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Key elements for guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and Black Sea

BACKGROUND

1. This document contains the key elements for guidelines on a harmonized environmental monitoring programme (EMP) for marine finfish cage farming in the Mediterranean and Black Sea within the activities of the Working Group on Site Selection and Carrying Capacity (WGSC). During the sixth and seventh sessions (Tirana, Albania, December 2008 and Rome, Italy, March 2010) of the Committee on Aquaculture (CAQ), it was agreed that there was a need to harmonize and to implement the procedures for site selection and management of Mediterranean aquaculture, and the importance to have an environmental monitoring programme (EMP) in place for the areas surrounding aquaculture activities was stressed.

2. At its thirty-sixth session (Morocco, May 2012), the Commission, acting upon the advice made on aquaculture management, gave mandate to the Secretariat and to the CAQ to proceed with the preparation of specific guidelines on EMP. Subsequently, at its eighth session, the CAQ endorsed the preparation of guidelines on aquaculture environmental monitoring for the Mediterranean and Black Sea. Finally, at the thirty-seventh session of the Commission, the need to prepare guidelines on harmonized environmental monitoring programme for Mediterranean and Black Sea aquaculture was reiterated.

3. The importance of a harmonized EMP for Mediterranean and Black Sea marine aquaculture activities has been evocated during the last years in many experts meetings and fora. This document embeds principles and builds on fundamentals which have been produced over time by CAQ and its subsidiary bodies. More specifically, it draws inspiration from the different documents and outcomes produced within the SHoCMed project activities, the results of ad hoc meetings (Morocco, February 2013 and Turkey, December 2013) and the collaboration with GFCM partners and CAQ network of experts and research institutes.

4. The key elements for guidelines comprise the scope and objective of an EMP, the essential information to be collected and the sampling design, EMP responsibility, as well as a glossary of the most common terms related to an EMP (Annex A) and the main bibliographic references (Annex B).

SUGGESTED ACTION BY THE COMMISSION

5. The Commission is invited to examine these key elements and provide further guidance as appropriate.

KEY ELEMENTS FOR GUIDELINES ON A HARMONIZED ENVIRONMENTAL MONITORING PROGRAMME FOR MARINE FINFISH CAGE FARMING IN THE MEDITERRANEAN AND BLACK SEA

INTRODUCTION

6. In the Mediterranean and Black Sea, aquaculture plays and will continue to play a major role in enhancing global fish production. The strategic role of the aquaculture sector in responding to the growing demand for seafood and in delivering social and economic benefits to coastal communities is widely recognized.

Marine cage finfish farming

7. Mediterranean and Black Sea marine aquaculture production has shown a staggering positive trend during the last twenty years, mainly due to the increased production of the European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*), which increased from a mere 11 300 tonnes in 1991 to about 273 374 tonnes in 2011. This was possible, among other things, thanks to the improvement of floating cage technology in fish farming. Starting from the early 1990s, culture of fish in floating cages has increased, with many farms progressively and steadily moving toward deploying installations in the open sea. Consequently, in 2011, marine finfish aquaculture in floating cages represented about the 85 percent of total production of European seabass and gilthead seabream.

8. However, the expansion of aquaculture is faced with a number of environmental and socioeconomic issues that may compromise its sustainability and further development. Foremost, there is competition for space with other sectors and activities when allocating an area at sea for aquaculture activities. In this respect, the lack of a regulatory legal framework as well as of criteria for the planning and implementation of an environmental monitoring programme (EMP) for aquaculture activities at sea are additional elements contributing to limiting the development of sustainable aquaculture.

9. The General Fisheries Commission for the Mediterranean (GFCM) is taking stock of the rapid expansion of marine aquaculture, which calls for an integrated coastal zone management (ICZM) approach in which aquaculture should be integrated with other coastal uses; this is also in accordance with the provisions under Article 9 of the FAO Code of Conduct for Responsible Fisheries (CCRF) and consistent with the principles of the ecosystem approach to aquaculture (EAA) development that requires, among other things, the establishment of appropriate policy framework strategies and development plans for sustainable aquaculture.

10. The GFCM acknowledges that opportunities for the aquaculture to grow further go along with the need to strike a balance between minimizing effects on the environment and pursuing a growing production in the region’s coastal zones. This calls for better harmonized regulatory and monitoring frameworks, especially in relation to environmental impact assessment (EIA) and site selection procedures, which would favour the development of zoning of aquaculture within an ecosystem perspective. Aquaculture activities, as well as all other human activities, if not managed in a sustainable manner could negatively affect marine ecosystem functions and services at the local, national and regional levels, particularly in the case of shared ecosystems.

Allocated zones for aquaculture (AZA) and allowable zone of effect (AZE)

11. Coastal marine aquaculture requires high quality water and strict environmental characteristics which may be available in limited areas where complex interactions with other coastal users may cause conflicts and competition for space. The sustainable integration of aquaculture in the environment and with other coastal zone activities would be achieved through the adoption and implementation of allocated zones for aquaculture (AZA), spatial planning, improved and harmonized

site selection criteria, and holding capacity standards adapted to the GFCM area within an EAA perspective.

12. The implementation of a regional strategy for the establishment of AZA is considered by the GFCM as an immediate priority for the responsible development and management of aquaculture activities in the Mediterranean and Black Sea. Consequently, in 2012, the Commission adopted a specific resolution (GFCM/36/2012/1) on Guidelines on allocated zones for aquaculture (AZA).

13. The Commission considered that the establishment of AZA may facilitate the integration of aquaculture activities into coastal zone areas that are exploited by other users and contribute to the enhancement of coordination between the different public agencies involved in aquaculture licensing and monitoring processes. In particular, the Committee on Aquaculture (CAQ) has stressed the relevance of environmental quality and recommended that an aquaculture environmental monitoring programme (EMP) should be implemented in areas surrounding finfish farms, known as "allowable zone of effect (AZE)". The Commission, at its thirty-sixth session (Marrakech, Morocco, May 2012), acting on advice on aquaculture management, gave a mandate to the Secretariat and to the CAQ to proceed with the preparation of specific guidelines on environmental monitoring of aquaculture.

14. The resolution adopted by the GFCM emphasises that the quality of the marine environment is essential and considers monitoring of finfish marine aquaculture to be fundamental for evaluating the effects and impacts of aquaculture on the environment and on aquaculture itself. For every AZA (or polygon within AZA), an AZE be defined in the close proximity of each farm. Such zone shall be accompanied by an EMP to ensure that the environmental quality standards (EQS) are within optimal levels, and consequently the agreed environmental quality objectives (EQO) are respected (Fig. 1). The EMP shall be flexible and adaptable, taking into account the scale (time and space) approach, and environmental monitoring shall be mandatory.

