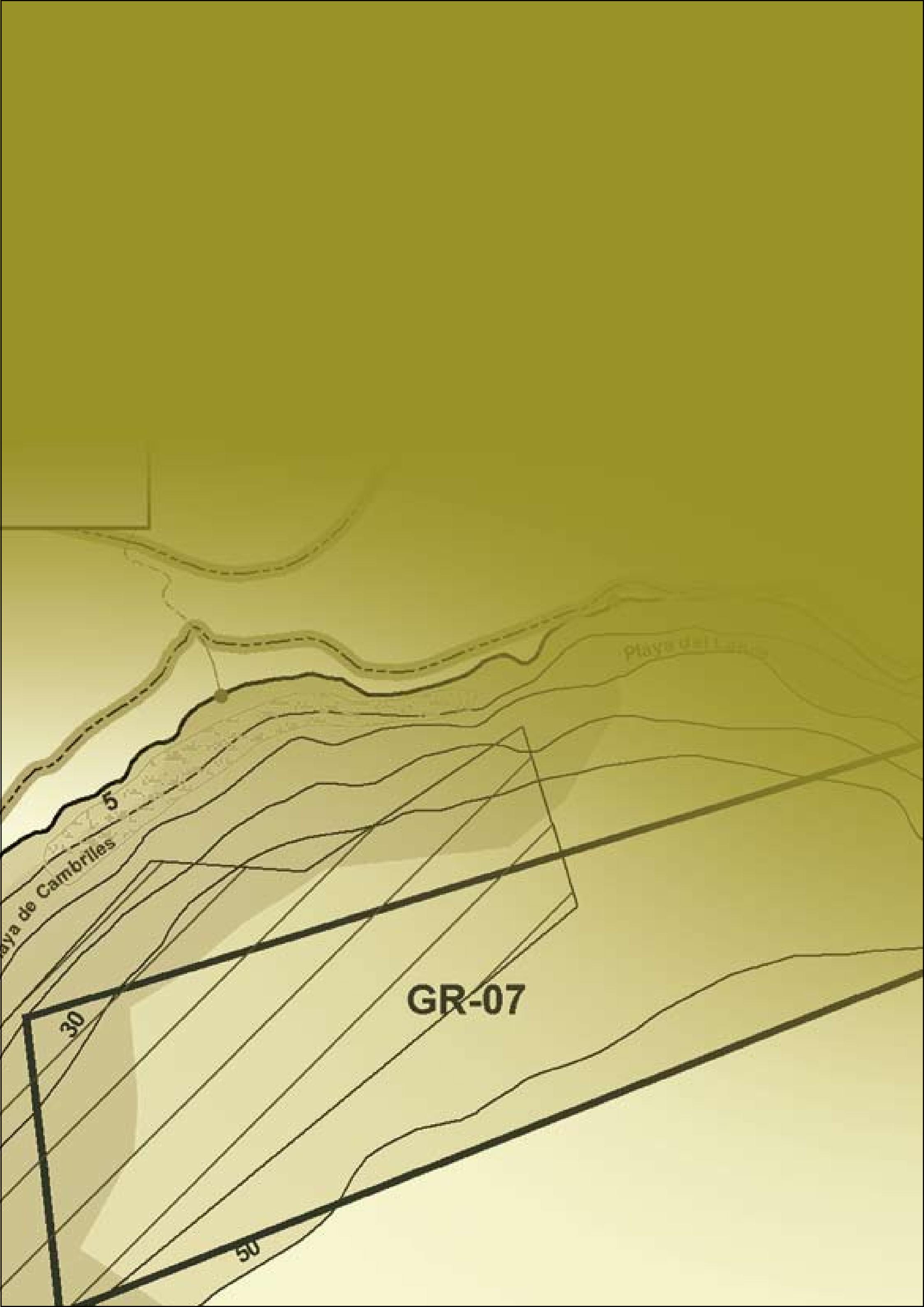
In terms of planning and licensing procedures, both central and local authorities are included and have their respective responsibilities. The central government provides the general stipulations in planning, assesses the environmental impact studies and issues the licences, whereas the actual concession procedure is implemented at a local level.

Each county in Croatia has to have a general physical plan, which needs to be in line with the national physical plan. The national physical plan is a very broad document, so considerable autonomy is left to the local authorities. The county physical plans provide for overall spatial definitions, allocating areas and zones to different activities. In most cases, areas have been allocated for human settlements, recreation zones and commercial activities, without an actual definition of what a 'commercial activity' in a given area is. In some cases, more detailed plans have been drafted, for example in Zadar County, where an in-depth study was undertaken in order to actually determine which areas would be suitable for marine aquaculture. Having such a detailed plan greatly helps in the development of an activity, and takes care of environmental requirements at the same time. When undertaking this study, the county took into account all available spatial users, their impact and development potentials. Then it took into account the geographical and bio-physical characteristics of the area, and implemented specific criteria for different aquaculture technologies and species. An implementing regulation, brought in pursuant to the Marine Fisheries Act, was used in this procedure. This regulation contains numerous environmental criteria, including depth, temperature, wave height, salinity and similar indicators which would be desirable for certain species (bass, bream, tuna and shellfish). Although essentially environmental in character, this regulation addresses both environmental protection and the best conditions for farmed organisms.

Once a county plan has been defined, more detailed municipality plans are drafted, which again have to be in line with the county plans. In these smaller-scale plans, locations are often allocated for a specific activity, but most are still left under a general 'commercial' heading.

When applying for an aquaculture licence, the potential investor submits a letter of interest to the local authorities, specifying the area in question and the commercial activity. The authorities then check for the availability and allocation of the area, and if the location is 'available', a public tender is issued. All potential investors may bid for the concession, and all have to submit several important documents. For a marine aquaculture plant, an environmental impact assessment (EIA) needs to be submitted, together with a detailed investment plan and a financial offer for the concession. The EIA has to contain all relevant information on the environment, activity and modelled impact, with all the mitigating elements. The EIA is subjected to an assessment and public debate and, if it is accepted, the bidder submits the full documentation for the concession. Once the concession has been issued, the bidder applies for an aquaculture licence, which in turn contains all relevant data on the area in question, the species and quantities that may be farmed, and other data from the concession contract. The concession is usually issued for a period of five years.

As there is no overall plan for marine aquaculture, the planning instruments and licensing procedures are mainly left to local authorities and are governed by numerous regulations. According to the National Strategy for Development of Fisheries, the development of aquaculture to high environmental standards is a strategic goal, and the activity is predicted to grow in the future. Croatia has great geographical advantages in terms of potential locations and areas suitable for marine aquaculture.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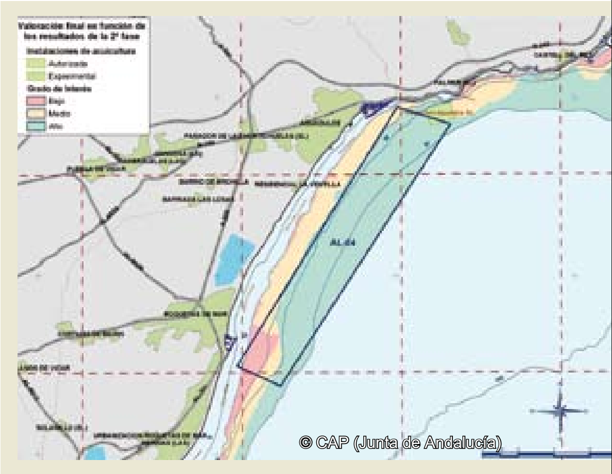
Sectoral planning

This guide presents sectoral planning as a means for achieving the sustainable development of the aquaculture sector and describes the direct links between planning and site selection and site management. A definition of sectoral planning and the components of the sector is given, followed by the role of the authorities and key aspects needed for the development of a sectoral plan. Finally, examples of sectoral planning procedures are described.



The selection of areas of interest for aquaculture is currently one of the most important processes for the orderly development of aquaculture in all regions, countries or geographical zones. Since the final objective is the sustainable development of marine aquaculture in the Mediterranean, it is essential to consider the issue from the point of view of the sector, its projected growth plans and needs, and the manner in which this is all regulated, programmed and supported by the administrative authorities through sectoral plans.

Sectoral planning refers to the set of guidelines or strategic plans proposed and adopted by the industry's various players for the purpose of ensuring the orderly and sustainable development of the activity, so as to generate development models within a logical regulatory context for each country's legal and economic framework.

Actors involved: components of the sector

The sector consists of the following players:

a. Companies and producers

Companies are devoted to production, and seek to be profitable in order to survive in a multidisciplinary context influenced by a large number of controls, laws, etc.

b. Associations

Producers, traders and/or ancillary enterprises join forces to collectively defend their common interests in associations such as FEAP. Their objectives are usually similar to those of private companies, although they seek to achieve them in a collective manner.

c. Research and study centres

Research bodies are devoted to the study of production-related physical, chemical and biological processes and their interaction with the environment, for the purpose of increasing the knowledge needed for the development of the activity.

d. Administrative authorities or managers

They process applications, handle permits, provide statistics, and analyse the results of environmental and sanitary monitoring. In other words, they authorize, control and manage the activity. Normally, these control and management actions are carried out with a 'political' objective. Aquaculture will be supported by the authorities depending on its influence on the economic and social fabric and on the availability of space in a certain region.

e. Others

National and international organizations, such as IUCN and GFCM, carry out certain actions with the aim of positively influencing the development of aquaculture.

The sectoral approach and perspectives

Sectoral plans generally arise for different reasons: either as a result of demand from the sector for support and planning, or as an initiative where the administrative authorities act as a driving force, or as a result of both. Indeed, the greater the role of aquaculture as a sector, the greater the demand for planning will be.

In the context of a sectoral approach, therefore, there exist two different, complementary perspectives:

- From the authorities towards companies, with the objective of sectoral planning;

- From companies towards the authorities, with the objective of growth.

The main actor or driving force behind this planning is usually a public authority with jurisdiction in the matter.

As a consequence, the selection of areas of interest for aquaculture can be seen as support for sectoral planning, to the same extent that the sectoral approach must be taken into account for the selection and management of areas of interest. This two-way influence benefits all actors in the sector: on one hand it facilitates the orderly growth of facilities for companies and producers; on the other, it provides associations with important information for the purpose of supporting the sector's sustainable development.

For research and study centres, the selection of areas represents a source of employment and a decision-making support tool. Lastly, it enables administrative authorities and managers to arrange, plan and manage aquaculture as a productive sector.

Key aspects

The approach is based on the diagnosis of key factors for the sector's development, such as production, marketing, socioeconomic aspects, administrative aspects, the environment and spatial organization. This requires the prior availability of human, material and financial resources with which to perform the diagnosis, which should take into account the following priorities:

- Knowledge of the sector and its possibilities or potential;

- Knowledge of potentially useful areas (suitable or of interest);

- Establishment of specific development objectives (strategic plans);

- Availability of an appropriate administrative system and useful statutory context.

Sectoral planning is thus a key element in the development of aquaculture. In this context, an explanation of the scope of the sectoral approach must briefly highlight the role of the selection of areas of interest, by means of the following analysis (Figure K.1):

- What is the basis of aquaculture development? The creation of new companies, which will need new licences or authorizations to carry out the activity.

- Applications for these new licences or authorizations are processed in specific administrative procedures, in which the key elements are the details of the aquaculture project.

- The two most important aspects of an aquaculture project are the activity to be carried out, in other words the type of crop, and where it is carried out, in other words the geographical location.

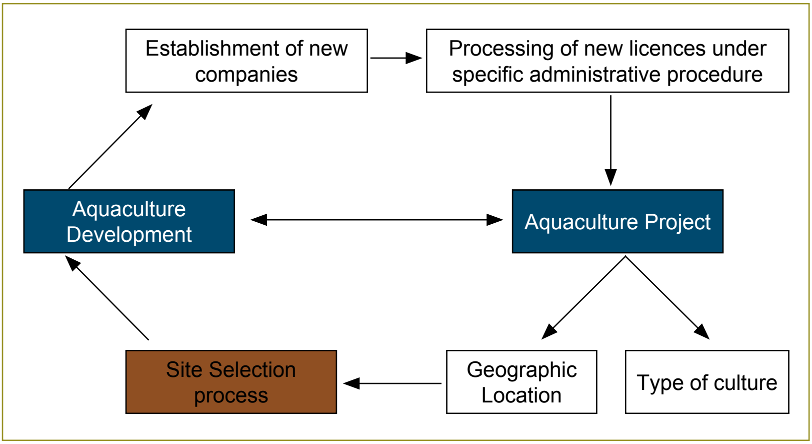


Figure K.1. The aquaculture development process

In addition, sectoral planning is closely linked to the socioeconomic, political and administrative context of the particular region, where the situation that exists depends on the degree of development of the sector and the characteristics of the country or region.

Countries like Norway or the United Kingdom (Scotland), where fish farming is far more developed than in southern Europe, have sector planning guidelines and tools that promote its orderly development.

In other countries like Greece or Turkey, the rapid development of the sector urgently requires spatial and sectoral planning, given the extent of the areas occupied by aquaculture facilities and their rapid spread.

In between, there are other countries such as Italy, France and Spain in which the sector has grown in a gradual and relatively orderly manner. Even though at times there is no real, objective planning, there are other instruments, such as strategic plans, white papers or other documents of intention, which have slowed the development of the sector by indicating the policies that it must follow in order to progress.

However, in general terms, there are currently few countries that have sectoral planning and organization based strictly speaking on the selection of areas of interest.

Justification

The development of aquaculture over the next few years is one of the main topics of discussion in a number of international forums on coastal area management, fishing, the environment and the supply of marine products. As a result, the prospects for growth in the short and mid-term are good and are tending to increase, with constant improvement in aspects such as diversification, technology, health and environmental management, etc. This projected development entails growth of the sector and of all activities that benefit from the synergies it generates. The selection of areas for aquaculture and sector planning are thus key elements for the activity's sustainable development.

Principle

The selection and management of areas for aquaculture should take into account a sectoral approach and sectoral planning.

Guidelines

- The potential for growth of the aquaculture sector in a particular geographical area should be taken into account as the starting point for the selection of sites. The prospect of growth is an essential factor to ensure that the activity appears and/or remains in a specific geographical area.

- The growth of the sector should be balanced with respect to other sectors sharing the same public domain areas. It is important to find a balance between the development of aquaculture and other activities that interact with it in public domain areas, which is why the growth of aquaculture must be planned and orderly.

- Sectoral planning should balance the sector's needs and the authorities' objectives. As principal actors in the process, both parties should interact and develop a co-construction process supported by other actors such as associations, research bodies and other organizations.

- Effective sectoral planning should be based on prospective studies. Empirical knowledge is needed to lay the foundations for sectoral plans. This in turn requires sufficient economic, material and human resources to obtain the information needed and make it available to the actors involved in the sector's development.

- Sectoral planning should be carried out with the help of instruments and tools that make appropriate spatial and temporal analysis possible. Geographical information systems are tools that facilitate the reading, representation and analysis of information.

Examples of linkage between sectoral planning and site selection and site management

a. Southern Spain

In Andalusia, in southern Spain, the Regional Department of Agriculture and Fisheries, through the Public Enterprise for Agricultural and Fisheries Development (DAP), has, in recent years, carried out a series of studies based on spatial analysis in order to develop sectoral planning for the aquaculture sector. The studies carried out are the following:

- A study to locate suitable areas for the development of aquaculture along the Andalusian coast. The study analysed the technical and administrative framework of the coastal strip from the shoreline to a depth of 50 metres. All the uses, activities and occupations that could interfere with aquaculture were then mapped, thus indicating the areas of potential use for aquaculture.

- A study to locate suitable areas for aquaculture along the public foreshore of Andalusia. In this second study, the technical and administrative context of the foreshore area was analysed, and again all the uses, activities and occupations that could interfere with aquaculture were mapped.

- The second phase of the study to locate suitable areas for the development of aquaculture along the Andalusian coast: study of the physical environment. This third study dealt with the technical and environmental factors of the foreshore, in other words the environmental conditions of the 18 areas pre-selected in the first phase. The result of the study is a map series for each of the 18 areas with zoning, depending on their environmental suitability for the development of aquaculture.

- A pilot project dealing with the organization of and potential for aquaculture in areas of Andalusia and Galicia. In this case, based on information generated in previous stages, a local-scale study was developed for a coastal municipality in Andalusia and one in Galicia that depend on fishing. In this phase, in addition to identifying suitable areas in greater depth, other socioeconomic and sectoral fishing-related aspects were analysed, and specific proposals to implement aquaculture projects were made for the areas selected.

As a result of these studies, a review of regulations and of the planning and zoning of the public domain area has been carried out to ensure that there are suitable zones for aquaculture, with the aim of encouraging private investment and the sustainable development of aquaculture in Andalusia.

b. Aquaculture parks in Murcia (Spain)

Another example of direct linkage between sectoral planning and site selection and site management is found in the development of aquaculture parks in the Region of Murcia, eastern Spain.

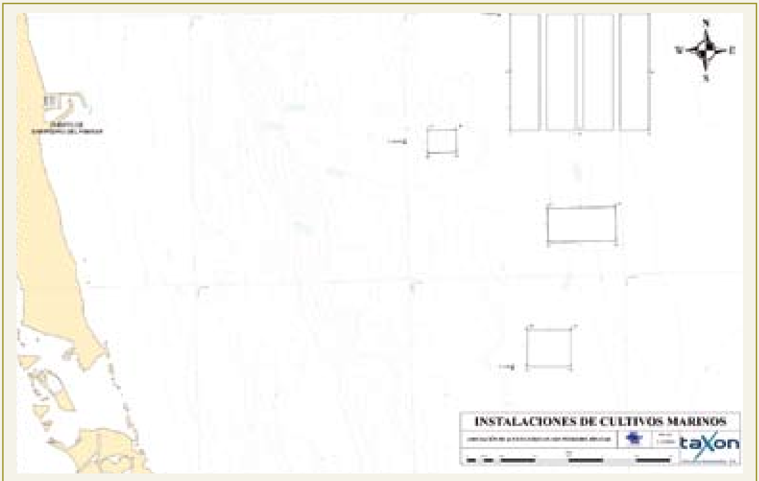


Figure K.2. Map of parks in Murcia

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 to bring together most of the marine aquaculture companies operating in the region. To this end, laws were passed and definitions laid down, such as:

- Law 2/2007 of 12 March on Marine Fisheries and Aquaculture of the Region of Murcia, giving 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. The regional ministry responsible may declare as areas suitable for marine aquaculture those areas that are considered appropriate for the installation of this type of establishment, 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 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. For this, the guidelines given in the ‘Protocol for identifying areas suitable for the installation of aquaculture cages at sea’, published by the National Marine Aquaculture Advisory Board (JACUMAR), were to be followed.

- Phase 2. Preparation of projects to accommodate the target facilities.

- 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 guidelines given in the 'Protocol for the environmental management of cage aquaculture facilities', published by the National Marine Aquaculture Advisory Board, were to be followed.

The best locations were then selected. The obligations and rights of users were laid down, together with the procedure for applying for a site. The parks were implemented by means of regulations and laws acting in both directions, that is protecting the environment and maritime traffic from the aquaculture activities as well as protecting the aquaculture from external activities. In addition a whole set of regulations was passed on the management of the marine aquaculture parks.

Eventually, three marine aquaculture parks were declared: San Pedro del Pinatar, Puntas de Calnegre, and El Gorguel (Cartagena). Except for the second, they are now operating. One park is off La Llana beach in the municipality of San Pedro del Pinatar, where there are seven facilities, and the other is off El Gorguel in Cartagena, where there are four facilities. These two parks cover approximately six million square meters, and currently produce between 7,000 and 7,500 tonnes per year, which may rise to 12,000 tonnes.

c. Algeria

In Algeria, fisheries produce around 126,000 tonnes a year (FAO, 2006), which allows for an average individual consumption of 3.8 kg per year. Additional production of approximately 190,000 tonnes per year would be needed to meet the average consumption of the five countries of North Africa (9.5 kg per person per year). Thus, despite under-production by 80,000 tonnes of exploitable biomass, aquaculture is indispensable.

Aquaculture is a relatively new industry in Algeria. Its history can be broken down into three main phases: (1) an old phase of extensive aquaculture in the Mellah lagoon (8°20'E, 36°54'N), (2) a more recent phase of extensive fish farming based on the stocking and restocking of inland water bodies with imported species, and (3) a current phase of intensive fish farming and shellfish farming. Aquaculture production is currently only 370 tonnes and essentially consists of lagoon and inland fishing. Shellfish farming, practised by two private operators, only produces a few dozen tonnes of mussels and is limited by the supply of spat.

The recent creation of a ministry responsible for fisheries and aquaculture reflects the commitment to develop this sector. Public aquaculture projects have been planned for demonstration purposes and to support production. Private projects are also underway for the establishment of marine and inland shellfish and fish farming businesses. These are subsidised by between 40% and 80%, and are currently between 20% and 90% complete.

In March 2005, the relevant ministry published a master plan for the development of aquaculture through to 2025, with a production target of 53,000 tonnes a year. This master plan divides the country into nine regions of activity, according to geographical and environmental criteria (Figure K.3). Within these regions, 53 areas of aquaculture activity have been established, defined as the most favourable places for sustainable development. For the spatial delimitation of these 53 areas, a specific techno-economic study of each one will be carried out, based on its legal status and the existing or planned multisectoral activities to be performed there.

A total of 450 favourable sites have been identified (112 coastal sites, 52 river mouths, 159 dams and hill dams, 115 semi-arid and Saharan sites, 12 chotts and sebkahs), distributed across nine branches of aquaculture: inland fishing, lagoon fishing, shellfish farming, freshwater fishing, marine fishing, crustacean culture, algae culture, tuna fattening and ornamental fish farming.

Although still at the initial stage of mastering the technical and economic aspects of aquaculture, the master plan addresses environmental considerations, as well as possible land use conflicts that could quickly come to dominate the concerns of managers. Indeed, several of the selected sites of interest for aquaculture are located in tourism development areas and protected areas (marine parks, marine reserves), or near hydraulic structures. Therefore, it is envisaged that implementation of the master plan will be based on identifying intersectoral relationships with the aim of harmonizing land use to ensure the sustainable development of the industry. The necessary legal and regulatory framework has been strengthened with the passing of new laws, particularly concerning the terms and conditions of granting concessions for the establishment of aquaculture facilities.

At present, a concession for the establishment of an aquaculture facility requires the approval of the authority responsible for fisheries, following examination of the application by a committee established at the province level and made up of representatives of different administrative bodies (state property, water resources, agricultural services, tourism, transport, forests, and environment).

Only three concessions had been officially awarded directly by the State Property Department before the regulatory legislation came into force. These concessions can remain in place provided they are brought into conformity with the new regulations; once compliant, a new concession agreement is issued by the State Property Department. The concession agreement grants the concession holder the exclusive right to establish its aquaculture facility on the plot assigned to it in the maritime, hydraulic or inland public domain, in order to perform its breeding and farming activities.

In practice, the new procedure is based on specifications, the technical aspects of which include: (1) a feasibility study, (2) a layout plan of the facility, (3) an assessment of the environmental impact of setting up the facility, and (4) a pre-established list of physicochemical and bacteriological analyses. Once authorization has been given, the concession is granted against the payment of an annual fee, the amount of which is specified in the Finance Act. The duration of the concession is 25 years, which can be renewed by tacit agreement. A recent specific law lays down the conditions for performing breeding activities, the different types of establishments, the conditions for their creation and the rules for their operation (Executive Decree No 07-208 of 30 June 2007).

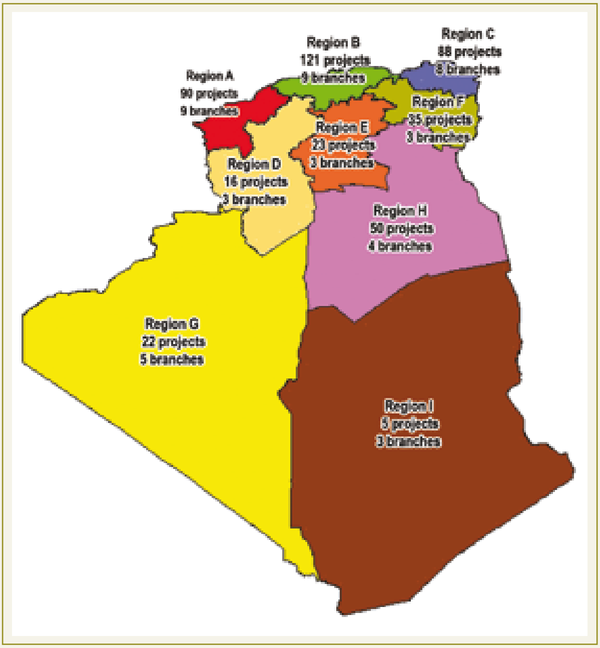


Figure K.3. Division of Algeria into aquaculture activity regions.

d. Morocco

From an administrative and institutional point of view, aquaculture in Morocco depends on two different administrative authorities. The High Commission for Waters and Forests and the Fight Against Desertification (HCEFLCD) under the Prime Minister is responsible for freshwater aquaculture, while the Marine Fisheries Department (DPM) under the Ministry of Agriculture and Marine Fisheries (MAPM) is responsible for marine aquaculture. The two types of aquaculture have different histories with different development strategies.

