DTU Library

Assessing stakeholder's experience and sensitivity on key issues for the economic growth of organic aquaculture production

Lembo, Giuseppe; Jokumsen, Alfred; Spedicato, Maria Teresa; Facchini, Maria Teresa; Bitetto, Isabella

Published in:
Marine Policy

Link to article, DOI:
10.1016/j.marpol.2017.10.005

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Marine Policy 87 (2018) 84–93

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Assessing stakeholder's experience and sensitivity on key issues for the economic growth of organic aquaculture production

Giuseppe Lembo[a,*], Alfred Jokumsen[b], Maria Teresa Spedicato[a], Maria Teresa Facchini[a], Isabella Bitetto[a]

[a] COISPA, Stazione Sperimentale per lo Studio delle Risorse del Mare, via Dei Trulli 18, 70126 Bari, Italy
[b] DTU Aqua, Nordsøen Forskerpark, Postboks 101, 9850 Hirtshals, Denmark

ARTICLE INFO

Keywords:
Organic aquaculture
Analytic Hierarchy Process
Stakeholders' engagement
Control system
Sustainability
Fish welfare

ABSTRACT

Participatory management is widely recognised as a working method of paramount importance, based on the principles of knowledge sharing, accountability and legitimacy. Hence, it is broadly considered suitable for addressing issues related to the sustainable development of the seafood industry, and specifically, of the aquaculture system. A survey focused on the current EU regulatory framework was carried out to elicit stakeholders' preferences, knowledge and experience on key issues for the development of organic aquaculture, supported by science-based regulations. The survey was completed by 65 stakeholders belonging to several categories, and it was supported by the implementation of the Analytic Hierarchy Process method. Stakeholders' preferences were elicited on organic production methods and control systems, the quality of the environment and organic products, fish health and welfare. The views expressed by the participants revealed both competence and awareness, despite the complexity of the subject. Several ideas and useful suggestions emerged regarding unresolved technical issues. In addition, the need for a targeted communication strategy on the quality of organic aquaculture products and the necessity of fostering European/national programs to support the production and marketing of organic aquaculture products were highlighted.

1. Introduction

Organic agriculture is one of the most dynamic food production sectors in Europe. According to Eurostat data, in 2015 the EU-28 had a total area of 11.1 million hectares organically cultivated, up from 5.0 million in 2002. There are almost 185,000 organic farms across Europe, and around 306,500 organic operators (producers, processors and importers) were registered in the EU-28 in 2015 [1]. However, organic production still represents a relatively young market segment, and the whole organic area, although constantly growing, represents only 6.2% of the total utilised agricultural area in Europe. According to the International Federation of Organic Agriculture Movements (IFOAM), organic agriculture is based on four principles: health, ecology, fairness and care. A succinct definition of organic agriculture is provided by IFOAM [2] as follows: "a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved."

Organic aquaculture is a fairly young sector, and the data collection system for organic production is subject to fragmentation and uncertainty. A praiseworthy attempt to shed light on the consistency of the organic aquaculture industry in Europe and its economic performance is provided by the European Market Observatory for Fisheries and Aquaculture Products (EUMOFA) in EU Organic Aquaculture [3]. According to this report, the total EU organic production was a little more than 50,000 t in 2015, equivalent to about 3.9% of the total European aquaculture production. The main species produced under organic standards, in order of importance, were i) salmon, ii) mussel, iii) carp, iv) trout, v) sea bass and sea bream.

European organic aquaculture started in the early 1990s in Austria with the first extensive carp farming experiences, and then a further boost came with the first organic salmon project in Ireland. Lacking specific rules for organic aquaculture, the objective at that time was to develop a standard for organic farmed salmon, based on IFOAM organic farming principles and the first European Organic Regulation (EEC) No 2092/1991. The Soil Association picked up the challenge and published the first organic standard for salmon in 1998, followed by Naturland, which designed the first organic shrimp standard at the end of the

* Correspondence to: COISPA, via Dei Trulli 18, 70126 Bari, Italy.
E-mail address: lembo@coispa.it (G. Lembo).

http://dx.doi.org/10.1016/j.marpol.2017.10.005
Received 28 June 2017; Received in revised form 3 October 2017; Accepted 3 October 2017
Available online 16 October 2017

1990s [4]. Then, in 2000 IFOAM published its first draft of basic standards for organic aquaculture, which were fully accepted five years later at the IFOAM General Assembly in Adelaide, Australia. This event received strong interest from consumers worldwide as well as from retailers and certifying bodies, stimulating the growth of organic seafood production. An aquaculture standard is now included in the IFOAM Norms for Organic Production and Processing [5].

