GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

COMMISSION GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

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COMMITTEE ON AQUACULTURE

WORKING GROUP ON SITE SELECTION AND CARRYING CAPACITY (WGSC)

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

OPENING OF THE MEETING, ARRANGEMENTS FOR THE WORKSHOP PRESENTATION AND ADOPTION OF THE AGENDA

1. The *Workshop on the definition and environmental monitoring within Allowable Zone of Effect (AZE) of aquaculture activities within the Mediterranean countries* of the Working Group on Site Selection and Carrying Capacity (WGSC) of the CAQ-GFCM was held from 16 to 18 November 2011 and was organised with and hosted by the Agencia de Gestión Agraria y Pesquera de Andalucía (AGAPA) de la Junta de Andalucía. The meeting was attended by experts from Croatia, France, Greece, Italy, Malta, Montenegro, Morocco, Spain, Tunisia and Turkey.

2. The Workshop was opened by Mr Fabio Massa from the GFCM Secretariat who thanked the AGAP and welcomed the participants. He underlined the role of the WGSC within the activities of the CAQ and recalled the main objectives of the meeting carried out within the activities of the Project SHoCMed (Developing site selection and carrying capacity guidelines for Mediterranean aquaculture within aquaculture appropriate areas). The SHoCMed Project is in support to the GFCM CAQ – Working Group on site selection and carrying capacity and is partly funded by the European Commission (EC) DG Mare. Mr Massa underlined that this is an important meeting especially in relation to the Allocated Zone for Aquaculture (AZA)concept which was adopted by the GFCM this year, the presentation of the draft AZA Guidelines and the Allowable Zone of Effect (AZE).

3. He emphasized that the recommend7ations derived from the Workshop could be further developed and that this become the GFCM position on this matter. He also noted that was important to have a number of experts attending the meeting to obtain valuable inputs. He recalled that during the 35th session held in Rome (May 2011) the importance of AZA within the Integrated Coastal Zone Management (ICZM) was stressed to guarantee sustainable aquaculture and that specific recommendations should be discussed in the near future by the Commission.

4. Mr Ioannis Karakassis, coordinator of the WGSC, acted as Chairman of the meeting and after welcoming the participants introduced the agenda of the workshop which was adopted. The agenda and the list of participants are attached to this report as Appendix 1 and Appendix 2 respectively.

5. Mr Karakassis presented an overview of the SHoCMed project and its contribution to aquaculture. It was emphasized that aquaculture could be the answer to respond to an increase in food request, and will need to produce more aquaculture products in future to provide food for the expanding human population which is envisaged to reach 9.2 billion by 2050 (50% increase today). This calls for more research to understand what the upper limit for this production is and how this production may be integrated in marine ecosystems and particularly in the sensitive coastal zone.

6. However, he stressed that the effect of aquaculture in the environment should be carefully taken into consideration to avoid irreversible impacts, especially on environment. On the other hand, aquaculture is also challenged by both its surrounding environment and human activities, including periodical toxic algal blooms, diseases and conflicts with other coastal zone uses.

7. The sustainability of aquaculture in the Mediterranean and Black Sea is a key aspect that the GFCM has been tackling through projects such as SHoCMed which deals with carrying and holding capacity and definition of commonly agreed standards in relation to fish farming. Carrying capacity encompasses several facets such as physical, production, ecological and social aspects and SHoCMed focuses on the ecological side. Identifying exclusion criteria and variables related to the characteristics of the receiving environment is key to evaluation of carrying and holding capacity. Identification of ecological thresholds of benthic and other components is essential for identifying cautionary and critical conditions of fish-farm environments, also especially under an increasing shift in production scale in aquaculture, which is likely to occur in the near future.

8. Mr Karakassis recalled the Allocated Zone for Aquaculture (AZA) concept (WGSC-SHoCMed, Seville 18-20 Oct 2010), and the need to define Allowable Zone of Effect (AZE) for aquaculture activities. He added that not all Mediterranean countries have yet adopted a monitoring system to evaluate the effects and impacts of aquaculture activities on the environment. However, he stressed that such monitoring schemes should be in place and that there is a need to identify and refine commonly agreed Environmental Quality Standards (EQS) to be used as descriptors of environmental change. He concluded by stating that such aquaculture monitoring systems should be further elaborated to be simple, efficient, and cost-effective and that other aspects should be considered for their adoption such as data storage, meta-analysis, environmental audit, adaptation of EQSs and industry standards. Participants concurred that monitoring the interaction of aquaculture with environment is extremely important when pursuing the sustainability of the sector.

9. The expert from Montenegro, Mr Aleksandar Joksimovic, highlighted that Montenegro is a small country with a short stretch of coast – but one that is very important to it. At the moment, all mariculture activities in Montenegro are limited to 20 mussel farms and 2 fin fish aquaculture operations, all of which are located in the Boka Kotorska Bay, 26 nautical miles inside mainland. As the Bay is very sensitive to any changes in the environment, all future mariculture activities will be limited to the open sea. For this reason, all recommendations provided during SHoCMed as well as InDAM[1] meetings would be very useful in order to enable the development of fish farms in the open sea. He also stated that locations that will be subject to further monitoring can be selected the according to AZA and AZE recommendations. These experiences will be of great use to the country in the future planning of all activities along the coast, as mariculture is believed to play a significant role in the development of coastal areas. Mr Joksimovic concluded saying that it would be useful to implement an InDAM pilot in Montenegro.

10. Mr Nhhala Hassan also welcomed the results from SHoCMed which would provide key inputs into the emerging aquaculture sector in Morocco.

ENVIRONMENTAL QUALITY STANDARDS (EQS) FOR MONITORING AQUACULTURE ACTIVITIES

[1]'Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean' project.

11. The Chairman introduced the issue of identification of Environmental Quality Standards (EQS) for aquaculture. He briefly recalled the decisions taken by the WGSC during the seventh session of CAQ held in Malta in November 2010[2], which included the establishment of a second round of Delphi-driven discussions involving a panel of experts in the Mediterranean areas to determine such standards. The new Delphi exercise would be carried out based on a technical questionnaire distributed among selected experts through a dedicated web platform and the results to be successively analyzed by the WGSC. This selection should also be based on the understanding of such indicators by stakeholders with relevance to the environmental assessment, to the feasibility of use (i.e. cost-effectiveness) and to their sensitivity in detecting environmental changes and to enable appropriate mitigation/management actions to be undertaken. The outcome of this exercise will have to be discussed with stakeholders to ensure maximum consensus and applicability in the Mediterranean context.

12. Mr Karakassis presented the results of the second round of Delphi which involved twenty-eight experts from a wide range of Mediterranean countries and different production situations. They were queried about a series of shortlisted EQS indicators which were the results of the first Delphi round discussion and selected according to a series of criteria including reliability, cost effectiveness and proven scientific merit. The pre-selected variables included the following: quality of the benthic habitats (Beggiatoa, gas bubbles, farm litter and redox potential); chemical variables for monitoring the benthic habitats (chemical oxygen demand (COD), total organic matter, sulphide, total sulphur, total phosphorus, total carbon and total organic carbon); biological indicators (total macrofaunal biomass, number of species, index of diversity (Shannon-Wiener), and AMBI (AZTI's Marine Biotic Index, dominance calculated using abundance data and Capitellids polychaetes as percentage of total faunal abundance); water column quality (dissolved oxygen, chlorophyll *a* and turbidity).