Marine aquaculture began in Morocco in the 1950s. Oyster farming was the first marine aquaculture activity, which was originally practised in Oualidia lagoon on the Moroccan Atlantic coast, south of Casablanca. It later spread to other coastal sites, such as Nador lagoon, Khnifiss lagoon and Dakhla bay. Some oyster companies are still operational, with a total annual production that has remained at around 200–300 tonnes for several years. After 2000, mussel farming began to develop in some coastal areas, mainly in Imessouane bay (Atlantic coast) and M'diq bay (Mediterranean coast). Marine fish aquaculture was initiated during the 1980s only on Mediterranean coast. It was developed first in Nador lagoon before spreading to other sites such as Saidia, M'diq and Azla. Of the four fish farms that were set up, only one of them is still operational and producing less than 100 tonnes per year.

National aquaculture production reached a total of only 1,161 tonnes in 2006, a drop of about 48% compared to 2005 (2,239 tone). This decrease was caused by a severe cutback of about 80% in marine aquaculture production (291 tone in 2006 against 1,449 tone in 2005), while freshwater aquaculture showed a small increase of about 9% (870 tone in 2006 against 790 tone in 2005). Total national aquaculture production represents only 0.2% of total national fisheries production.

In Morocco, the complexity of administrative procedures has affected the development of aquaculture. Indeed, the management of the aquaculture sector is shared among several administrative authorities:

- The HCEFLCD manages the development of inland fish farming and controls its operations;
- The Marine Fisheries Department manages marine aquaculture and issues permits for aquaculture activity in marine locations, and authorizations for the import and marketing of marine aquaculture products, in close consultation with the Livestock (Veterinary) Directorate;

- The Ministry of Infrastructure is responsible for issuing permits to occupy the marine public domain;

- The Livestock Directorate (under the Ministry of Agriculture, Rural Development and Fisheries) is responsible for enforcing health regulations.

The development of aquaculture in Morocco relies on sequential development plans, which are integrated in national plans and established as action programmes for periods of three or five years. These programmes are developed on the basis of the fisheries development plan relating to priorities, mainly fisheries resource preservation, social improvement, modernization of the fisheries and aquaculture sector and incentives. However, Moroccan aquaculture suffers from a lack of clear vision and strategy by the authorities. The current thinking seems to be converging towards a real resurgence of interest, with a desire to alleviate the constraints, including those of the administrative, institutional, legislative and regulatory environment, according to new rules of socioeconomic viability and trade competitiveness in the Euro-Mediterranean context.

The development of marine aquaculture is seen as a part of a vision to create regional development poles, consisting of aquaculture activities where the type, technology and species to be cultured will be determined according to local conditions, including environmental and socioeconomic characteristics. The establishment of local plans for areas suitable for aquaculture, based on ecosystem studies and environmental and socioeconomic integration measures, is considered one the main priorities.

Generally speaking, Moroccan aquaculture is going through a critical period that requires all public and private bodies to make concerted efforts to harmonize and standardize basic structural foundations and to ensure and strengthen the conditions for the integrated and sustainable development of aquaculture activities. There is no doubt that all administrative, scientific and professional actors are aware of the need for a new aquaculture development strategy, which should be concerted, credible and established for the long term. An action programme for marine and freshwater aquaculture development, which is effective and compatible with the reality of challenges at local, national and regional levels, is therefore imperative for the promotion of aquaculture production and fishing based on aquaculture. It will contribute to creating regional poles of integrated development beneficial to the local economy and may encourage local and foreign investment, with joint supervision of the activity, a common organization of marketing, and a collective insurance system.

e. Turkey

This summary expresses the views of the Official Union of Aquaculture Producers (Ankara Central Office and İzmir branch), the Muğla Fish Farmers' Association and the Federation of Aquaculture and Fisheries of Turkey.

Whilst governments have been applying modern strategies to improve aquaculture in Turkey, there is much still to do regarding the establishment of negotiated aquaculture zones. Although permission for new sites is being given to the aquaculture sector by the authorities concerned, there are still some problems of legal permanence. It is not unknown for newly developing farms to be asked to relocate a second time. These problems mostly stem from a lack of proper preliminary scientific information and planning. Further, fish farmers often come into conflict with the tourism sector, owners of summer holiday villas, environmentalists and poorly informed public opinion. Much of this situation is due to insufficient integrated coastal zone planning and management. Frequently aquaculture suffers more than other activities using the coastal zone. Initial good planning and site selection are certainly vital in terms of sustainability, environmental sensitivity and the protection of natural resources. Further, more effective monitoring and enforcement are also essential. In this, both self-monitoring by the farmers and regional integrated coastal zone management (ICZM) are of equal and complementary importance. In addition, the relevant ministries are required to monitor all fish farming by law.

More importantly, scientifically-defined parameters must be built into the legal framework. As a result of this monitoring and assessment, precautionary measures may be taken to prevent or correct negative effects.

The expectations of the aquaculture sector concerning site selection and the establishment of marine aquaculture zones are as follows:

- ICZM plans should be negotiated among all stakeholders.
- Zones for establishing aquaculture and potential sites for this sector should be decided within ICZM parameters and formalized in an ICZM Master Plan.
- These plans should be negotiated and announced. They should not be changed or abolished unless absolutely necessary, and then only with the agreement of all parties. Once an aquaculture zone has been defined there should be no further need for bureaucratic impediments or licensing. Contracts should run for long periods.
- Sites for aquaculture should be determined on the basis of scientific criteria. Data from all fields should be collected, but in general, the depth of water should be considered the basic criterion.
- Zonal environmental plans which include environmental impact assessment (EIA) studies should be drafted and this process should be conducted in a shorter time and in a less complicated manner than at present.
- In Turkey, sites for aquaculture are currently leased for 15 years. During this period of time, fish farms should not be required to move to another location. Furthermore, the sector wants 15 years to be the minimum lease.

- The rent payable for marine aquaculture activities should be reasonable.

- Environmental monitoring should not only be required for aquaculture sites but also for such other sectors as may have a negative impact on the environment.

- If fish farms are required to move offshore for environmental reasons, support in the form of credit as well as technological and other planning advice should be provided by the government.

- In an organized aquaculture zone the following requirements are important:

  - For reasons of security and monitoring (EIA), the close packing of farms is good practice.

  - When an aquaculture zone is at the planning stage, it is essential to designate an on-land base, for logistic reasons.

  - At the fry stage (approximately 2-10 grams weight), it is essential to have protected, inshore nursery cages.

- At the outset of change, a new on-land site for hatcheries should also be included in the ICZM Master Plan.

Private sector organizations

This guide defines professional organizations and associations as organizational structures developed by the private sector. Their roles and commitments are explained as well as their importance in the site selection and site management process. With reference to Mediterranean organizations, the scale factor is considered together with observed trends due to globalization. Finally some examples are given as well as guidelines on how private sector organizations can contribute to the sustainable development of aquaculture.

Professional organizations and associations are non-profit entities managed by professionals and devoted to the promotion and defence of the interests of specific economic sectors. They are the driving force, from a private perspective, behind planning in the sector. These organizations support their members and represent them in their dealings with administrative authorities and other entities, when they defend their members' interests and demand the enforcement of their rights.

They carry out the following activities, amongst others:

- Promoting the sector and its products, and seeking to improve quality;
- Promoting good environmental and social practices;

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- Influencing the establishment of policies that directly affect the sector's development and intervening in participatory processes;

- Improving transparency and traceability of products in respect of the market;

- Supporting continuous training for professionals;

- Encouraging contacts and exchange of information amongst professionals, and acting as a meeting point;

- Promoting company research and innovation.

Even though aquaculture is an emerging productive activity, in the Mediterranean the sector is fairly well structured and organized. Given the special features of this activity, aquaculture companies share a large number of common technical and management factors, and as a consequence have similar needs and requirements, irrespective of the country in which they are located.

The selection and management of areas for aquaculture is a common denominator affecting all producers in the same manner, and is of crucial importance for the development of this activity.

The organizational capacity of any sector in order to defend common interests and take advantage of synergies is essential for its development, in particular when the activity involved is one that shares the use of public domain areas with other sectors.

The degree of establishment and development of aquaculture in the Mediterranean region and the business structure of aquaculture enterprises vary greatly from one country to another. Different situations are easily identified: there are countries with numerous middle- and large-sized company-run facilities, countries with a large number of small family-owned facilities, and even countries with very few facilities, where aquaculture is an emerging activity.

It is important to stress the role that professional associations can have in this last scenario, not only to intervene as mediators in defence of the sector's rights and opportunities, but also to support small companies that usually lack the capacity to access professional and legal information regarding methods of organization, the environment, certification and decision making.

In any case, the aquaculture industry, irrespective of the capital involved, is aware of the need to organize in order to achieve common objectives, especially in the context of globalization. Indeed, the trend followed by Mediterranean aquaculture initiatives is towards a globalized economic model, in which a smaller number of multinational companies own increasingly larger numbers of local production sites. In recent years, this trend has been observed in companies producing giltheads and sea bass in the Mediterranean, following the example set by northern European salmon producers: initially there were many small and medium-sized producers and now there are only a few multinational companies that own most of the production facilities.

This scale factor is essential with respect to the features and scope of action of associations, whether they are constituted at a local, regional or national level. Several associations are active in the Mediterranean area, including the Muğla Fish Farmers' Association in Turkey, Asociación Empresarial de Productores de Cultivos Marinos (APROMAR) in Spain, Federation of Greek Maricultures, Associazione Piscicoltori Italiani, Malta Aquaculture Producers' Association, Association Marocaine de l'Aquaculture (AMA), the Egyptian Aquaculture Society (EgAS) and the Fish Breeders' Association in Israel.

At a more global level, the national associations of aquaculture producers of the European Union Member States have joined together to form the Federation of European Aquaculture Producers (FEAP). The Federation's main objectives are geared to developing and establishing a common policy on matters pertaining to the production and commercialization of aquatic species and putting its interests and the rules and regulations it has established across to the competent authorities.

The geopolitical structure of countries, in turn, favours the organization of the business framework, as in the case of the European Union with the FEAP as an example. However, such a situation does not exist across the

Mediterranean, although it may be time to encourage or propose an organization or association of producers at a global level for the entire Mediterranean area.

Common interests are constantly increasing, in particular with respect to the common use and availability of space, which will eventually be globally managed as facilities are increasingly located farther away from the coastline. This fact, together with the globalization of markets and the competitiveness of fish protein in the world, may be an appropriate context for a future 'Federation of Mediterranean Producers'.

Justification

Professional organizations are the most suitable tool for defending the common interests of any sector. Heavily regulated sectors, such as aquaculture, have a greater need to create organizations in order have more influence in society and amongst policy makers. In general, administrative authorities prefer to address professional organizations rather than individual companies, as a way of promoting more transparent and unbiased actions.

In the field of aquaculture site selection and management, professional associations play a fundamental role as interlocutors defending the sector's interests. Knowledge of the sector's economic and business situation enables these organizations to establish growth and planning criteria. Their experience and points of view are essential when it comes to choosing sites, not only from a technical point of view but also in respect of the scale of occupation.

Associations facilitate and encourage a participatory approach to the selection and management of sites for aquaculture. It is essential that associations act as forums for companies to meet and to voice their needs in connection with the selection and management process, particularly within the framework of integrated coastal zone management, so as to adequately represent the aquaculture industry.

Principle

Professional associations and sectoral organizations should be promoted in order to defend the feasibility of private initiatives in the selection and management of aquaculture sites.

Guidelines

- Aquaculture companies and professionals should organize themselves in order to defend common interests. By associating they gain greater social presence and a greater ability to reach top administrative and political levels, which otherwise would remain inaccessible for most companies.

- Professional associations should establish and implement codes of conduct and better management practices for all their members. Implementing these initiatives, even if they are voluntary, contributes to improving both productive practices and social acceptability.

- Public authorities should support professional associations. Since the weak spot of structures such as professional associations is usually their limited financial capacity, administrative authorities should have public grants at their disposal.

- Professional associations should be created at a local level, with the intention of joining organizations at a higher level. The creation of a professional association at the local level provides an immediate basis for the identification of common topics and problems. However, there also exist common problems and challenges at higher territorial levels, such as the Mediterranean region, that can only be dealt with effectively through higher-ranking organizations such as federations.

- All producers should have the opportunity to join and participate in an association. Membership of a professional association must be open to all producers, regardless of their production volume, type of farming or location, and all members must have the right to participate and vote.

Sectoral overview by aquaculture producers' organizations

Algeria

In Algeria, aquaculture producers and fishermen are organized in the Algerian Chamber of Fishing and Aquaculture (CAPA). At the local level, CAPA is represented by 21 provincial or inter-provincial fishing and aquaculture chambers. These are public industrial and commercial bodies with legal status and financial autonomy. They are placed under the supervision of the minister responsible for fisheries. Their organization, functioning and missions are governed by an Executive Decree (No.- 02-304).

The role of CAPA includes:

- Representing and defending the social and professional interests of its members;
- Submitting proposals and opinions regarding the development of fishing and aquaculture activities to the administrative authority responsible for fisheries;
- Organizing and developing various forms of dialogue, coordination and information-sharing among its members;
- Working to build closer links between its members and institutions and bodies active in the production, financing, supply, distribution, marketing and processing of fishing and aquaculture products;
- Establishing relations and undertaking cooperation and exchange activities with foreign organizations of a similar nature or that pursue the same objectives;

- Creating, developing and managing commercial and industrial infrastructures.

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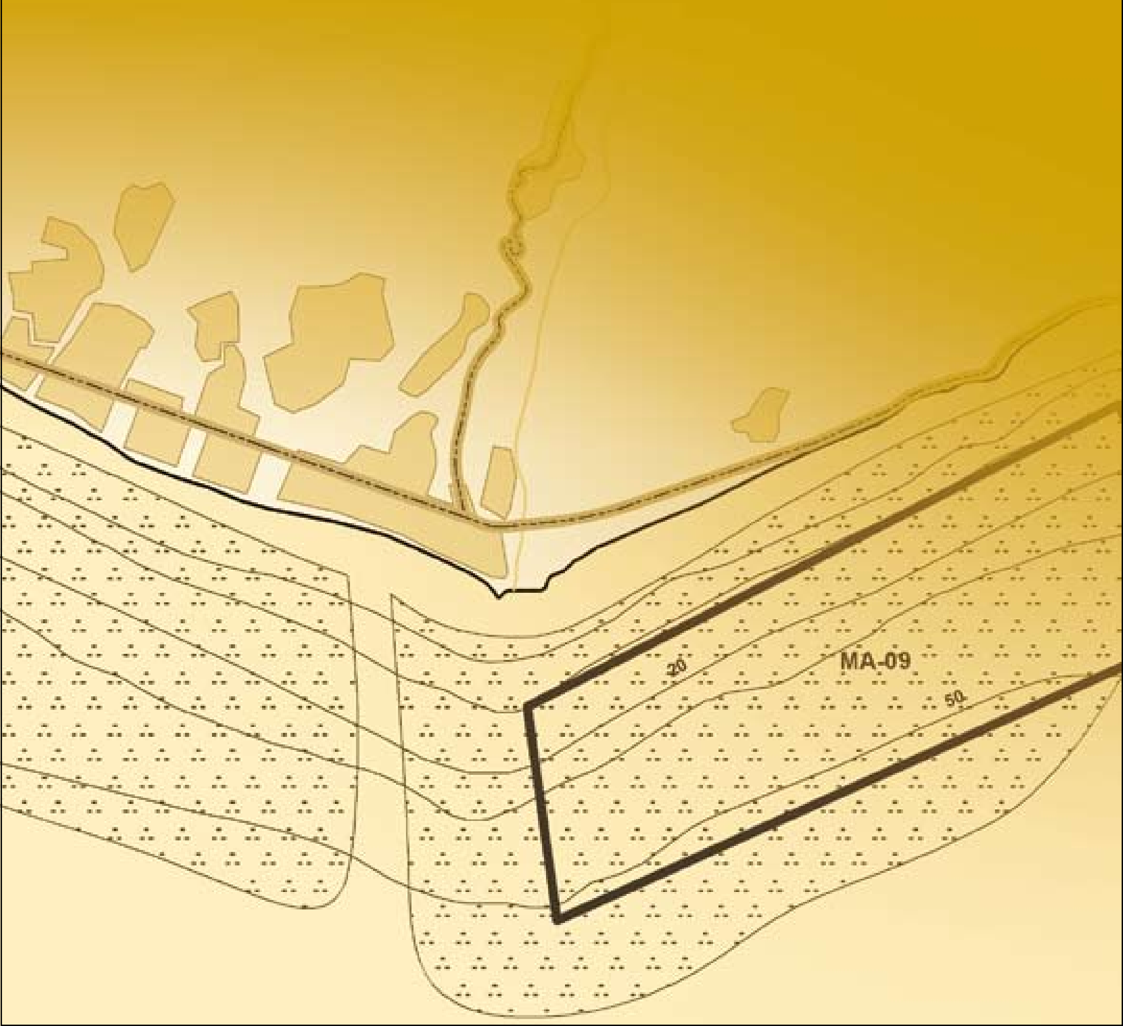
The structure of the Algerian Chamber of Fishing and Aquaculture comprises: the general assembly, the president, the board, technical committees and the executive director. The provincial or inter-provincial chambers are made up of full members and associate members. Full members (representatives of fishing and aquaculture cooperatives, representatives of trade associations, and professionals) have voting rights. Associate members participate in the work of the bodies of the Chamber, without having voting rights; they are local-level representatives of the administrative authorities and organizations whose work is related to the activities of CAPA. The list of members is fixed by an order of the minister responsible for fisheries.



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Integrated coastal zone management (ICZM)

This guide highlights the need to take all the stakeholders involved in a particular coastal area into consideration in order to ensure that the diverse frameworks and processes occurring in the zone are properly implemented. In this sense, integrated coastal zone management can facilitate aquaculture site selection and site management and its further sustainable development.

In a number of sectors such as fisheries and aquaculture, existing management efforts do not respond adequately to the scope and speed of the changes induced by environmental events like climate change or natural disasters. Furthermore, the increasing concentration of urban conglomerations, industry and tourism development lead to coastal modification as well as water quality changes. The consequent environmental degradation and resource depletion in coastal areas will have economic repercussions for sectors directly associated with the marine ecosystem and will also threaten human health and well-being.

In connection with the development of aquaculture, such environmental pressure can make the process of site selection and site management quite difficult and can hinder its sustainable development because of the activity's high dependency on a healthy ecosystem.

Individual management efforts undertaken by sectors depending directly on the marine ecosystem, like fisheries or aquaculture, may no longer be sufficient to respond to the rapid changes occurring in catchment areas or coastal zones. Thus, when the usual methods no longer result in the desired outcomes, it makes sense to look for new approaches, preferably with a comprehensive and adaptive outlook.

Integrated coastal zone management (ICZM) lies at the crossroads of different management strategies and could ensure that the diverse frameworks and processes within a specific area are properly implemented. ICZM is a dynamic process which promotes the sustainable management of coastal zones and seeks to balance the environmental, social and economic dimensions of sustainable development within the limits set by the area's natural characteristics and carrying capacity. However, the ecosystem services that provide the basis of life for fish, birds, marine mammals and humanity itself are transboundary in character, typically cutting across existing political and jurisdictional boundaries and thus subject to multiple management systems.

The objective of ICZM is to properly take into consideration all policies, sectors and, as far as possible, individual interests, involving all coastal stakeholders in a participatory way. Aspects like ecosystem conservation and economic development are also taken into account.

In such a process, governance and reliable knowledge to support decision making are considered the two main pillars. Past experience has demonstrated that the development of new governance methods for coastal ecosystems can no longer be the outcome of a single, isolated strategy, but rather the result of an ensemble of them linked to ecological, socioeconomic and cultural aspects of the region. The strength of governance not only resides in its proper plurality but also in its adaptability to changing processes in a given area. Management also has to adapt to permanent changes exerted by the socioeconomic system and their consequent impacts on the ecosystem. Such flexibility can only be achieved through stakeholders' sense of accountability, regardless of the scale of governance (from local to global).

ICZM is a learning process which must be used with caution due to its experimental nature, and which also needs to become more widespread in order to be globally implemented in an increasingly effective way.

In any field, including aquaculture development, the management process can only be efficient and effective when it is grounded in sustained learning that connects current and proposed actions to a thorough appreciation of what has succeeded and what has failed in previous management cycles in a given place. However, experiments must have controls. Without them, it is difficult to prove whether the variables that are being examined are the cause of the outcomes observed.

In the Mediterranean, the major ICZM issues of regional concern include:

- Uncontrolled urban growth in areas near the coast: constructions have major impacts on natural coastal habitats and completely modify the land use structure as well as the catchment area or coastal zone directly linked to it;

- The impact of tourism: the Mediterranean is a popular holiday destination, attracting approximately one-third of global tourism, with the consequences that such popularity brings;

- The impact on coastal waters of land-based and coastal activities: rivers bring down a load of polluting elements from urban, industrial and agricultural discharges upstream, which add to the pollution and pressure generated by activities directly linked to the coastal and marine area;

- Loss of marine and coastal biodiversity: in the Mediterranean Basin, this is directly linked to habitat destruction, pollution, intensive exploitation and the introduction of alien species.

Coastal zones are of prime importance for economic growth, livelihoods and quality of life and must therefore be managed sustainably. Despite this, policy and legislation often lack an integrated view of the coastal resources and uses affecting the development of the aquaculture sector.

The implementation of ICZM should be a long-term process, facilitating the integration of aquaculture in a given area where resources are already used by other sectors. This process should be clear and transparent, taking into account social, environmental and economic aspects. However, it is worth noting that the lack of financing mechanisms to secure contributions from stakeholders and beneficiaries is often a hindrance to sustaining any ICZM process.

Considering the urgent need for action, the Barcelona Convention Contracting Parties have prepared a comprehensive ICZM Protocol with principles, objectives and actions to be applied at regional, national and local levels. By August 2008, 14 Mediterranean countries had signed this protocol.

On the European side, the 2002 ICZM Recommendation has recently been reinforced in the framework of the European Maritime Policy and its new Marine Strategy Directive, promoting an ecosystem-based scientific approach to management.

There is increasing awareness of the need for Integrated Coastal Zone Management for sustainable socio-ecosystem development, whereby environment, society and economy will be better balanced for the benefit of human well-being.

Justification

Individual management efforts undertaken by sectors have shown that sustainable development can no longer be achieved in that way, especially for recent activities such as aquaculture that need to be integrated with an ecosystem that is already under pressure in order to meet their development objectives. Aquaculture site selection and site management can be facilitated through Integrated Coastal Zone Management (ICZM), which is an adaptive process based on two main pillars, namely clear and transparent governance and thorough knowledge to support decision making.

Principle

In the process of site selection and site management for aquaculture, Integrated Coastal Zone Management (ICZM) represents a new form of governance that should be implemented.

Guidelines

- A preliminary study exploring each sector's needs in a given area should be implemented. Aquaculture must be seen as one of several activities that use the same marine ecosystem, the development of which requires a search for new sites.

- A thorough understanding of existing and potential interactions that affect the different activities and resources in the area and how they are likely to develop over time is needed in order to integrate aquaculture with the others. Management efforts can no longer be carried out individually by different sectors using the same marine ecosystem. It is necessary to encourage benefits from complementary interactions and to find ways of limiting antagonistic ones.

- The costs and benefits of all activities, including aquaculture, should be identified in order to take into account their beneficial as well as harmful effects on other activities. It is important from an economic point of view to be aware of the direct and/or indirect impacts that may result from such coexistence. Integrated Coastal Zone Management is an adaptive, never-ending process.

- Relevant ICZM elements in the legal framework should be identified and improved. Traditionally, pieces of legislation may be produced for individual sectors. To integrate the various sectors using the same marine ecosystem as aquaculture, it is necessary to give the existing legal framework a broader outlook to allow them to coexist on a legal basis.

- National experiences with such an experimental process as ICZM applied to aquaculture site selection and site management should be shared globally. This information may be helpful on the one hand to countries whose ICZM capabilities are just emerging and on the other to countries which already apply ICZM yet require further information about the process.

- ICZM activities should be well financed in order to uphold and allow further sustainable development of sectors such as aquaculture. Effective coastal zone management requires regular financing in order to support its ongoing ICZM process, the objective of which is to take all the stakeholders into account, including the aquaculture sector.

The Protocol on Integrated Coastal Zone Management in the Mediterranean[5]

A new Protocol on Integrated Coastal Zone Management (ICZM) was signed in Madrid on 21 January 2008 at the Conference of the Plenipotentiaries on the Integrated Coastal Zone Management Protocol (PAP/RAC, 2007). Fourteen Contracting Parties to the Barcelona Convention signed the Protocol at the Conference, and the others announced they would do so in the very near future. The Parties are now urged to ratify the protocol so that it enters into force as soon as possible. The signing of the protocol came after a six-year process of consultation, negotiation and refinement on the protocol layout and dedicated work by all the Parties.

The ICZM Protocol is the seventh protocol in the framework of the Barcelona Convention and represents a crucial milestone in the history of the Mediterranean Action Plan (MAP). It completes the set of Protocols for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. It will enable the Mediterranean countries to better manage and protect their coastal zones, as well as to deal with emerging environmental challenges affecting the coast, such as climate change.

[5] The Protocol on Integrated Coastal Zone Management in the Mediterranean is available on the PAP/RAC web site: http://www.pap-thecoastcentre.org/itl_public.php?public_id=314&lang=en.

This protocol is the only legal instrument on ICZM in the entire international community and could serve as a model for other regional seas.

The ICZM Protocol text is:

- Precursory, representing innovation in international law, since there is no precedent of regional initiatives;
- Forward-looking and proactive, aiming at preventing and not only reacting to coastal problems;
- Comprehensive, covering all issues crucial for the coastal environment and its protection in the 21st century;
- Integrated, ensuring institutional coordination at national, regional and local levels, involving non-governmental organizations and other competent organizations as well as integrating sea and land areas.