In addition, the European Commission launched a European Action Plan on Organic Food and Agriculture [6] with the intention to assess the current situation and lay a foundation for policy development, thereby providing an overall strategic vision for the contribution of organic farming to the Common Agricultural Policy. The Commission's Directorate General for Maritime Affairs and Fisheries (DG Mare) organised a conference in December 2005 to kick off the discussion with the organic aquaculture sector, followed by a series of meetings with organic aquaculture experts. Meanwhile, organic aquaculture was included, for the first time, into Council Regulation EC n° 834/2007 [7], which provided the overall principles guiding the sustainable development of organic production. Subsequently, a Commission Regulation addressing the rules for implementing organic farming (Commission Regulation EC n° 889/2008) was adopted, but without the section on aquaculture. Finally, after a thorough process spanning several years to streamline a number of different organic standards and national certification schemes in Europe, Reg. EC n° 889/2008 was amended by the Reg. EC n° 710/2009 [8] to introduce detailed rules for organic aquaculture animal and seaweed production. A common European regulation that created basic standards was highly welcomed, but it also highlighted many problematic issues, such as fish welfare, feed and environmental concerns, which still require appropriate solutions. Indeed, Reg. 889/2008 [9] has since undergone several amendments on different aspects of the organic farming regulation.

Thus, an Expert Group for Technical Advice on Organic Production (EGTOP) was established by the Commission Decision 2009/427/EC of 3 June 2009. The mandate of the group is to provide the Commission with technical advice on the authorisation of products, substances and techniques for use in organic farming and processing, to develop or improve organic production rules and, more generally, to provide advice for any other matter relating to organic production. The EGTOP group has delivered three reports on organic aquaculture issues to date [10–12].

To further advance the development of the EU Regulations on organic aquaculture, the EU FP7 project "European Organic Aquaculture - Science-based recommendations for further development of the EU regulatory framework and to underpin future growth in the sector" was launched in 2014 (www.oraqua.eu). The overall vision of the project was the economic growth of the organic aquaculture sector in Europe, supported by science-based regulations in line with the organic principles and consumer confidence.

Aim of this paper is to analyse data collected through the participatory management process accomplished during the OrAqua project in order to assess multi-stakeholders' knowledge, experience and perception of key issues regarding organic aquaculture development. To this end preference modelling methods were applied to draw conclusions.

Participatory management is widely recognised as a working method of paramount importance, based on the principles of knowledge sharing, accountability and legitimacy, for addressing the sustainable development of the seafood industry and, specifically, of the aquaculture system. In addition, cooperation among industry, citizenship and science can ensure more coherent information, enhance credibility as well as contribute to the progressive, sustainable development of a seafood production system. Indeed, the use of survey-based methods for eliciting public and stakeholder preferences has been applied to a wide range of marine multi-objective problems [13,14].

As in "real world" situations, alternative solutions are reached through compromise, resulting from trade-offs between various (sometimes) conflicting objectives of the stakeholders and decision-makers, utilising negotiations to reach consensus. This involves seeking "optimal solutions" to multiple alternatives, such as prioritising between fish health/welfare and farm economics/competitiveness. Conflicting approaches to the wide range of multidisciplinary and complex organic farming issues may challenge stakeholders with different backgrounds, knowledge and possibly even conflicting objectives and preferences on specific farming issues (feed, welfare, environment, economic, etc.) connected to the EU regulation. These "optimal solutions" can be effectively pursued using preference modelling methods, namely, the Multi Criteria Decision Analysis (MCDA) [15], which is a family of techniques meant to facilitate informed decisions among alternative approaches. Although applications MCDA techniques have been reported in many peer-reviewed publications [16–21] related to fisheries management, aquaculture and marine conservation, there are still challenges and emerging issues with the application of participatory MCDA that must be addressed. One of these issues is the way uncertainties around the integration of different stakeholder value judgments are included in the process [21–25]. It is also fundamental to evaluate trade-offs and the weights of the different objectives that stakeholders must decide upon. Different MCDA methods have been used to establish the weights of importance among objectives. The Analytic Hierarchy Process (AHP) is one of the most widely applied methods for prioritising alternatives [26–28], which develops a set of pairwise comparison matrices, expressing the intensity of preference over a broad range of scores.