13. He recalled that, for the second Delphi, the experts were asked to provide (a) their opinion on the usefulness of the indicator and (b) thresholds for the safe conditions (i.e. close to normal) and critical conditions (i.e. the values beyond which the ecosystem services are severely compromised) as well as other comments on each variable. The critical condition, when exceeded, should trigger more intense monitoring and mitigation measures including the possibility for introducing production strategy measures (reduction, species change, etc.). The responses were analysed according to (a) the percentage of approval regarding the usefulness of the indicator as a descriptor of the ecological quality at the impacted sites and (b) to the number of thresholds provided by the experts for the critical values. Thresholds for safe and critical levels were derived as the median of the values provided by the experts in order to avoid dominance of extreme values or outliers. A summary of the results from the EQS Delphi exercise is reported in Appendix III.

14. Participants discussed the results of the Delphi exercise and a discussion generated around the use of these indicators for the monitoring of the environment around marine finfish cages and within the AZE, with particular regards to the physical, chemical and biological parameters of the benthic habitats and of the water column. The main idea is that within the AZE (i.e. in the immediate vicinity of the farm) some deviation from national and international standards is expected but not beyond a point (threshold) where critical goods and services provided by the marine ecosystem are irreversibly compromised.

15. Regarding the Delphi approach, it was reported that experts responded well and provided data and other information. Mr Karakassis pointed out that the Delphi should also be linked to raw data (metadata analysis), and a template could be prepared during the Workshop to be used to collect this kind of data. Participants pointed out that some environmental indicators are site-specific (e.g. according to the sea bottom composition), and it was suggested that there are some other species belonging to the polychaetes class which could be employed as efficient indicators rather than the Capitellids. It was acknowledged that the benthic fauna is a suitable indicator and that it would be

[2] See report GFCM:CAQVII/2011/Inf.13.

good practice to have the identification at species level at least once each season to fully understand the benthos composition and subsequently continue the monitoring and identification at family level.

16. It was also argued that Beggiatoa and gas bubbles should not be used as indicators for EQS because their presence would mean that the monitoring programme did not work properly to arrive at the stage where these two events occur, and that aquaculture production should have to be stopped before. Other suggestions were that Chlorophyll *a* should be employed only for closed bays; water turbidity is a good indicator especially for public opinion but difficult to be used in some place; and when measuring dissolved oxygen it should be clearly indicated where in the water column this parameter is measured. Finally it was suggested that indicators could be clustered into different groups and according to the weight they have in monitoring aquaculture operations.

ALLOWABLE ZONE OF EFFECT (AZE): HOW TO IMPROVE AND IMPLEMENT THEM

17. The Chairman introduced the concept of AZE which was adopted by the WGSC during the seventh session of CAQ held in Malta in November 2010, and that was broadly defined as the area that can be influenced by the farm and in which the monitoring activities should be done. The Malta Workshop confirmed that a monitoring system (and associated EQS) in the immediate vicinity of the farms would be more efficient and realistic in addressing the issues of environmental protection and some technical consideration were also made on the EU Water Framework Directive that instead requires a wide area of monitoring without specifically considering the zone of effect of aquaculture activities.

18. Mr Pablo Sanchez delivered his presentation on the AZE. He introduced the AZE concept by recalling that the environmental sustainability of Mediterranean aquaculture depends on the reduction of the local impact on both environmental conditions and biodiversity, and the respect of the ecological services of the ecosystem. The development of floating cages on coastal systems needs to build a regulatory framework for offshore aquaculture, considering important aspect such as permits and site selection because of the potential harmful effects on the marine environment. For management purposes, the concept of AZE defined as '*the area of sea-bed or volume of the receiving water body in which competent authority allow the use of specific EQSs for aquaculture, without irreversibly compromising the basic environmental services provided by the ecosystem*' could provide a degree of flexibility in the regulation of farm effects and recognises that it is quite impossible to cause no environmental effects from intensive fish production in the immediate surrounding area. AZE are within the Allocated Zones for Aquaculture (AZA) and the concept is common in several countries although it is called with different names e.g. mixing zone; allowed zone of effect; local impact zone; aquaculture management areas; Zone A; etc.

19. Mr Sanchez emphasized the need to employ Marine Spatial Planning as a tool for a better integration of multiple uses in coastal zone. Within a legislation framework, the definition of AZE through an Environmental Impact Assessment (EIA) follows the establishment of AZA within marine spatial planning and precedes the set up of a proper EQS Monitoring Programme. He also highlighted that establishing AZE requires spatial accuracy for the mooring of fish farms and that the shape of AZE could follow either the administrative process or the dispersion model. The former coincides with the administrative area identified in the spatial license and according to the Environmental Impact Assessment, species to be produced, size of production and the carrying or holding capacity of the receiving body of water. On the other hand, the boundaries of the latter are identified through mathematical models to determine the extension and magnitude of the environmental impact that fish farming will have on a water body taking into consideration the environmental sensitivity of an area to aquaculture development with regard to the input of nutrient and impact on the benthic communities. Generally the spatial scale of AZE delimitation from the cages system is of ten's of meters.

20. Mr Sanchez pointed out that specific monitoring for aquaculture within AZE should be carried out in order to ensure that this zone is not degraded to a point beyond which the services provided by the

ecosystem will be severely or irreversibly compromised. Monitoring the environmental effect could be considered at three spatial scales: farm; water body and regional scale. Monitoring programmes should be adaptive and related to EQS goals, farm size and the sensitivity of the surrounding environment, whilst standardization of monitoring programmes for Mediterranean aquaculture could be complex, and site and species specific. He also added that one aspect to be taken into account for monitoring AZE is the management of discharges, such as organic matter due to faeces and rest of food sedimentation, and sporadic spills (e.g. chemical use for external parasites). A variety of sampling design and methodology could be employed to set up the monitoring system.

21. The presentation concluded with some considerations on recovery of AZE after aquaculture termination: avoiding the permanent degradation of the marine ecosystem is the only way to convince that Mediterranean aquaculture is sustainable and it is not damaging future ecosystem services.

22. In the discussion which followed all participants agreed on the importance of AZE, the responsibility of which (in terms of management and monitoring) should be entirely given to farmers. The latter should be fully accountable for the environmental quality under the cages systems and around them, at local (AZE) and regional scale. It was also stated that one of the main aspects related to the AZE is the need to consider the costs associated with the EQS analysis and that an economic aspect should be taken into consideration in the capital investment, including adding the economic value of the ecosystem service. Some clarification was requested about the distance of effect from the farm/cage(s) which should be considered in setting and monitoring AZE. Furthermore experts stressed that the impact and the dispersion modality are a function of three main variables i.e. velocity, depth and production per cage, and it was concluded that a possible solution for deciding shape and size of AZE would be a mix of administrative process and dispersion model.

23. The experts agreed to further work on refining the definition of AZE and also to proper define roles and responsibilities in setting up AZE and monitoring them. The results of the discussion including agreed definitions, EQS, and temporal and spatial definition of monitoring programme around AZE are reported in Appendix IV.

GLOSSARY ON SITE SELECTION AND CARRYING CAPACITY

24. Participants were informed by the Secretariat about content and structure of the glossary on site selection and carrying capacity whose preparation is on-going and which will be finalized in due course and made available on the GFCM – SIPAM website.

GUIDELINES ON THE APPLICATION OF ALLOCATED ZONES FOR AQUACULTURE (AZA)

25. Mr Jose Carlos Macias presented the draft Guidelines for the establishment of AZA in the GFCM area. Mr Macias clarified the relationship between AZE, AZA and EQS and reminded us of the definition of AZA as agreed during the seventh session of CAQ held in Spain in October 2010[3]: 'For coastal areas, 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 prior to other uses; (ii) an area dedicated to aquaculture, recognized by physical or spatial planning authorities, which would be considered as a priority for local aquaculture development'.