The text of the protocol emphasizes that the Parties shall define a common regional framework for integrated management of the Mediterranean coastal zone and shall take the necessary measures to strengthen regional cooperation for this purpose. The responsibility of the Mediterranean countries is to ratify and implement the ICZM Protocol. The MAP is ready to assist them in that endeavour. Countries should develop their national ICZM strategies as a basis for all other ICZM activities, and prepare coastal implementation plans and programmes.

The protocol should ensure the sustainable development of the coastal zone, the sustainable use of natural resources and the integrity of coastal ecosystems, landscapes and geomorphology. It should protect the coastal zone and prevent the effects of natural hazards, and achieve coherence between public and private initiatives.

The protocol is very precise regarding:

- Its definition of the coastal zone as '... 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';

- Its determination of setback as '... a zone where construction is not allowed. Taking into account ... the areas directly and negatively affected by climate change and natural risks, this zone may not be less than 100 meters in width', but it allows for the possibility of adapting that;

- The formulation and development of coastal strategies, and also land-use strategies, plans and programmes covering urban development and socioeconomic activities, as well as other relevant sectoral policies;

- The formulation of environmental impact assessments for public and private projects, and strategic environmental assessments for plans and programmes which affect the coastal zone;

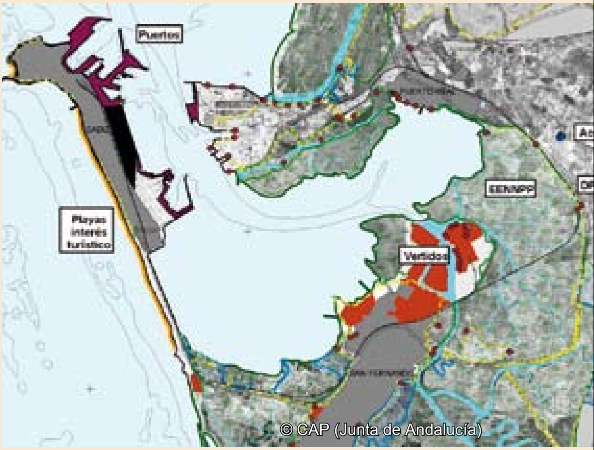
- The development of policies for preventing natural hazards, particularly those resulting from climate change;

- The application of the ecosystems approach to coastal planning and management so as to ensure the sustainable development of coastal zones, taking into account the individual characteristics of coastal ecosystems, in order to preserve coastal natural habitats, natural resources and ecosystems, as well as landscapes;

- Mechanisms for reporting on the implementation of the protocol, including measures taken, their effectiveness and the problems encountered during their implementation.

The site selection process

This guide provides a method for site selection, taking into account all the aspects needed to achieve the sustainable development of Mediterranean aquaculture. Key aspects, concepts and terminology are explained and special attention is given to the sequence of the process itself. The guide includes a basic list of parameters to be studied and mapped as well as a practical example in Spain.



The selection of sites for aquaculture constitutes a technical and administrative procedure aimed at establishing areas of interest for the development of this activity on the basis of sectoral and spatial analysis. By technical procedure we mean those matters, whether socioeconomic, environmental or technological, that require scientific applications.

An area of interest for aquaculture is one where it is appropriate to install an aquatic activity that is compatible with the ecosystem, socially acceptable and economically feasible, thus complying with the objectives of sustainable development. To achieve this goal, in addition to appropriate environmental conditions for the development of marine farming, possible administrative incompatibilities or interference with other activities must also be taken into account.

A positive aspect of the development of aquaculture is the supply of marine products. As a productive activity it has special requirements, which include technological progress, optimization of production procedures, marketing improvements and above all the need for suitable available areas in which it can be established.

Marine aquaculture activities are usually established in coastal areas, which are considered part of the public domain; in other words such areas are state owned. These coastal areas where aquaculture seeks sites in which to expand its activities are also subject to a great deal of pressure from many different interests and other priorities in respect of their use.

As a consequence, the scenario for aquaculture site selection in the Mediterranean basin is highly varied due to the circumstances of each region. The relatively recent development of aquaculture, the need to integrate it with existing activities, the availability of natural resources, and government priorities based on sources of wealth and employment are limiting factors that make the process more difficult.

These aspects were highlighted in 2000 in the Communication from the Commission to the Council and the European Parliament on 'Integrated coastal zone management: a strategy for Europe' (COM/2000/0547), which analysed the strategic importance of coastal planning for Europe and the rest of the world. The document examined the physical and biological problems of coastal areas and pointed out that in many cases they gave rise to others of a social nature, stressing, amongst other points, that 'the low availability of sites for aquaculture as a result of allocation of space for other uses constitutes a significant limiting factor on the expansion of this activity.'

The Communication from the Commission to the Council and the European Parliament regarding 'A strategy for the sustainable development of European aquaculture' (COM/2002/0511) was published in 2002. In this communication, the challenges that are highlighted include 'competition for space'. The recent growth of aquaculture, particularly in coastal regions where large numbers of activities already exist, has made it a newcomer that is disrupting the status quo established by existing users.

One of the objectives highlighted, however, is sustainable economic development, and in this sense coastal areas that depend on fishing currently require new activities to generate wealth and employment as a result of the ongoing decline of extractive fisheries. Consequently, the problem of space for aquaculture has to be dealt with in a comprehensive, sustainable and orderly manner. Studies geared to locating, identifying and determining areas of interest for marine farming must therefore be carried out on the basis of the principles established by the European Commission for integrated management.

The purpose of area selection is to obtain complete and relevant information to enable the orderly and adequate development of aquaculture. This information will supplement other information that companies and entrepreneurs have, enabling them to find the best sites in which to install their aquaculture facilities. In addition, it will be a tool for administrations to plan the activity and establish areas of interest.

Thus, the general objective of the site selection process is to provide a knowledge-based instrument to help administrative authorities and other decision-making bodies in planning and developing this activity.

Methodology: key aspects and concepts

In the process of site selection, certain basic factors must be taken into consideration in decision making, including the following parameters.

a. Scope

In location studies, the spatial context is an aspect that must be taken into account because it will determine how deeply the study parameters are analysed and whether or not it is appropriate to make specific aquaculture proposals for particular areas, or, in other words, whether development plans should be drawn up.

Thus, from a spatial point of view, the selection of sites of interest for aquaculture can be carried out at:

- Regional level, where most of the information will be of a technical-administrative nature, i.e. identification of uses, activities and occupations, without too much detail on the socioeconomic and environmental analysis or farming proposals;

- Provincial or sub-regional level, where more abundant environmental and socioeconomic information should be obtained to allow for more detailed site selection. However, depending on the size of the areas studied, certain parameters may be studied in greater detail than others. At this level, farming proposals may be general and non-specific;

- Local level, where the technical-administrative and environmental spheres must be analysed in detail in order to specify all the limiting factors or priorities that will determine if the area under consideration is suitable for different types of farming. At this level, farming proposals or proposals of use will be suitable, objective and appropriate to actual measurements.

Other aspects that should also be taken into account in the site selection process are the following:

- Identifying the information needed on the areas and the activities to be carried out;

- Specifying the appropriate spatial and temporal context;

- Designing a plan to obtain appropriate information on existing needs and available resources.

b. Terminology

The terms to be used in the work of locating and selecting sites for aquaculture should be defined before starting. These terms include the following:

- Suitable areas, excluded areas, or areas with limitations;

- Suitable or unsuitable areas;

- Areas of interest: high, average or low.

Of all these terms, the most appropriate one to define the areas we are looking for in the site selection process is 'areas of interest', since the others could lead to misunderstandings on the part of the final users of the information.

c. Spatial analysis

Current aquaculture activities in Mediterranean countries are usually carried out in three different types of location, and the selection of areas of interest must bear in mind the difficulties inherent to each type:

- Inland aquaculture (in wetlands, estuaries or inland)
  The analysis of this type of area is more complex due to the large number of uses and forms of occupation that may exist, together with the variety of urban development plans implemented by the different administrative authorities responsible for such areas.

- Coastal aquaculture (marine facilities near the shore)
  The greatest concentration of use of the coast is found in these areas, although normally the number of activities is lower than inland. This coastal area comprises depths that range from 20 to 50 metres. Closeness to the shore and shallow water imply a greater concentration of uses, as this is the area traditionally used for tourism, coastal navigation, etc.

- Open-sea aquaculture
  This is aquaculture carried out in exposed areas offshore (more than 3 nautical miles from the coast), and also includes floating or semi-submerged shellfish and fish farming systems. In these areas there is much less interference from other uses, since they are farther from shore and therefore more difficult to reach, and have more complex environmental and oceanographic conditions. On the other hand, obtaining environmental information about these areas is more difficult and more expensive, which is why they are often less well known.

d. Study of parameters

In view of the scarcity of information regarding marine environments and the costs involved, the parameters of the following two spheres should be studied, in addition to other more general or basic descriptive parameters:

- The technical-administrative sphere, in which all the interferences of use which may arise in the area in which we seek to develop aquaculture are analysed;

- The technical-environmental sphere, in which the water mass and seabed where the aquaculture activity is to be located are studied.

This division, which enables us to have a more complete view of what happens in the area under study, also helps to optimize the in-depth analysis of certain aspects, since a pre-selection can be made once the analysis of the administrative sphere has finished.

A minimum number of appropriate study parameters should be selected. Once the study area and type of aquaculture to be developed have been decided, it is important to select the best parameters while weighing the material and financial resources needed to work with them against the benefits or the quantity and quality of information to be obtained from them.

The most important parameters to study will depend directly on the characteristics of the site in question, on how urgently the data are required and on the type of aquaculture to be developed. The site characteristics to be examined, aside from those relating to the environment, include the traditional activities carried out in the area, interference with other activities in terms of use, and the particular socioeconomic elements present.

The parameters to take into account will depend on the area chosen for the site location and selection study, but in general terms the most important ones in most cases are the following:

Basic information

The description of the study area will draw on basic information, to which other information or parameters of the study area will subsequently be added. In general terms, this basic information concerns:

- Bathymetry;
- Coastline;
- Basic infrastructures;
- Population centres (towns and villages) and provinces.

Administrative sphere

Once the basic information has been obtained, parameters are analysed from an administrative point of view; in other words, the uses, activities or forms of occupation in the area that could interfere with aquaculture are studied. These parameters will depend directly on the special features of the area of study. In general terms, the following may be considered:

- Port areas or infrastructures;
- Protected areas: natural parks, heritage sites;
- Dumping points and underwater outlets along the coast;
- Areas with underwater cables or conduits;
- Areas of interest for tourism: beaches;
- Underwater areas of archaeological interest;
- Traditional fishing areas;
- Artificial reefs;
- Other aquaculture facilities;
- Vessel anchorage areas;
- Areas of military interest;
- Others: e.g. in some Mediterranean countries such as Spain, areas with sand deposits are delimited so that the sand can be used to regenerate eroded beaches.

Environmental sphere

In this second stage, once sufficient information has been obtained regarding possible interferences of use, it will be easier to demarcate the area where the aquaculture facilities are to be located. At this stage it is essential to have information on current environmental conditions, for two major reasons:

- To assess the technical and biological feasibility of the farming;

- To understand the natural surroundings and their value in order to objectively assess potential effects on the farming;

Furthermore, this will make it possible to design objective environmental surveillance programmes that are appropriate for the type of environment described.

The number of environmental parameters to be studied and the detail in which they are analysed will mainly depend on the area under consideration, on the type of aquaculture to be carried out and obviously, on the financial budget available for the study.

In general, the parameters of greatest interest are the following, grouped by category:

Climate	Water quality	Seabed	Oceanographic conditions
Temperatures: max., min., average Wind speed: average values Wind direction: average values Precipitation Evaporation	Oxygen profile Salinity Chlorophyll Average temperature Solids in suspension Nutrients (NH_4, etc.)	Granulometry Organic matter Concentrations Biological factors: benthic fauna Redox potential	Significant wave height and return period Currents: speed and direction Coastal dynamics Hydrodynamic model

Obviously, this series of parameters will have to be adapted to what is foreseen for the area under study, in other words the type and level of aquaculture farming to be developed.

e. Demarcation of the study area

Once the information above has been obtained, it is important to spatially delimit the study area, bearing in mind what type of facilities and production are planned, the type of aquaculture existing in the area, the statutory context, the environmental conditions and the social and economic context.

With regard to the last of these aspects, it is highly relevant to analyse how aquaculture can contribute socially to the development of coastal areas that depend on fishing, by generating employment and activities connected to the traditional exploitation of the sea. Aquaculture has usually been considered an activity that can and must absorb workers from extractive fishing, which is why this analysis is so important.

This spatial demarcation will also be affected by the interests of the administrative authority or body that carries out the site selection study and by the presence of different geomorphologic units, and in one way or another by all the other parameters mentioned above.

This stage of the study can be divided into three parts, as follows:

- Methodological aspects. The main methodological aspects relate to the geographical information system (GIS) tool, and it is necessary to know how the system works, its applications and the means provided to map the information. GIS is very useful as a tool to locate, describe, identify and select areas of interest for aquaculture. It is relatively easy to use, but during the mapping process other factors will have a direct impact on the applicability of the maps obtained.

- Establishing criteria. Establishing the mapping criteria is as important as mastering the GIS technique. These criteria will relate directly to the information provided by the different authorities, together with the project objectives and the factors determining the procedure. The criteria will be divided into two groups: administrative criteria and environmental criteria.

- Thematic mapping. This is the map construction phase and can be a relatively easy process or a very complex one, depending on the level of information provided by the agents involved but above all on the manner in which said information is provided. In this sense, the necessary information must be either collected or generated. In the first case, it can be found as follows:

- On paper without georeferencing (it will therefore need to be georeferenced and digitized);
- On paper and georeferenced (it will have to be digitized);
- In digital format and georeferenced (as GIS-ready layers).

In the second case, if the information has to be generated, work guidelines will have to be drawn up and the collection and georeferencing (establishing the system of coordinates, etc.) of data will have to be well planned.

f. Farming proposals and management programmes

The project or aquaculture site location and selection study finishes with a series of data and cartographic information that will be used to plan and organize the activity in a specific geographical area. This information can be used in different ways: in publishing and disseminating the results, or in developing regulations governing the occupation of the areas selected. In both cases, regulation and dissemination, this information must be supplemented with development and management plans for these areas, aiming at the orderly occupation of the site and the planned development of the activity.

These plans must lay down the type of aquaculture and species (including carrying capacity), environmental surveillance programmes, marking with buoys and signs, the collective management of services (changing nets, feeding, surveillance, etc.), and sanitary management.

Justification

Locating and identifying areas of interest or areas that are suitable for aquaculture is a key factor in ensuring the sustainable development of this sector in the Mediterranean. The process facilitates administrative procedures, saves time and money, and allows for better management and forecasting of growth. To achieve this, a suitable methodology should be developed, taking into account all the necessary aspects to be dealt with sequentially.

A large amount of spatial, environmental and sectoral information is collected throughout the process, which can be mapped and interpreted by means of GIS to facilitate an analysis of the potential and possibilities for growth and interactions with other uses. The amount and quality of the information collected and mapped will depend on the expected results and the established needs. The process thus becomes a management and information tool for the administrative authorities and the sector itself.

Principle

A clear and sequential site selection process should be put in place in order to ensure sustainable aquaculture.

Guidelines

- Site selection should depend on the aquaculture activity planned and the existing environmental conditions. In designing a process, all limiting factors or priorities that could interfere with the proposed objective of selecting sites for the sustainable development of aquaculture must be taken into account.

- The scale factor should be applied in order to size the project, taking into account the degree of detail required and the budget available for the process. The material and financial resources required to carry out a site selection process should be considered in terms of balancing investment against expected results.

- The methodology to be used in a site selection process should begin with a sectoral analysis and the identification of needs. The sectoral analysis must provide information on the type and size of aquaculture planned. This information will be essential in order to identify the best parameters for the study, the agents involved and the project's scope.

- The study methodology should preferably be selective and dynamic. Administrative factors should be addressed first due to possible incompatibilities with other uses and to select and focus on the environmental factors to study. The process should be dynamic, so that information obtained is progressively interpreted and added to allow for feedback and updating.

- The choice of parameters should directly relate to the statutory context in force for the aquatic activity in the study area. The parameters selected for the study should be the main basis for determining the suitability of the area and should include those that interfere directly or indirectly with the planned activity.

- The site selection method should include the chronological sequence of actions required to carry out the study within the expected timeframe. A schedule should be established for the collection of information, map development, consultation and validation by agents, final results and mapping.

- The results of site selection processes should be mapped at a scale and in a format that can be easily read and interpreted. The information obtained and its interpretation must be represented graphically and be intelligible to the general public.

Example of Barbate and Costa da Morte

The geographical context of the project comprises two different regions of Spain, the municipality of Barbate, located in Cadiz province on the southern Atlantic coast of Andalusia, and the municipalities along the Costa da Morte, located in A Coruña province on the north-western Atlantic coast of Galicia. The places selected for the study are areas that have traditionally depended on fishing and have strong links with the sea, and where proposed new activities such as aquaculture could bring new employment opportunities and socioeconomic progress for the local population.

The general aim of the project is to create local employment and business development by promoting the sustainable growth of the aquaculture sector. This will be done by identifying suitable areas for aquaculture development by means of the integrated planning of coastal areas, supported by geographical information systems (GIS).

The identification and location of areas of interest for aquaculture requires a large amount of spatial, environmental and sectoral information, which, once it has been mapped and interpreted, will enable us to analyse the various possibilities of sectoral development. To support and complement the spatial analysis, we described the environment of the areas studied, analysed the socioeconomic context and also examined current and recent aquaculture experience.

The methodology used in this pilot project was structured as follows:

1. Identification of needs
2. Analysis of the aquaculture sector
3. Analysis of the statutory context
4. Environmental description of the surroundings
5. Description of the socioeconomic context
6. Spatial analysis and delimitation of the study area
7. Selection of study parameters
8. Identification of agents involved
9. Field work and information collection
10. Preparation of preliminary maps
11. Consultations and validation of areas
12. Definitive maps
13. Proposal of aquatic activities
14. Drafting of a management and monitoring plan.

The cartographical information generated is based on the aquaculture activity, available space, uses and activities, and the legal framework, together with the criteria obtained from the interviews.

In the identification of areas of interest, we found a number of locations where aquaculture could be developed since they complied with the technical-environmental requirements and showed no incompatibilities with administrative or other uses.

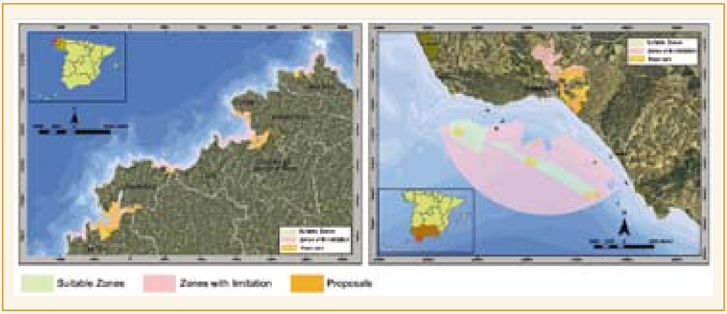


Figure N.1. Thematic mapping of zones and proposed aquaculture sites: Barbate (left) and Costa da Morte (right).

In addition, a series of specific aquaculture proposals were made for those areas, including the most appropriate type of activity, the level of investment and production, and the type of development, the objective being to offer different types of activities for different types of potential entrepreneurs.

The ecosystem approach

This guide promotes the application of the ecosystem approach for managing the impacts of human activities on the ecosystem, with the aim of optimizing its use without damaging it. It would therefore be more accurate to call it an ecosystem-based approach to integrated management (EBM). It is a step-by-step management tool based on the best available scientific, traditional and local knowledge on the ecosystem and complies with the 12 principles recommended by the Conference of the Parties to the Convention on Biological Diversity.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The ecosystem approach is a tool for the integrated management of human activities, based on the protection of land, water and living resources; it is a strategy that promotes conservation and sustainable use of the ecosystem in an equitable way. It has been called for by decision makers as a result of the failure of previous strategies to manage human activities, because most of humankind depends upon the ecosystem for their livelihood, whichever ecosystem component it may be (lands, forests, wetlands, seas and oceans).

The ecosystem approach is based on the best available scientific knowledge on the ecosystem in order to identify and take action on stressors which are critical to the health of marine ecosystems (EU Marine Strategy Stakeholder Workshop, Denmark, 2002). Accordingly, the precautionary approach and its operational tool, the Risk

Management Framework (RMF), are nested within the strategy. Therefore, it does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it by managing the impacts of human activities, thereby achieving the sustainable use of ecosystem goods and services and the maintenance of ecosystem health and integrity.

In 1972, the United Nations Conference on the Human Environment (UNCHE or Stockholm Conference: UN 1972)[6] first expressed the notion that environmental aspects are a right for humanity, focusing on the great ability of humankind to modify the natural environment through development.

The ecosystem approach was pointed out as a management tool within the United Nations Convention on Biological Diversity (CBD) in 1992[7]. There was a particular focus on actions related to the marine environment during the Jakarta meeting of the CBD in 1995[8], addressing the issue of species decline in terms of both abundance and richness. The importance of ecosystem considerations was forcefully recalled at the Johannesburg World Summit on Sustainable Development in 2002 (WSSD, guide IV of the Johannesburg Plan of Implementation: UN 2002)[9], when the recommended timelines for the implementation of the ecosystem approach covered the 2005–2012 period.

There is a need to address all the impacts of human activities on the marine environment at the same time, whether they are land-based or strictly marine, to maintain the ability of the marine ecosystem to support the development of all these activities. Accordingly, integrated ocean (or broadly marine) management (IM), which is based on protecting ecosystem targets, certainly represents an improvement to managing human activities in a sustainable manner. However, this is not a panacea and the process requires further development. Prior to

[6] Conference on the Human Environment. United Nations Environment Programme. Final report available at http://www.unep.org/Documents/Default.asp?DocumentID=97.
[7] CBD website: http://www.cbd.int/
[8] The Jakarta Mandate on Marine and Coastal Biodiversity: http://www.cbd.int/doc/meetings/cop/cop-02/official/cop-02-19-en.doc
[9] World Summit on Sustainable Development WSSD. Johannesburg Plan of Implementation. Guide IV, 'Protecting and managing the natural resource base of economic and social development'. United Nations, 2002. Available at http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIGuide4.htm

specifically addressing the ecosystem approach, it should be noted that the ecosystem approach does not mean managing the ecosystem, but managing the impacts of human activities on the ecosystem. Therefore, to avoid any confusion, it is better to talk about an ecosystem-based approach to integrated management (EBM) rather than just ecosystem management.

The EBM approach aims to achieve sustainability and particularly to deal with the following properties of an ecosystem:

- The health of the ecosystem, as its ability to preserve its own functions;
- Resistance, as the ability to withstand change;
- Resilience, as the ability to recover its previous state after change.

The ecosystem-based approach to integrated management (EBM)

EBM considers all activities together as a body, in order to take into account interactions between activities as well as their cumulative effects. In the classical framework, the process should first identify key ecosystem components that need particular attention, and then address activities that potentially impact these components.

EBM complies with the 12 principles recommended in 2000 by the Conference of the Parties to the Convention on Biological Diversity[10]:

1. The management of land, water and living resources should be determined through negotiations and trade-offs among all the stakeholders involved with their different perceptions, interests and intentions.
2. Decisions should be made by those who represent the appropriate communities of interest and management undertaken by those with the capacity to implement the decisions in a decentralized system. The closer management and decisions are to the ecosystem, the greater are the responsibility, ownership, participation, and use

[10] SBSTTA 5 Recommendation V/10, available online at http://www.cbd.int/recommendations/?m=SBSTTA-05&id=7027&lg=0

of local knowledge. It is a matter of balance between local interests and the wider public interest.

3. As ecosystems are not closed systems, but rather open and often connected to others, ecosystem managers should consider the impacts of their activities from a local to a broader scale.
4. Many ecosystems provide human beings with economically valuable goods and services. Because often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs such as polluters escape responsibility, alignment of incentives should promote biodiversity conservation and sustainable use.
5. The priority target of the ecosystem approach should be the conservation of ecosystem structure and function and ,if necessary, their restoration in order to maintain ecosystem goods and services in the long term.
6. Ecosystems must be managed within the natural limits in which they function. Attention should be given to the environmental conditions that limit natural productivity and ecosystem structure, functioning and diversity, through appropriately cautious management in order to preserve a sustainable ecosystem.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales in order to address issues relating to the dynamic character of ecosystems.
8. Ecosystem management requires a long-term view because of the varying temporal scales and lag-effects that characterize ecosystem processes. Ecosystem goods and services should not be perceived as short-term gains.
9. Management must recognise that change in the ecosystem is both natural and inevitable and must utilize adaptive methods to anticipate and cope with such changes, while being cautious in remaining open to different options.
10. The ecosystem approach should seek a balance between conservation and wise use of ecosystem goods and services.
11. The ecosystem approach needs to be comprehensive and therefore it should consider all forms of relevant information,

including scientific, indigenous and local knowledge, as well as innovative practices.

12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines at all levels: local, national, regional and international.

Though its principles are very attractive, their implementation raises some serious concerns. Consequently, the IUCN has undertaken many initiatives to make the EBM strategy operational; in particular, its Commission on Ecosystem Management (CEM) has drafted a document specifying five practical steps that bring together the 12 principles:

1. Area and key stakeholders (principles 1, 7, 11,- and 12);
2. Ecosystem structure, function, health and management (principles 2, 5, 6,- and 10);
3. Economic issues (principle 4);
4. Adaptive management over space: impact on adjacent ecosystems (principles 3 and 7);
5. Adaptive management over time: long-term goals and flexible ways ofreaching them (principles 7, 8,- and 9).