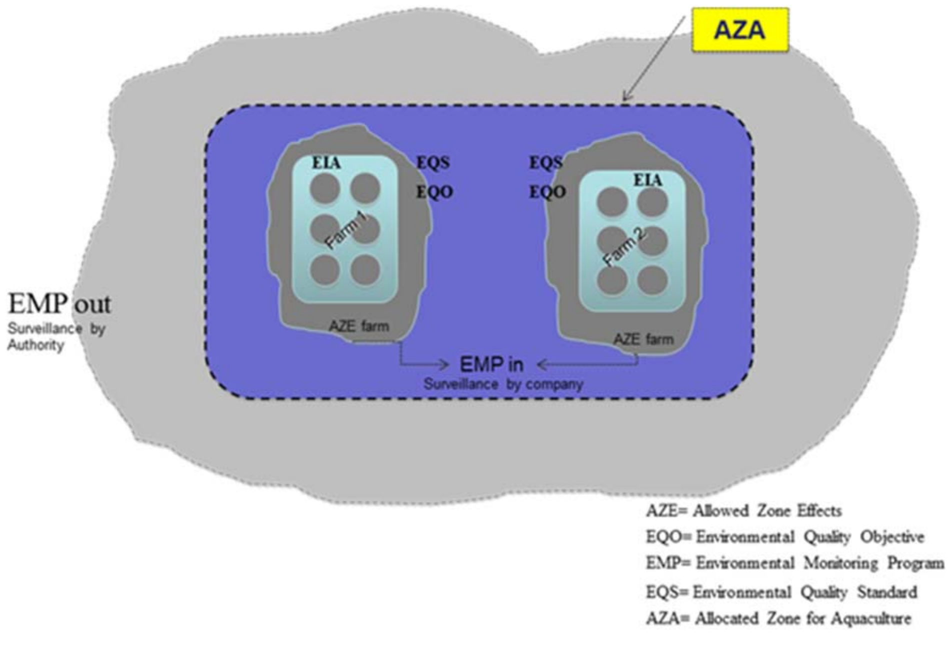

Figure 1: Different zones within an AZA (Source: Macias *et al.*, in preparation).

DEFINITION, SCOPE AND PRINCIPLES, CRITERIA, AND OBJECTIVES OF THE ENVIRONMENTAL MONITORING PROGRAMME (EMP)

EMP definition

15. The EMP for marine cage finfish farming is defined as a functional tool at the disposal of the authorities and the aquaculture industry (e.g. farmers) for aquaculture management practices to ensure the sustainability of the sector itself. The EMP is also intended as a record-keeping system for documenting series of information and values of environmental parameters relevant to aquaculture activities, which will be used to perform periodic environmental assessment and monitoring.

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

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

EMP scope and principles

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

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

20. More specifically, the information provided by the EMP will serve to:

- minimize the global impact of aquaculture;
- respect the ecological services provided by ecosystems;
- minimize local impacts on the environment and biodiversity;
- ensure compliance with regulations and achievement of environmental objectives and contribute to the protection of biodiversity;
- ensure the long-term sustainability of fin-fish culture;
- help define actions to be taken to improve farm management practices; and
- evaluate the achievement of quality objectives of the measures adopted to protect the environment and of bringing the obtained results to the attention of the civil society and the public.

EMP functionality

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

22. The monitoring requirements should comprise a minimum scheme that can be applied in any type of marine environment, as well as additional requirements that can be adapted according to the

different scales of farm activities and depending on the sensitivity of the receiving environment.

EMP reporting system and contents

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

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

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

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

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

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

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

30. Logbook 1 should contain at least the following information:

- Maps with locations of the fish farm, fish cages and monitoring stations;
- Water depth (min, max, mean);
- Mean sea current speed;
- Sediment grain size;
- Information on the benthic community;
- Information on sensitive habitats, if any;
- Information on the finfish farm/farms: (cages farming system and characteristics; cultured species and cycles; production capacity; estimated feed conversion ratio (FCR); potential maximum cultured biomass per year; potential maximum feed quantity used per year).

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

32. The sampling frequency should be annual and made during the period when there is maximum biomass in the cages.

33. The number of sampling stations[1] should be as follows:
- 2 control stations
- 1 under the cages
- 1 up-current located 50 m from the cages
- 1 down-current located 25 m from the cages
- 1 down-current located 50 m from the cages

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

Water monitoring*	Sediment monitoring
Temperature (°C)	Macrobenthic community
Salinity (psu)	Visual inspection
Turbidity (Secchi depth)	Redox potential (Eh, mV)
Dissolved oxygen (% saturation; mg/l)	Sulphide (μM)
Chlorophyll a (mg/l)	Organic matter (LOI, %)
pH (unit)	pH (unit)
Ammonium (N-NO_4, μM)	Total Organic Carbon (TOC, %)
Nitrite (N-NO_2, μM)	Total Nitrogen (μM)
Nitrate (N-NO_3, μM)	Total Phosphorous (μM)
Phosphate (P-PO_4, μM)	Gas bubbles (Outgassing)
TSM - Total Suspended Matter (mg/l)	Litter present on the seabed in the vicinity of the farm
POM - Particulate Organic Matter (mg/l)	

*At each station, samples will be collected at three different layers (surface, intermediate, and deep)

35. In Logbook 2 there should also be some dedicated space to allow the recording of:

- Escapee incidents (species; size; number)
- Disease incidents (type of disease; species at risk; number of outbreaks; medical treatment used)
- Disasters and weather-related events (e.g. presence of jelly fish; mortalities caused by exogenous pollution; storm events, etc.)

EMP design of sampling stations

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

37. The EMP sampling design should be based on transects located within the AZE (*EMP-in*), while control stations should be located outside the AZE (*EMP-out*) see Figure 1. Sampling designs are usually of two main types: i) use of transects that follow the direction of the main sea current (Figure 2) and ii) random stratified sampling (Figure 3).

38. Sampling stations should be located such that consideration is given to the putatively impacted zone around the farm, while the sampling protocol should be site-specific. In the case of uncertainty, sampling stations should be located at a distance of 50 m from the farm operations. Reference data

[1] The sampling station layout design shall be reported separately.

should include data collected before deployment of the finfish cages. The use of BACI (Before-After-Control-Impact) or M-BACI (multiple controls) designs are considered as the most appropriate.

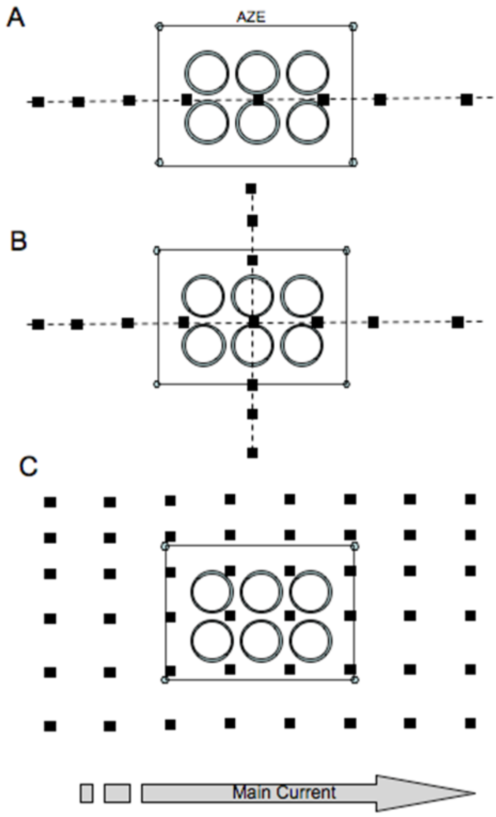

Figure 2: Examples of monitoring programmes based on transects laid across the AZE. A) Simple design using a single transect following the direction of the main current. B) Two transects that intersect at the centre of AZE. C) Several transects laid perpendicular to AZE, with the aim of applying spatial statistics such as the Kriging technique. At each sampling site, one or several samples can be collected. Source: Sanchez-Jerez and Karakassis, 2012.