26. Mr Macias pointed out that despite the rapid expansion of finfish marine aquaculture in the Mediterranean, one of the main constraints to further development is the lack of appropriate coastal space formally devoted to aquaculture, identified through a participative and inclusive process, and regulated by norms and procedures including management and monitoring. He emphasized that AZA

[3] See report GFCM:CAQVII/2011/Inf.12.

would facilitate the promotion of aquaculture with the society as well as reduce the chance of conflicts among coastal users. Within this context, the Guidelines would be a planning and management knowledge-based tool to support the administrations and public bodies involved in the development of sustainable aquaculture in selecting, establishing and managing AZA towards sustainable aquaculture development, as well as help stakeholders, new developers and businesses in the setting up of an aquaculture project.

27. He described the major elements to be considered when setting up an AZA including legal framework, administrative procedures, availability and collection of social, economical and environmental information, planning and implementation. The latter should possibly be carried out within an Integrated Coastal Zone Management framework to assure full consistency and compliance with existing and future uses of coastal area. In the preparation of AZA relevant authorities should be involved in order to facilitate the process of licensing procedures.

28. Subsequently, the main principles for developing an AZA were illustrated. These include the need to have an appropriate Environmental Monitoring Programme (EMP), to follow an Ecosystem Approach to Aquaculture (EAA) promoting sustainable development, equity and resilience of interlinked social and ecological systems, and to employ a participatory approach with a wide stakeholder involvement. Assessment tools (administrative, socio-economic and environmental), and data integration and spatial analysis by using the Geographic Information System (GIS) and Remote Sensing (RS) should all be used to establish an AZA.

29. Mr Macias highlighted the criteria behind the site selection for setting an AZA, especially those related to space delimitation and socio-economic and environmental studies whilst also emphasizing that from a spatial point of view, the selection of AZA could be carried out at national, regional and local level. The Guidelines provide a series of checklists which could be used for gathering structured information on basic data on the selected potential area for AZA, administrative as well as environmental and socio-economic aspects. Those data would then help in doing a spatial analysis by employing GIS and decide the validity of the potential AZA. He also stated that in terms of site selection and aquaculture planning, the existence of a law for aquaculture in a country is positive to guarantee, in a mandatory way, the criteria and requirements for site selection.

30. He also stated that a key aspect in an AZA is the presence of a management and monitoring plan which should contain a minimum set of elements including the type of aquaculture and species to be farmed with associated carrying capacity, environmental surveillance programme, collective management services and sanitary management plan. He concluded by presenting in chronological order the main steps to be followed when establishing an AZA.

31. The participants appreciated the presentation and the draft Guidelines' structure and content which has to be fine tuned to take countries' specific features into consideration. The meaning and the spatial relationship between AZA and AZE was further clarified. AZA would be inside in an industrial park with specific regulations to manage the aquaculture industry, whilst rules and regulations will provide specific system and species provisions on how to carry out aquaculture within an AZA. After a first round of discussions, Mr Macias presented the draft worksheets for case studies to be included in the Guidelines. Participants offered to provide maps, documents and other material to fill the worksheets.

32. The Turkish experience was shared as a good and viable example of using AZA for aquaculture development. In Turkey, following the boost of marine aquaculture, several AZA were allocated by the Government[4] coupled with specific provisions in legislation whereby more responsibility is given to farmers in AZA management through the affiliation to a joint commission. The commission would

[4] In Turkey the average area occupied by an AZA is about 1% of a bay, and an AZA can have different shapes.

assure that all farmers within an AZA would follow the same farming rules and main practices (e.g. type of medicine used) in order to harmonize the management of AZA. Those who do not comply with the set rules would be excluded from the AZA.

33. It was particularly stressed by participants that as well as the land-based farms which are accountable for the impact they produce, one of the main aspects linked to AZA is the responsibility for taking care of the environment in the farming and surrounding area (environmental stewardship) which should stay with farmers. Differences exist in that for land-based operations, boundaries are clear unlike in the sea where the environment under the cages is not well confined due to currents, depth, wind, etc. It was also said that AZA is a global collective investment/undertaking which calls for collective effort in planning and management similarly to what happen in ports, airports and other public infrastructure which have an impact on everyone in the society.

34. The concept of AZA and AZE are strictly interlinked and two important aspects related to both were thoroughly addressed by participants, i.e. the boundary of impact (AZE) and the cumulative effects of multiple operations within an AZA. An ideal AZA should have the shape of a polygon where all the interactions with other coastal zone users and its carrying capacity are well described. Questions were raised whether AZE concept relates to the single farm obtaining concession or is the responsibility of the cluster of farms in the same AZA; and also whether all AZE should be contained inside an AZA or the cumulative effects could also be detectable outside the AZA. It was suggested that an AZA should take into consideration both single farm effects as well as cumulative effects from all farms, and that the name of the area with cumulative effects and its monitoring system should be defined and described in the Guidelines. There is a need to have different level of monitoring according to scale, and modelling could help in understanding better how the cumulative effects of farms interact, but in any case the dangerous cumulative effect should be avoided by preventive good planning.

SPATIAL PLANNING FOR MARINE AQUACULTURE

35. As a contribution to the discussion, some case studies were presented from Croatia, Malta, Spain (Murcia), and Italy as follows.

36. Ms Maja Polic delivered a presentation and updated the participants on spatial planning for marine aquaculture in Croatia. She presented a brief review of the Croatian aquaculture production as well as the basic legislative framework, and informed that Croatian coastline is under seven administrative regions (also called Counties) all of which, according to law, have to define an AZA in their physical plans. The latter are linked to the location permits based on criteria which vary according to farmed species, environmental data and geographical location. Ms Polic pointed out that an EIA is mandatory for farm operations located in protected coastal area and with annual production above specific amounts. The EIA defines maximum production quantity taking into consideration farmed species and system, site and defines monitoring procedures. A County gives concessions based on location permit for a maximum period up to 20 years, and a concession cannot be extended except in special cases and upon agreement of the government.

37. Ms Polic highlighted the importance of the Integrated Costal Management (ICM) approach in Croatia as a means to avoid conflicts among stakeholders and different users. She then presented the case of Zadar County which accounts for more than 50% of Croatian marine aquaculture and where aquaculture zonation is based on the AZA and ICM principles. Within the AZA the monitoring system considers both the water column (general indicators; physical-chemical parameters; biological parameters, microbiological parameters and biological indicators) and the sediment (physical-chemical parameters). She concluded that after four years of implementing AZA in the Croatian aquaculture, the experience could be considered very positive if the principles are employed correctly.

38. Mr Joseph Borg presented an overview of AZA in Malta: the concept originated in mid 2000s from the need to move existing tuna farms offshore and to provide additional sites for new tuna farms. He explained that although Malta is an island, identifying a suitable sea area for setting up AZA was difficult due to several reasons (i.e. conflicts with areas allocated exclusively for bunkering activities, shipping lanes, yachting, tourism, excessive water depth, areas supporting ecologically sensitive habitats, long access distance etc.). Eventually, a site located six km off the south-eastern coast of Malta was identified. The newly established AZA had several advantages for society at large such as being away from sight, the presence of strong currents that efficiently transport waste and uneaten food, and a predominantly sandy/muddy seabed which was deemed to be of a lower ecological value compared to areas supporting maerl beds and seagrass habitat. On the other hand an AZA so far offshore carries many disadvantages for the farmers, including being suitable mostly for tuna farming and not for in-shore species (e.g. sea bass and sea bream), increased overall operational costs (travel time to site, fuel costs etc), huge expenses to deploy cage moorings and to service the cages in deep waters, and high exposure to adverse sea conditions, which also makes insurance coverage more difficult and costly. Mr Borg concluded that from an environmental point of view, the AZA in Malta is working well and since the tuna farming operations started in 2006 there, not significant changes in sediment attributes, benthic diversity and gross biological and physical characteristics of seabed have been detected. However, given the difficult conditions linked to the area chosen for the AZA, only 2 - 3 tuna farms had used it since, out of the total six potential allocations within the AZA.