In this paper the stakeholders' position was analysed using the AHP method and uncertainty was addressed using the Monte Carlo approach.

2. Materials and methods

2.1. Survey

During the OrAqua stakeholder meeting held in Rotterdam on October 2015, back to back to the European Aquaculture Society (EAS) Conference, a survey focused on the current EU regulatory framework was carried out to elicit stakeholders' preferences, knowledge and experience on key issues related to organic aquaculture development, supported by science-based regulations. The 65 participants to the survey were selected by the OrAqua stakeholders platform in order to have a balanced representation of the following categories: consumers, retailers, researchers and organic farmers, as well as experts from the organic certification bodies, aquaculture associations, environmental NGOs, feed industry and public institutions.

A broad discussion of the concept, objectives, problems and technical issues of the survey took place before the administration of a specific questionnaire. The participants were encouraged to participate in a plenary discussion about the survey objective and methods. They were then invited to answer the questionnaire anonymously. The closed questions concerned the following 18 thematic areas: (1) Institutional framework; (2) Consumer perception; (3) Environmental interaction; (4) Fish health and welfare; (5) Control provisions; (6) Production rules; (7) Legislative framework; (8) Production systems; (9) Product qualities; (10) Product ecological qualities; (11) Energy use; (12) Recycling; (13) Environmental impact; (14) Quality of water; (15) Quality of feed; (16) Quality of the rearing environment; (17) Physiological condition; and (18) Husbandry practices. The stakeholders also had the additional possibility to submit free contributions. A glossary of the terminology used in the survey was distributed to all the participants in advance to ensure a homogeneous interpretation/understanding of the questions.

Ethics approval was not required for this study. However, the survey was carried out in compliance with the "Ethics Review procedure for researchers as a part of the 7th EU Framework Programme (FP7)" of the European Commission, and oral informed consent was obtained from the participants.

2.2. AHP implementation

The AHP method facilitates the in-depth analysis of important objectives/goals, breaking them into smaller components for evaluating interests/alternatives (e.g. protein source, fat source, amino acid profile, fatty acid profile, feed utilisation, growth rate, discharge of nitrogen and phosphorus, etc.), finally integrating each component through a ranking, weighting and scoring process. Rather than prescribing a "correct" decision, the AHP helps decision makers to find “optimal solution” that suits their goal, providing a comprehensive and rational framework for structuring a complex decision problem.

At the beginning of the AHP procedure a complex decision problem is decomposed into simpler problems to form a decision hierarchy. The advantage of this process consists of generating more easily understandable sub-problems, so that each of them can be analysed independently, although the different levels of the hierarchy must be linked from the top to the lower level. Alternatives are selected using pairwise comparisons, which reduces the complexity of decision-making since only two items are considered at a time. This generates the prioritisation in the process. Cardinal rankings of the alternatives, at each level, are derived once the factorisation is completed. The final step is to combine the relative weights obtained in the previous step to produce composite weights. This is done by means of a sequence of multiplications of the matrices of relative weights at each level of the hierarchy.

AHP converts human expert judgment into numerical values, allowing diverse and often incommensurable elements to be quantitatively compared in a rational and consistent way. Consequently, for this study, five main steps were followed: (1) identification of three levels of hierarchy; (2) distribution of the questionnaire with pairwise comparisons in order to gather stakeholders' preferences regarding the alternatives; (3) transformation of the pairwise comparisons into weight vectors for the alternatives by means of the principal eigenvector method [27]; (4) calculation of the composite weight of each alternative [28]; and (5) group decision-making (synthesis of the prioritisations expressed by the stakeholders).