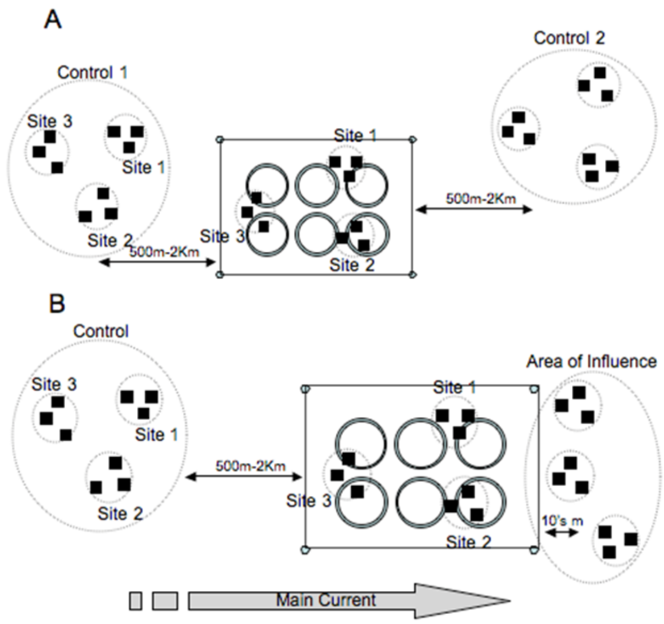

Figure 3: Random stratified sampling considering (A) an Impact zone (AZE) with two control zones that are sufficiently distant from the aquaculture facilities, and (B) three zones: Impact zone (AZE), area of influence and one or several controls. Inside each zone, several sites are randomly selected, with three samples collected, for example, using a Van Veen grab. Source: Sanchez-Jerez and Karakassis, 2012.

EMP responsibility

39. The responsibility for the EMP and data recording should be:

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

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

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

Annex A

EMP GLOSSARY

Term	Definition	Reference
Allocated zone for aquaculture	For coastal areas, an allocated zone for aquaculture (AZA) is intended as a spatial planning system or zoning, carried out at local or national level; an AZA is also: (i) a marine area where the development of aquaculture is given priority over other uses; (ii) an area dedicated to aquaculture, recognized spatial planning authorities, which would be considered as a priority for local aquaculture development.	GFCM. 2010. Report of the workshop on allocated zones for aquaculture (AZA). Sevilla, Spain, 18–20 October 2010. GFCM:CAQVII/2011/Inf.12. 12 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).
Allowable zone of effect	An allowable zone of effect (AZE) is an area of the seabed or volume of the receiving water body within which a competent authority allows the use of specific environmental quality standards (EQS) for aquaculture, without irreversibly compromising basic environmental goods and services provided by the ecosystem.	GFCM. 2011. Report of WGSC-SHoCMed Workshop on the definition and environmental monitoring within allowable zone of effect (AZE) of aquaculture activities within the Mediterranean countries, Malaga, Spain, 16–18 November 2011. 34 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).
Aquaculture	Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans, other invertebrates, crocodiles, alligators, turtles, amphibians and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquaculture production is defined as an increment of biomass and/or an increment in number of individual organisms produced during the period of farming. Therefore, in order to measure aquatic production, both inputs to and outputs from the farming environment are needed. Seed going into a culture-based fishery is considered as an output from aquaculture to fishery, while seed collected by fishery for aquaculture is considered as an input from fishery to aquaculture.	GFCM. 2009. Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM). Trabzon, Turkey, 9–10 December 2009. 19 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).
Area of interest	In site selection for aquaculture, it refers to coastal and maritime areas, which are free of incompatibilities or interference of use from an administrative point of view and are selected by governments to encourage the development of aquaculture.	IUCN. 2009. Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management. IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp.
Azoic sediments	Freshwater or marine sediments that are devoid of living eukaryotic organisms. Azoic sediments are often found in heavily loaded, anoxic sediments below fish farm cages.	Tavare, P.C., Machado, M. and Cancela da Fonseca, L. 2008. Colonization process in soft-bottom macrofauna communities using azoic sediments: comparison of two wetland systems with different organic loads. Fundamental and Applied Limnology, Archiv für Hydrobiologie 171: 219–232.
Bathymetry	The science of measuring and charting the depths of water bodies to determine the topography of a lake bed or sea floor.	ESRI GIS Dictionary. 2012. [online – accessible from http://support.esri.com/en/knowledgebase/GISDictionary/term/bathymetry)
Benthos	Organisms that live on or in the sediment in aquatic environments.	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese).
Better management practices	Better management practices (BMP) are management practices aimed at increasing both the quantity and quality of products taking into consideration food safety, animal health, environmental and socio-economic sustainability. BMP implementation is generally voluntary. The term 'better' is preferred to 'best' because aquaculture practices are continuously improving, i.e. today's best is tomorrow's 'norm'.	NACA. @2001–2012. Certification terms – Web Site. In: Network of Aquaculture Centres in Asia-Pacific [online]. Bangkok. [Cited 20 April 2012]. http://www.enaca.org/modules/certificationprojects/index.php?content_id=9.