Whatever the process implemented to achieve the EBM approach, its principles and main rules are similar, particularly the need for information and accordingly the involvement of scientists to feed the process. Moreover, because EBM is a management tool, it entails several necessary procedures such as:

- The participation of all stakeholders in order to share both the onus of the decisions and the potential benefits derived from good management practices;

- A technical mechanism to inform all stakeholders in a transparent way;

- An adaptive ('learning by doing') process based on feedback provided from monitoring (once implemented);

- A communication tool to seek consensual decisions or fair decision-making process;

- The use of the precautionary approach built on a risk management framework (RMF), which allows for a risk assessment to be performed within a risk matrix and leads to mitigation measures if necessary.

Operationalizing the EBM approach entails the implementation of several steps, mostly sequential, but simultaneous as well in specific cases. Once the area and stakeholders have been identified by overlaying geological, biological and social and administrative considerations, the state-of-the-art should be established in terms of knowledg, based on the best science available and on traditional and local ecological knowledge,. Then ecosystem and/or conservation objectives can be set. This part of the analysis represents a top-down (ecosystem property-based) process. Once these tools have been produced, actual or projected activities are assessed for their impact on the ecosystem attributes. This is a bottom-up (activity-based) process, and both have to converge on the ecosystem attributes (Figure O.1).

Once ecosystem objectives have been set and functionally important areas identified, activities can be planned and/or assessed if they already exist. Aquaculture site selection often raises problems because much of the time the space is already used for other activities. Moreover, aquaculture's needs (ecological as well as practical and operational ones) are specific and limit the availability of space. Whenever possible, it is best to devote specific areas to aquaculture; this practice is cost-effective for both managers and producers, but it is limited by the carrying capacity of the site and depends on the level of technology available. From a financial and investment point of view, there are thresholds (minimum and maximum) that can help guide aquaculture site selection and assess the most appropriate number of farms.

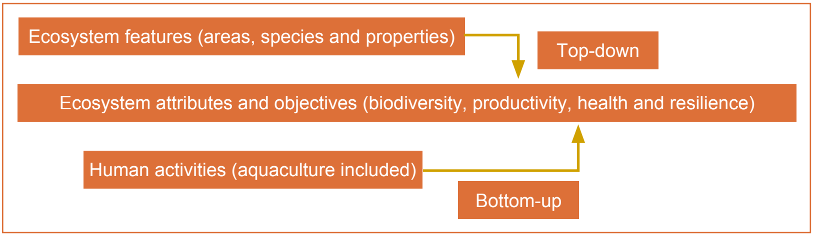


Figure O.1. The top-down and bottom-up processes of the EBM approach

It does not seem very realistic to undertake a large-scale aquaculture planning process for many reasons; first of all, doing so can lead to conflicting situations with other users, especially when for strategic reasons there may be stronger imperatives (such as military, energy or port requirements) or historical reasons, such as fisheries; moreover, some activities are more strongly supported by the public and can develop detrimentally to aquaculture, such as tourism. All such uses are valid but may jeopardise the aim of the project.

As a consequence, it seems more relevant to plan aquaculture sites using other arguments, such as the value they add or the lesser harm they cause to the ecosystem, especially because aquaculture can also improve the quality of a specific site and increase its value. Indeed, these considerations relate to the CBD principles of cost-effectiveness. Accordingly, aquaculture site selection can be carried out in many ways, the most important being that managers must check compliance with ecosystem requirements that are specified with sustainable objectives.

Thus, any solution is welcome so long as ecosystem objectives are set and achieved, because the maintenance of the ecosystem is of global interest.

Conclusion

The EBM approach is becoming generally accepted as classical compartmental marine management fails. It is, however, critical to understand that EBM is not merely a way to protect some ecological features (though that would be enough to justify its use), but also a means to optimize objectives and achieve sustainability. The EBM framework is useful so long as data is available. In this context, one important issue is the nature of the information and its format, so that many different sources of information can be merged. Most of the time, the information provided is a blend of quantitative and qualitative data, and it seems easier to turn it into semi-quantitative variables, because precision in the quantitative data is not mandatory, sometimes difficult to achieve and often illusory.

Addressing aquaculture in a sustainable fashion can be difficult because there is usually no room available for new activities in a busy marine and coastal environment. EBM ensures a voice for the aquaculture industry, placing it on the same level as all other users, and links the interactions between land-based and marine activities at the watershed level.

The EBM approach will certainly lead to improved management and reduce the footprint of human activities; besides, it is the best way to involve local communities and make them more responsible for their future.

Justification

EBM is a powerful tool which takes into account every human activity, including aquaculture, in terms of its possible impact on the ecosystem. This impact may be heavy or light and therefore needs to be assessed. Aquaculture is an integral user of environment goods and services and its development depends on the health of the aquatic ecosystem: the healthier the ecosystem, the more aquaculture can thrive. This may mean that aquaculture, when well managed, can serve not only to protect the ecosystem but also to improve its status and increase its overall added value.

Accordingly, the EBM approach is not a frozen dogmatic framework to protect useless ecosystem components but, on the contrary, it is a living process that enables people to live and benefit from ecosystems.

Principle

Site selection and site management should be addressed within an ecosystem-based approach to integrated management.

Guidelines

- In an ecosystem-based approach to integrated management (EBM), site selection and site management should be based on cause-and-effect relationships between stressors, namely the activity, and impacts, so as to provide information on the state of the ecosystem. Assessment tools, such as Pathways of Effects or Cumulative Effects, can help managers to propose mitigation measures or modifications to activities that have a negative impact on the e cosystem conservation objectives.

- EBM is a management tool which should be implemented at all scales, from local to international, without undergoing changes. The ecosystem approach is a space-based strategy taking into consideration environmental and socioeconomic aspects, with the aim of promoting the conservation and sustainable use of the ecosystem in an equitable way.

- Aquaculture site selection and site management should be addressed with EBM, once the top-down process has been carried out. This will secure the ecosystem attributes and objectives relating to biodiversity, productivity, health and resilience and therefore the sustainable development of any activity depending on them.

The ecosystem-based approach to integrated management as a strategy

a. Operational framework

Implementing an EBM approach entails providing management tools, i.e. social and economic tools, based on ecosystem considerations. Both aspects should be addressed concomitantly but in two separate sets, with bridges and connections between the ecosystem and the socioeconomic features (including cultural considerations). A summary of the process is given in Figure O.2 (next page).

1. Initiate the planning process

Decision makers initiate the EBM process because there is a need to consider all activities that are going on in a specific area and to address the interactions among them. Once the decision has been made, the spatial process begins, based on scientific principles (geological, geographical, and ecological criteria) to identify ecoregions. These ecosystem units are further divided into management units, which overlap administrative boundaries.

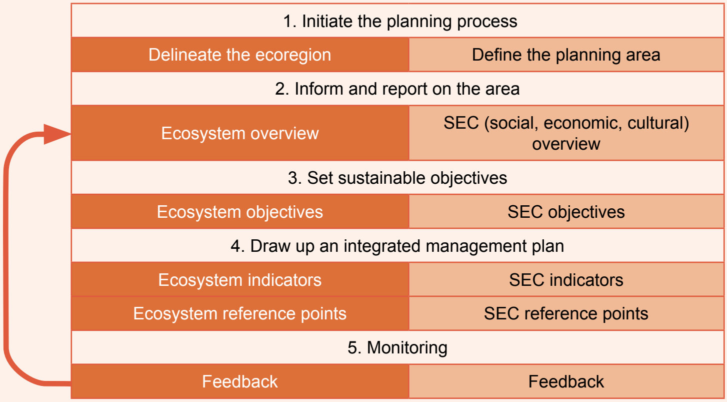


Figure O.2. Main steps of the EBM approach

Once delineated, the borders of the ecoregions, or parts of them, have to be made to match administrative and management boundaries. For this purpose, the most important criteria are the continuity of ecological (physical, chemical and biological) processes on one hand and the ability to share management information on the other.

2. Inform and report on the area

Informing and reporting is a specifically scientific task that also draws on additional information such as traditional or informal knowledge. All the information collected should be summarized in a report covering:

- The geological, biological and ecological characteristics of the area;
- Human activities, including aquaculture, that have an impact on the marine ecosystem.

The report table of contents is a guide for the EBM process on how to organize the information, in order to describe ecosystem features and discuss the environmental issues observed in a given ecoregion. It should be adapted to the study area. Based on the information gathered, the state of the ecosystem should be assessed. However, the informative process is generally lengthy and some areas need more urgent conservation measures. To this end, marine protected areas (MPAs) can be established prior to any supplementary investigation to protect endangered species and their habitat or specific functions of the ecosystem (such as spawning grounds, growth areas and migratory routes). Particularly important areas can be granted specific protected status using the MPA framework straightaway; that does not mean there will be no human activity but, because of their ecological significance, these areas will be managed more strictly.

The same process should be undertaken to identify significant species that play a particular ecological role (such as forage species, nutrient importers/exporters or iconic species). The ecosystem descriptors used for this are ecological indicators, supported by scientific ecological knowledge.

The most important goal at this stage is to identify particular areas and species that play a critical role within the ecosystem (Figure O.3). Once these areas and species have been identified, those that

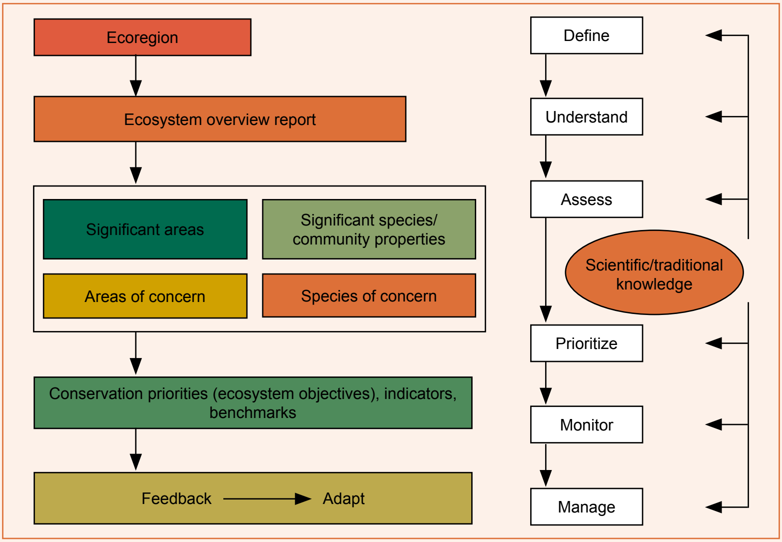


Figure O.3. Main tools to implement the EBM approach related to ecosystem continue to be of environmental concern will perhaps deserve further attention.

Rather than focusing on quantitative parameters, the process is based on a qualitative assessment of the importance of each parameter. This procedure introduces a high degree of subjectivity and variability in scoring a given area; indeed, the aim is to achieve a consensus among practitioners and other interest groups, including scientists, local communities with traditional knowledge, and decision makers aware of what is at stake. Use of a scale varying between low and high can help reduce uncertainty, with each criterion being scored as a semi-quantitative variable. However, this approach entails first weighting each parameter.

3. Set sustainable objectives

Once these particular priority areas are identified, the following step will be to draw up ecosystem (or conservation) objectives. Although this step of establishing objectives will certainly be based on scientific knowledge, it is important to include social and economic considerations at the same time. However, merging ecosystem and social/economic factors is still difficult and, pending the provisions of suitable tools, the two kinds of objective will have to be set separately. Setting conservation objectives based on both modern and traditional knowledge is a critical step towards addressing sustainability.

Conservation objectives comprise three main ecological themes:

- Biodiversity: to conserve sufficient ecosystem components (coastal landscapes, habitats, species, populations, genetic features) to maintain the natural resilience of the ecosystem;

- Productivity: to conserve each component of the ecosystem so that it can play its historial role in the food web;

- Ecosystem characteristics: to conserve the physical and chemical properties of the ecosystem.

These themes will be addressed at several levels, from large-scale landscapes/seascapes down to local habitats.

Once objectives have been set, indicators and benchmarks should be established to validate the process. A risk management framework should be applied to reduce uncertainty caused by natural variability within the ecosystem, also taking into consideration indirect causes of ecosystem-level change, particularly climate change.

The impacts of aquaculture on the aquatic environment are well known (*Interactions between aquaculture and the environment,* IUCN, 2007), and its effects on biodiversity, substratum characteristics and water quality should be reviewed, as well as the food supply from fisheries and the species balance. Forms of aquaculture that rely on reduced (of concern, threatened or collapsed) aquatic resources cannot be considered sustainable. Aquaculture feed is usually based on fishmeal, which in some cases is produced in an unsustainable way. Such an imbalance is unacceptable, unless the species used as feed for fish aquaculture are not otherwise consumed. In other words, aquaculture must be a value added for the capture of fish that are not directly targeted by the market.

Addressing cause-and-effect relationships

Many methods have been explored to address cause-and-effect relationships between stressors and impacts. The main tool is the Driver-Pressure-State-Impact-Response DPSIR model (Figure O.4 next page). It is a complex model addressing many stressors at the same time, but it needs a large supply of information and therefore it is difficult to manage. For that reason, it may be better to use other tools that are less powerful but strong enough to describe the state of the ecosystem, such as the Pathway of Effects (PoE), so as to standardize the process and thus lead to the same conclusions for any given activity. PoEs identify the impact of human activities using three levels. The first level describes the activity responsible for the effect; the second level refers to the stressor, while the final level relates to the impact. To address cumulative impacts a fourth level is added, merging several pathways that have the same impacts. The PoE model is a part of the risk management framework. At this stage, it is critical to carefully engage all stakeholders and define the procedures for sharing the information and the burden of proof.

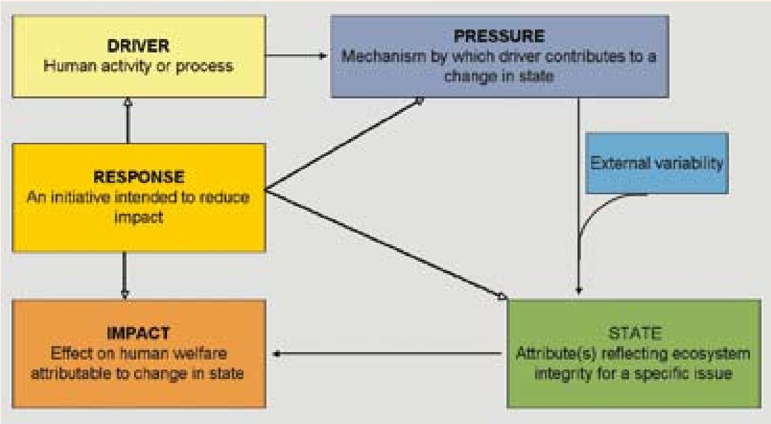


Figure O.4. The DPSIR model

4. Draw up an integrated management plan

This step is both technical and political at the same time. Once the impacts have been assessed and solutions identified, it is critical to count on the participation and support of all stakeholders from the outset, since without it the policy options cannot be implemented. In this context, the following general principles must be applied (see the relevant guides):

- the participatory approach
- the adaptive approach
- social acceptability
- the scale approach

- the use of knowledge
- governance.

Implementing an integrated management plan will depend on the current situation and the frameworks developed by each region or state. There is no single solution, and the process must tie in with existing circumstances and use them as a support mechanism.

5. Monitoring

The following steps will focus on the monitoring of the process and on ways to adapt it to the actual evolution of the ecosystem.

The main issue here is how to link the ecosystem process to the social, cultural and economic factors. Much work remains to be done to build bridges between the two areas to make them consistent. Ideas in this field are still being developed, and solutions are even a little overdue. Some decision makers would like to focus on cultural considerations while others favour attaching more importance to economic and marketing issues. The way that seems most suitable is broader in scope and relates to considerations at society level. Accordingly, there is a need to come up with comprehensive indicators and benchmarks, such as the human well-being indicator. Measuring the connection between society and the ecosystem requires a specific metric, provided by the ecological footprint.

- To be efficient, monitoring will have to comply with two main requirements:
- Ensuring feedback from management measures that have already been implemented;

Developing a framework for adaptive management, i.e. forecast procedures to make adaptive management operational (Who does what? When? What are the triggers that initiate the process? Who will responsible for it? How to consult? For how long? How often?).

b. Site selection and aquaculture management within the framework of EBM

Aquaculture is addressed within EBM by means of the bottom-up process. The main spatial management tool used in aquaculture is bay management (spatial planning), and the search for oceanographic and biological information on a specific area suitable for aquaculture has generally been carried out from the viewpoint of the mariculture itself, looking at those optimum parameters that allow the activity to develop. Therefore, the focus has to be shifted away from aquaculture to the ecosystem.

In order to include aquaculture within the EBM framework, certain steps must be taken, particularly:

- Combining all aquaculture activities within the EBM spatial ecosystem unit;
- Including interactions between aquaculture and other human activities;
- Addressing interactions between activities and their cumulative impacts on a specific area or objective.

The main challenge in fitting aquaculture management areas within the EBM framework is a matter of spatial scale. That not only means looking at the broader scale, but also implies implementing aquaculture management tools that are compatible with the ecosystem report, based on ecosystem properties and the potential impacts of aquaculture on them.

Decision makers can assign a specific area to aquaculture on the basis of the ecosystem report, once ecologically significant features (areas and/or species) have been protected. Nevertheless, although aquaculture needs planning, site selection should include other considerations, especially mechanisms to integrate different activities in a complementary way. Achieving a balance between activities in terms of spatial use and synergetic strengths is critical for successful planning. The PoE or more broadly the DPSIR model can help more meaningfully at this stage. The aim of the exercise is to address ecosystem objectives in the context of aquaculture itself (Table O.1 next page).

c. Case studies

Within the framework of the CBD, the IUCN Centre for Mediterranean Cooperation has undertaken an assessment of two different aquaculture situations in North African countries—in the Delta Area in Egypt and Tipaza Wilaya in Algeria—in order to validate the ecosystem approach for aquaculture, based on implementation of the theoretical method. Algeria is still an emerging country in terms of aquaculture, while in Egypt this industry has traditionally been well developed. This study should assist stakeholders in improving and/or setting up a more robust management framework, in order to shift to a consensual approach among activities based on carrying capacity, from biological, social, economic and knowledge standpoints. Funded by the Spanish Agency for International Development Cooperation (AECID) through its Nauta Programme, this project will help to prepare guidelines and management tools for implementing EBM.

The results obtained during the two field studies and the two workshops in Egypt and Algeria were classified by the methods outlined above.

The stakeholders were identified and sorted out according to their relationship with the ecosystem. An assessment of their management abilities and their motivation in relation to the ecosystem revealed that the two regions suffer from a lack of communication among stakeholders and an absence of scientific and civil society involvement. Land planning issues were also raised: several land-tenure conflicts (concerning tourism, agriculture, fisheries and aquaculture in Algeria; urbanization, road and port facilities and aquaculture in Egypt) and inappropriate planning seriously hamper the sustainable development of aquaculture in the regions. Thus, the establishment of a stakeholders' forum will help to make management decisions sustainable.

Table O.1. Examples of relationships between aquaculture issues and ecosytem objectives

EBM objectives	Aquaculture issues	Investigation methods
Biodiversity	Escapes and genetic issues	Domestication is the best way to avoid the risk of genetic pollution. The aim is to produce sterile and/or hybrid or domesticated species that can neither cross with wild species nor survive in the wild.
	Non-native species	This concern can be addressed in different ways, depending on the current situation in the area. If the new species can provide added value while using an ecological niche that is available (for whatever reason), then the introduction would be acceptable under certain stringent conditions. Quarantine is mandatory for all introduced organisms. If species introductions are unintentional and harmful to the ecosystem (invasive species for example), all means should be used to combat them in a sustainable way.
	Therapeutic products	The use of therapeutic products can lead to loss of biodiversity; they can make some populations more vulnerable to pathogens and pollute other links in the food web.
Productivity	Larvae and juveniles from the wild	This practice is common for species that are not artificially reproduced; the principle is to harvest a negligible amount compared to natural mortality, which is very high in the early stages, although this is not the case for cultured tuna caught at later stages.

EBM objectives	Aquaculture issues	Investigation methods
	Adults from the wild	Harvesting adults can raise concerns, and this technique is allowed only when the species are not threatened, except when it is for population recovery purposes. Other factors have to be taken into account from a genetic standpoint, to balance genetic diversity between different populations or stocks.
	Feed ingredients	Most of the feed provided for aquaculture comes from capture fisheries. Because fisheries harm several species, aquaculture will not be sustainable if it worsens the situation. This matter relates partially to the socioeconomic regulations that can influence demand. Sustainable aquaculture needs feed diversification to reduce the pressure on fisheries; thus sustainable aquaculture implies sustainable fisheries. Several avenues are currently under investigation, and more science is required.
Habitat	Effects on the substratum	Cages and other rearing devices alter the substratum in different ways. The shadow cast by the mesh deprives the area of light and leads to a damaging cascade of effects. This issue is very localized and relates to carrying capacity as well. Spatial planning taking ecologically significant ecosystem features into account helps avoid this problem.
	Anti-fouling products	Anti-fouling and other chemicals have local effects that can spread throughout the site. Alternative products and relating the amounts used to the carrying capacity may be solutions.

The ecosystem boundaries are delineated on geological, physical chemical, biological and ecological grounds, while socioeconomic and administrative boundaries outline the management area. However, the case studies show that the ecosystem limits do not coincide with administrative limits. If administrative boundaries alone are taken into account, some essential components of ecosystem function (e.g. part of the hydraulic system) may be excluded and unable to benefit from a consistent management analysis. Harmonization of management structures seems necessary or even compulsory within the ecosystem.

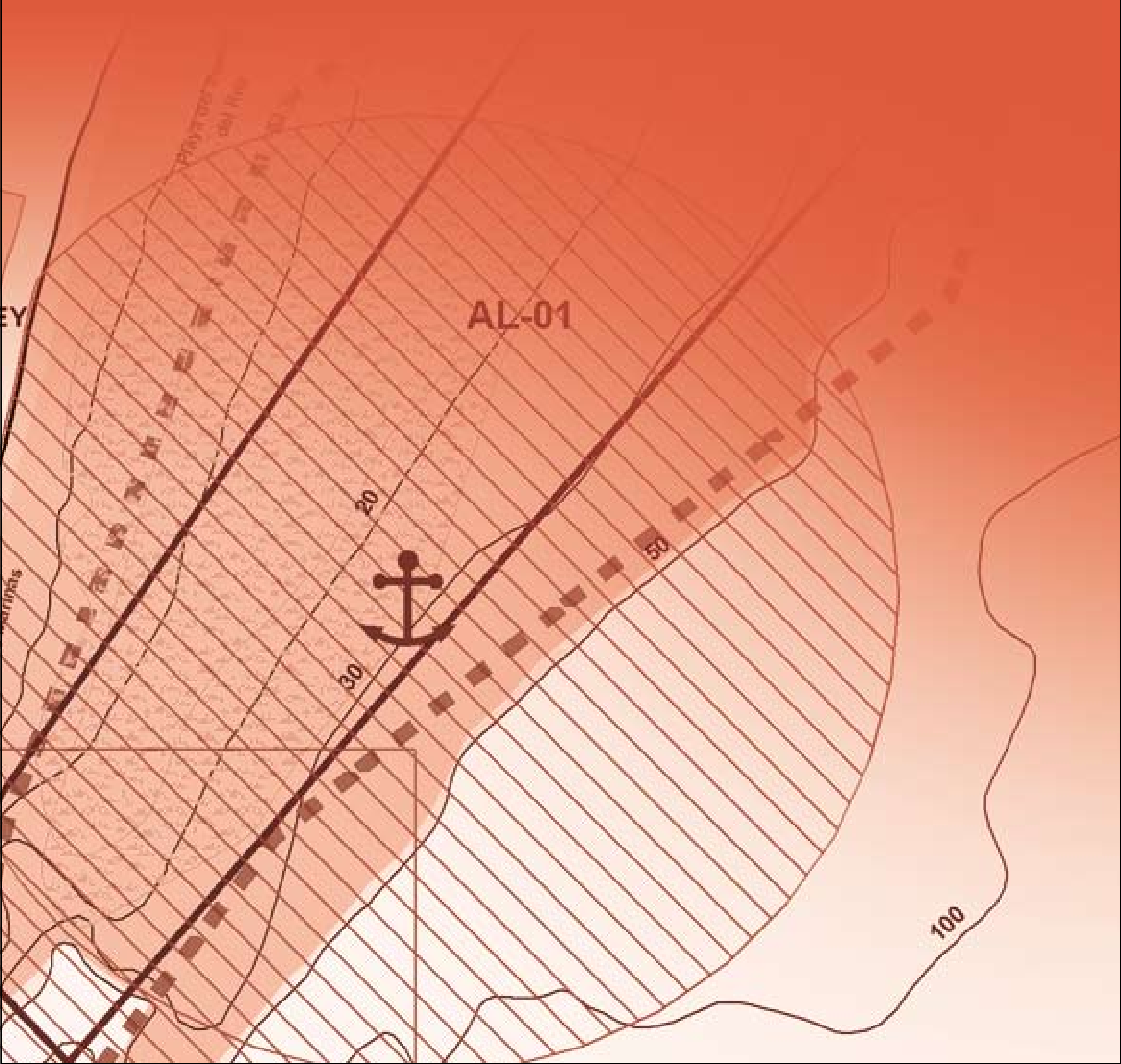
In terms of the relationship between stakeholders and the area, the role of each stakeholder with regard to the management of an ecosystem subsection should be clarified beforehand. Identifying the ecosystem structure and function constitutes the second step of the method. The lack of information on the ecosystem and the activities performed (particularly aquaculture and fisheries production and resource assessment), as well as the lack of socioeconomic data, especially in Egypt, have been underlined.