The preferences were expressed on a scale of semantic scores ranging from 1 to 5 (see Table 1). The stakeholders were asked to evaluate the degree of importance of one subject compared to another, with the value 1 representing equal importance and the value 5 representing higher importance.

Then, a set of 176 pairwise comparison matrices was structured. The preferences expressed were equally weighed regardless of the stakeholders’ membership category.

The results were elaborated using a pairwise comparison matrix:

$$A = (a_{i,j})_{i,j=1,2,\ldots,N} \tag{1}$$

where N is the number of alternatives and $a_{i,j}$ is the score assigned by the stakeholder in the pairwise comparison between the *i-th* and *j-th* alternatives. A is a positive reciprocal square $N \times N$ matrix, where a square matrix is reciprocal if $a_{i,j} = \frac{1}{a_{j,i}}$. Further, the weight vector in each of the three hierarchical levels was computed, through the eigenvalue/eigenvector averaging technique, according to Saaty [27,28], who demonstrated that a good approximation of the priority vector is represented by the principal eigenvector of A. The eigenvector was then normalised to obtain a priorities vector for each pairwise comparison matrix. The principal eigenvalue (or its multiple) λ_{max} is associated with the principal eigenvector, and it is used to estimate the consistency of the answers provided by the stakeholders participating in the survey.

Table 1
Scale of semantic operators and relative score adopted in the survey.

Semantic score for importance	Numerical score
Equally important	1
Little more important	2
More important	3
Much more important	4
Exceptionally more important	5

A measure of coherence (Consistency Ratio) for each matrix of preferences was calculated using the following formula:

$$C.\,R. = \frac{C.\,I.}{R.\,I.} = \frac{\frac{\lambda_{max} - N}{N-1}}{R.\,I.} \tag{2}$$

where *C.I.* is the consistency index, computed using the principal eigenvalue λ_{max} and the number of alternatives N; the random index *R.I.* is a randomly generated value, computed assuming that the numbers in pairwise comparison matrix A are completely random. The value 0.1 is considered a threshold value beyond which a progressive impoverishment of the responses coherence occurs [28].

2.3. Sensitivity analysis and preferences estimate

A sensitivity analysis was carried out to evaluate the robustness of the results with respect to the uncertainty associated with the weights expressing the relative importance of the elements considered in the AHP. To this end, the Monte Carlo approach was applied, utilising the following two steps:

a) Application of uncertainty to the normalised vector of weights at each hierarchical level for each stakeholder, multiplying the deterministic local weights by the factor $(1 + \varepsilon)$, where ε is a normally distributed error with a mean of 0 and standard deviation of 0.15 (so that 90% confidence bounds encompass the original value of the weight ± 20%). A total of 1000 extractions were made;
b) The perturbed local weights were normalised to add up to 1.

An exploratory analysis on the perturbed weight vectors was then carried out to detect signs of skewness among the preferences expressed by the stakeholders. For each hierarchical level, considering all the runs of all the stakeholders as a whole, a global frequency of being at the first, last or intermediate position in the preference ranking was calculated. This frequency can be viewed as an empirical probability to obtain the higher or lower preference for a given alternative, based on the judgment expressed by all stakeholders. This empirical probability is affected by both the uncertainty introduced in the process and the natural variability among the stakeholders’ preferences.

The stakeholders’ preferences were estimated on the 1000 vectors of weights, with the relative variability. The relevant percentiles (0.05, 0.25; median, 0.75, 0.95) and statistics (minimum, maximum, mean, standard deviation and CV) were also calculated. For each statistic and percentile, the corresponding global vector was derived as a geometric mean of all stakeholders’ preferences and represented by box plots. These estimates and the associated statistics are only affected by the uncertainty introduced in the process, as the variability due to the different judgements expressed by the stakeholders is smoothed by the geometric mean.

All the algorithms and computations were performed using an ad hoc routine developed in R language.