Term	Definition	Reference
Biodiversity (biological diversity)	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems.	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese).
Carrying capacity	(1) 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. (2) Carrying capacity is now also being described by the following four definitions commonly applied to both bivalve farming and finfish cage culture: Physical carrying capacity: defined as the total area of marine farms that can be accommodated in the available physical space; Production carrying capacity: defined as the maximum sustainable yield of cultured organisms that can be produced within an area; Ecological carrying capacity: defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, species, populations, or communities in the environment; Social carrying capacity: defined as the amount of aquaculture that can be developed without adverse social impacts.	(1) Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese). (2) McKindsey, C.W., Thetmeyer, H., Landry, T. & Silvert, W. 2006. Review of recent carrying capacity models for bivalve culture and recommendations for research and management. Aquaculture, 261:451–462. (3) Byron, C.J. & Costa-Pierce, B.A. 2010. Carrying Capacity Tools for Use in the Implementation of an Ecosystems Approach to Aquaculture. Presented at the FAO Expert Workshop on Aquaculture Site Selection and Carrying Capacity Estimates for Inland and Coastal Waterbodies. Institute of Aquaculture, University of Stirling, Stirling, UK, 6–8 December 2010.
Chlorophyll a	The concentration of Chl-a in the water column provides a measure of the phytoplankton biomass which is likely to be affected by various factors such as nutrient input from the fish farms but also from other uses of the coastal environment, discharges from rivers, agricultural runoff etc. Several papers (Pitta et al., 1999; Soto & Norambuena, 2004) have shown that fish farming does not induce high Chl-a concentrations, probably due to grazing by zooplankton (Pitta et al. 2009). However, the monitoring of this variable could provide some information regarding the trophic status of the farming site and the risk for diel oxygen fluctuations. The method used for the analysis of Chl-a content in marine water samples (Yentsch & Menzel, 1963) is of relatively low cost and the results may be obtained rather quickly.	(1) Pitta, P., Karakassis, I., Tsapakis, M., Zivanovic, S. 1999. Natural vs. mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. Hydrobiologia 391: 181-194. (2) Soto, D. & Norambuena, F. 2004. Evaluation of salmon farming effects on marine systems in the inner seas of southern Chile: a large-scale mensurative experiment. J Appl Ichtyol 20:493–501. (3) Pitta, P., Tsapakis, M., Apostolaki, E.T., Tsagaraki, T., Holmer, M., Karakassis, I. 2009. 'Ghost nutrients' from fish farms are transferred up the food web by phytoplankton grazers. Marine Ecology Progress Series 374: 1-6. (4) Yentsch, C.S. & Menzel, D.W. 1963. A method for the determination of phytoplankton chlorophyll and phaeophytin by fluorescence. Deep Sea Res 10:221-231.
Coastal zone	Coastal zone means the geomorphologic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities.	UNEP/PAP/RAC. 2008. Protocol on Integrated Coastal Zone Management in the Mediterranean. 89 pp.
Criteria	Within a principles-criteria-indicators methodology, criteria break down each principle into several specific themes or homogeneous elements and specify the issue(s) to be addressed through the relevant variables to be monitored. Criteria should be formulated expressing the degree or state of the variable, e.g. level of…, control of…, existence of …, access to…, capacity of…, as in "level of input efficiency".	GFCM. 2011. Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.
Dissolved oxygen	The dissolved oxygen (DO) concentration in the cages or, preferably, at the benthic boundary layer, beneath the farm provides a serious indication of the ambient conditions in the farming environment but also an alarm for risks that might endanger the production and/or the health of the farmed stock. According to the ECASA toolbox (www.ecasatoolbox.org.uk), eutrophication effects in an inshore area could result in increased DO consumption in the basin water (1). This could be caused by increase in organic matter from fish farms (1). Low DO levels often result in basins with long residence times, and the lowest concentration of oxygen will occur at the end of a stagnation period. The level at that time will therefore also strongly	(1) International Union for Conservation of Nature. 2007. Guide for the sustainable development of Mediterranean aquaculture. Interaction between aquaculture and the environment. IUCN, Gland Switerland and Malaga, Spain. (2) Stigebrandt, A., 2001: Physical Oceanography of the Baltic Sea. Chapter 2 (pp. 19-74) in A Systems Analysis of the Baltic Sea (F. Wulff, L. Rahm and P. Larsson, eds.), Springer Verlag. (3) Erlandsson, C.P., Stigebrandt, A. and Arneborg, L., 2006: The sensitivity of minimum oxygen concentrations in a fjord to changes in biotic and abiotic external forcing. Limn. & Oceanogr. 51, 631-638. (4) Methods of Seawater Analysis. 1983.

Term	Definition	Reference
	rely on the rate of water exchange and hypsography of the area and climatic variations of the water exchange may be important as well (2, 3). The minimum oxygen concentration that could occur in the bottom water might change due to changes in the vertical flux of organic matter from the surface water and/or fish farms. The measurement of DO could be straightforward by using a water sampling bottle and a portable oxygen meter, although it would be advisable to calibrate it regularly using the Winkler titration method.	Second. Revised and Extended Edition.Edited by K.Grasshoff. M.Ehrhardt. K.Kremling. Verlag Chemie. 419p.
Ecosystem	A natural entity (or a system) with distinct structures and relationships that liaise biotic communities (of plants and animals) to each other and to their abiotic environment. The study of an ecosystem provides a methodological basis for complex synthesis between organisms and their environment.	GESAMP. 2001. Planning and management for sustainable coastal aquaculture development. GESAMP Reports and Studies, No. 68. Rome, GESAMP. 90 pp.
Ecosystem services	Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services, such as spiritual and cultural benefits; and supporting services, such as nutrient cycling or waste degradation, that maintain the conditions for life on Earth.	Alcamo, J., Ash, N.J., Butler, C.D. et al. 2003. Ecosystem and human well-being. A framework for assessment/Millennium Ecosystem Assessment. Washington, DC, Island Press. 245 pp.
Ecosystem approach to aquaculture	An ecosystem approach to aquaculture is a strategy for the integration of an activity within the wider ecosystem so that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems.	FAO. 2010. Aquaculture development. 4. Ecosystem approach to aquaculture. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. Rome, FAO. 53 pp.
Environmental Impact Assessment (EIA)	A sequential set of activities designed to identify and predict the impacts of a proposed action on the biogeophysical environment and on man's health and well-being, and to interpret and communicate information about the impacts, including mitigation measures that are likely to eliminate the risks. In many countries, organisations planning new projects are required by law to conduct EIA. In fisheries, an analysis of the expected impacts resulting from the implementation of a fisheries management or development plan (or some other proposed action) on the environment. The EIA is also referred to in some countries as Environmental Statement (ES).	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese).
Environmental quality standard	An environmental quality standard (EQS) is a value, generally defined by regulation, which specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water*. **The CAQ Working Group on Site Selection and Carrying Capacity (WGSC) considers also "sediment".*	GESAMP. 2012. Environmental Quality Standards - Web Site. In: The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) [online]. UK. [Cited 5 February 2012]. http://www.gesamp.org/work-programme/eqs.
Eutrophication	Over enrichment of a water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen concentration (1). Natural or artificial nutrient enrichment in a body of water, associated with extensive plankton blooms and subsequent reduction of dissolved oxygen (2).	(1) A dictionary of Ecology, Evolution and systematics, R.J. Lincoln, G.A. Boxshall, P.F. Clark, Cambridge University Press, 1986. (2) Anonymous (1998) AQUALEX. Multilingual glossary of aquaculture terms / Glossaire multilingue relatif aux termes utilisés en aquaculture. CD ROM, John Wiley & Sons Ltd. & Praxis Publ., UK. (FAO, glossary of aquaculture)
Farmers´organizations	A formal voluntary membership organization created for the economic benefit of farmers (and/or other groups) to provide them with services that support their farming activities such as: bargaining with customers; collecting market information; accessing inputs, services and credit; providing technical assistance; and processing and marketing farm products. Formal membership criteria could include payment of membership fees or a percentage of farmers' production. Informal membership criteria could be based on ethnicity or gender	Kassam, L.; Subasinghe, R.; Phillips, M. 2011. Aquaculture farmer organizations and cluster management: concepts and experiences. FAO Fisheries and Aquaculture Technical Paper. No. 563. Rome, FAO. 90p.