In order to set up a management system, the various ministries need to be involved and all actions must be supported at local level. In the case of the Ministry of the Environment, a protection programme for the area should be defined that identifies conservation objectives and includes concrete mechanisms (e.g. a programme to improve the Delta hydraulic system in Egypt). Cooperation should be established with the Fisheries Ministry, which should lead a resource and production assessment. In Algeria the procedures to apply for a concession should be simplified, while in Egypt the development of hatcheries should be fostered to limit the pressure on wild resources. The Ministry of Tourism should collaborate with the Environment and Fisheries Ministries to solve land planning problems. In both countries, decision-making processes deserve to be made much more transparent.

With regard to economic issues, subsidies granted by these countries benefit fisheries and are detrimental to sustainable development.

Moreover, support programmes, financial monitoring and investment security within aquaculture are very weak and should be improved. The information available on the internalization of the costs and benefits within the ecosystem is not sufficient for a full analysis.
Adaptive management in spatial terms is essential in both regions; management should take into account the functioning of the ecosystem as a whole, with harmonization of the decision-making structure throughout the ecosystem. Adaptive management in terms of time, although already implemented within the activity, will be made more efficient following the launch of the ecosystem-based management approach.

These two cases studies have therefore validated the method, although some criticisms could be made about the way in which the method was implemented. The identification of the stakeholders could be undertaken in relation to the area studied. The case studies underline the importance of specifying the boundaries of the ecosystem first, followed by those of the management area, and then seeing which stakeholders interact with the area. Moreover, a considerable amount of work is involved in identifying the stakeholders and understanding their respective roles in the management of the area. In order to apply this management method, structures need to be established that allow for stakeholders to be represented. The structural deficiencies should be mitigated through their support for this operation.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Carrying capacity, indicators and models

This guide provides definitions and tools for measuring carrying capacity. Different dimensions and meanings of carrying capacity are given, as well as criteria and variables to be used. Examples and models are proposed and guidelines are provided relating to site selection and site management for the sustainability of aquaculture.

Environmental carrying capacity may be defined as the maximum number of animals or amount of biomass that can be supported by a given ecosystem for a given period of time. The term 'carrying capacity' is often used in the context of coastal management or planning, with regard to human activities such as industry or aquaculture. In the case of extractive shellfish aquaculture, which relies on natural resources such as microalgae to feed the shellfish, this term is appropriate.

However, when considering other forms of aquaculture, such as finfish cultivation in net pens, which provides allochthonous food to the farmed organisms, it is more accurate to speak of 'holding' rather than 'carrying' capacity. In such cases our concerns focus on the ability of the environment to absorb and assimilate excess loading of organic compounds and nutrients. If the receiving environment cannot efficiently 'metabolize' or assimilate the load of nutrients and organic matter, we observe negative effects, for instance deterioration in water or sediment quality that may jeopardise the integrity and health of the ecosystem.

Guide P

A recent assessment of the sustainability of bivalve farming by McKindsey et al. (2006) established the following breakdown of 'carrying capacities':

- Physical carrying capacity: the total area of marine farms that can be accommodated in the available physical space;
- Production carrying capacity: the stocking density of bivalves at which harvests are maximized;
- Ecological carrying capacity: the stocking or farm density which causes unacceptable ecological impacts;
- Social carrying capacity: the level of farm development that causes unacceptable social impacts.

Speaking in terms of 'unacceptable impacts' implies that it is something defined by policy makers rather than by scientists, and some arbitrariness is to be expected. In order to minimize the arbitrariness, there is a need to achieve consensus among stakeholders and among countries in order to ensure harmonization with respect to acceptable aquaculture impacts across the Mediterranean.

One way to define acceptable impacts is by establishing criteria and variables to be used for estimating carrying and holding capacity. In this case, some of the most difficult issues that need to be considered include:

- The ecological component of carrying capacity; that is to say, what are unacceptable ecological impacts? A series of environmental variables like low oxygen in the water (hypoxia), high chlorophyll a or particulate organic carbon (eutrophication), as well as damage to important habitats or species may be chosen. One example is the use of 'exclusion criteria' such as protected habitats or species, for example *Posidonia oceanica* meadows (distance > 800m) or maerl beds, as well as activities that could be harmful for aquaculture by causing harmful algal blooms (HABs) or polluted sites;

- The cumulative effects of aquaculture farms on water bodies or coastlines with limited space;
- Synergistic or antagonistic effects with other uses or other sources of nutrients;
- Unbalanced regulation, where, for example, a rigid regulation is used to reduce nutrient emissions from aquaculture in areas where it contributes a minor proportion of the total nutrient discharge.

Another approach that has been tested in Greece is to use variables related to the characteristics of the receiving environment, such as:

- Depth (minimal effect on fragile coastal ecosystems);
- Openness/exposure (maximal water renewal and removal of wastes);
- Distance from shore (minimal conflict with other users of the coastal zone).

Moreover, we could use variables relating to environmental quality or standards, such as primary production levels, sediment oxygen levels or the status of benthic communities, and compare measured values against established threshold values to determine when the impacts of the activity are 'unacceptable'. Examples of this last approach include, for instance, standards in the EU Water Framework Directive (WFD).

The role of environmental and coastal managers is to plan human activities so that the risks of unacceptable ecological, social and economic impacts on the environment of concern are minimized. One of the tools that have been developed to help managers protect the environment is the Environmental Quality Standard (EQS). These standards generally set concentrations in the environment for certain compounds, below which unacceptable effects are expected not to occur. Some standards are legally enforceable limits, such as for 'List 1' chemicals under the Water Framework Directive, whereas others are specified in guidelines and codes of practice. Most Mediterranean countries have currently no specific EQSs for marine aquaculture. Furthermore the use of EQSs is still problematic because they are locally disputed and therefore standards of the Water Framework Directive could be employed instead.

One of the first steps towards development of environmental standards is the selection of indicators of environmental status. Ecological indicators are quantifiable variables that enable us to assess changes in habitat characteristics and ecological function and structure. Indicators may also be used to characterize the effect of the environment on aquaculture, as well as social and economic changes related to aquaculture. An examination of the commonly used indicators in European aquaculture was undertaken in the EU FP6 project ECASA in order to establish which of them are most useful and practical for managers and for aquaculturists. The ecological indicators consisted of variables that characterize the status of the water column, sediments and benthos, whereas the socioeconomic indicators dealt with various public preference and site selection issues.

Indicators provide useful information on the status of the environment before, during or after an event such as the start of the aquaculture growing cycle. Because there is often bias in the use of indicators, it is recommended that several different indicators be used to describe the impacts on the marine environment. Indicators are therefore very useful in monitoring programmes that continuously probe the state of the environment.

If we want to assess the suitability of a site for aquaculture, we need to predict potential future impacts of the planned activity, and to do this we need to employ models. Validated models can predict future conditions without any further measurements since they have been field-tested before use. Models are increasingly more flexible and precise, mainly due to increasing computer power, but their quality and applicability depend on the validity of the underlying assumptions and testing across a large range of environmental conditions. Using both indicators and models greatly increases the ability of scientists, regulators, producers and environmental consultants to carefully assess the potential impact of new aquaculture operations, to characterize and evaluate any actual impact, and to define areas where the impact of marine aquaculture could be minimized.

Indicators have also been developed for other purposes. CONSENSUS was a European project dedicated to the sustainable development of aquaculture in Europe. Its strategic objective was to demonstrate to consumers the benefits of high-quality, safe and nutritious farmed fish and shellfish grown under sustainable conditions. This analysis led to the production and assessment of a list of 78 indicators for sustainable aquaculture, including economic viability, public image, resource use, health management and welfare, environmental standards, human resources and finally biodiversity.

Example of models: ECASA

Benthic macrofauna is the traditional measure of benthic impact; yet it is time-consuming, expensive and requires skill and experience to identify quantitatively. Considerable effort has therefore been invested in an attempt to identify simple, universal biogeochemical sediment indicators that may be used as proxies. In some cases (e.g. Greece and Israel) the concentration of organic matter in the sediment has been successfully used to indicate the 'degree' and spatial extent of fish farm impact, but in general most countries require macrobenthic as well as geochemical indicators to be determined for monitoring purposes.

In the ECASA project, data were collected at 58 stations on biological variables (abundance or species richness), location variables (current velocity, depth, distance to the cage or latitude), sediment variables (grain size, redox potential or total organic carbon (TOC)), and farm activity (years of functioning and production). The most important factors explaining variability in biological indicators were those related to the activity of the farms (production, years operating, distance to the cages) and the hydrographical characteristics of the area (current speed, water depth); these factors together explained 29% of the variability for all locations.

When the latter factors were analysed together with the sediment characteristics (grain size, redox, TOC), they explained 21% of the variability; whereas sediment alone explained only 5% of the total variability. Hence, the selected biological indicators represent well the extent of the impact of aquaculture, although it is important to consider the high percentage of unexplained variability (45%), which is probably due to intra-site specific characteristics that were not studied in this project.

Water column indicators

Although the full list of water quality indicators was longer, the four indicators evaluated at nine ECASA study sites were ammonium, reactive phosphorus, chlorophyll a (Chl a) and Secchi disk depth, used primarily as an indicator of phytoplankton abundance/biomass. These four indicators did not provide conclusive evidence of the impact of finfish and shellfish farms or, in particular, of any potential adverse effects on the pelagic ecosystem. Monitoring of ammonium and reactive phosphorus provides evidence on average of nutrient enrichment near the farms. However, deviations of Chl a and Secchi disk depth from the reference values observed at those sites were not correlated with those of the nutrients.

Several previous studies have failed to find clear links between local primary production and water column nutrient concentrations. In many cases this is because the timescale of biological response is greater than the residence time of the receiving water body. This therefore leads to broader-scale considerations and cumulative effect assessment and this is best addressed with models.

However, models require validation data, and we do not therefore suggest that collecting data on water column indicators has no value but rather that the objectives in collecting such data need to be clear. From the fish/shellfish health perspective, water column oxygen concentration is clearly a key indicator which is routinely measured at many culture sites.

Data collected within the ECASA project suggest that nutrient enrichment is not correlated with high phytoplankton concentration in the 'impacted' areas, as has also been demonstrated in various other studies (Pitta *et al.,* 1998, 2006; Karakassis *et al.,* 2001; Dalsgaard & Krause-Jensen, 2006; Sarà, 2007). Instantaneous sampling and measurements do not allow for monitoring of nutrient fluxes and, in the case of nutrients released into the water column from point sources, the flux is more important than the 'standing stock' nutrient concentration.

To get around the shortcomings of the standard methods, Dalsgaard and Krause-Jensen (2006) devised a method to assay the flux of nutrients and their potential impact on local algal populations. This 5-day 'bioassay' was employed at several of the ECASA study sites to study the nutrient fluxes emanating from the aquaculture activity. In all cases, there was a very significant increase in concentration of Chl a over the 5-day incubation, as compared to initial values (in sharp contrast to most findings, which show practically no difference in standing stock of phytoplankton around or away from fish farms), and at most sites there was a clear decrease in concentration of Chl a with distance from the point source (farms), corresponding to a reduced flux of nutrients.

Justification

The industry is striving to increase the size of fish farms in order to achieve economies of scale. In the present state of knowledge it is not safe to assume that a change in the scale of production will be environmentally acceptable, socially equitable and economically viable, as defined for the sustainable development of aquaculture. There is a need, therefore, to establish criteria for the maximal aquaculture production at each site in order to avoid degradation of the marine environment and particularly the coastal zone, which is already under considerable human pressure in most parts of the world. However, at the moment there is little consensus as to what these standards should be for Mediterranean aquaculture.

Principle

Operational measurements of carrying capacity should be taken into account for aquaculture site selection and site management in order to allow for the sustainable use of marine resources.

Guidelines

- The carrying capacity of all measurable parameters should be considered in site selection and site management. In order to achieve the sustainable development of aquaculture, it is important to consider the environmental, social, physical, production and economic aspects of the activity.

- Areas with evidence of limited carrying capacity should be avoided. Aquaculture requires good water quality for its implementation; polluted sites or areas with frequent harmful algal blooms or oxygen deficits should therefore be avoided.

- Aquaculture facilities should adjust their production to the carrying capacity of the local environment. Each ecosystem has a different capacity to absorb and assimilate excess loading of organic compounds and nutrients. Therefore production should be low in shallow, inshore, sheltered areas and higher in deep, offshore, exposed sites.

- Even under the most favourable environmental conditions, an upper limit of production per farm should be established. Any revision of limits should be supported by intensive and regular monitoring, providing sufficient evidence that this maximum production level does not cause irreversible adverse impacts.

- An assessment should be made of the maximal allowable proportion of space that may be used for aquaculture in each water body, taking into account other uses and local wildlife. Ecological and socioeconomic indicators as well as models and standards must be used to obtain the best possible integrated assessment of space allocation.

- Consultation and dialogue should be encouraged among regulators, producers, scientists and relevant stakeholders in order to arrive at generally acceptable terms. The establishment of common environmental quality standards and regulations among the Mediterranean countries and regions will lead not only to fair competition but also to a higher degree of environmental protection and an enhanced environmental profile of the aquaculture industry.

Models

Table P.1. Models for assessing the impact of aquaculture on the environment

Model name	Scale	Brief description
MERAMOD DEPOMOD AutoDEPOMOD	A	Particle tracking models used for predicting the impact of particulate waste material (and special components such as medicines) from fish farms and the benthic community impact of that flux. MERAMOD was developed for sea bass and bream in Mediterranean farms, DEPOMOD and AutoDEPOMOD for salmon farms in the North Atlantic.
CSTT model	B	CSTT is a single-box model that predicts the maximum phytoplankton chlorophyll that can result from nutrient enrichment. CSTT refers to the UK Comprehensive Studies Task Team. The model also exists in a dynamic version (dCSTT) using the same ACExR physical model as LESV.
LESV	B	Loch (fjord) ecosystem state vector model, a development of the CSTT model including oxygen and phytoplankton type and able to simulate seasonal change; includes a 3-layer physical model (ACExR) derived from FjordEnv
ShellSIM	Ib	Dynamic model for feeding, biodeposition, metabolism, excretion, and growth among bivalve shellfish as a function of temperature, salinity, and sexton availability and composition. Bivalves include mussels (Mytilus edulis, M. galloprovincialis, Perna canaliculus), oysters (Crassostrea gigas, Ostrea plicatula), scallops (Chlamys farreri) and clams (Tapes philippinarum, Tegillarca granosa, Sinonvacula constricta).
EcoWin	B, C	An object-oriented programming system for implementing aquatic ecosystem models, using a spatial (1D, 2D or 3D) framework of boxes, within each of which the relevant biogeochemistry and population dynamics can be resolved
FARM	A	A web-based model for modelling of shellfish farms in coastal and estuarine waters, including waste transport, shellfish individual growth for several species, population dynamics and dissolved oxygen balance. FARM makes use of the ASSETS procedure to assess environmental impact.
Long lines	B	Combined ecophysiology and box model for simulating growth of mussels reared on long lines
DEB	Ib	Dynamic Energy Budget model which can simulate an individual organism's growth rate and reproduction as a function of varying food densities and water temperature.

Model name	Scale	Brief description
DDP	Ib	Model to assess temporal variations in the demographic structure of the standing stock of oysters and mussels as a function of the mortality rate and the growth rate (represented by an empirical function of water temperature and food concentration) in the Thau lagoon.
Hydro	3-H: B, C	Solves the three-dimensional Reynolds-averaged Navier-Stokes equations with hydrostatic approximation and free surface boundary condition. Density evolution is allowed and related to temperature and salinity variations through a state relationship. Horizontal computational domain is a regular grid.
TRIMODENA	3-H: A, B	Includes a 3D finite element hydrodynamic model for the numerical simulation of dispersive processes, and a 3D Lagrangian particle tracking model to simulate particle dispersion; both have been applied to maricultural pollution
EDMA	1-S	Uses BNRS (Biogeochemical Reaction Network Simulator, for organic decay and oxidation processes in sediment): a general programming environment made freely available by the Geochemistry Department of Utrecht University.
BREAMOD Tapes-IBM MG-IBM	Ib	Bioenergetic individual-based models that describe the growth of: Gilthead sea bream Sparus aurata Clam Tapes phillippinarum Mussel Mytilus galloprovincialis (somatic weight and gonadic dry weight)
KK3D	B	Particle tracking model used to predict the impact of particulate waste from fish farms, including hypoxia on the bottom. Model has been parameterized for finfish.
FjordEnv	B	Three-layer model for fjord exchange, parameterizing many physical processes and including simple pelagic biology and light penetration.
MOM	A	The MOM model can be used to calculate the holding capacity (TPF-Total Fish Production) of an area for fish farming containing four sub-models: a fish model, a cage water quality model, a dispersion model, and a benthic model.

Scales A, B, C refer to spatial scales: A is local to the cage, B is water-body scale, and C is regional. Ib is an individual-based model, and 1-S and 3-H refer to 1-dimensional (vertical) sediment and 3-dimensional hydrodynamic models, whose scale is to some extent set by the application.

Resources needed to use a model

Developing and documenting a model is expensive. The following costs should be considered when planning to use a model for the purposes described in this toolbox:

- Licensing costs for the computer program used to run the model. In some cases this program is proprietary to ECASA partner institutions. In other cases the program might be open source but needs proprietary software such as Matlab to run. Some of the ECASA models can be accessed through websites, but a password may be needed.

- Costs of running the program and interpreting the results: computing costs are negligible in most cases, but users may need to develop skills in using the program and model.

- Costs of obtaining and preparing the information on the 'specified conditions' relevant to the site or water body: detailed information on sea-bed topography (needed for hydrodynamic models) and boundary condition data are often difficult or expensive to acquire.

Some of ECASA's models use standard software such as a spreadsheet or web browser, thereby minimizing the first two kinds of costs; however, there remains the cost of getting the information needed.

Environmental impact assessment (EIA)

This guide outlines the environmental impact assessment as an essential tool to be implemented before a site is approved for aquaculture. It ensures that proper decision-making processes are in place, supported by accurate data on the impacts of the activity, and it takes into account the socio-environmental acceptability of the project. It should be consistent with both sustainability criteria and best practice.


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The environmental impact assessment (EIA) is a decision-making process for reducing impacts on the environment resulting from human activities. It consists of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to making major decisions and commitments (IAIA and Institute of Environmental Assessment, 1999).

EIA was introduced and its requirements formulated firstly in the US National Environmental Policy Act (NEPA) in 1969 (Fischer, 2003). Nowadays it is used all over the world in countries with different administrative and political procedures for most activities that are potentially harmful to the environment, such as aquaculture, fisheries or tourism. Strategic environmental assessment (SEA) is the term used to describe the environmental assessment process for policies, plans,- and programmes (De Boer and Sadler, 1996).

In an EIA, decisions are supported with precise data and the socioenvironmental acceptability of the project is measured. An EIA is implemented by making changes to: i) a project (private company); ii) activity plans (aquaculture regional/national planning); iii) a strategic action (national/regional/local strategy) or, if necessary, by preventing a project from going ahead at all.

For aquaculture, EIA is undertaken in most countries prior to approving a new aquaculture site or prior to extending an existing one. The various objectives for the EIA in aquaculture were established by the Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 1996), and include the following:

- Identify the positive and negative impacts, including direct and indirect impacts;
- Establish mitigation measures and ways to reduce the negative impacts on all environmental, social and economic areas during all phases (farm installation, operation, or decommissioning, if the activity has been stopped);
- Identify residual impacts that can be neither corrected nor attenuated;
- Develop strategies to monitor the impacts;
- Aid site selection.

EIA is a process consisting of three stages:

- Screening, in order to filter the projects that need to undergo the EIA process;
- Scoping, to define which risks should be assessed and on what terms, depending on any predictable environmental impacts and public concerns;

- Preparation of a written EIA report to produce the Environmental Impact Statement (EIS), which will be reviewed by the stakeholders and general public and followed by a phase of overall review by the administrative authorities and/or independent entities. The final decisions will be made by the competent authority. The EIS should include a presentation of the environmental monitoring strategy and protocol that will be developed during the environmental monitoring of the production phase to ensure the assessment of risk has been effective.

EIA statement description

The Espoo Convention, signed in 1991, lays down the minimum content of an EIA in its Appendix II. This information is listed below (modified and expanded):

- The purpose of the project;

- A technical description of the operation proposed: species, quantity, site description, staff, tools and infrastructure on land and at sea such as mooring, cages or boats;

- A description of the possible process and operational alternatives that are relevant for the location and functioning of the activity;

- A non-technical summary;

- A description of the environment of the proposed project (geomorphology, currents, climate, wind, waves, seagrass beds and other natural habitats), transport and infrastructure, administrative organization, sensitive environmental areas, protected areas, other aquaculture activities in the vicinity and other sources of activity/pollution, and other coastal users such as fisheries, tourism and navigation;

- A description of the potential environmental and socioeconomic impacts of each step of the proposed activity and its alternatives, and their estimated magnitude during all stages of production: installation (land used for cage preparation, disturbance of traffic, impacts of mooring), production phase (benthos/water column, traffic on land and at sea, etc.), and decommissioning phase (e.g. removal of the mooring system), plus an estimate of the potential impact magnitude and significance (see below);

- A description of possible mitigation measures and their expected effects to keep adverse environmental impact to a minimum;
- An explicit indication of predictive methods and underlying assumptions as well as the relevant environmental data used;
- An identification of gaps in knowledge and uncertainties encountered in compiling the required information;
- A control system, with a monitoring plan including a description of its design and methodology.

A concern encountered in EIA is how to deal with uncertainties in data and methods. In this context, the precautionary principle or approach is an important element in an EIA. In general the EIA is performed with the support of consultants and is based on a field study supported by literature-based analysis and specific site/area conditions. It often has to meet specific national requirements in terms of presentation and standards, and should take the topics described below into consideration.

a. Local environmental impacts

Aquaculture impacts represent less than one percent of nutrient loads in the Mediterranean Sea, while the major contribution comes from agriculture and sewage (Karakassis, *e.t.,* 2005). This overall effect does not preclude significant local impacts of aquaculture as a human activity, which have been studied by EIA and monitored by specific monitoring protocols.

The collection of data and study of the local environmental situation prior to installation is the costliest and most important part of the EIA. A baseline protocol requires a field analysis to be carried out underwater on key sampling stations (below cages and across the current pattern: see the guide on the environmental monitoring programme). It will produce data to establish a baseline for comparison with data collected afterwards, once the business is up and running.

The impacts will vary with the species farmed, which can lead to a complicated EIA and licensing process. For example, the impact of sea bream and sea bass is different, as that of sea bream has a wider or less concentrated distribution, whereas the impact of sea bass is principally located below the cages and is more densely concentrated. Their faeces also differ in size, density and chemical composition.

In order to measure environmental impacts two main aspects should be considered: magnitude and significance. Impact magnitude refers to the level of the changes in environmental quality resulting from the establishment of a new project, that is, the difference between the situations with and without the activity. Impact significance relates to the importance attached to that difference.

The significance of environmental impacts is largely dependent on the spatial distribution of the effects of the proposed action and of the affected receptors. However, in current EIA practice, this spatial dimension of impacts is often ignored or hidden in the overall decision-making process. The information generated by the use of Geographical Information Systems (GIS) in the impact identification and prediction stages of EIA could be used in the assessment of impact significance through the computation of a set of impact indices (Antunes *et al.,* 2001).

The prediction of the magnitude of impacts is often undertaken by the application of simulation models (Fedra, 1993) (see below under 'dispersion of organic matter').

The following elements are usually assessed:

- Water column quality, which includes levels of dissolved oxygen and nutrients (ammonia, nitrates, nitrites and phosphates), pH, salinity, chlorophyll a, and turbidity. Many studies in the Mediterranean conclude that at short spatial scales there is no systematic effect on water column variables by fish farming (Poseidon *et al.,* 2006).

- Sediment quality. In particular, organic matter and redox potential are measured to evaluate oxygenation of sediments and impacts on benthic populations such as those of nematodes or polychaetes; other variables measured are granulometry/ particle size, organic/mineral content, free sulphide and percentage cover of *Beggiatoa*. The presence/absence of pellets and food is also indicated, and in some countries heavy metals and pollutant levels are required or can be measured. Analysis of these elements shows the significance of sediment type, coarse or fine, as being largely a factor of site exposure, and liability to sedimentation.

- Benthos quality. This is used to establish benthic diversity and appropriate benthos quality indicators. Specific species can be indicators of organic pollution, and the benthos is of importance to the food chain as well. It reveals the biological quality of the benthic fauna and the changes occurring in it.

- *Posidonia oceanica* and other sensitive seagrass meadows present. Aquaculture is often expected to be located close to the shore, where sensitive protected species like *Posidonia oceanica or Cymodocea nodosa* seagrasses are present. The state of *P. oceanica* meadows is established by measuring shoot density, shoot morphological characteristics, and the volume and nutrient composition of epiphytes such as seaweeds, hydrozoans and bryozoans.

- Mammals, seabirds and endangered species occurring in the site, as well as other endangered Mediterranean species such as coral or maerl habitat have to be assessed. Other impacts on sea mammals and seabirds should especially be presented.