3. Results and discussion

3.1. Stakeholders’ portrait

Hereinafter, the survey results obtained by the analysis of the preferences expressed by the 65 stakeholders “all together” are reported. A separate analysis was also carried out considering each of the following categories: 1) Consumers, retailers and NGOs; 2) Aquaculture associations and organic certification bodies; 3) Organic farmers; 4) Researchers; and 5) Other. Four of the five categories consisted of 13

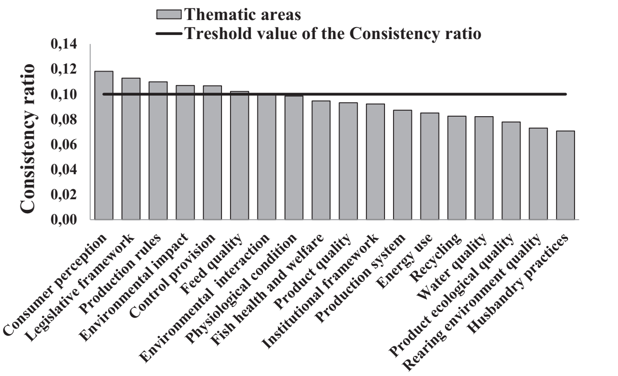

Fig. 1. Level of coherence of the stakeholders' responses in relation to the 18 thematic areas of the survey.

stakeholders, except for the organic farmers (10 stakeholders). Three stakeholders did not declare their affiliation. Since the main purpose of this study was to help decision makers to find "optimal solution" among various (sometimes) conflicting positions of the stakeholders with different background, the results by individual category of stakeholders have not been included in this paper.

The most represented geographical region was Western Europe (21), followed by Northern Europe (18), Mediterranean Europe (17), Central Europe (7) and other geographical region (2). The gender of the large majority of the participants was male (49 of 65). The average age of the participants was over 35 years.

The consistency ratio was slightly over 0.1 (Fig. 1) only in five out eighteen thematic survey areas. Given the complexity and length of the questionnaire, these levels of coherence of the stakeholder responses to the survey questions can be considered satisfactory.

The European Commission opened a consultation for the review of the European policy on organic agriculture in 2012–2013. The aim was to consult experts, stakeholders and the public on areas where a new action plan might be needed and lay the foundations for a new regulation on organic production. In the framework of this revision process it became clear that the consumers' opinion is a key factor that policy makers should take into account when defining the regulatory framework of organic aquaculture.

Indeed, analysing stakeholder preferences in Fig. 2a, it became clear that, for the majority of the stakeholders, the most important element to be taken into consideration to promote the development of organic aquaculture was consumer perception, that is, consumers' opinions regarding the principles and regulations of organic production. Whereas the institutional framework, which refers to the social, economic and legislative background/basis of the organic regulation, was considered the least important.

Similar conclusions are highlighted in Fig. 2b, that is, consumer perception has the highest probability of being considered the most important element to be taken into consideration to promote the development of organic aquaculture. Fish health and welfare followed consumer perception closely in the ranking of preferences.

3.2. Organic production and control systems

European stakeholders show fairly clear opinions on the type of production systems that are consistent with organic principles. Indeed, looking into the survey results, the production system considered more in line with organic principles was the Integrated Multi-Trophic Aquaculture (IMTA), which is a multi-trophic synergistic cultivation system, well integrated in the natural environment, that uses waterborn nutrients and energy transfer. Conversely, the system considered to be least in line with organic principles was the Recirculation Aquaculture System (RAS), which refers to a facility where aquaculture occurs within an enclosed environment on land or on a vessel, involving the recirculation of water and depending on permanent external energy inputs to stabilise the environment for the aquaculture animals (Fig. 3).

This is in line with the results of consumer focus groups carried out by Feucht and Zander [41], who found higher consumer preferences for earth ponds and flow-through systems, as the fish are kept outdoors with a lower stocking density compared to RAS, which was perceived as the most industrialised and non-natural method. Among the alternatives shown in Fig. 3, pond rearing was not on top of the preferences list, probably because such production system was considered less profitable by an audience that was not limited to consumers but included different categories of stakeholders. These results, however, show a deep cultural divergence between the two shores of the Atlantic Ocean. Although there is no national organic aquaculture legislation in the United States, public opinion there would seem to oppose flow-through systems and sea cages, while it would be more prone to accept RAS systems. These divergences have been the main reason for the failure of the forty-third session of the CODEX Committee on Food Labelling, held in Ottawa on May 2016, which would have approved the "Guidelines for the production, processing, labelling and marketing of organically produced foods: organic aquaculture" [42].