Term	Definition	Reference
Fish	Literally, a cold-blooded lower vertebrate that has fins, gills and scales (usually), and lives in water. Used as a collective term it includes fish, molluscs, crustaceans and any aquatic animal which is harvested.	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese)
Gas bubbles	Gas bubbles or outgassing i.e. the release of gas (H2S or even CH4) from the bottom sediments is a clear sign of anaerobic processes in the benthic environment, occasionally found beneath the cages mainly during the warm seasons of the year (Karakassis et al., 2002). It is an easy to observe environmental characteristic. The release of H2S is considered as a risk for the farmed stock due to the toxicity of H2S to most marine fish. However, it is worth noting that H2S is rapidly oxidized in the seawater (ca 90% of it is removed from the bubbles after ascending 20m from the sediment surface).	Karakassis, I., Tsapakis, M., Smith, C.J., Rumohr, H. 2002. Fish farming impacts in the Mediterranean studied through sediment profiling imagery. Marine Ecology Progress Series, 227: 125-133.
Grain size sediment structure	As in the case of silt and clay content, other sediment variables such as the Median diameter of particles of the sediment are important for the characterization of the seabed. The protocols for the analysis for all different fractions of the sediment are provided in Buchanan (1984).	Buchanan, J.B. 1984. Sediment analysis. In: N. A. Holme & D. McIntyre AD (eds) Methods for the Study of Marine Benthos. Blackwell Science, Oxford: 41-65.
Habitat	The locality, site and particular type of local environment occupied by an organism; local environment.	A dictionary of Ecology, Evolution and systematics, R.J. Lincoln, G.A. Boxshall, P.F. Clark, Cambridge University Press, 1986.
Holding capacity	Synonymous with "Carrying Capacity".	
Indicator	(1) Within a principles-criteria-indicators methodology, indicators are a simple way to express the information related to the criteria. They are communication tools identified at farm, local, national and regional level which serve to quantify and simplify information in order to make it understandable to a target audience. Indicators provide benchmarks to assist in monitoring, evaluating, forecasting and decision-making. (2) An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria. (3) Indicators are tools for monitoring, evaluation, forecasting and decision support. They are defined by reference to agreed targets; the confrontation of values taken by an indicator with the corresponding objective allows judging the effectiveness of an action. Indicators are also communication tools that are used to quantify and simplify information to make it understandable to a targeted audience	(1) GFCM. 2011. Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp. (2) FAO. 1999. Indicators for sustainable development of marine capture fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 8. Rome, FAO. 68 pp. (3) Madec, P. 2003. Les indicateurs de développement durable. INRA-University of Montpellier II. 118 pp.
Integrated coastal zone management	Integrated coastal zone management (ICZM) means a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts.	UNEP/PAP/RAC. 2008. Protocol on Integrated Coastal Zone Management in the Mediterranean. 89 pp.
Intensive culture	It is a method of culture whereby all the nutrition that the culture stock requires is provided externally.	GFCM. 2009. Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM). Trabzon, Turkey, 9–10 December 2009. 19 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).

Term	Definition	Reference
License for aquaculture	License in aquaculture context, is a legal document giving official authorization to carry out aquaculture. This kind of permit may take different forms: an aquaculture permit, allowing the activity itself to take place, or an authorization or concession, allowing occupation of an area in the public domain so long as the applicant complies with the environmental and aquaculture regulations.	IUCN. 2009. Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management. IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pp.
Litter in the surrounding area	The presence of litter in the vicinity of the fish farms is probably among the environmental effects the one which is most visible to the public. Although the presence of litter normally would not have any toxic effect on the farmed stock and/or the consumers, it is likely to attract negative publicity and to result in local conflicts with other users of the coastal zone. Litter can cause losses to aquaculture operations due to damage or entanglements (1).	(1) Cheshire, A.C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L.,Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B., Westphalen, G. 2009. UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter. UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83: xii + 120 pp.
Map	Graphic representation of the physical features (natural, artificial, or both) of a part or the whole of the Earth's surface, by means of signs and symbols or photographic imagery, at an established scale, on a specified projection, and with the means of orientation indicated.	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese)
Mariculture	Mariculture is the cultivation of the end product which takes place in seawater, such as fjords, inshore and open waters and inland seas where salinity is generally high and is not subject to significant daily or seasonal variations. Earlier stages in the life cycle of these aquatic organisms may be spent in brackish water or fresh water.	GFCM. 2009. Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM). Trabzon, Turkey, 9–10 December 2009. 19 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).
Marine spatial planning	Marine Spatial Planning is a process of analyzing and allocating parts of three dimensional marine spaces to specific uses, to achieve ecological, economic, and social objectives that are usually specified through the political process; the MSP process usually results in a comprehensive plan or vision for a marine region. MSP is an element of sea use management.	Ehler, C. & Douvere F. 2007. Visions for a Sea Change. Report of the First International Workshop on Marine Spatial Planning. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 48, IOCAM Dossier. No. 4. Paris, UNESCO.
Monitoring	Systematic recording and periodic analysis of information over time.	Crespi, V. & Coche, A. (comps). 2008. Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese)
Number of macrofaunal species	The number of macrofaunal species indicates the level of degradation of the seabed since it is one of the variables which are significantly linked with the macrofaunal succession along gradients of organic enrichment (Pearson & Rosenberg, 1978). On the other hand, the number of macrobenthic species provides a measure of the potential of the benthic communities to provide ecological services such as the mineralization of the settling organic material. The technical requirements are similar to those for abundance and biomass, plus the identification of the specimens at the species level which normally entails substantial taxonomic expertise.	Pearson, T. & Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review 16: 229-311.
Outgassing	Release of a gas that was dissolved, or otherwise contained within a substrate, e.g. marine sediments or a liquid, e.g. seawater. This release occurs as a result of physical disruption, e.g. bioturbation or sediment resuspension or after the concentration of the gas exceeds its dissolution limits.	Samuelsen, 0.B. , Ervik, A., Solheim, E. 1988. A qualitative and quantitative analysis of the sediment gas and diethylether extract of the sediment from salmon farms. Aquaculture 74: 277-285