- Dispersion of organic matter and nutrient patterns of the proposed production. Ecological models could be used to evaluate quantitative and qualitative relationships between habitat attributes (e.g. pollution gradient, organic particles in sediments in this case) and fauna or vegetation properties. This is based on the expected production level, the species to be farmed and their faecal particles and metabolism, and the current patterns, information on which is obtained from the literature and hydrodynamic models. Modelling plays an important, perhaps essential, role in determining acceptable limits of aquaculture or any other anthropogenic impacts, since without predictive models we cannot assess whether the impacts are acceptable until they have occurred and been observed, which is almost always too late (Silvert, 2001). Hydrodynamic and transport models can predict dispersion of particulate and dissolved wastes from aquaculture facilities. They are used to explain levels of dilution and the size of the particle/faeces/nutrient impacts around the cages. To reduce the cost of such models, simple ones have been developed, such as Trimodena in Spain or Bardau in France, but, despite the quality and usefulness of such visual tools, in practice the use of models to predict ecosystem impacts from pressures is complicated and difficult. They at least give a picture of the size of sediment particles and organic matter on the bottom. There are some sophisticated models which couple the results of hydrodynamic and dispersion simulations with different ecological models in order to simulate the biological effects of wastes (COHERENS, MOHID, etc.), but they need a high level of expertise to be run correctly.

Provisional impacts and analyses corresponding to each measurement are presented in Table Q.1 (next page), based on Mediterranean literature on existing habitats and species located around the site. Some of them were summarized in the European MEDVEG and AQCESS programmes and, in spite of certain differences from one country to another, they are similar across the region.

Table Q.1. Sensitivity of key habitats and species to aquaculture pressure (from Poseidon et al., 2006)

Habitat / Species	Pressure categories: Smothering		Change in bio-geochemistry											
	Smothering	*Turbidity*	*Dissolved O_2*	*Nutrients*	Change in coastal processes	Infrastructure impacts	Visual land & seascape modification	Disturbance	Predator control	Chemical use	Pathogen transmission	Inter-breeding with wild organisms	Introduction of alien species	Indirect ecosystem pressures
Reefs: mussel bed communities	High	Low	Moderate	Moderate	Moderate	High				High	Moderate			
Reefs: polychaete worm communities	High	Low	High	?	Low	High				?	?			
Seagrass beds on sublittoral sediments	High	Moderate	High	High		High			Low	High			High	
Sandbanks, mudflats & sandflats	High	Moderate	High	High	Low	High	High	High	Low	High			Low	
Maerl beds	High	Moderate	High	High	Low	High				?			High	
Kelp and seaweed communities	High	High	High	High		Moderate	Low			?			High	
Saltmarsh communities	Low		Low	Low	Low	Moderate	Moderate	Moderate	Low	High	?			
Sand dune communities					Moderate	Moderate	Moderate	Moderate	Moderate	Low				
Shingle communities	Low					Moderate	Moderate	Moderate	Low		?			
Cetaceans								Moderate	High	Moderate				
Pinnipeds								Moderate	Low	Moderate				
Otters	Low					Low		Low	Low	Low				
Fish	Low		Low					Low		Low	High	High	Low	High
Birds	High	Moderate	High			High		Low	Low	Moderate				High

High | **Moderate** | **Low** | **Negligible** | **? Uncertain**

As an example of mitigation measures, the results of all the measurements and the producer/consultant analysis can indicate ways to reduce impacts, such as changing the position of the cages in a specific current and at an appropriate depth, improving feeding procedures, integrating production, or creating artificial reefs associated with the aquaculture facility to increase filtration capacity and improve and enrich the water column. With regard to endangered or sensitive species, the general recommendation is to place the cage far from any *Posidonia* or maerl.

b. Physical impacts on land and at sea

This section corresponds to a description of the cage anchorage and impacts on mooring systems, as well as transport from the sea (from plant to harbour, etc.). It presents the impacts at all stages, including during the installation and decommissioning periods.

Improvements to the mooring system are usually presented as well as short-term transport changes in public areas, technical sites on land and security harbour locations, which are all examples of mitigation measures.

c. Impacts of farm practice and management

This involves describing each step of production and its impacts: from larva and fingerling production to their transfer to the cages and the feeding process (pellets and artificial food origin and quantity, fresh fish quantity and impacts), as well as the slaughter and processing procedures and impacts on animal welfare. It also addresses the expected volumes of organic wastes from processing plants, and the processing and management of solid wastes.

All the mitigation measures presented are intended to improve farm management, the feeding process or animal welfare, *inter alia*.

d. Impacts and relationship to protected areas and endangered species

This section usually discusses specific impacts, if any, on Natura 2000 areas, protected areas, protected species or sea traffic (Poseidon *et al.,* 2006).

Mitigation measures may be presented by means of clear maps or GIS data on the area. Delimitation of the production site and any sensitive areas is required to show the distance to each protected area, and the relevant legislation to be taken into account should be given. The distance from the installation to *Posidonia oceanica* meadows should conform to international recommendations (IUCN, 2004).

e. Chemical inputs, sanitary impacts and safety at sea and on land

This section takes into consideration disease risks and the potential transfer to wild fish populations, and also the processing system and all concerns relative to public health. In general, chemical inputs into the environment are connected with disease prevention. When chemicals are added to the environment, a specific item may be retained in the environment and the impact of this should be estimated.

Some examples of mitigation measures are those developed to reduce disease risks, such as larva and broodstock quality certification, prophylaxis and use of natural chemical measures, improved stocking densities and reduction of stress, frequency of removal of dead animals, slaughter conditions and development of a conditioning process, and quality certification measures as well as ice infrastructure.

f. Wild stocks, interbreeding and indirect ecosystem impacts

Aquaculture is one of the causes of fish biodiversity loss due to farmed species (Naylor *et al.,* 2005). A specific EIA item is usually prepared with regard to their impact on wild stocks through genetic interactions or genetic competition, as well as disease. Another aspect is the consumption of wild stocks as feed, since aquaculture consumes 50 percent of the fish food produced worldwide. Impacts on species of commercial interest are usually briefly discussed, as well as those on fish populations under or around the cages (the attraction phenomenon and effects of fish attraction devices, changes in biodiversity and impacts on fisheries). This concerns all species, including bluefin tuna (BFT) ranching. Lastly, the environmental impact statement or assessment document should present the relation between production levels, the species produced and the risk of introduction of alien species. Usually only Mediterranean species should be proposed for farming.

Mitigation measures usually address the feeding process, the quality of the proposed feed and hatchery quality standards in order to avoid the introduction of alien species. For bluefin tuna aquaculture, BFT quotas, quality standards for the origin of fresh feed, and the dependence and impact on local fisheries should be included. For other aquaculture species, the positive impact on local commercial and small-scale fisheries that catch fish close to the cages (Giannoulaki *et. al.,* 2005) should be mentioned.

g. Predator impacts

The fish and shellfish stocks held by aquaculture operations will inevitably attract the attention of wild predators like marine mammals or seabirds. Predator control can be challenging since many predators are protected by Member States' and EU legislation, especially within designated sites of conservation interest. Control may be possible under Article 9 of Council Directive 79/409/EEC.

As an example of mitigation measures, long-term results are usually achieved by using a combination of methods and by frequently alternating the devices used. These include scaring techniques and devices that are regularly moved to different positions, as well as nets positioned above the cages to prevent predation by birds.

h. Visual land and seascape, and disturbance (sound and air pollution) impacts

Visual impact concerns mostly how visible the cages are from the shore and what the landscape impacts are in the case of land installations. For some bluefin tuna ranches, the harvesting process often relies on slaughtering the fish at the cage site with guns, which produces temporary noise impacts. Usually there is no air pollution.

Mitigation measures may relate to the size and colour of the cages, with a preference for black or blue cages, as well as reducing the size of above-water physical elements in order to reduce the seascape impact, but in all cases without prejudice to the regulations on the proper marking of the facilities for boaters. They may also include siting the cages far from the shore or using submersible cages.

i. Socioeconomic impacts

This topic is often not well addressed. The EIA should examine the impacts of production on the volume of new direct and indirect employment, and its relation to local employment. Its impacts on other coastal users should also be developed, especially those linked to fisheries, tourism, transport and diving. Impacts on the local economy, such as income, taxes and exports, are also a key element.

The socioeconomic impacts are usually positive, where a permanent marine-based employer comes to a more tourist-influenced coast, although some conflicts with fisheries may arise. As a mitigation measure, various initiatives can be proposed, like mobilizing the fishery actors, developing partnerships with local companies, training local people to improve their qualifications, and in general making a positive impact on the local economy (through employment, income, taxes, exports, and transport and harbour infrastructure). They may also include initiatives to support sustainable coastal zone development through artificial reefs associated with the cages, integrated aquaculture, and scientific research or education programmes on the marine environment.

EIA is thus a preventive instrument related to the sustainable management of aquaculture in the context of site selection. Therefore, the environmental assessment should be extended to earlier stages of the policy-making and planning process, when the strategic decisions (such as location or type of project) have not yet been made (Arce & Gullón, 2000; Schotten *et al.,* 2001). In addition, to be comprehensive and effective in providing information, the decision-making process must provide opportunities for public consultation and encourage communication between the public and the operator (Scholten *et al.,* 2001). In the context of aquaculture site selection and sustainable development, and taking into account the concepts of integrated coastal zone management (ICZM) and ecosystem-based management (EBM), EIA provides a framework for projects to be structured in a way that is consistent and compliant with the environmental, social, political, and economic conditions. It contributes to a better planning and monitoring process and is a potential tool for decision making, as well as for producers to reduce their impacts and improve their activity and project planning, helping them to integrate their projects better into the local socioeconomic environment.

Why carry out an environmental impact assessment?

An EIA is necessary to demonstrate to the public and local authorities what the potential footprint of a new human activity may be on the environment and ecosystem. It helps to show how well the project integrates with the environment and what measures may be adopted to reduce its impacts.

Justification

Economic studies (Katranidis, 2001) have shown that the social acceptability of aquaculture depends, among other things, on the size of the industry, its effects on the local economy, and the time elapsed since the investment. However, negative effects, such as the aesthetic degradation of the landscape, have often caused conflicts with other user of the coastal zone and particularly with landowners in the vicinity of an aquaculture site, which have yielded a large number of court cases.

At the same time, and in line with the ecosystem approach, all economic activities proposed or taking place in the sea should undergo a prior assessment of the possible impacts that could affect the surrounding environment, not only to preserve it but also to secure the sustainable development of the activity.

Principle

For appropriate aquaculture site selection and installation, the environmental impact assessment (EIA) procedures should be mandatory and implemented.

Guidelines

- An environmental impact assessment should be mandatory for all projects, including aquaculture site selection, and incorporated in legislation. The sea is an area in the public domain and specific laws should be implemented in order to ensure the appropriate and sustainable use of the ecosystem, thereby promoting the sustainable development of aquaculture. The responsibility for bearing the costs of the EIA should be discussed.

- To facilitate the process of aquaculture site selection, the current environmental impact assessment protocols, standards and models should be simplified and harmonized throughout the Mediterraneanand a regular review of the statements should be carried out. Proper indicators for environmental quality standards (EQS) and impacts must be developed in the Mediterranean for the various types of production (shellfish and finfish).

- The environmental impact assessment should be based on the best and most appropriate scientific knowledge, covering technical, socioeconomic and environmental aspects, as well as on the precautionary principle. Scientific facts, assumptions and expert judgements, and the consequences of the range of error for the assessment have to be discussed. In this context, the precautionary principle or approach is an important element for an EIA.

- The decision-making authorities must keep abreast of innovations affecting environmental impact assessments by means of regular training, while the private sector must also be given easy access to such information. Stakeholders are not always aware of recent developments or reasons for changes. Therefore, regular updating is required to facilitate proper aquaculture site selection.

- Research on current issues, such as cumulative effects or mitigation measures, as well as future topics should be promoted and developed in order to achieve the sustainable development of aquaculture. Innovative techniques, such as those involving distance between cages or limits on diseases, as in examples of prevention from Norway, or any activities that take advantage of the nutrient enrichment of the environment caused by aquaculture have to be more extensively studied and exploited.

- Stronger socioeconomic compensation measures should be introduced in the environmental impact assessment. This would allow for aquaculture projects to be more effectively integrated into the local environment and for synergies to be observed and developed.

Examples of the EIA situation in the Mediterranean

An EIA is not performed unless it is compulsory and enforced by a legal or administrative body.

In most European countries, an EIA is performed prior to the installation or expansion of an aquaculture facility. However, the type and level of requirements differ from one country to another. The need for the harmonization of regulatory, control and monitoring procedures has been highlighted in a number of reports (Cowey, 1995; GESAMP, 1996). Not much progress has yet been made and, in general, EU countries have continued to proceed independently. Directive 97/11/EC of 3 March 1997, amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, which includes aquaculture in Annex II, emphasises the need for certain projects to undergo compulsory EIA, depending on scale, intensity and local conditions.

The Water Framework Directive (WFD) (Directive 2000/60/EC) has already had an automatically strong impact on aquaculture, as marine and coastal waters are specifically designated in different classes up to a distance of one nautical mile from the shoreline. Different special protection levels for shellfish areas, bathing areas, sailing areas, and sensitive areas are related to habitat or species protection. This last category will have a major impact on aquaculture located close to the shore. In addition, the

WFD states that 'protection of water status within river basins will provide economic benefits by contributing towards the protection of fish populations, including coastal fish populations.' Not all the constraints of WFD apply to aquaculture yet and there is a need for anticipation.

Although there is a standard requirement for an EIA, there is little common ground on regulatory issues among Mediterranean countries. A proposal for a common site selection protocol (Dosdat et al., 1996) has not been uniformly adopted by Mediterranean countries. The initiatives developed have been mainly regional and no analysis of past experiences has been completed in order to propose appropriate measurements and procedures based on experience.

- Malta. To our knowledge, the EIA process is requested and managed by the Malta Environment and Planning Authority (a government agency), and undertaken by private independent consultancies which are hired by the applicant, subject to approval by the Malta Environment and Planning Authority. The role of the National Aquaculture Centre is to provide the applicant with guidance on administrative procedures and site selection and to issue the operating licence.

- France and Spain. Each company or project has to present an EIA and monitoring results. In France, it follows the ICPE procedure (Installations Classified for the Protection of the Environment) (Roque d'Orbcastel *et al.,* 2004). In Spain, some regional administrative bodies and researchers support the assessment, and regional protocols are defined for EIA in cases where an aquaculture strategy is well established. However, a lack of harmonization due to the power and autonomy of the regional governments leads to differences in environmental quality standards (EQS) and protocols. For example, in one region there are 13 parameters, and in another there are 16.

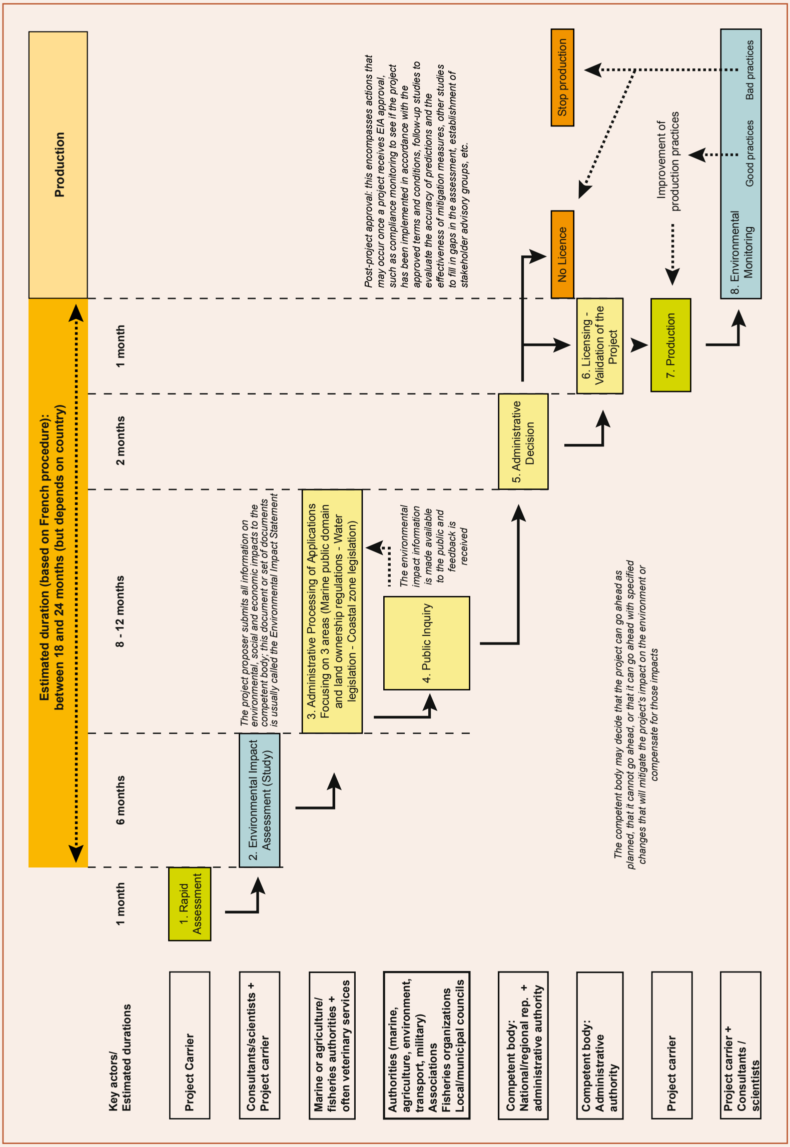
- Turkey. EIA studies are now starting to be requested, and one of the main difficulties is the large number of administrative bodies with responsibilities in this field.

- Greece. In the leading country in terms of production, the administrative authorities impose a series of procedures for the approval of a farming site, but there are no precise requirements for the data to be included in the EIA. The practice is far from satisfying European Commission requirements, since situations are very different from one region to another. Many farms have been developed and expanded without a proper EIA. A recent change in the regulatory framework provides for the establishment of Areas for the Organized Development of Aquaculture (AODA) that have undergone prior assessment for environmental issues.

- Cyprus. Since joining the European Union, Cyprus has become a good example of a country with strong regulations on EIA, where specific criteria and protocols are developed and followed. A stricter regulation imposing minimum depth and distance from the coast has been passed, and the regulatory framework, called the Strategy for the Development of Aquaculture, is periodically revised by external panels of experts.

- Southern Mediterranean countries. Countries on the southern shore of the Mediterranean usually impose EIAs without much national scientific knowledge of the protocols, due perhaps to the high cost and the technology needed, as well as EQS limits. Hence there is a lack of information for decision making. Most of the time, the EIA is only grudgingly accepted and it therefore loses its importance. It does not sufficiently take into account national competencies or the ability to undertake several types of measurements and analysis. There is a major need for harmonization and understanding of marine environmental issues and their importance for productive activities.

Table Q.2. Summary description of the EIA and public inquiry process, based on the situation in France



The EIA procedure as part of the licensing process

The EIA usually follows a preliminary site analysis and a rapid coastal assessment based on expert opinion or producer knowledge, which examines the key factors, key actors and key supports and constraints to define the best sites for aquaculture. The EIA is nowadays required by law in most countries and will determine the baseline environmental conditions by means of desktop research or field surveys, for instance. The EIA process can take 4–6 months, and the results are then presented to a public inquiry and go through administrative procedures, which are still not harmonized at a Mediterranean level. In the case of France, it can take one to two years depending on administrative constraints.

EIA case study in Egypt

This example shows how the Egyptian authorities took extreme corrective measures to halt the impacts of aquaculture on the environment of the Nile delta. This situation was caused by the rapid growth of the sector and probably the lack of prior environmental impact assessments and further monitoring.

Aquaculture production in Egypt rose from 36,078 tonnes in 1986, which was 16.5 percent of total fish production for that year, to 595,029 tonnes in 2006, or 61 percent of the year's total. The Egyptian aquaculture map shows that fish farming activities are mostly concentrated on non-agricultural land in sub-regions of the Nile delta, where the water resources are available. A very few other projects are located in Upper Egypt and along the Mediterranean and Red Sea coasts.

Extensive and semi-intensive earthen ponds with a total surface area of roughly 140,000 hectares in Egypt are characterized by medium stocking densities and a limited water exchange rate. The private sector produces 98.6 percent of total aquaculture production, and the public sector contributes only 1.4 percent.

Intensive aquaculture is also practised in the Nile using mainly cages and in the desert with a few tank farms. In 1985 the first eight tilapia cages were established in the Damietta branch of the Nile with a yearly production 1.92 tonnes; after that date there was a rapid increase in cage numbers and production, reaching 12,495 cages and 80,000 tonnes in 2006. Most of the tilapia cage projects were located in five provinces in the northern delta, making up about 98 percent of the total volume of tilapia cages in Egypt, and the rest are located in three different governorates in Upper Egypt. Because of pollution problems caused by the cages at the ends of the two Nile branches, in 2007 the Egyptian authorities completely removed the Nile cages before the last two dams, which control freshwater flow into the Mediterranean.

In Egypt the resources of both fresh and brackish water are the major constraints on further development, with use for drinking water and land crop production having priority over aquaculture activities. A key policy issue is the plan to increase the reuse of agricultural drainage water in the delta region by 2014 to 1.4 times the amount reused in 2002, which was 3,219 million m^3/year. In three Nile delta regions, the Integrated Irrigation Improvement and Management Project (IIIMP) is currently implementing an irrigation system improvement covering almost 235,000 hectares, which will be the focus for irrigation improvement in four different governorates. It is thought that there will be an adverse impact on drainage water quantity and salinity of -12 percent and +4 percent, respectively.

Such environmental impacts will affect aquaculture production in the Nile delta, as the water available for earthen fish ponds will be not adequate and the increase in salinity could affect both production capacity and production composition. In addition, paddy fields and the raising of grass carp in drainage channels could be adversely affected. This policy, which aims at securing a vital resource for Egyptians, could retard the development of aquaculture, since Nile cage culture provides approximately 11 percent of the total Egyptian aquaculture production, and the new irrigation strategy could affect 60 percent of current aquaculture production.

The Egyptian Government is currently studying a number of strategic proposals to maintain a sustainable aquaculture industry in the country.

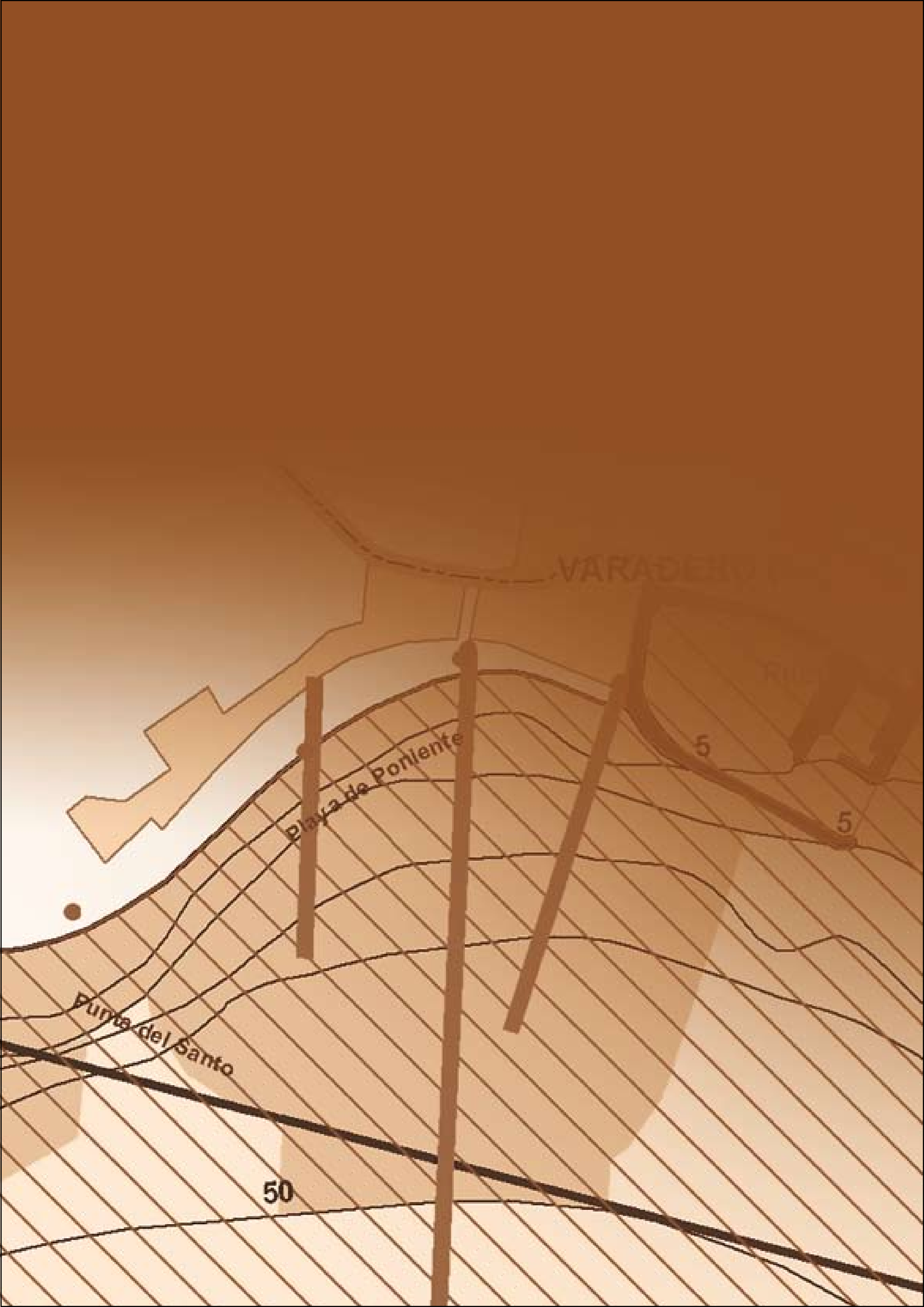
Future trends

An analysis of Mediterranean studies on environmental impact assessments in Italy, Greece and Spain came to the following conclusions (Molina Domínguez & Vergara Martín, 2005):

- No impact on the water column is observed (i.e. dilution does not allow the detection of any impact at distances greater than 50m from the cages).