Among the organic production rules (i.e. the whole set of rules and practices that distinguish organic aquaculture from conventional aquaculture), a slightly higher preference was given to the establishment of an environmental pollution monitoring system, followed closely by the ratification of more detailed procedures for the separation of organic and conventional production on the same farm (Fig. 4a). Whereas, according to the empirical probability analysis, the two production rules were equally preferred (Fig. 4b). However, the stakeholders' were generally against a potential alternative involving the prohibition of parallel production, that is, the rearing of organic and non-organic fish of the same species in the same production units.

It should be noted that, as part of the long and multifaceted process that started in 2012/13 and aimed at the revision of the current European regulations on organic production, an option that would ban parallel production was considered, with the intention to homogenise the organic regulation of animal husbandry and aquaculture. However, the participants in the survey, while sharing the need to strengthen the separation procedures for organic and non-organic fish in the same farm, rejected the ban of parallel production, likely in consideration of the difficulties of converting aquaculture farms, which are of medium to large size in Europe, entirely to organic production.

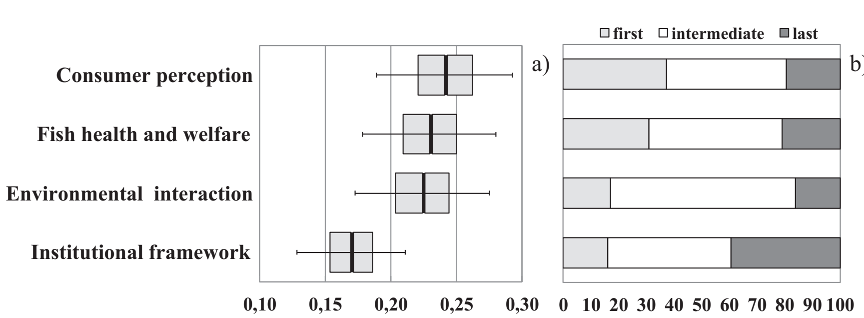

Fig. 2. The most important element to be taken into consideration in order to promote the development of organic aquaculture. a) Ranking of the stakeholders' preference in relation to four alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

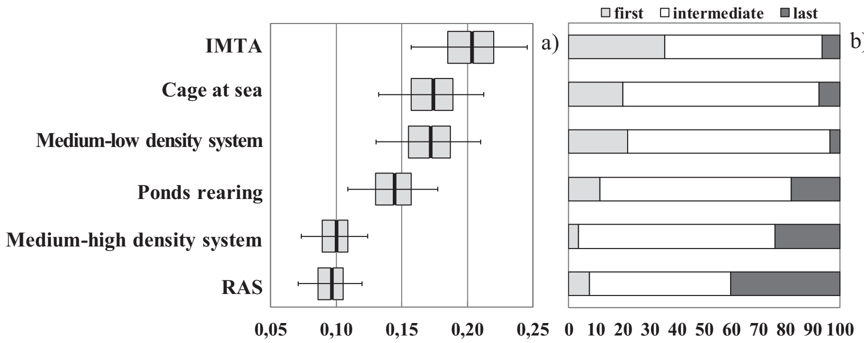

Fig. 3. The production systems considered more in line with organic principles. a) Ranking of the stakeholders' preference in relation to six alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

An ethical approach is also needed when considering the societal expectations of sustainable aquaculture. Such an approach should be used to analyse the sustainability of animal husbandry, as well as what is considered as acceptable implications on animal welfare. A confirmation of this vision can be found in the results shown in Fig. 5, which highlights that setting threshold limits for stocking density is the measure considered most appropriate for maintaining good water quality in the organic rearing environment, followed closely by setting threshold limits for oxygen and nutrients. The stakeholders' feedback also suggests that the three alternatives that received more preferences are actually three non-separable conditions for good aquaculture practices (i.e. low stocking density, appropriate levels of oxygen and nutrients).