Term	Definition	Reference
Percentage of Capitellid polycaetes over macrofaunal biomass	*Capitella capitata* or (more correctly) the *Capitella* sp. complex is the most well known opportunistic organism found in heavily polluted (organically enriched) marine sediments (Pearson & Rosenberg, 1978). Although not all the species of the Capitellidae family are opportunistic, the high percentage of capitellids in a sample is almost certainly due to proliferation of the opportunistic species of this taxon. Capitellids are fairly easy to identify provided of course that the samples have been collected and the specimens have been extracted from the sediment. Therefore the cost for this indicator is higher than weighting the total biomass but considerably lower than that required for Shannon, number of species or AMBI.	Pearson, T. & Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review 16: 229-311.
Percentage of silt/clay in sediments	The silt and clay content of the sediment is an important variable for the characterization of the seabed since it describes in a way rather easy to understand one of the most determining characteristics of the benthic environment. The sediment contains silt and clay from natural sources but also there is an increase due to sedimentation of suspended solids in the vicinity of the sea cages (1). The technique used is rather straightforward and inexpensive. It involves drying the sediment, weighting, wed sieving over a 63microns sieve, drying the aliquot with the fine particles and weighting again (2).	(1) Chou, C.L., K. Haya, L.A. Paon, and J.D. Moffatt. 2004. A regression model using sediment chemistry for the evaluation of marine environmental impacts associated with salmon aquaculture cage wastes. Marine Pollution Bulletin 49:465-472; (2) Shepard F.P. 1954. Nomenclature based on sand, silt, clay ratios. Journal Sedimentary Petrology, 24: 151-158; (3) Buchanan , J.B. 1984. Sediment analysis. In: N. A. Holme & D. McIntyre AD (eds) Methods for the Study of Marine Benthos. Blackwell Science, Oxford: 41-65.
Polygonos	These are specially designated areas (also known as allocated zones for aquaculture) for cage mariculture that were established by the Spanish Ministry of Environment in consultation with the administrations for defence, marine navigation, tourism, ports, local authorities and coastal planning.	Chapela-Perez, R. 2009. Cage Aquaculture Development in the RECOFI Region. “Regional technical workshop on sustainable marine cage aquaculture development” Draft Review document on cage aquaculture licensing procedures Case Studies in Spain, Chile, Greece, USA and Norway. Centro Tecnológico del Mar Fundación CETMAR Vigo Spain.
Principle	Principles are associated to the dimensions of sustainable aquaculture. Within a principles-criteria-indicators methodology, they are the high-level goals to address an issue and determine the criteria and indicators to be selected. Principles should be formulated as short statements, with actions verbs originated from management vocabulary such as: contribute, ensure, adapt, strengthen, minimize, etc. For example, “Minimize the impact of aquaculture on the environment”.	GFCM. 2011. Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.
Redox potential	The reduction/oxidation (redox) potential (also known as Eh) is a chemical expression (in volts or millivolts) of the tendency of a given compound to attain electrons and become chemically "reduced". In aquaculture, redox potential is often measured in sediments to examine the sediment "quality" insofar as the suitability (or inhospitality) of chemical conditions for the presence of natural fauna/flora. Organically-enriched, anoxic and sulfidic (impacted) sediments are often characterized by highly negative redox potential values, whereas 'healthy' sediments have positive redox potential values. (1) The oxidation-reduction (redox) conditions in the surface sediment depend on the degree of organic enrichment and therefore the measurement of Eh can be used as a proxy for the calculation of organic loading with the method described by Zobell (1946). The redox state of sediment is the result of the combined effect of biological and chemical processes of reversible and/or irreversible nature. The Eh decreases with the depth and with decreasing O2 concentration in the interstitial water. Negative redox-potential values are associated with anoxic conditions, i.e. degradation of the organic matter by anaerobic bacteria, which, in marine sediment, use mainly sulphate as electron acceptor and release hydrogen sulphide. Redox potential is measured by profiling an electrode down a sediment core to as deep as is necessary to detect the redox discontinuity layer (RPD)), the point at which redox values change abruptly from highly negative values to either less negative, or to positive values (2).	(1) Pearson T.H., Black K.D. 2001. The environmental impacts of marine fish cage culture. In: Black, K.D. (Ed.), Environmental Impacts of Aquaculture, Academic Press, Sheffield, UK, 1– 27. (2) Zobell, C.E. 1946. Studies on redox potential of marine sediments. Bulletin of the American Association of Petroleum Geologists 30, 477-511. (2). (3) Hinchey, E.K. and L. C. Schaffner**.** 2005. An evaluation of electrode insertion techniques for measurement of sediment redox potential in estuarine sediments. Chemosphere 59:703-710.

Term	Definition	Reference
Reference point	For a given indicator, a reference point or standard is a specific value against which the data are measured and classified. Reference points indicate the particular state of a broad issue to be monitored. Once an indicator is associated with its reference point, it is possible to assess the particular state of the broad issue to be monitored. The value (whether qualitative or quantitative) of a reference point should be validated by international literature, and/or be agreed upon between experts through common opinion or by driven discussions (for example Delphi), and/or endorsed through a multi-stakeholder consensus.	GFCM. 2011. Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 218 pp.
Scale	The ratio or relationship between a distance and area on a map and the corresponding distance or area on the ground, commonly expressed as a fraction or 165 ratio. A map scale of 1/100 000 or 1:100 000 means that one unit of measure on the map equals 100 000 of the same unit on the earth.	ESRI. 2001. The ESRI Press dictionary of GIS terminology. Environmental Systems Research Institute, Inc. Redlands, California. USA.
Seabed	This is the bottom of the sea and is also known as the "seafloor". It may be composed of soft (e.g. sand or mud) or hard (e.g. rock) substrates and the biotic community that lives in or on the seafloor is called "benthos".	Hiscock, K., Langmead, O., Warwick, R., and Smith, A. 2005. Identification of seabed indicator species to support implementation of the EU Habitats and Water Framework Directives. Second edition. Report to the Joint Nature Conservation Committee and the Environment Agency from the Marine Biological Association. Plymouth: Marine Biological Association. JNCC Contract F90-01-705. 77 pp.
Sectoral planning	The strategic planning for a specific industry or sector, which is generally the responsibility of the government, but should also include participation of the private sector. In order to succeed, the plan should consider issues such as: a) the current status of the sector and the desired situation (aspirations), b) how the desired situation may be attained, c) the resources needed to accomplish the desired status, d) the obstacles that may hinder the plans and e) a contingency plan to deal with the obstacles.	Asian Development Bank. 2000. Handbook for the Economic Analysis of Health Sector Projects. Manila, Philippines, ADB. 156 pp.
Sediment grain size (granulometry)	The grain size distribution is one of the basic and characteristic properties of a particular sediment which may change as a result of various processes, such as runoff, bioturbation, eutrophication, etc. Grain size analyses consist of measurements of particle sizes and/or their hydraulic equivalents, and a summary of the size data yields a frequency distribution. Grain size data are of value to a wide range of scientists, including geologists, sedimentologists, engineers, geochemists, ecologists, hydrologists and coastal managers.	Friedman, G.M., and Sanders, J.E., 1978. Principles of Sedimentology: New York (Wiley). Barth, N.G., 1984, Modern methods of particle size analysis, John Wiley and Sons, 309 p.
Sediment resuspension	This is a process that involves singular or multiple events of redistribution of benthic sediment particles into the water column. Resuspension may be motivated by physical (e.g. waves, currents) or biological (e.g.bioturbation, activities of demersal animals or burrowing fishes) processes. The extent of physical resuspension depends largely on the depth, the energy of the driving forces, bathymetry, sediment composition, etc. Resuspension may release nutrients, resting cells and toxins into the overlying water and may make the water column turbid.	Bloesch, J. 1994. A review of methods used to measure sediment resuspension. Hydrobiologia 284: 13-18
Sensitive habitat	A habitat: - Essential to the ecological and biological requirements of at least one of the life stages of the species; - Crucial for the recovery and/or the long term sustainability of the marine biological resources and the assemblages to which the priority species belongs; - Any other habitat of high biodiversity importance potentially impacted by fisheries activities; - Any other habitat of high biodiversity importance potentially impacted by climate change.	GCFM. 2008. Criteria for the identification of sensitive habitats of relevance for the management of priority Species. GFCM: SAC11/2008/Inf.20.