- The only negative impacts found are on the sediments and benthos in the area located directly below the cages, mostly due to sedimentation.
  The quality of the sediments is indicated by the organic carbon and total nitrogen content, as well as by the biomass of benthic macrofauna.

Consequently, researchers are proposing to simplify the protocols for EIA and harmonize the standards based on such arguments. In addition, many EIAs are now including aspects of carrying capacity linked to hydrodynamic models, but the lack of knowledge on models, marine ecosystems and cumulative effects does not provide sound results or clear criteria on these issues (see Guide P on Carrying capacity, indicators and models).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Environmental monitoring programme (EMP)

This guide deals with the environmental monitoring programme (EMP), which has to be consistent with sustainability criteria. This tool, used after the environmental impact assessment (EIA), uses sampling to highlight the extent to which aquaculture management affects the ecosystem over time, by comparing current data collected at various points in time with data obtained before development as well as with other existing data.

Monitoring is often designed at the end of the EIA and is part of the EIA statement. The monitoring protocol proposes what type of indicators should be used to monitor the impact of the farm at various points in time. It usually focuses on environmental parameters.

Monitoring looks at many topics and levels, including the scale of impacts, general ecological change, and implementation of acceptable limits or acceptable zones of effect over a defined timeframe. The latter is achieved using environmental quality standards (EQSs) set out either within an EIA or by environmental bodies and government authorities as part of a regulatory plan. These EQSs are usually based on data derived from laboratory study and field investigation and often include a 'safety' factor, using the precautionary principle or approach (Telfer and Beveridge, 2001).

Content of the environmental monitoring programme

The monitoring results support decision makers as well as the producer himself with the size of the impacts and ways to improve management and regulate the activity. The input of phosphate and nitrate to the environment and the environmental impact of a farm will depend on three factors, namely:

- The frequency, direction and strength of water currents in the area, indicating the rate at which the water mass is renewed around the installation. A 1000-tonne fish farm can have less impact than a 100-tonne fish farm if placed in a position where currents and depth provide better dispersion in the environment.

- The phase of the production cycle. In summer, Mediterranean species develop their greatest need for feed during the year; hence the spillage at this time will be greater than in January.

- The management practices. Good feeding and disease prophylaxis procedures have low impacts on the environment.

In monitoring the environmental effects of aquaculture, as in all studies on environmental change, data are collected at various points in time and are compared with original, pre-development data as well as with contemporary reference data. This will show changes over time due to the impacts, and natural environmental change will also be taken into consideration. Survey techniques vary but generally require the following (Telfer and Beveridge, 2001):

- A baseline definition: based on data collected before development. This provides essential background ecosystem data for subsequent comparison. The survey may be both spatial and temporal, providing pre-development data on the natural environment and its changes throughout the proposed development area. Such data can aid in the design of an appropriate monitoring study, focusing, for example, on the areas which are most relevant for investigating change in a particular environment. The survey will also answer important management questions for the developer: in this case, will the site support aquaculture? There are several types of experimental design incorporating the baseline survey. One of the most commonly used is the BACI or BACUP system (Underwood, 1991).

- A monitoring survey: the collection of post-development data provides information on the actual impacts, in relation to the contemporary reference and baseline data. Once interpreted, the results may be used directly for management decisions by both fish farmers and environmental regulators by ensuring adherence to EQSs and acceptable zones of effect (AZEs). Care should be taken in designing the monitoring study so that data are generated to answer the questions posed by all users of the data. For the environmental regulator, are AZEs and EQSs or the original conditions of the EIA being adhered to? For the fish farmer, is our environmental resource being damaged?

In general, the protocol for monitoring is based on previous knowledge of the existing zone and will take into consideration:

- Frequency of sampling,
- Position of sampling stations,
- Method of sampling water or sediments,
- Method of analysis of the samples taken to measure the determinants.

Sampling strategies usually attempt to maximize data collection per expended effort, which normally entails the use of transects aligned with the direction of principal current flow rather than a less efficient but more statistically rigorous random sample or grid approach.

Transects and specific station protocols are particularly good at allowing detailed investigation of gradients from a discharge point, as illustrated in Figure R.1.

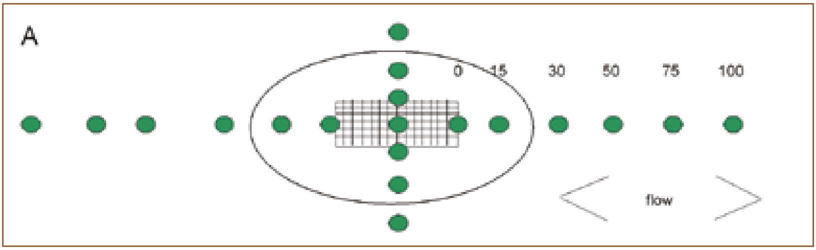


Figure R.1. Sampling station layout to detect gradients from a discharge point (a marine fish cage) (from Telfer and Beveridge, 2001)

If no previous information is available, the minimum required is based on the protocols developed by AZTI (Technology Centre for Marine and Food Research) and private consultants in Spain:

- Two sampling campaigns in extreme seasons: one at the end of winter, when strong winds and currents have removed wastes and the site is in recovery or under minimum impact; one in summer, when the site is under maximum impact conditions including maximum production rate and cage densities, lowest oxygenation, highest water temperatures and best conditions for pathogens;

- Five sampling points, the layout of which should be based on the main dispersion pathway for the waste from the cages. At least one of these points should be below the point where the cages are to be installed and another should serve as a reference point for the future in an area unlikely to be affected;

- The sampling depths are left to the criterion of the specialist carrying out the work, in accordance with the project that is presented.

The analysis may be done using:

- Univariate indicators to show changes in community composition by statistical comparison of time point data with baseline and reference values or comparison of calculated values with an EQS value of diversity set for a particular site by regulatory authorities. If an EQS approach is used, the standard should be site specific and set in relation to the background level, for example the Shannon index (Hs) as a percentage of background level at any particular time (Telfer and Beveridge, 2001);

- Multivariate methods of analysis to reveal similarities between sampling stations in space and/or time.

The various parameters monitored are similar to those measured during the EIA. They usually consist of the following:

- Visual observations;

- Water column measurements;

- Sediment and bottom community measurements;

- Cumulative effects measurements;

- Interference with other users.

a. Visual observations

Based on special in situ transect sections and/or video transect analysis, these observations describe the following:

- Real distance of sedimentation impacts (from faeces, remnants of feed pellets or trash fish);

- Superficial state of the sediment due to organic concentration below or around the cages;

- Signs of ecosystem changes below or around the farm due to the presence or absence of *Beggiatoa* bacteria on anoxic sediments, the number and type of wild species below and around the cages (e.g. fishes, octopus, pelagic/benthic fishes and detrital invertebrates), or a reduction of macroscopic life;

- Status of *Posidonia* meadows (in terms of quality and extent).

b. Water column measurements

Measurements are taken of temperature, salinity, dissolved oxygen, optical properties (turbidity, suspended solids, Secchi disk transparency), nutrients (phosphorus, ammonium and nitrogen) and chlorophyll a.

Various studies show that the follow-up of dissolved oxygen and other elements in the water is not very useful since no measurable change is identifiable beyond 50m from the cage and the high dispersion capacity of the water does not reflect the impact of the farm on the Mediterranean.

c. Sediment and bottom community measurements

Particulate wastes tend to settle to the sediments creating a 'footprint' effect usually distributed in the direction of the main current flow (Beveridge, 1996).

Distribution of the soft substrate in the area should be measured, with data on granulometry, redox potential, organic and mineral content, free sulphides and *Beggiatoa* percentage, and the presence or absence of pellets and food. Where appropriate, pollutants may be studied, based on the EIA results. In addition, phanerogam quality and density should be described, based on specific transect protocols.

Benthic communities are usually described using bioindicators as key elements in the analysis of the bottom reactivity of the farm since they are the species or groups of species that provide evidence for a specific environmental factor. Besides identification, data on species richness, abundance, biomass and diversity (using the Shannon index) should also be produced.

Measurements of sediment and bottom community species are highly relevant since they incorporate all the elements from the production farm, such as impact on phanerogam photosynthesis, biotransformation in the sediment or trends towards anoxia. Because of this, it is also the topic that has been most studied up to now (FAO/GFCM, 2004).

Figure R.2 shows the frequency distribution of affected components of the ecosystem according to the results and conclusions of reviewed publications. The blue portion of the bar represents the proportion of effects found to be significant.

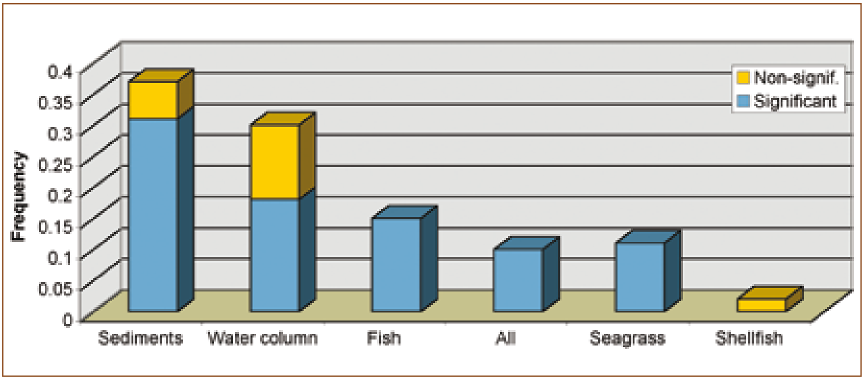


Figure R.2. Frequency of significant and non-significant effects on ecosystem components

d. Cumulative effects measurements

In some cases, albeit rarely up to now due to the complexity and cost of the task and the lack of experience, cumulative effects studies are requested. The first trial studies are often carried out by regional or central government agencies to analyse possible synergies or cumulative effects such as the maximum stocking rate, based on simulations using data from the EIA.

e. Interference with other users

A small section concerns monitoring of conflicts and relations with other users. In general this section is not very complete or well researched by the monitoring consultancy or researchers.

Indicator species

The monitoring document can classify areas based on indicator species as follows (Giménez Casalduero, 2001):

- Non-impacted area, where the number of species and diversity are high;
- Stressed area, with medium pollution and high diversity, abundance and species richness. We find a large number of indicator species of organic pollution, such as the polychaetes *Notomastus, latericerus*, *Nicolea venustula*, *Nematonereis unicornis* or *Lumbrineris latreilli*. Species such as *Hyalonoecia bilineata* may be very dominant in this situation;
- Very polluted area of the second order, where the number of species decreases and the community is dominated by high organic pollution indicator species like *Capitella capitata* or *Capitomatus minimus* together with other species in low abundance;
- Very polluted area of the first order, where the species richness and diversity are minimal. Only indicator species of severe pollution survive, such as *Capitella capitata*, *Capitomatus minimus* or *Cirratulus cirratus*;
- Area of extreme pollution, where the whole macrofauna disappears. Even opportunistic species are not able to survive in this area.

Recent monitoring improvements: developing an adaptive approach

In terms of monitoring, the best examples to be followed in the future could be the MOM (Modelling–Ongrowing fish farms–Monitoring) system from Norway, which allows for adaptive monitoring measures depending on management by the producer as well as the size of the environmental impacts (see the example on MOM below). A Spanish adaptation of a monitoring protocol based on MOM has also been developed for large production areas and local farms (Figure R.3).

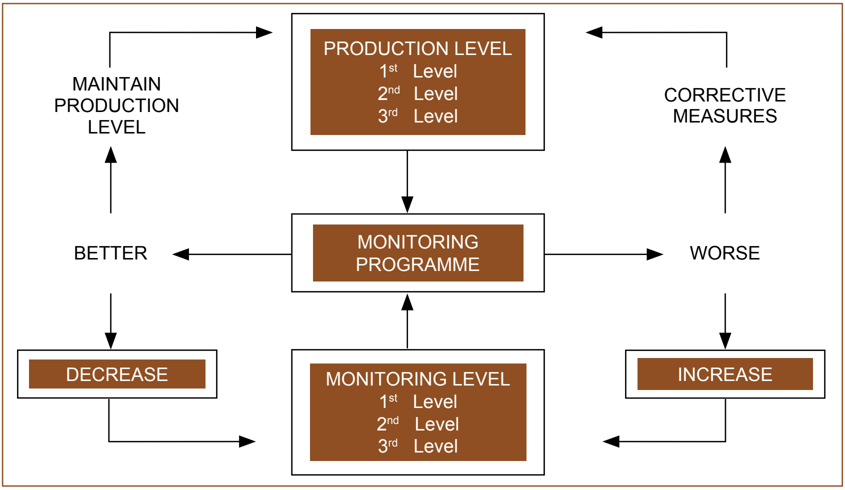


Figure R.3. Adaptive monitoring diagram developed for pre-selected aquaculture sites in Murcia and the Canary Islands (Spain) (From Perán Rex et al., 2003; Taxon Estudios Ambientales, 2007)

This system is the target for all future EMPs. It allows for the level of sampling protocols and monitoring efforts to be reduced to a minimum when management is efficient and impacts are standard or low. Conversely it increases the monitoring pressure (sampling stations, type of measures, etc.) on the producer when production is not well managed, impacts are increasing or a specific crisis needs close monitoring.

Environmental monitoring programmes in relation to licensing and site management

An EMP is usually demanded together with the EIA for aquaculture licensing. Whether proposed by the companies or established by the administrative authorities, these programmes need to be considered in the initial project in order to evaluate and control the progress of the activity with regard to the surrounding environment.

Another aspect is the decision of who has to pay for it. In any case, and from the data observed, monitoring is seen as a low-cost item compared to private companies' incomes, accounting for about 2 percent of the total cost of installation for sea bream and sea bass farms and 1.3 percent in the case of tuna (Belmonte *et al.,* 2001). However the requisite level of monitoring in some countries such as France may be beyond the means of small producers.

Why perform an environmental monitoring programme?

The importance of monitoring programmes has been underlined not only from the environmental point of view but also from the point of view of farming, as the waste produced from the farm can be harmful to the farm itself.

Monitoring fulfils its mission when it facilitates the establishment of management objectives such as:

- The determination of acceptable areas for the installation of aquaculture farms;
- The establishment of environmental quality objectives or standards (EQS).

Among the reasons presented for monitoring, the following have been stated:

- Establishment of a legal regulation;
- Farm management (optimization of resources);
- Human health;
- Research (identification of impacts and model validation, development of methods, etc.);
- Its relationship with feedback processes in the EIA.

Justification

For an established or new aquaculture project, environmental monitoring programmes are needed and should be compulsory for site management. It is not logical to carry out an environmental impact assessment without subsequent monitoring of the changing situation due to the development of the farm.

Principle

Environmental monitoring programmes should be implemented and should be compulsory for sustainable aquaculture site management.

Guidelines

- A baseline study should be implemented prior to the environmental monitoring programme. Thorough, in-depth knowledge of the surrounding environment and aquaculture practices is needed to define the best possible specific environmental monitoring programme.

- Reliable monitoring should be used to detect environmental responses to changes in the scale of production and to readjust the thresholds of environmental quality standards. Due to the continuous development of the industry, monitoring must be adaptive to assess the dynamic linkages between aquaculture and the ecosystem within which it operates.

- Standardization and harmonization of EMP should be imposed by law in all Mediterranean countries. Supported by research programmes, the same EMP procedures should be followed, so as to make aquaculture sustainable throughout the Mediterranean.

- The EMP, together with environmental quality standards, should be regularly revised and harmonized by reliable multidisciplinary bodies and the results disseminated in an easily understandable way. A well-conceived EMP is a highly effective method that links environmental changes with activity inputs. However, there are no set ways of monitoring or interpreting the data obtained. These are dependent on the aims of the study, the size (in the case of development), the site characteristics and existing scientific knowledge.

- The sampling frequency used in the EMP should be determined in the environmental impact assessment. Sampling of the sediment and water column should be done at least during the period of greatest impact, in summer. The EMP could be adaptive, so that negative effects would increase the level of monitoring, whereas positive effects would reduce it.

- A regular socioeconomic analysis in the EMP should be developed and revised at least every 5 years. This is in order to monitor the socioeconomic impact and review what was expected in the environmental impact assessment.

Examples of the Mediterranean monitoring situation

Monitoring is not undertaken unless it is compulsory and enforced by a legal or administrative body.

The quality and level of EMP requirements laid down in the EIA vary from one country to another. There is little common ground on regulatory issues among Mediterranean countries. Some countries do not enforce EMP on their farms. In addition, none of the Mediterranean countries carry out regular socioeconomic monitoring at all.

- Malta. The Malta Environment and Planning Authority (MEPA) is the body responsible for ensuring that monitoring of farms is carried out regularly, as per the licence conditions. Most environmental monitoring is undertaken by independent consultants that must be approved by MEPA. The National Centre of Aquaculture also undertakes some environmental monitoring of the farms.

- France and Spain. EMPs have to be proposed and implemented by individual companies. In France, the Veterinary Service evaluates the quality of the reports and Ifremer, a research institute, is often a member of the advisory committee, since it is in charge of monitoring general environment quality of the coastal area in France. In Spain, EMPs are developed where regional reserved areas for aquaculture have been defined. Again, differences are found between regions, especially in parameter criteria.

- Turkey. The EIA requires an EMP, but there is no consensus among the administrative bodies that take part on the technical aspects and criteria to be implemented.

- Greece. In spite of the high production rate, there is no specific EMP and no requirement for one, and there is a considerable lack of public information and risk assessment. Only the recent change in the regulatory framework of Areas for Organized Aquaculture Development (AODA) includes monitoring and control.

- Cyprus. There are strong regulations and EMP is well developed and implemented according to specific criteria and protocols. All farms have been regularly monitored in recent years using the recommendations of GESAMP 1996 (Poseidon *et al.,* 2006).

- Southern Mediterranean countries. The EIA does not require a strong EMP, and there are no defined parameters or homogeneous guidelines.

As has been seen, EMP is an area to be developed throughout the Mediterranean. As a consequence, researchers are proposing to simplify EIA protocols and monitor and harmonize standards based on such arguments.

Monitoring and management of local environmental impacts of fish farming in Norway

In Norway, aquaculture in marine net pens is a large and expanding industry. Culture of salmonids accounts for the bulk of the fish farming in Norway, with 1,198 salmon and trout farms producing 689,000 tones of fish in 2007. In addition to salmonid farming, 415 concessions farmed other species such as cod, halibut and arctic char. During the more than 30 years of commercial fish farming in Norwegian coastal waters, the industry has evolved greatly with respect to both optimization of production efficiency and reduction of environmental impacts. In this context, prevention of over-exploitation of farm sites and maintenance of good rearing conditions has been emphasised.

As an effort to avoid over-exploitation of farm sites and to ensure good rearing conditions a management system called MOM (Modelling–Ongrowing fish farms–Monitoring) has been developed. In parts this concept has been made mandatory for the establishment and operation of fish farms, and negative results or insufficient monitoring might result in fallowing or relocation of farms.

The MOM concept is based on the appreciation that marine areas are more or less sensitive to effluents from fish farms and therefore have varying capacities for fish production. The system involves environmental impact assessment and monitoring applied to a set of environmental standards (EQS). The amount of monitoring depends on the degree of environmental impact, and a high degree of exploitation (DEX) calls for a high level of monitoring.

The MOM system focuses primarily on preventing the accumulation of organic matter in the sediments, which in turn might have negative effects on the benthic fauna. At present, other types of environmental impacts, such as genetic effects of escaped farmed fish and propagation of parasites, diseases and chemicals, are not addressed by MOM. In the MOM system, the holding capacity of a site is this defined as the maximum production that allows for viable benthic macrofauna under and around farms.

The monitoring programme in MOM consists of three types of investigation (A, B and C) of increasing elaboration and accuracy. In general, sites with a low DEX are less monitored than sites with a high DEX. The A-investigation monitors the organic output from farms by sampling particles in sediment traps, and is not mandatory.

The B-investigation is the core of the monitoring and involves analysing sediments collected primarily under farms with respect to the occurrence of macrofauna, pH, redox potential, thickness of organic material, smell, colour, consistency and gas bubbles. The B-investigation is designed to be simple and inexpensive. The results from the different parts of the B-investigation are assessed using a score system which provides a simple categorization of the environmental status under and around farms and finally allows determination of the DEX in accordance with a set of EQSs. The B-investigation is mandatory both for the establishment of new farms and for monitoring of the status of existing farms. This investigation should be carried out during periods when the DEX is expected to be highest, i.e. in periods of maximum production/biomass. If the DEX as defined from the results of the B-investigation is high the monitoring activity will be intensified, and if low the monitoring will be reduced. In addition, results indicating a high DEX may also lead the management authorities to instruct the fish farmers to carry out the more comprehensive C-investigation.

The C-investigation involves studies of the benthic macrofauna communities over larger areas than covered by the B-investigation. The C-investigation deals with long-term environmental changes in the sediment in transects from the local impact zone into an intermediate impact zone and in areas where waste is expected to accumulate.

The Norwegian MOM concept aims to ensure that the farming activity does not exceed the holding capacity of the site. In cases where the capacity is exceeded, optimization of feeding schedules or selection of other sites with stronger currents or greater depth might be necessary. A weakness with the MOM system is that it involves benthic impacts only. A growing body of evidence, not only for salmonids, suggests that fish farming also causes other serious environmental impacts (e.g. fish escapes and the spread of diseases and chemicals). An explicit goal for future monitoring of the environmental impacts of aquaculture should thus be to cover a larger range of impacts than embraced by MOM.

For more detailed information about MOM the reader should consult Ervik *et al.,* 1997, Hansen *et al.,* 2001 and Stigebrandt *et al.,* 2004.

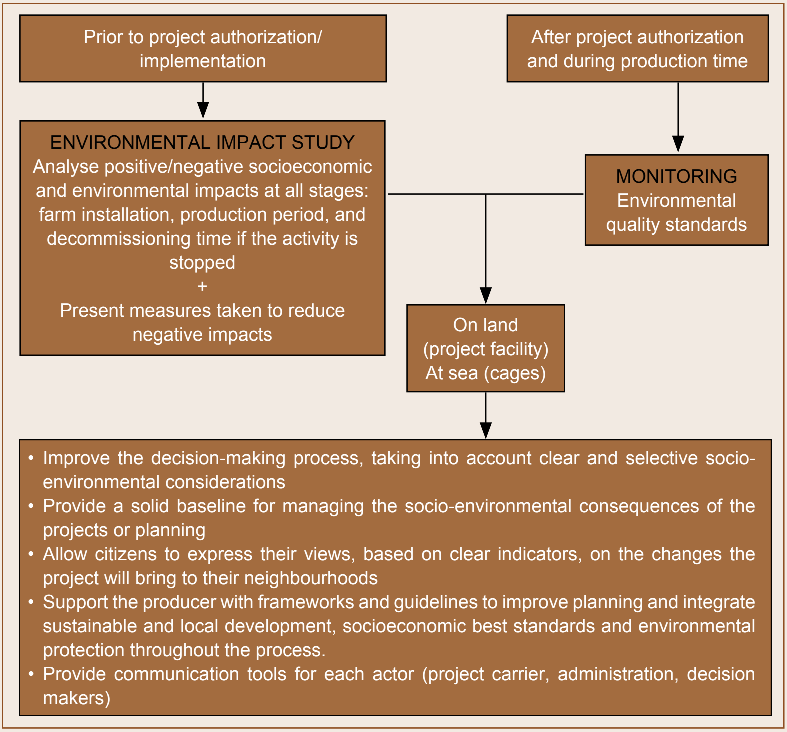
Summary of environmental impact assessment and monitoring in aquaculture

Three tools are needed for appropriate site selection and site management:

- The EIA addresses the project in detail, with its positive/negative potential, direct and indirect impacts, and how to mitigate them. It should take into account all uses and interests in order to reduce risks and conflict.

- Environmental quality standards (EQS), based on the precautionary principle, other countries' experience, the recommendations of the Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and EC directives, as well as local experience, should be established to set the limits between production and societal values for environmental integrity.

- Environmental monitoring programmes (EMPs) are needed to ensure compliance with EQS, to assess and support effective management, and to validate models and predictions.



Geographical information systems (GIS)

This guide defines what geographical information systems are and their application to site selection and site management. A brief description of the tool is given, and the features that GIS should have in order to make it useful and effective. An example of a GIS produced in Andalusia (southern Spain) is presented.

Many definitions have been offered to describe what a geographical information system (GIS) is, depending on the context in which it is used and the purpose or viewpoint that the author is trying to put across. Regardless of the focus intended in the definition of a GIS, however, all definitions include a reference to a feature that is invariably present. This feature is the spatial component of the processed data. It is important to highlight, therefore, that the main difference between a GIS and other information systems is its ability to work with spatial information, i.e. all the data used can be situated at a point in space.

What are the main characteristics of a GIS that make it different from other information systems? The following stand out:

- Complex geographical information can be visualized in maps (Figure S.1).