39. Mr Jose Miguel Gutierrez Ortega presented the methodology and some of the results of the assessment of the carrying capacity for offshore fish farming in the Murcian Coast. The work described is part of a study founded by the Fisheries and Aquaculture Service of the Murcian Autonomous Government. The work was developed by TAXON Estudios Ambientales Ltd. and MARETEC (IST, Lisbon University). MOHID[5] was the modelling tool to simulate hydrodynamic, ecological and culture scenarios. The productive and environmental sustainability of the scenarios was assessed comparing the results of the model with the critical values for the culture or the environment. The selected indicators to assess the Productive Carrying Capacity were the levels of toxic substances (concentration of toxic ammonia nitrogen species) or the necessary ones for cultured fish survival (concentrations of dissolved oxygen). The Environmental Carrying Capacity was assessed by means of eutrophy in sediments and water and the tolerance of benthic organisms to organic matter sedimentation. Eutrophication was evaluated both studying the oxygen, organic matter and nutrient concentrations, and using regression models of benthic structure indexes versus organic matter content.

40. Mr Paolo Tomassetti from the Italian National Institute for Environmental Protection and Research (ISPRA) in Italy reported information on the number, the productions and the locations of Italian marine fish farms. Two different approaches in regulating mariculture activities were reported in order to show what is happening in Italy regarding law and rule to be applied to aquaculture: regional guidelines were edited by Regione Sicilia and a proposal of AZA by Regione Marche. By the end the item connected with *zero kilometre policy* carried out by some large supermarket chains (e.g. Coop Italia) that have a policy to source fish close to their outlets was introduced for discussion,. Arguably this would cause a migration of fish farms based on their market of reference and could also have consequences with establishing AZA in some Italian regions.

41. After the presentation, followers were informed that ISPRA had been appointed by both the Italian Ministry of Environment and the Ministry of Agricultural, Food and Forestry Policies to support the development of the aquaculture legislative framework for Italy. ISPRA would therefore provide a platform which will be the basis for building the new legislation, and AZA and AZE will be proposed in this context. The Geographic Information System (GIS) will be also employed as a key strategic planning tool.

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[5] http://www.mohid.com/

SYNTHESIS OF THE MAIN ASPECTS RELATED TO AZA, AZE AND EQS AND CONCLUSIONS

42. Participants agreed that the AZA concept and approach could really play a crucial role for aquaculture development in the Mediterranean and Black Sea, and good examples could be found in some areas where farmers within an AZA established an association representing farmers' interests, and who are interested in increasing their production and approved monitoring programme within an aquatic animal plan. Furthermore AZA would be very useful to protect farmers from effects which are caused by other users/sectors, for example pollution from coliforms bacteria caused by activities related to tourism. Initial resistances to the establishment of AZA would be overcome once obtaining consensus from decision-makers.

43. The importance of both InDAM and SHoCMed projects was acknowledged as they strive to experiment and implement activities related to important issues rarely considered by other projects. It was highlighted that the two projects have complementary objectives, and while InDAM looks at aquaculture sustainability as a whole, SHoCMed is technically tackling the issue on how to avoid impacts of aquaculture site selection and how to protect the aquaculture itself from adverse environmental conditions. They work in parallel and both are highly participatory with the active involvement of authorities, farmers, researchers and other key stakeholders. This would result in valuable social capital and the channel of communication created would pave the way to the adoption of newly introduced concepts such as AZA, AZE and EQS.

44. Participants argued that the discussion around AZA have been so far only for fin fish marine aquaculture in cages and that perhaps in planning AZA there is a need to consider also land-based marine aquaculture, capture-based aquaculture as well as other type of aquaculture e.g. tuna farming and mollusc farming (e.g. mussel). The latter has usually a milder environmental impact compared to fin fish culture but is prone to problems linked to harmful algal blooms. It was suggested that when planning off-shore AZA should also consider that a part of a cycle is land based and an increased fingerling mortality had been founded in Turkey when fingerlings are directly stocked in the cages at sea.. The importance of considering the whole range of farming operations from small, medium to large scale within SHoCMed in order to preserve the industry diversity was also highlighted.

45. Participants concurred that the concepts of AZA, AZE, and EQS and their interconnectedness should be further defined and that in many cases it is not easy to distinguish bewteen them. Moreover, it is important to have an agreed glossary of commonly used terms (e.g. the term 'impact') to avoid any misunderstanding and misinterpretation among the same stakeholders. In addition, the term 'socio-economic' should be avoided and used the two terms separately i.e. 'social' and 'economic' instead.

46. During the discussion it was stressed that the legislation of a country must be very prescriptive when setting up an AZA in that the use of AZA shall be used exclusively for carrying out aquaculture. This in turn would not prevent complementary and temporary uses of AZA, for example organized tourist visits by boat to fish farms which, however, must be agreed in advance with the farm's owner. Furthermore participants pointed out that local fishermen could also benefit from establishing an AZA e.g. possibility to fish around AZA (recreational fishing) and navigation.

RECOMMENDATIONS

47. The results achieved so far from SHoCMed should be published in peer-reviewed journals to get feedback from the scientific community, and documents in a form suitable for the GFCM assembly should be prepared.

48. The outcomes of InDAM and SHoCMed projects should be discussed in a Forum of the coordination meetings in order to take advantage of good results from both projects e.g. include the participatory approach used in InDAM into AZA guidelines. One of the outcomes of both projects is

the valuable social capital and the channel of communication created which would pave the way to the adoption of newly introduced concepts such as AZA, AZE and EQS.

49. It is extremely important to have an agreed glossary of commonly used terms to avoid any misunderstanding and misinterpretation, and the concepts of AZA, AZE, and EQS and their interconnectedness should be well defined

50. Monitoring the interaction of aquaculture with environment is extremely important when pursuing the sustainability of the sector. Aquaculture monitoring systems should be further elaborated to be simple, efficient, and cost-effective; and that other aspects should be considered for their adoption such as data storage, meta-analysis, environmental audit, adaptation of EQSs and industry standards.

51. The Delphi approach and methodology has proven to be an efficient and reliable tool to gather data and information, and this method could be complemented by other tools such as metadata analysis.

52. **AZA**:

- AZAs are a priority for aquaculture in that theycalm fears of uncontrolled proliferation everywhere, but there are also limitation in space;

- AZA is a matter of governance in that it is an expression of the Government commitment to support the industry. It is not an easy strategy and the process of integration of several coastal zone uses is a difficult and complex undertaking which is the reason behind the many overlapping sectorial plans in the same area;

- AZA is the secure and transparent way to secure the sector because a defined area is specifically devoted to aquaculture, and this would arguably reduce the conflicts over the use of coastal marine areas. There are examples of successful AZA being established in some Mediterranean countries from whom we can learn valuable lessons. On the other hand, a balance between social expectations and AZA viability from the farmer point of view should be sought to avoid situation like in Malta where AZA located very far from the coast are only partially being used by farmers;

- Many aquaculture failures and unsustainable initiatives are associated with bad planning and zoning. Prior to establishing AZA there should be an impact-analysis and then a cost-benefit analysis to assess the consequences of establishing an AZA. This would corroborate decisions which sometimes are made based on political basis rather than on solid social, economic and environmental evidence;

- Within this context, the Guidelines would be a planning and management knowledge-based tool to support the administrations and public bodies involved in the development of sustainable aquaculture in selecting, establishing and managing AZA towards sustainable aquaculture development, as well as help stakeholders, new developers and businesses in the setting up of an aquaculture project;

- Setting up AZA should possibly be carried out within an Integrated Coastal Zone Management framework to assure full consistency and compliance with existing and future uses of coastal area;

- AZA should take into consideration both single farm effects as well as cumulative effects from all farms, and the name of the area with cumulative effects and its monitoring system should be defined and described in the Guidelines. There should be different level of monitoring according to scale, and modelling could help in better understanding of how the cumulative effects of farms interact. In any case, dangerous cumulative effects should be avoided by preventive good planning;