A significant point of importance, according to the stakeholders, is the organic control system that is perceived as non-homogeneous in the different countries and certification bodies (see Fig. 6). Therefore, specific actions should be envisaged for making the organic control system more effective. It is worth pointing out here that the analysis of the survey' results carried out separately for the different stakeholders' categories has always highlighted the same order of priority shown in Fig. 6.

This perception is likely to be emphasised by European organic farmers, who see their production threatened by the imports of non-European organic aquaculture seafood which, in their opinion, would be subject to less effective controls. Organic certification bodies must be accredited according to DIN EN 45011 or ISO Guide 65, but the EU regulation has not imposed additional requirements on the qualification of the certification personnel and aquaculture inspectors. Therefore, there is a potential risk that this will result in unequal qualification of these personnel in different countries, which might result in unfair competition [45]. Other authors have also found consumer distrust of the organic certification procedures [39].

3.3. Quality of the environment and organic products

There is evidence, based on studies carried out in the Mediterranean Sea and Scotland, that the social acceptability of aquaculture is closely connected to the perceived environmental impact of fish farming [32,33]. This clearly poses a challenge to policy makers in deciding the weight to assign to such a concern within a governance framework for the industry. This issue was addressed by Whitmarsh and Palmieri [13], who developed a survey-based approach using AHP, which aims to elicit stakeholders' views on the environmental performance of aquaculture.

Figs. 7 and 8 show that in order to minimise the environmental impact of organic aquaculture and the waste production, the stakeholders placed the highest value on the prevention of chemical and antibiotic dispersion in the natural environment and on the choice of less-packaged products. The stakeholders also confirmed their view that allowing RAS for the on-growing phase of fish production is a less appropriate alternative, although RAS are considered appropriate for minimising the environmental impacts in conventional aquaculture [43,44].

From Fig. 9a it seems that the majority of the stakeholders consider the product ecological qualities (e.g. environmental friendly, animal friendly, sustainable, local/domestic production) to be the most relevant factor influencing consumers' opinion, closely followed by the product qualities (e.g. no chemicals, no additives, no hormones, good appearance, good smell, good taste, good texture). Looking into Fig. 9b, however, the empirical probability analysis shows that the product quality is ranked as first preference. The reason why the two metrics show different results may be a consequence of the very high score assigned by some stakeholders to product ecological qualities in contrast to very low score assigned to product quality. In other words, very skew position among stakeholders does not allow convergence between the two metrics and, therefore, does not allow to identify a clear preference between the two alternatives.

There is evidence that consumers have become increasingly concerned about food quality and safety issues, as well as about the impact of food on their own health [35]. Indeed, the most appreciated quality of organic aquaculture products was the absence of hormones, followed by the absence of chemicals, while the least relevant quality was considered a good appearance (see Fig. 10). Even in this case, due to the very skew position of some stakeholders, it is not clearly identifiable what makes the higher preferences between the absence of chemicals or hormones.

Several authors have observed that the term organic has been often associated and confused with terms such as "green", "ecological",

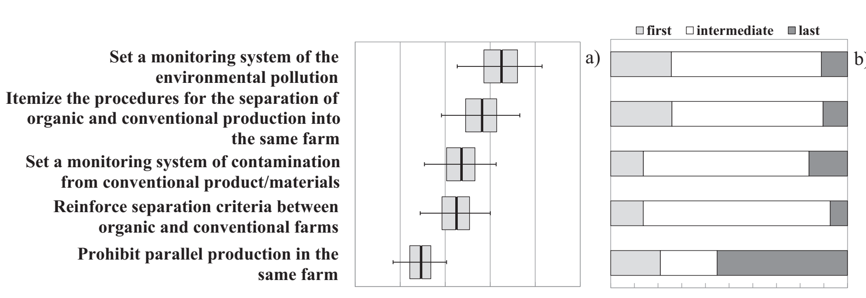

Fig. 4. The production rules and practices that may distinguish organic aquaculture from conventional aquaculture. a) Ranking of the stakeholders' preference in relation to five alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