Term	Definition	Reference
Site selection	The success of aquaculture projects relies heavily on the proper selection of the site for this activity, regardless of whether the site considered is on land or at sea. In addition to the actual geographic location, consideration must be given to physical, chemical and biological/ecological factors, as well as to the socio-economic aspects of the proposed venture. The optimal situation is where the aquaculture activity is deemed environmentally, socially and economically sustainable. This involves planning with respect to the specific culture systems and the species to be cultivated and requires foresight regarding the impacts of aquaculture on the environment as well as the effects of surrounding activities and the environment on the enterprise.	(1) FAO. 1987. Site selection for aquaculture: Introduction, technical and non-technical considerations in site selection. Lectures presented at ARAC for the Senior Aquaculturists course. Project Report AC 170, ARAC/87/WP/12-1&2, 9 pp. (2) IUCN. 2009. Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management. Gland, Switzerland and Malaga, Spain, IUCN. 303 pp.
Spillovers	Spillover effects are the outcomes of activities that affect those that are not directly involved. The visual impact of net-cage fish farms that affects the property value of coastal homeowners is an example of a negative spillover effect on the stakeholders; whereas the increased employment provided by the farms is a positive spillover effect upon the local residents.	Tisdell, C. A. 2004. Aquaculture, environmental spillovers and sustainable development: links and policy choices. In M.A. Quaddus and M.A.B. Siddique (Ed.), Handbook of sustainable development planning : studies in modelling and decision support 1st ed. (pp. 249-268) Cheltenham, UK, Edward Elgar Publishing.
Sulphide	The pathways of sulphide oxidation in marine sediments involve complex interactions of chemical reaction and microbial metabolism where Sulphide becomes partly oxidized and bound by Fe(III), and the resulting iron-sulphur minerals are transported toward the oxic sediment-water interface by bioturbating and irrigating fauna (Jørgensen & Nelson, 2004). Established relationship between organic enrichment processes and concentration of sulphide within the sediment pore water are given in Wildish et al. (2004). The sedimentary sulphide is measured by means of combined electrodes (Blackburn & Kleiber, 1975; Heijs et al., 1999). Brooks & Mahnken (2003) give examples in the literature of this technology being used in assessment of aquaculture impacts.	(1) Jørgensen, B.B., Nelson, D.C. 2004. Sulfide oxidation in marine sediments: Geochemistry meets microbiology. Geological Society of America Special Papers 379:63-81. (2) Wildish, D.J., Dowd, D., Sutherland, T.F., Levings, C.D. 2004. A scientific review of the potential environmental effects of aquaculture in aquatic ecosystems. Volume III Near-field organic enrichment from marine finfish aquaculture, Can. Tech. Rep. Fish. Aquat. Sci. 2450, 117pp. (3) Blackburn, T.H. & Kleiber, P. 1975. Photosynthetic sulphide oxidation in marine sediments. OIKOS 26:103-108. (4) Heijs, S.K., Jonkers, H.M., van Gemerden, H., Schaub, B.E.M., Stal, L.J. 1999. The buffering capacity towards free sulphide in sediments of a coastal lagoon (Bassin d'Arcachon, France) – the relative importance of chemical and biological processes. Estuarine, Coastal and Shelf Science 49:21-35. (5) Brooks, K.M. and Mahnken, C.V.W. 2003. Interactions of Atlantic Salmon in the Pacific northwest environment II. Organic wastes. Fisheries Research 62: 255-293.
Thresholds for environmental change	In an ecological, economic or other system, thresholds are the critical values beyond which the system goes through a substantial change. Small changes in crucial variables (e.g. a slight rise in seawater temperature) can lead to large responses in the system (e.g. large drop in reproductive success of a keystone marine species).	(1) Muradian, R. 2001. Ecological Thresholds: a survey. Ecological Economics 38:7–24. (2) Groffman, P., Baron, J., Blett, T., Gold, A., Goodman, I., Gunderson, L., Levinson, B., Palmer, M., Paerl, H., Peterson, G., LeRoy Poff, N., Rejeski, D., Reynolds, J., Turner, M., Weathers, K., & Wiens, J. 2006. Ecological thresholds: the key to successful environmental management or an important concept with no practical application? Ecosystems 9:1–13.
Total nitrogen in sediments	Total Nitrogen (TN) is defined as the sum of organic nitrogen, nitrate, nitrite, and ammonia. The Nitrogen levels are elevated under fish farms as a result of diagenesis of the organic material settling on the seafloor. Although nitrate and nitrite are not released by the stocked organisms, and are not toxic to most marine organisms, they may help in determining the risk of eutrophication at a given site (GFCM, 2011). Total Nitrogen concentrations are expressed as % of N in sediment. The concentration can be referred to the whole 6 to 10 cm core or to the surface sediment (1 to 1.5 cm). It is measured in sediment samples using a CHN Elemental Analyzer according to the procedure described by Hedges & Stern (1984).	(1) GFCM. 2011. Site Selection and Carrying Capacity in Mediterranean Marine Aquaculture: Key Issues (WGSC-SHoCMed). Draft March 2011 - GFCM:CAQVII/2011/Dma.4 rev 2. (2) Hedges, J.I. & Stern, J.H. 1984. Carbon and nitrogen determination of carbonate containing solids Lirnnol Oceanogr 29: 657-663.