- AZA cannot be considered exclusively as an aquaculture zoning tool. It should also be considered an area where all administrative procedures are shortened and the farming license is given in a relatively short time;

- A country legislation must be very prescriptive when setting up an AZA in that the use of AZA shall be exclusively for carrying out aquaculture, and therefore statements such as ‘priority use of AZA is for aquaculture’ should be avoided;

- Aquaculture sector and AZA should be proposed as a collective action to reinforce the advocacy of the industry which, as the other industries in each country can generate jobs contributing to the development;

- Further work on AZA should focus on land-based aquaculture, capture-based aquaculture, and multi-trophic aquaculture and also look at the wide range of farmed species in the Mediterranean and Black Sea and including mollusc culture, tuna farming, etc. All typology of farming operations from artisanal to large scale should be considered to preserve the industry diversity;

- The use of GIS/RS as strategic tools for planning aquaculture should be fostered;

- Problems within AZAs e.g. min distance, sanitary issues, and common management should be explored;

- To collect all available data would take years and there is a need to decide the kind of information that would be mandatory/necessary to develop an AZA and that which is desirable, but not really essential;

- The GFCM approach with guidelines could be introduced/exported as a suitable methodology;

- After setting up an AZA, specific indicators of pressure should be developed and include pressure indicators e.g. eutrophication of marine waters and indicators for the impact of coastal activities. Within a monitoring scheme, there is a need to measure the cumulative effect of other human activities, and that is what is needed for the marine strategy at European level.

53. **AZE and EQS**:

- The AZE and related terms were discussed and agreed upon and reported in Annex IV;

- AZE and EQS legally bind the farmers and society. The responsibility of AZE (in terms of management and monitoring) should be entirely given to farmers who should be fully accountable for the environmental quality under the cages systems and around them, at local and regional scale. In this way, AZE could be an instrument/incentive in that a farmer respecting AZE requirements could have the lease for the area renewed further;

- EQSs could impose a burden and a cost to farmers but they also provide a yardstick to measure their effects and to defend themselves against allegations that they are harmful to the environment;

- A common EQS monitoring scheme for Mediterranean and Black Sea and EQS inter-calibration exercise to finalize the list of indicators should be carried out. Monitoring the environmental effect could be considered at three spatial scales: farm; water body and regional scale. Monitoring programmes should be adaptive and related to EQS goals, the farm size and the sensitivity of the surrounding environment;

- Management of AZE and the regional area of influence should address environmental goals following a precautionary management, and trying to conserve and maintain the biological diversity and ecosystem health as much as possible;

- Decisions about the mitigation and modification of production level or reallocation of fish farm should be based on statistical decision criteria after the detection of unacceptable changes on environmental indicators;

- Estimation of carrying/holding capacity of AZE would be important, in spite of the technical problems for correct definition of these environmental descriptors. Other elements of carrying capacity e.g. the social dimension, should also be considered;

- Management objective should be defined to ensure no permanent impacts (e.g. accumulation of chemicals), because of the potential bio-accumulation and the potential press impact after farming cessation;

- Marine Spatial Planning as a tool for a better integration of multiple uses in coastal zone should be employed;

- Establishing AZE requires spatial accuracy for the mooring of fish farms and the shape of AZE could follow a mix of administrative process and dispersion model. The use of mathematical models to incorporate AZE-EQS should be considered;

- Once AZE is defined, environmental quality objectives should be identified, and the use of several reference/control sites is needed;

- The relation among the AZE and other existing monitoring and regulatory schemes such as the EU Water Framework Directive (WFD), should be also addressed.

SHOCMEDPROGRAMME OF WORK FOR 2012 AND BEYOND

54. The framework of the SHoCMed project was discussed and the activities for 2012 and beyond were proposed by the participants as follows:

OUTPUT 1
Completion of the preliminary study to design the best strategy to achieve consensus on site selection and establishment of Mediterranean standards for carrying/holding capacity of aquaculture farms.

- Finalisation of guidelines on Allocation Zone for Aquaculture activities.

- Organisation of regional training on site selection and carrying capacity to upgrade the capability of technicians and other key aquaculture development stakeholders.

- Organisation of a regional workshop on the definition of reference points for EQS and monitoring the aquaculture activities within allowable zone of effect of aquaculture.

- Design and implementation of the programme of dissemination of the technical results and outcomes of the SHoCMed activities.

OUTPUT 2
Production of criteria and related guidelines (including standards) for aquaculture site selection in the GFCM region.

- With reference to the database and meta analysis system structure formulated in SHoCMed, the establishment of an IT forum platform on Site Selection and Carrying Capacity aiming at strengthening the existing network of WGSC experts by facilitating data and knowledge sharing activities;

- Finalisation of the Glossary on Site Selection and Carrying Capacity for aquaculture activities.

OUTPUT 3
Issues regarding carrying capacity of aquaculture sites and carrying capacity standards and identification of Environmental Quality Standards (EQS).

- Establishment of an IT forum platform on Site Selection and Carrying Capacity for aquaculture activities in the Mediterranean region in order to strengthen the existing network of WGSC experts and share data and knowledge;

- Carry out an EQS inter-calibration exercise involving various countries and set up a database hosted by GFCM-SIPAM. The exercise will include a review/meta-analysis of data and the outcome would be the percentage of farms passing the crash-test;

- Preparation of a common EQS monitoring scheme for Mediterranean and Black Sea, taking into consideration, among the other, the following:

    - Expertise regarding the monitoring in various countries in the region and their relation to regulation;
    - Further elaboration of the monitoring scheme and the properties it should have to get a chance to be adopted (simplicity, efficiency, cost effectiveness, trans-Mediterranean availability of expertise etc); and

- Future of the scheme in case it is adopted (data storage, meta-analysis, environmental audit, adaptation of EQSs and industry standards).

NOMINATION OF THE WGSC COORDINATOR

55. Mr Ioannis Karakassis was unanimously reconfirmed as WGSC Coordinator.

APPENDIX I

AGENDA

1. Opening and arrangement of the meeting

2. Adoption of the Agenda

3. Environmental Quality Standards (EQS) for monitoring Aquaculture Activities

4. Discussion and synthesis of the main Allowable Zone of Effect (AZE), how to improve and implement them

5. Glossary on Site Selection and Carrying Capacity

6. Allocated Zones for Aquaculture (AZA) how to improve the licensing procedures for aquaculture and their implement

7. Production of criteria and related guidelines (including standards) for aquaculture site selection in the GFCM region

8. WGSC on SHoCMed -Programme of work of the Third Phase, 2012 and beyond

9. Conclusion and Recommendations

10. Any other matters

11. Nomination of the WGSC Coordinator

APPENDIX II

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APPENDIX III

RESULTS FROM THE SECOND EQS DELPHI EXERCISE[6]

SELECTED PARAMETERS

Total Organic Matter in Sediments (%)					
1		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**28** (100)	**22** (79)	**7** (25)	
	Median values	**Safe (%)**		**Critical (%)**	
		4		10	
	Definition	This variable 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.			
	Comments	Useful as general characteristic of site and cheap to do, it is considered clearly important because it correlates well with benthic results. There are no generally established safe limits and these will be context dependent. The interpretation of the data depends on the natural background levels. In a depository environment, the % OM will naturally be higher than in an area with strong currents. Measure should be taken at multiple distances from the farm and comparison should be made between several reference and farm sites.			

Total Phosphorus (%)					
2		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**28** (100)	**17** (61)	**6** (21)	
	Median values	**Safe (%)**		**Critical (%)**	
		0.05		0.18	
	Definition	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).			
	Comments	It has some use as an indicator where feed is fishmeal rich as it is present in fish bones. There is some variability in the background levels. Samples for P, as well as for other sediment variables should be carried out during the high production period (i.e. summer). The method depends on SCUBA diving to get sediment cores, thus increasing the cost, but besides this the cost for determination is rather low.			