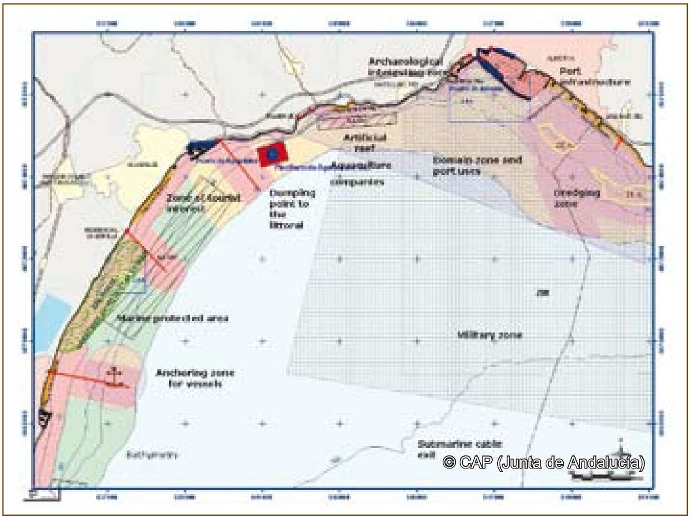


Figure S.1

- A GIS works as a sophisticated database in which spatial and thematic information is stored and referenced (Figure S.2).

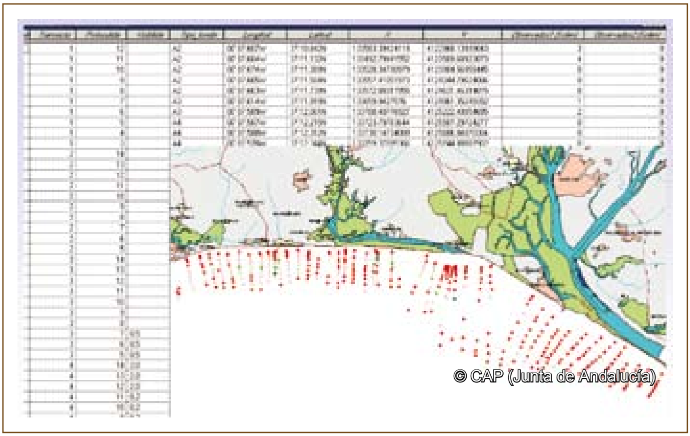


Figure S.2

- The difference from conventional databases lies in the fact that all the information contained in a GIS is tied to geographically located entities. That is why in a GIS the position of the entities is the backbone for data storage, retrieval and analysis.

- It is an information integration technology.

- It has been developed from technological innovations in specialized fields of geography and other sciences, such as image processing, photogrammetric analysis and automatic mapping, forming a single system that is more powerful than the sum of its parts.

- Information in a GIS can be unified in coherent structures, and a wide variety of functions, such as analysis, display or editing, can be applied to it.

- This integrating and open nature of a GIS makes it an area of contact between various types of computer applications designed to manage information for various purposes and in various forms. They include, for example, statistical programs, database management applications, graphics programs, spreadsheets and word processors.

How does a GIS work? A GIS splits the subject into distinct themes, i.e. information layers or strata from the area we want to study. As they are superimposed on each other, these information layers create a graphic representation of reality, the final result of which takes shape as a map (Figure S.3). Parallel to this, the technical analyst can process information separately, if so required at the time, or relate the various layers or themes to each other—an important capability in data analysis.

Figure S.3

The spatial database of a GIS (a geodatabase) is nothing more than a model of the real world, a digital representation based on discrete objects. A geodatabase is, in the end, a collection of data referenced in space which serves as a model of reality. The rules by which the real world is modelled by means of discrete objects make up the data model. Two main methods exist for modelling spatial reality: according to properties (vector models) or location (raster models).

Vector models

In vector models real entities can be represented by means of points, lines or polygons. The combination of these entities produces a graphical representation of reality (Figure S.4). In general, the vector data model is suitable when working with geographical objects with well-established limits, such as farms, roads, etc.

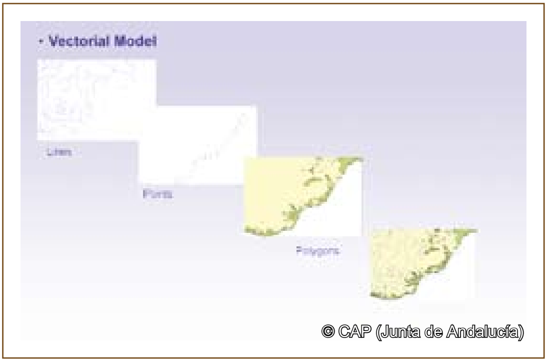


Figure S.4

Raster models

Space is split into portions of equal size and shape (cells) by superimposing a grid. Each cell contains information, generating a grid of rows and columns with associated values depending on the features they represent. Thus, raster models do not explicitly record geographical boundaries between elements, although these can be inferred approximately from the cell values (Figure S.5).

Obviously, to obtain a precise description of the geographical objects contained in the raster database the cell size has to be small at the scale in question, which produces a high-resolution grid. However, the greater the number of rows and columns in the grid, and hence the higher the

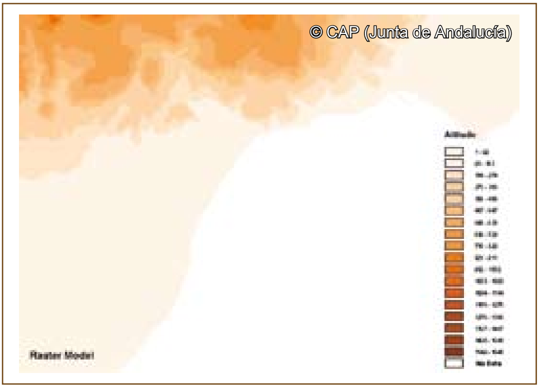


Figure S.5

resolution, the greater the effort required to capture the information and the greater the time required for its analysis.

The raster data model is especially useful for describing geographical objects with diffuse boundaries, for example the dispersion gradient of a pollutant cloud or the surface temperature of an ocean, where the outlines are not absolutely clear; in these cases, the raster model is more appropriate than the vector.

So for example, vector models are very suitable for delimiting protected areas, administrative boundaries, prohibited areas, etc., while raster models are more suitable for representing surface temperatures, currents, pollutant dispersion areas, etc.

Comparison of raster and vector models	**raster**	**vector**
Allows for greater graphic precision	−	+
Used in traditional cartography	−	+
Can cope with a greater volume of data	−	+
Topology can be implemented	−	+
Calculations are more easily performed	+	−
Data update is simpler	+	−
Allows for representation of continuous spatial variation	+	−
Data from different contexts are more easily integrated	+	−
Discontinuous spatial variation is more easily represented	−	+

− Disadvantage compared to the other model   + Advantage compared to the other model

Data and parameters to be assessed

Technically speaking, GIS as a data storage tool should not have limits. But in terms of data management, understanding and representation, it is important to select the parameters and define the amount of data in advance. This is especially important for site selection and site management processes.

The data contained in the GIS is going to be the information given to decision makers, and therefore it should be the most appropriate data for the objectives to be met. Data should be obtained through prospective work and validated. For this purpose, professional independent working teams should be organized to ensure the quality of the data.

When assessments are made based on different parameters, a weighting factor should be set for each one. In the final assessment, parameters which are more important to the development of aquaculture activities thus carry more weight. For example, water quality is a more important factor for aquaculture than the bathymetry of the area, so when the suitability of an area is assessed on these parameters, the former must outweigh the latter in the final outcome. For this weighting, it is essential to be clear about the importance of each parameter considered in the study in relation to the others. This will guide the process of obtaining the information and entering it in the system.

Another type of data specified is metadata. This is data on the data, or information about the data, such as the source of the information, the coordinate system used, the reliability of the information, the body which updates it, its confidentiality level, etc.

Output and understanding

It is important to highlight that a GIS is not just a computer system for drawing maps, although it can produce maps to various scales, on different projections and in several colours. A GIS is an analysis tool for identifying spatial relationships between the distinct pieces of information contained in a map. A GIS does not store a map in a conventional manner. It stores data from which it can create the appropriate representation for a specific purpose or generate new maps using the system's analysis tools.

Throughout this process, simplicity without loss of quality should be the aim, in order to ensure understanding and correct interpretation. Therefore, in the assessment of potential aquaculture areas, three levels of suitability (high, medium and low) should be defined. That is sufficient for establishing space management benchmarks for aquaculture development. It is not a good idea to distinguish too many degrees of suitability, which may ultimately prove difficult to interpret.

GIS has special characteristics such as flexibility and adaptability that allow it to develop and adapt to the changing environmental, administrative and socioeconomic context.

All these components, together with perhaps the most important one, the reliability of the information, are invaluable in the process of site selection and site management. At the same time GIS is an important tool for the sustainable development of aquaculture because of its functionality and its inputs to knowledge, participatory processes, and so on.

Justification

When deciding whether a zone is suitable for aquaculture, a large number of factors has to be taken into account, ranging from the purely administrative to physical, chemical and environmental parameters.

The pieces of information processed to obtain a criterion of suitability are of so many different types that interrelating them all is very complicated. In this regard, the use of a geographical information system as an information integration tool is extremely useful in the selection and management of areas for aquaculture.

Once the spatial component has been added to the information held (georeferencing), a model of the area can be produced and the data processed on the basis of their common component (their position in space). Because of its ability to integrate information, a GIS should be used to characterize a potentially suitable area for aquaculture, since it is an extremely useful tool for multi-criterion decision making.

Principle

Geographical information systems (GIS) should be used as a tool for site selection and site management.

Guidelines

- Geographical information systems (GIS) should be used as a tool in participatory and co-construction processes. This will help people's understanding and focus the discussion on the real problems, balancing power among all stakeholders.

- The information contained in a GIS should be objective and based on reliable sources. Since these are tools for decision makers, the information must be based on good authority and only be open to question by means of empirical demonstration.

- The information stored in a GIS should be maintained and kept up to date. A GIS should be considered a live system in which the information it contains varies over time; it should therefore prevent decision-making errors resulting from the use of obsolete data.

- Information on the characteristics of the data contained in the GIS (metadata) should be made available. The metadata must conform as far as possible to internationally recognised standards, providing reliability.

Example: Location of suitable areas for the development of aquaculture in Andalusia

Between 2000 and 2003, the Directorate General for Fisheries and Aquaculture, part of the Regional Ministry of Agriculture and Fisheries of the Andalusian Government, conducted the study called 'Location

For the selection of areas, as much information as possible on the Andalusian coast was collected during the first phase of the study. This focused on administrative aspects relating essentially to the uses, activities and occupations of the public shoreline that might interfere with aquaculture due to competition for space. Then, in the second phase, work could focus on analysing the technical environmental aspects of those areas that had been identified as being of interest in the previous phase.

The use of GIS as a working tool was decided upon for the storage, processing and analysis of all the data collected throughout the study; this system proved critical for achieving the desired results.

For the first phase it was decided to store the administrative information using a vector model, as the parameters to be represented had well-defined geographical locations (primarily polygons and lines), so that the final result could be mapped using this model (Figure S.6).

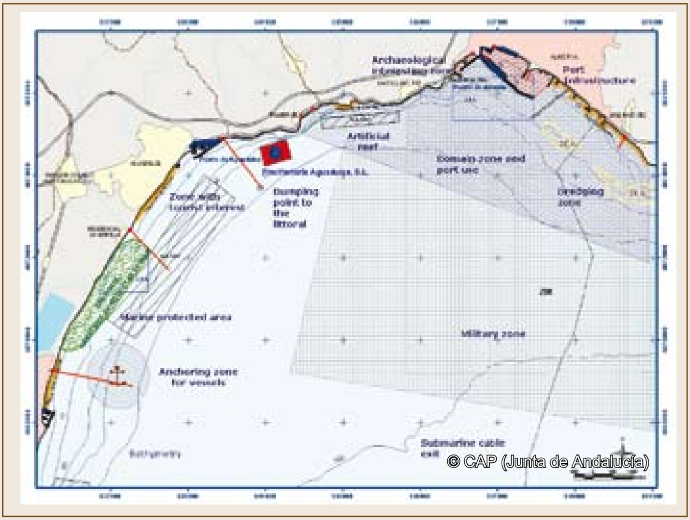


Figure S.6

The criterion used for evaluating the suitability of areas for aquaculture development was based on the compatibility of this activity with existing uses of the same area. The suitability of areas was considered high where their current uses were fully compatible with aquaculture, medium where their existing uses, while not incompatible with aquaculture, might impose some limitations on its development, and low where their existing uses were incompatible with the development of aquaculture activities.

For the second phase of the study, the various physical, chemical and environmental parameters that were used in assessing the areas were stored in the GIS using raster models. This was because the data to be represented, obtained from sampling campaigns, were mostly numerical values that varied continuously in space (surface water temperature, average current speed, salinity, etc.).

Once the raster model had been set up, each parameter was given a score depending on its suitability (-1 for low suitability, 0 for medium suitability and 1 for high suitability). This score was assigned in a reclassification operation in which different value ranges were grouped according to their suitability for aquaculture activities.

For example, in the case of the bathymetry of the area, the study considered the best depths for locating aquaculture facilities to be between 20 and 50m, while shallower depths were not considered appropriate. Although facilities can be located where depths are greater than 50m, such depths are not the most suitable because of the high cost of maintenance. Thus bathymetry values of less than 15m were assigned low suitability (-1), bathymetry values between 20 and 50m high suitability (1) and depths exceeding 50m medium suitability (0) (Figure S.7).

In the case of the areas' environmental value parameter, several factors were considered, such as existing communities, species diversity and

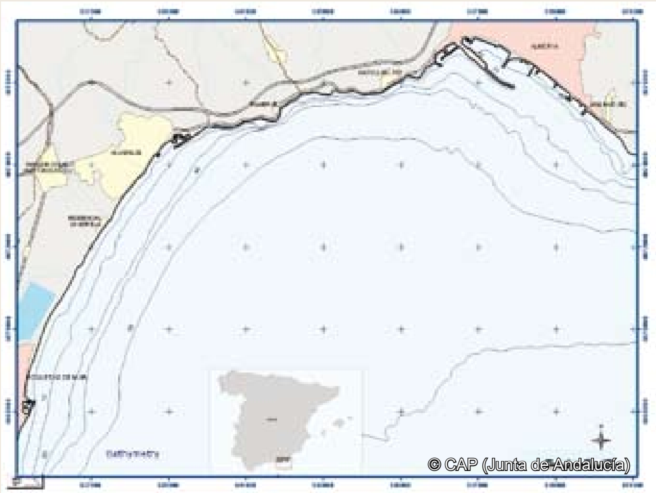


Figure S.7

abundance, etc. These variables were combined in an overall score derived from the weighted scores for each of the factors considered. This final overall score was used to rate the suitability of an area based on this parameter (Figure S.8). A similar method was used to assess the

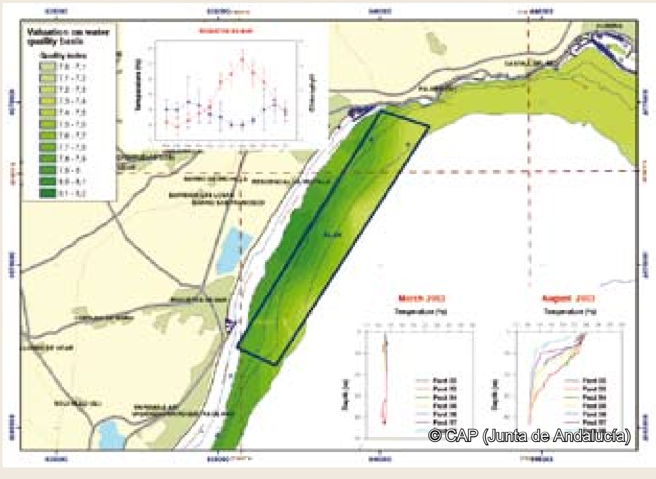


Figure S.8

suitability of an area in terms of water quality, in which a water quality score was used that was derived from factors such as temperature, salinity, dissolved oxygen, turbidity, chlorophyll, etc.

Finally, all the scores for all the parameters considered were used to produce a final weighted suitability score for the various areas studied (Figure S.9).

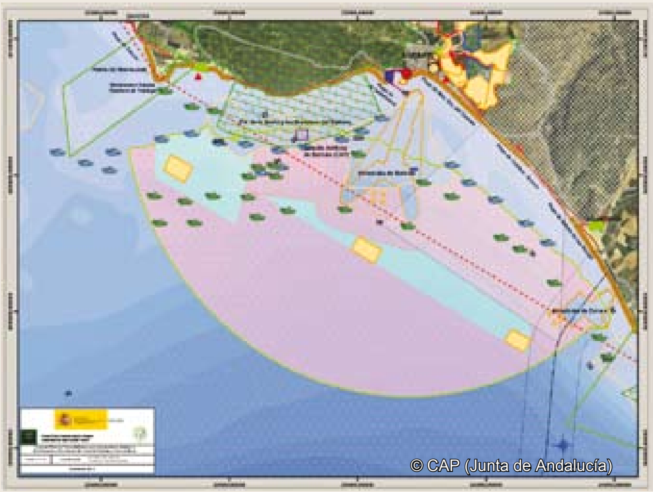


Figure S.9

Lastly, the evaluations made in the first and second phases were combined to provide the final assessment of the suitability of the various areas studied for aquaculture development. Areas of low suitability in either phase retained that level of suitability. Those of medium suitability in either phase remained as such provided they were not rated low in the other phase. Finally, areas of high suitability for the development of aquaculture were defined as all those which were not rated medium or low in either of the study phases (Figure S.10).

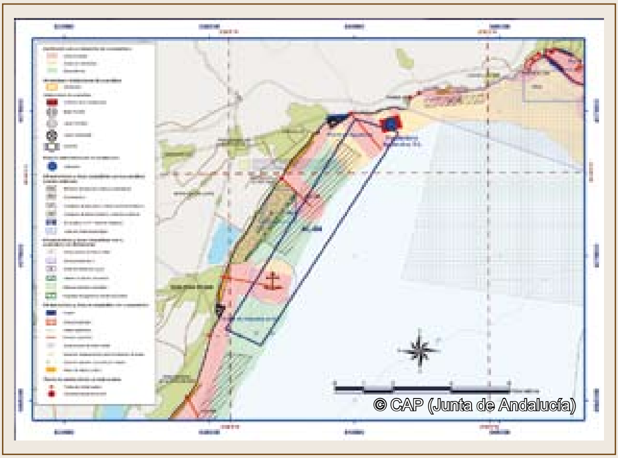


Figure S.10

The end result of this work is a useful tool for the management of aquaculture activities, not only for the authorities with jurisdiction in the field, but also for entrepreneurs, who gain some initial guidance on potential locations for their future facilities.

Annexes

Glossary

Aquaculture licence
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.

Aquaculture licence fee
The fee that must be paid for holding an aquaculture licence. Normally this fee is paid because an area in the public domain (water or land) is being used and/or occupied.

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.

Carrying capacity
According to the FAO, 'Carrying capacity is 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.'

Coastal zone management
The management of coastal and marine areas and resources for the purposes of sustainable use, development and protection.

Cost-benefit analysis
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 recognised. These include financial, socioeconomic and environmental variants.

Decision maker
Person, group or organization whose judgements can be translated into binding commitments.

Economic/monetary valuation
Assigning an economic value to environmental factors and considerations. This helps give weight to such considerations where they might otherwise not be taken into account. Full valuation requires significant information, time and resources. Valuation methodologies may be based on actual markets, surrogate markets or non-market techniques.

Ecosystem objective
Ecosystem attribute which is a particular aim that stakeholders have agreed upon; it can relate to the protection of a specific species, specific area or a function that the ecosystem provides locally.

Environmental externality
An activity by one agent that causes a loss/gain to the welfare of another agent and the loss/gain is uncompensated.

Exposed aquaculture
Aquaculture is usually considered exposed when 'cage aquaculture is developed in marine areas not protected by the coastline from adverse marine conditions'.

Fallowing
This refers to leaving an aquaculture site empty of fish stock and all removable production structures for a certain period of time. It can be done for environmental or sanitary reasons. For an aquaculture company, fallowing implies having several sites in order to maintain production capacity year round.

One-stop shop

An agency or department that provides a number of different services under one roof. In terms of aquaculture procedures, it acts as a central register receiving all information and coordinating all services. It is like a primary hub for service delivery.

Production cycle

The time necessary to rear any aquaculture species to marketable size.

Public domain (maritime and terrestrial zones)

Areas that are public property. They 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.

Sheltered aquaculture

Aquaculture is usually considered sheltered when 'cage aquaculture is developed in marine areas protected by the coastline from adverse marine conditions'.

Site selection and site management

Site selection is the process of selecting a certain space in the marine environment by examining environmental, technical, legal, administrative, social, economic and other related aspects, in order to set up an aquaculture project. Site management refers to all the actions involved in maintaining the activity on the site, including the environmental, legal, administrative and managerial aspects of the activity.

Stakeholder

Person, group, or organization that has a direct or indirect stake in an organization because it can affect or be affected by the organization's actions, objectives, and policies.

Stressor

That part of the activity that will affect a particular ecosystem component.

Total economic value

The sum of all function-based values provided by a given ecosystem and measured in monetary units. The values may stem from direct uses of the ecosystem services or from benefits derived by people who make no direct use of them. Measurement may be based on market activity or elicited through a variety of methods for valuing goods and services for which there is no market.

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The workshop in Istanbul took place from 22 to 23 Ocober 2007. It was organized thanks to Güzel Yücel-Gier. It gathered more than 40 participants. It aimed at scoping and discussing all the issues relevant to site selection and site management.

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The workshop of Alicante took place from 28 to 29 February 2008 in the buildings of the Marine ecology laboratory of Alicante University. It was organized thanks to Pablo Sanchez. It aimed at discussing in details scientific issues relevant to site selection and site management such as carrying capacity, environmental impact assessment and monitoring.

The workshop of Split took place from 6 to 8 March 2008 in the offices of the PAP/RAC of the Mediterranean Action Plan. It was organized thank to Iviça Trumbic, Zeljka Skaricic and Ljiljiana Prebanda. It aimed at discussing concepts and methods such as social acceptability, governance, precautionary principle, integrated coastal zone management and ecosystem approach.

List of acronyms

ACO:	Aquaculture Consultant Office
APROMAR:	Spanish Marine Aquaculture Producers Association (Asociación Empresarial de Productores de Cultivos Marinos)
BRLi / SECA:	French Consulting Office on Environment
CBD:	Convention on Biological Diversity
CETMAR:	Technological Centre of the Sea (Centro Tecnológico del Mar)
COHERENS:	Coupled Hydrodynamical-Ecological Model for Regional and Shelf Seas
DAP:	Public Enterprise for Agricultural and Fishireries Development (Empresa Pública Desarrollo Agrario y Pesquero)
EC:	European Commission
ECASA:	An Ecosystem Approach to Sustainable Aquaculture. European Union FP 6 (Sixth Framework Programme)
EEA:	European Environment Agency
EMAS:	Eco-Management and Audit Scheme
EU:	European Union
FAO:	Food and Agriculture Organization of the United Nations
FEAP:	Federation of European Aquaculture Producers
GESAMP:	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM:	General Fisheries Commission for the Mediterranean
ICES:	International Council for the Exploration of the Sea

ICPE:	Installations Classified for the Protection of the Environment
IEO:	Spanish Institute of Oceanography (Instituto Español de Oceanografía)
INRA:	National Institute of Agronomical Research (Institut National de la Recherche Agronomique)
ISO:	International Organization for Standardization
IUCN:	International Union for Conservation of Nature
JACUMAR:	National Marine Aquaculture Advisory Board
MAP:	Mediterranean Action Plan
MOHID:	Water Modelling System
NINA:	Norwegian Institute for Nature Research
NOAA:	Oceanic and Atmospheric Administration
OECD:	Organisation for Economic Co-operation and Development
OSPAR:	Oslo/Paris Convention (for the Protection of the Marine Environment of the North-East Atlantic)
PAP/RAC:	Priority Actions Programme Regional Activity Centre
RAC/SPA:	Regional Activity Centre for Specially Protected Areas
SEPA:	Scottish Environmental Protection Agency

Ministry of the Environment and Rural and Marine Affairs

The Spanish Ministry of the Environment and Rural and Marine Affairs (MARM) is the ministerial department that draws together all State competencies linked to the natural environment in the joint aim of protecting the land and biodiversity, as well as promoting and protecting the agricultural, livestock, forestry, fishing and food production factors. The General Secretariat of the Sea is dedicated to the task of protecting and conserving the sea and the public maritime and terrestrial domain.

www.marm.es

Regional Ministry of Agriculture and Fisheries of the Autonomous Government of Andalusia

The Regional Ministry of Agriculture and Fisheries, attached to the Autonomous Government of Andalusia, and according to Decree 120/2008 of April 29, is responsible for agriculture, fisheries, food and rural development. Through the General Directorate of Fisheries and Aquaculture, it is responsible for research, technology development and transfer, training, planning and management of fisheries and aquaculture.

www.cap.junta-andalucia.es

Federation of European Aquaculture Producers

The Federation of Aquaculture Producers (FEAP), founded in 1968, currently represents 28 national aquaculture associations in 23 European countries, with a finfish annual production of over 1.3 million tones. FEAP is a Member Organisation of the Advisory Committee on Fisheries and Aquaculture of the Commission of the European Union and carries out numerous European and international activities for the aquaculture sector.

www.feap.info

IUCN – Centre for Mediterranean Cooperation

The Centre was opened in October 2001 and is located in the offices of the Parque Tecnologico de Andalucia near Malaga. IUCN has over 155 members in the Mediterranean region, including 15 governments. Its mission is to influence, encourage and assist Mediterranean societies to conserve and use sustainably the natural resources of the region, work with IUCN members and cooperate with all other agencies that share the objectives of IUCN.

www.uicnmed.org

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