Term	Definition	Reference
Total organic carbon	Total organic Carbon (TOC) is the amount of carbon bound in an organic compound and material derived from decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals. As in the case of organic matter it is related to the sedimentation of fish faeces and unused fish feed in the vicinity of the farms but also to natural sedimentation of organic material e.g. from primary production in the water column. It is determined in sediment samples using a CHN Elemental Analyzer according to the procedure described by Hedges & Stern (1984).	Hedges, J.I. & Stern, J.H. 1984. Carbon and nitrogen determination of carbonate containing solids Lirnnol Oceanogr 29: 657-663.
Total organic matter in sediments	Total organic matter in sediment provides an estimate of the organic content in the sediments beneath the aquaculture installation. For coastal aquaculture, major concerns are on discharge of wastes in the form of uneaten food and fish excretions which will especially have an effect on the benthos and species that are particularly sensitive to an increase in input of organic matter. Organic matter input is closely dependent on species, production, culture method, hydrography, feed type and management (Wu, 1995). The Organic Material (or loss on ignition, LOI) is determined as the weight loss of the dried sample after combustion for 6 h at 500°C (Kristensen & Andersen, 1987), regarding the units, 1% is equal to 10 mg/g sediment.	(1) Wu, R.S.S. 1995. The environmental impact of marine fish culture: towards a sustainable future. Marine Pollution Bulletin, 31: 159–166. (2) Kristensen, E. & Andersen, F.O. 1987. Determination of organic carbon in marine sediments: a comparison of two CHN analyzer methods. J Exp Mar Biol Ecol 109:15-23.
Total phosphorus	As in the case of organic Carbon or organic material in total, P is released in particulate form (fish faeces and unused feed) and precipitates beneath and close to fish farms. High sedimentation rates of P have been measured around fish farms (Holmer et al. 2008) and discernible distribution patterns have been found in profiles and transects around fish farms (Karakassis et al., 1998, 2000). P has been suggested as a useful indicator of fish farm waste loading (Holmer et al. 2008) and it has also been proposed as an indicator of fish farm impact on P. oceanica habitats (Pergent-Martini et al., 2006, Apostolaki et al., 2007). Total phosphorus is determined in the dried sediment samples, which were homogenized by grinding and digested with a mixture of perchloric and nitric acid (Burton & Riley, 1956; Sturgeon et al., 1982). The concentration of P is determined colorimetrically as molybdate reactive phosphorus (Strickland & Parsons, 1972).	(1) Holmer, M., Argyrou, M., Dalsgaard, T., Danovaro, R., Diaz-Almela, E., Carlos, M.D.E., Frederiksen, M., Grau, A., Karakassis, I., Marba, N., Mirto, S., Perez, M., Pusceddu, A., Tsapakis, M. 2008. Effects of fish farm waste on Posidonia oceanica meadows: Synthesis and provision of monitoring and management tools. Marine Pollution Bulletin 56:1618-1629. (2) Karakassis, I., Tsapakis, M., Hatziyanni, E. 1998. Seasonal variability in sediment profiles beneath fish farm cages in the Mediterranean. Marine Ecology Progress Series, 162: 243-252. (3) Karakassis, I., Tsapakis, M., Hatziyanni, E., Papadopoulou, K.N., Plaiti, W. 2000. Impact of cage farming of fish on the seabed in three Mediterranean coastal areas. ICES J. Mar. Sci. 57: 1462-1471. (4) Pergent-Martini, C., Boudouresque, C.F., Pasqualini, V., Pergent, G. 2006. Impact of fish farming facilities on Posidonia oceanica meadows: a review. Marine Ecology-An Evolutionary Perspective 27:310-319. (5) Apostolaki, E., Tsagaraki, T., Tsapakis, M., Karakassis, I. 2007. Fish farming impact on sediments and macrofauna associated with seagrass meadows in the Mediterranean. Estuarine coastal shelf Science, 75: 408-416. (6) Burton, J.D. and Riley, J.P. 1956. Determination of soluble phosphate, and total phosphorus in sea-water and of total phosphorus in marine muds. Mikrochim Acta 9:1350-1365. (7) Sturgeon, R.E., Desaulniers, J.A.H., Berman, S.S., Russell, D.S. 1982. Determination of trace metals in estuarine sediments by graphite-furnace atomic absorption spectrometry. Analytica Chim Acta 134:283-291. (8) Strickland, J.D.H. and Parsons, T.W. 1972. A practical handbook of seawater analysis (2nd edition), Fisheries Research Board of Canada, Bulletin 167, Ottawa, Canada, 2nd edition, 310p.
Turbidity	Turbidity may be easily measured by means of a Secchi disk. The Secchi depth (i.e. the maximum depth at which the Secchi disk is visible from the surface) has significance in deep stratified waters, where the amount of matter resuspended from the bottom sediment is insignificant (see ECASA toolbox at the site: www.ecasatoolbox.org.uk). The significance is less in shallow homogeneous waters where the amount of resuspended matter might be quite large. The Secchi depth can be calibrated to estimate the concentration of particulate organic matter (POM) or equivalently Chl-a in the surface layers. After local calibration, it can also account for coloured matter supplied by freshwater runoff in coastal and inshore waters if synoptic vertical profiles of salinity are measured. Secchi depth is obviously of great significance to	(1) Preisendorfer R.W. 1986. Secchi Disk science: visual otics of natural waters. Limnol. Oceanogr., 31: 909-926. (2) International Union for Conservation of Nature. 2007. Guide for the sustainable development of Mediterranean aquaculture. Interaction between aquaculture and the environment. IUCN, Gland Switerland and Malaga, Spain.

Term	Definition	Reference
	farmers of filter feeders and to authorities interested in environmental effects of fish farming. If widely used, it might also be of significance to scientists. It does not require any special training. Thereby Secchi depth observations often can replace Chl-a measurements at sites where Chl-a is used as an indicator of eutrophication. As Chl-a fluctuates during the season so does the Secchi depth and measurements needs to be done regularly. Particulates or solids from feed and fish waste are two primary sources of turbidity associated with cage culture (2). Increased turbidity may result in lower light penetration affecting phytoplankton production (2)	
Water column	This is the body of water that extends from the sea surface to the seafloor. The water column is also referred to as the "pelagic zone" which may be broken down to different depth zones, with characteristic conditions and biota. The water column is often referred to in the environmental context with respect to "water quality" (see also item 2482 in the FAO Glossary of Aquaculture); the various physico-chemical properties that make it suitable or unsuitable for aquatic life.	Connor, D. W., Gilliland, P. M., Golding, N., Robinson, P., Todd, D. and E. Verling. 2006. UKSeaMap: the mapping of seabed and water column features of UKseas. Joint Nature Conservation Committee Report, Peterborough.
Water quality	This term encompasses the chemical, physical, and biological characteristics of water with respect to its suitability for a specific purpose, e.g. drinking, bathing, aquaculture. Water quality is a subjective term and "good" versus "poor" quality is defined by the properties (e.g. clarity or pH) and the levels (e.g. chemical concentration or salinity) of these properties that we set for the chosen purpose. In aquaculture, we determine the water quality variables that must be monitored to safeguard both the cultivated organisms and the surrounding environment.	(1) Boyd, C.E. 2000. Water Quality. An Introduction. Kluwer Academic Publishers. Boston, Dordrecht, London. 325 pp. (2) American Public Health Association (APHA). 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. American Public Health Association, Washington, DC. (3) Zweig, R. D., Morton, J. D., & Stewart, M. M. 1999. Source water quality for aquaculture: A guide for assessment. Washington, D.C: World Bank Publication, 62pp
Zoning	Dividing an area in zones or sections with different characteristics, or reserved for different purposes or uses, or conditions of use such as no-take zones or reserves (see MPAs), biodiversity corridors, non-trawling areas and areas for exclusive use by small-scale fisheries or aquaculture. Ocean zoning is an element of marine spatial planning.	Carocci, F.; Bianchi, G.; Eastwood, P.; Meaden, G. 2009. Geographic information systems to support the ecosystem approach to fisheries: status, opportunities and challenges. FAO Fisheries and Aquaculture Technical Paper. No. 532. Rome, FAO. 101p.

Annex B

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