[6] Based on: Karakassis, I. and Jerez, P.S. 2011. Environmental Quality Standards for Mediterranean Marine finfish farming based on the response of experts to a Delphi questionnaire. GFCM report. 29p.

Total Nitrogen in Sediments (%)					
3		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**28** (100)	**19** (68)	**7** (25)	
	Median values	**Safe (%)**		**Critical (%)**	
		0.10		0.25	
	Definition	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).			
	Comments	Useful especially when used to compute C:N ratio an indicator of carbon quality, is used in Law 14 Feb 1997 for the Andalusian water quality regulation. It is considered pH and salinity dependent and some experts feel that no definite value can be stated for either cautionary or critical condition since baseline values differ between different sites in the same locality and between different localities.			

Total organic Carbon or TOC (%)					
4		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**28** (100)	**22** (79)	**9** (32)	
	Median values	**Safe (%)**		**Critical (%)**	
		1.5		2.5	
	Definition	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).			
	Comments	Useful in itself and in computing C:N ratio, it may give a good idea of natural sedimentation which may be a guide to site selection. It is used in Turkish regulation. Some experts feel that no definite value can be stated for either cautionary or critical conditions since baseline values differ between different sites in the same locality and between different localities, and that it does not seem to correlate reliably with benthic impact. On the other hand Hyland *et al.* (2005) have shown that TOC concentration in sediments is a very good indicator of stress in marine benthos.			

Sulphide					
5		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**28** (100)	**16** (57)	**7** (25)	
	Median values	**Safe (micromoles)**		**Critical (micromoles)**	
		1000-2000		3000	
	Definition	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.			
	Comments	According to the ECASA toolbox (www.ecasatoolbox.org.uk), this method is *useful in that it can be used in-situ and instant measurements are obtained. This technology could be used in the field in monitoring surveys to give information on the zone of impact of the aquaculture operation. By obtaining this information quickly, sampling stations for macrofauna could then be appropriately placed on a site specific basis, rather than using a non-site specific spacing between stations. This is particularly relevant in determining the boundary of the zone of impact which may not be known until some preliminary samples are taken*". Some experts expressed doubts whether the data/limits provided by Brooks & Mahnken (2003) can be used also for the Mediterranean, and also suggested that no definite value can be stated for either cautionary or critical condition since baseline values differ between different sites in the same locality and between different localities. Scepticism was also expressed regarding its cost-effectiveness and the interference with metals.			

Redox Potential or Eh (mV)					
6		**Total responses**	**Experts approval**	**Threshold given**	
	No. (%)	**27** (96)	**20** (74)	**10** (37)	
	Median values	**Safe (mV)**		**Critical (mV)**	
		0		-100	
	Definition	The oxidation-reduction (redox) conditions in the surficial 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 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).			
	Comments	Experts considered it is as an important variable which is very widely used and there is potential for comparative studies. The main critique is that the Eh measurement is very variable due to sediment heterogeneity and the repeatability is rather low. Simpson *et al*. (2005) consider acceptable Eh error ranges of 20-40 mV.			

Macrofaunal Biomass (g/m^2)

7		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**20** (71)	**3** (11)
	Median values	**Safe (g/m^2)**		**Critical (g/m^2)**
		10		5
	Definition	The total macrofaunal biomass (expressed in g/m^2) represents one of the macrobenthos elements of the benthic components. The macrofaunal biomass is an indicator for cautionary and critical conditions related to marine sediments located under fish farms (GFCM, 2011). Both abundance and biomass of macrofaunal species are significantly modified along organic enrichment gradients (Pearson & Rosenberg, 1978). Azoic conditions close to heavily polluted sites result in zero abundance and biomass, which gradually increase with spatial distance from the site or temporal distance from a pollution event. The determination of biomass requires quantitative sampling of macrofauna, sorting of samples to separate benthic animals from the sediment, and weighting of the wet or dried mass of the specimens.		
	Comments	Biomass is very useful but can be very expensive to measure. Many indices do not use biomass but mean animal size gives an idea of bioturbation potential. Care should be taken with the interpretation of the data because total biomass could be driven by one large individual. Time consuming, generally low additional information. Too onerous to apply for rapid assessment. Biomass changes along an organic gradient are typically quite complex, with peaks in biomass associated with peaks in opportunistic species and a larger peak in biomass at unimpacted locations, therefore there are some implications regarding the use of biomass as an indicator of environmental quality.		

Number of (macrofaunal) species (No.)

8		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**20** (71)	**6** (21)
	Median values	**Safe (No.)**		**Critical (No.)**
		10		3
	Definition	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.		
	Comments	Some experts consider it as a key-variable to measure. It is already used in Scotland and Turkey. Typically it is very low beneath the cages, composed of opportunistic species but it increases rapidly with distance from the cages. Criticism involves the dependence of the values on the ecotope (i.e. mainly sediment type) and the high cost required for the identification of the specimens to species level. The sample size regarding the number of individuals or area sampled affects significantly the number of species found.		

Shannon diversity index				
9		**Total responses**	**Experts approval**	**Threshold given**
	No. (%)	**28** (100)	**20** (71)	**4** (14)
	Median values	**Safe (H')**	**Critical (H')**	
		> 2.25	< 1.5	
	Definition	The Shannon index (Shannon & Weaver, 1949) is derived from a data set of macrobenthos identified to species level (as described in the number of species above). This index is sensitive to two diversity components i.e. the number of species and the equitability i.e. the equal/unequal distribution of specimens among the species found in the sample. Despite its' widely acknowledged limitations it is probably the most commonly used diversity metric in the history of Benthic Ecology. It has been shown to change with distance from fish farms (Karakassis *et al*., 2000) but also it varies considerably among different sediment types.		
	Comments	Very dependent on the environmental conditions and ecotope-type, mainly granulometry. Is important to consider if there are indicator species (or families) or not. Shannon index is influenced by sampling effort and sampling size. More than using limits, it would advisable to assess the variation from initial conditions. The cost is quite high as in the case of the number of species above.		

AMBI Biotic index				
10		**Total responses**	**Experts approval**	**Threshold given**
	No. (%)	**28** (100)	**20** (71)	**6** (21)
	Median values	**Safe (AMBI)**	**Critical (AMBI)**	
		< 3.35	> 5	
	Definition	The AMBI, was defined by Borja *et al*. (2000, 2003), and is a biotic index which provides a 'pollution classification' of a particular site, representing the benthic community 'health'. It uses scores for an extensive number of species which may be found in the database of AZTI (www.azti.es) and calculates a total score i.e. a number in a range of 0-6 (7 for azoic sediments) that can be simplified into five classes from undisturbed communities to extremely disturbed communities or from High to Bad Status (*sensu* EU WFD, in the assessment of the Ecological Status.		
	Comments	Borja *et al*. (2009) found that AMBI and ITI correlated well. AMBI is probably preferable on theoretical grounds but ITI does seem to work better in some circumstances. Other experts expressed doubts whether AMBI is better than BENTIX or M-AMBI and particularly in the Mediterranean, whereas others thought that perhaps it is not cost-effective and therefore not very suitable for rapid assessment. As alternative it was suggested to identify only polychaetes at the family level and then use multivariate data analysis techniques. It was also mentioned that no limits should be used but rather focus on the variation from initial conditions.		

Percentage of Capitellid polycaetes over macrofaunal biomass (%)

<table>
<tr><td rowspan="5">11</td><td></td><td>Total responses</td><td>Experts approval</td><td>Threshold given</td></tr>
<tr><td>No. (%)</td><td>28 (100)</td><td>20 (71)</td><td>7 (25)</td></tr>
<tr><td rowspan="2">Median values</td><td colspan="2">Safe (%)</td><td colspan="1">Critical (%)</td></tr>
<tr><td colspan="2">< 28</td><td>> 50</td></tr>
<tr><td>Definition</td><td colspan="3">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.</td></tr>
<tr><td></td><td>Comments</td><td colspan="3">Most experts thought it as a relevant bioindicator, easy to calculate (for abundance as well). Some experts considered more relevant the situations with dominance of Capitellids or other indicators species (or families) such as the ITI group 4, than the % of Capitellids. Capitellids are usually indicators of high pollution levels that are well past a 'cautionary' stage. It was also suggested to be considered with reference to initial number.</td></tr>
</table>

Gas bubbles (outgassing)

<table>
<tr><td rowspan="5">12</td><td></td><td>Total responses</td><td>Experts approval</td><td>Threshold given</td></tr>
<tr><td>No. (%)</td><td>28 (100)</td><td>22 (79)</td><td>- (0)</td></tr>
<tr><td rowspan="2">Median values</td><td colspan="2">Safe</td><td>Critical</td></tr>
<tr><td colspan="2">-</td><td>-</td></tr>
<tr><td>Definition</td><td colspan="3">Outgassing i.e. the release of gas (H_2S or even CH_4) from the bottom sediments is a clear sign of anaerobic processes in the benthic environment, occasionally found beneath the cages mainly during the warm seasons of the year (Karakassis et al., 2002). It is an easy to observe environmental characteristic. The release of H_2S is considered as a risk for the farmed stock due to the toxicity of H_2S to most marine fish. However, it is worth noting that H_2S is rapidly oxidized in the seawater (ca 90% of it is removed from the bubbles after ascending 20m from the sediment surface).</td></tr>
<tr><td></td><td>Comments</td><td colspan="3">This would be a limit and critical situation that should be prevented in advance. If gas bubbles present, the critical conditions are reached. It is therefore too late. A good Environmental Monitoring Programme should prevent this type of situations. If the sediment is outgassing this is a clear indication that it is grossly overloaded with organic material. It can be helpful in some areas but gas bubbles should not be given a high priority in monitoring programmes. Monitoring programmes must exist in any case but the appearance of bubbles is a bad signal. No experts provided values for thresholds in this variable. It is considered as a qualitative indicator that should be recorded in the framework of EMP.</td></tr>
</table>

Beggiatoa-type mats				
13		**Total responses**	**Experts approval**	**Threshold given**
	No. (%)	**27** (96)	**17** (63)	**-** (0)
	Median values	**Safe**		**Critical**
		-		-
	Definition	These are formed by chemotrophic bacteria living on the interface between oxic and anoxic conditions. Beggiatoa-type mats may be seen beneath fish cages during the warm season, in shallow sites with high organic content and often with silty sediments. Their presence indicates that the sediment is fully reduced i.e. anoxic with not even a few mm of surface mixed oxic sediment. Occasionally, depending on the seabed morphology, the sediment and the direction of local water currents there are patches of Beggiatoa-type mats in parts of the seabed whereas other parts of the site are colonized by macrofauna. The presence/absence of Beggiatoa-type mats is relatively easy to measure by means of divers, ROVs or even SPI devices (Karakassis *et al*., 2002).		
	Comments	Indicates bad management (accumulation of uneaten food and/or casualties). Beggiatoa presence means that the sediment is sulphidic up to the surface and this is an obvious indicator that all is not well. Beggiatoa is a matter of good production practices. The presence of Beggiatoa could be recorded by divers or by video camera. It is more a qualitative indicator than a quantitative indicator. A visual estimate of % cover would be more relevant and cost-effective. No experts provided values for thresholds in this variable. It is considered as a qualitative indicator that should be recorded in the framework of EMP.		

Dissolved Oxygen (mg/l)				
14		**Total responses**	**Experts approval**	**Threshold given**
	No. (%)	**28**(100)	**23**(82)	**14** (50)
	Median values	**Safe (mg/l)**		**Critical (mg/l)**
		> 5		< 4
	Definition	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. This could be caused by increase in organic matter from fish farms. 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 rely on the rate of water exchange and hypsography of the area and climatic variations of the water exchange may be important as well. 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.		
	Comments	The maintenance of high DO levels is a matter of good production practices- it should be obligatory daily evidence registered in the logbook of the farm - participation of the farmer in the monitoring program is also necessary. A large decrease in the oxygen level would be detrimental to the farmed fish themselves and it is therefore very unlikely that values of this variable will be allowed to lower as a result of fish farming activities. Water column needs to be intensively sampled in order to have representative data.		

Chlorophyll *a* (mg/l)

15		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**16** (57)	**3** (11)

Median values	**Safe (mg/l)**	**Critical (mg/l)**
	< 2.4	> 5

Definition	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.
Comments	No definite value can be stated for either cautionary or critical condition since baseline values differ between different sites in the same locality and between different localities. It could be of importance when monitoring a huge aquaculture area. It depends on the site. One-off measurements are probably not worth doing.

Turbidity (m)

16		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**17** (61)	**4** (14)

Median values	**Safe (m)**	**Critical (m)**
	> 5	< 2.25

Definition	This variable 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 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.
Comments	No definite value can be stated for either cautionary or critical condition since baseline values differ between different sites in the same locality and between different localities. Water column needs to be intensively sampled in order to have representative data. It is easily accessible for general public.

Percentage of silt/clay in sediments (%)

17		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**24** (86)	**6** (21)
	Median values	**Safe (%)**	**Critical (%)**	
		< 70	> 85	
	Definition	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. 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.		
	Comments	The structure of sediment should be known for Site Selection. Variations on this structure should be monitored. This variable is useful for interpretation of other variables, it should be measured but it is not suitable as EQS.		

Grain size sediment structure (Median Diameter in mm)

18		Total responses	Experts approval	Threshold given
	No. (%)	**28** (100)	**20** (71)	**-** (0)
	Median values	**Safe**	**Critical**	
		-	-	
	Definition	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).		
	Comments	More useful it is not sure it is really cost effective. More cost effective might be a visual description of the sediment type. Small particle (5-25 micron) blocks egg incubation, big size (>25 micron) damages gill filaments. It depends on the zone. This variable is useful for interpretation of other variables. It is very dependent of the granulometry of the original sediment. No critical conditions, depends on the ecotope. It provides indication on the current speed on the bottom. This parameter is important, but 'site dependent'. No experts provided values for thresholds in this variable. It is considered as a qualitative indicator that should be recorded in the framework of EMP.		

<table>
<tr><td colspan="5">Litter in the surrounding area</td></tr>
<tr><td rowspan="6">19</td><td></td><td>Total responses</td><td>Experts approval</td><td>Threshold given</td></tr>
<tr><td>No. (%)</td><td>27(96)</td><td>24 (89)</td><td>- (0)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">Median values</td><td colspan="2">Safe
-</td><td>Critical
-</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Definition</td><td colspan="3">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.</td></tr>
<tr><td></td><td>Comments</td><td colspan="3">Litter is a telling indicator of the quality of farm management. If a site is dirty smelly or has lots of litter then you can bet that their staffs is demotivated, management is poor and environmental impacts are greater than they need be. It could be a quick component of a video or diver survey. Important for the evaluation of the environmental management. A useful qualitative indicator. If we monitor the area around the farm, perhaps we need to do the same at reference stations far way. No experts provided values for thresholds in this variable. It is considered as a qualitative indicator that should be recorded in the framework of EMP.</td></tr>
</table>

DISCUSSION ABOUT EQS FOR MEDITERRANEAN MARINE FINFISH FARMING

The overall exercise gave a number of variables that could be used as a basis for discussion among stakeholders for the adoption of a common set of environmental quality standards. In Table 1 below the indicators were ranked depending on a combination of cost and confidence on the information provided by each indicator and on the EQS that have been provided. In this case the confidence is inferred from the percentage of experts that considered it useful and from the number of those that provided thresholds.

In this context dissolved oxygen is considered as the best indicator for the water quality, whereas redox potential and total organic matter and TON are selected for the benthic effects. Three more characteristics (Litter, % silt and gas bubbles) are believed to convey very useful qualitative information that should become part of standard monitoring although there are no reliable threshold variables to be used as EQSs.

Table 1. Summary of the Delphi exercise results. Additionally cost levels (L: low, M: medium, H: high), confidence on EQS and on information provided by the indicator.

Environmental Variable	% considering useful	thresholds given	Safe	Critical	Cost	EQS	info-	over-all
Dissolved oxygen (mg l^{-1})	82%	13	5	4	L	High	High	
Redox potential (mV)	74%	10	0	-100	L	High	High	
Litter in surrounding area	89%				L	IR	High	Y
% of silt – clay in sediment	86%	6	70%	85%	L	Mod	High	Y
Total organic matter (%):	79%	7	4.0%	10.0%	L	High	High	
Gas bubbles	79%				L	IR	High	Y
Total nitrogen (%)	68%	7	0.10%	0.25%	L	High	Mod	M
Total organic carbon (%)	79%	9	1.5%	2.5%	M	High	High	
Total phosphorus (%)	61%	6	0.05%	0.18%	L	Mod	Mod	
Capitellids biomass(%)	71%	7	28%	50%	M	High	Mod	Y?
Turbidity (m)	61%	4	5	2.25	L	Mod	Mod	L
Litter Far from the area	54%				L	IR	Mod	
Grain size sedim. structure	71%				L	None	Mod	
Chlorophyll a (µg l^{-1})	57%	3	2.4	5	L	Mod	Mod	
Beggiatoa	63%	diverse			L	IR	Mod	
Macrofaunal biomass (g m^{-2})	71%	3	10	5	M	Mod	Mod	
Sulphide (%)	57%				L	None	Mod	
Number of species	71%	6	9.5	3	H	Mod	Mod	
AMBI (Marine Biotic Index)	71%	6	3.3	5	H	Mod	Mod	
Shannon Diversity (bits)	71%	4	2.25	1.5	H	Mod	Mod	
Total sulphur (mg g^{-1})	43%				L	None	L	
Total carbon (%)	32%				L	None	L	

Further down the list there are also the benthic macrofaunal indicators which are of fairly high cost but are considered as useful/important by ca 71% of the experts. The percentage of capitellids in the total biomass, the total macrofaunal biomass are ranked higher because of the low cost of the analyses although the indicators involving taxonomy and diversity are likely to supply more information even if they are analysed at higher taxonomic levels.

In the Table 2 below some details for the sampling frequency and the requirements for each method are presented. Most of the methods are straightforward and may be used by personnel with a reasonable amount of training. The exception is the CHN analyzer which needs specially trained and normally dedicated staff as well as in the case of macrofaunal variables including taxonomy (species number, AMBI, Shannon diversity etc).

Table 2. Suggested sampling frequency or sampling season, indicative time required to obtain the results, major equipment required and indicative cost (sampling /diving expenses not included)

Environmental Variable	sampling frequency	time to get results	Equipment required	Cost / sample (Euros)
Dissolved oxygen (mg l^{-1})	daily	minutes	oxygen meter, Niskin bottle	0
Redox potential (mV)	seasonally	minutes	electrode, corers	0
Litter in surrounding area	seasonally	minutes	none	0
% of silt – clay in sediment	annually/ summer	10 hours	drying oven, sieves, balance	10
Total organic matter (%):	annually/ summer	10 hours	drying oven, sieves, balance	10
Gas bubbles	seasonally	minutes	none	0
Total nitrogen (%)	summer	1 day	CHN analyzer – Oven – balance	20
Total organic carbon (%)	summer	1 day	CHN analyzer – Oven – balance	20
Total phosphorus (%)	summer	1 day	Drying oven, chemistry lab	10
Capitellids biomass(%)	summer %	8 hours	sampling gear, sieves, balance, microscopes	70
Turbidity (m)	seasonally	minutes	Secchi disk, rope	0
Litter Far from the area	seasonally	minutes	None	0
Grain size sedim. structure	summer	2 days	drying oven, sieves, balance, water bath	20
Chlorophyll a (μg l^{-1})	seasonally	12 hours	filtering system, fluorometer	20
Beggiatoa type mats	summer	minutes	SCUBA diving	0
Macrofaunal biomass (g m^{-2})	summer %	6 hours	sampling gear, sieves, balance, microscopes	70
Sulphide (%)	summer	minutes	corers, electrodes	0
Number of species	summer	2 days	sampling gear, microscopes, taxonomic keys	140
AMBI (Marine Biotic Index)	summer	2 days	>>	140
Shannon Diversity (bits)	summer	2 days	>>	140

The above set of EQSs may be seen as a starting point but also as a yardstick. A starting point because it helps to coordinate monitoring among different countries, institutes and companies, to bring together data and to assess how these EQSs match the real picture of the environmental interactions in the Mediterranean. But also as a yardstick because it provides values against which producers but also other stakeholders may evaluate the results of monitoring. This set of EQSs should by no means be seen as the end of the discussion on environmental interactions of fish farming in the Mediterranean. A period of application with a pilot set of farms in different regions covering different depths, background environmental conditions, farming practices and farmed species and or the meta-analysis of existing data sets are likely to provide a better understanding of the interactions under all these sources of variability.

APPENDIX IV

DEFINITION OF AZE AND RELATED TERMS

What is AZE?
The area of sea-bed or volume of the receiving water body in which competent authority allow the use of specific EQSs for aquaculture, without irreversibly compromising the basic environmental services provided by the ecosystem.

Aim of the AZE?
The utility of AZE is to define the boundary of impact of responsible aquaculture activities in order to permit the free and safe use of marine space for the other stakeholders outside the AZE. The use of AZE gives some responsibility to farms for good practices.

Who should declare it?
Administration will declare an AZE. The administration, following a site selection process, with a baseline study, will define the AZA in a determined region. Within this space, farmers will apply for a space for culturing, carrying out an Environmental Impact Assessment. Size of AZE, management programme, species, total production, etc will be defined by modelling. A monitoring programme will be defined for evaluation of affection on AZE an area of influence. Carrying and holding capacity should be defined for AZA and split on individual AZE within AZA.

Who will be the responsible for the monitoring programme?
The farmers will be accountable for the environmental quality under the cages systems and around them, at local (AZE) and regional scale. Cumulated impacts will be taken into account if several productions units are deployed in the same AZA. Total influence of aquaculture on AZA will be considered for ICZM and environmental quality of the region. Monitoring of potential negative effects from other activities to aquaculture should be implemented.

Who will define the EQS?
Administration, based on experts' consultation, will define the EQS, regarding to Environmental Quality Objectives (EQO). EQO will be defined following a participatory approach but some guidelines and constrains could be established by CAQ. A consulting enterprise could carry out the monitoring, evaluating the effects of the activity and proposing mitigation measures but administration should evaluate the quality, accuracy and veracity of monitoring programme.

What it should contain?
AZE, depending of the national policy, will correspond with the administrative concession within the AZA or it will be located within the administrative concession, corresponding with the production units (cages and mooring system). Modelling will help to define spatial and temporal extent of AZE.

Temporal and spatial definition of monitoring programme around AZE
AZE will be monitored from the beginning of the activity on water and benthic habitats, considering influence area and controls. At least once per year, during the high production period, the evaluation of EQS should be carried out. The monitoring programme should be adaptive to good practices and changes on production, and always must be economical viable for enterprises.

APPENDIX V

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