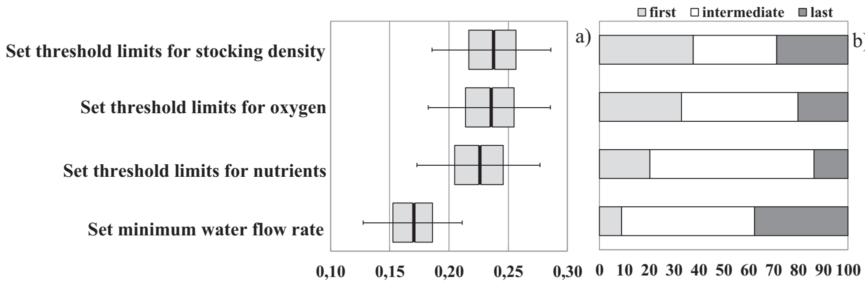

Fig. 5. The measures considered more appropriate to maintain good water quality in the organic rearing environment. a) Ranking of the stakeholders' preference in relation to four alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

"environmental", "natural" and "sustainable" [36–39]. According to a recent study on consumers' expectations of sustainable aquaculture in Germany, the two terms organic and sustainable are often used synonymously [40], with a heuristic meaning of naturalness. All these remarks seem to be in line with the stakeholder preference shown in Fig. 11, which identify in a holistic concept of sustainability the most appreciated ecological quality of organic aquaculture products. Indeed, the organic philosophy does not rely merely on principles of environmental conservation or protection but rather on a holistic concept of sustainability.

3.4. Fish health and welfare

An important question with regard to animal husbandry is if it is morally acceptable to use animals merely as a resource or means to meet human needs, or whether there are moral considerations that should place restrictions on such use [34]. Such an approach could be used to analyse the sustainability of animal husbandry, breeding and feeding, as well as what is considered as acceptable implications on animal welfare.

Actually, physiological conditions and quality of feed are key elements influencing fish welfare [46]. Physiological condition, along with the quality of feed, were pointed out also by the stakeholders involved in the survey as the most relevant elements influencing fish welfare (see Fig. 12).

Further, the stakeholders showed a fairly clear awareness that to ensure good physiological conditions, both of the following measures are necessary: i) routinely monitoring fish behaviour and fin damages/injuries; ii) keeping fish stocking density at a safer level (see Fig. 13).

Feed quality is one of the main bottlenecks in organic aquaculture. According to Reg. EC n° 889/08, feeding regimes shall be designed with the following priorities: a) animal health; b) high product quality, including the nutritional composition, which shell ensure high quality of the final edible product; and c) low environmental impact. Addressing all these priorities is the most important challenge, especially when feeding carnivorous fish. High-quality fishmeal provides a balanced amount of all essential amino acids, minerals, phospholipids and fatty acids found in the normal diet of fish [47–49]. Furthermore, high-quality fishmeal has a high nutrient digestibility and hence high utilisation by the fish, which results in minimum discharge of nutrients to the environment. Thus, the use of high-quality fishmeal addresses each of the three priorities mentioned above. The problem is that, due to the worldwide overfishing situation [50,51], the global supply of fishmeal and fish oil is no longer sustainable, and this is the reason why Reg. EC 889/2008 gives priority to the use of fishmeal derived from trimmings. However, fishmeal from trimmings is lower in protein and higher in phosphorus content [29,30], which might conflict with national environmental legislation, as well as fish health. It is worth remembering that feed supplementation with synthetic amino acids is not allowed according to Council Regulation EC n° 834/2007. For all these reasons, the European Commission approved an amendment to the organic aquaculture regulation allowing the use of fishmeal derived from whole fish (Reg. EU n° 1358/2014) [52]. Extensive insights on this topic can be found in the 2013 EGTOP Final Report on Aquaculture (part A), where, in addition to proposing the use of fishmeal derived from whole fish, essential amino acids and lipids obtained by fermentation or other similar procedures are also suggested as ingredients/additives in carnivorous fish feed.

The views expressed by the survey participants revealed both competence in and awareness of the complexity of this subject (see Fig. 14). Indeed, answering to the question: which is the most appropriate measure for ensuring feed quality, their order of preference was the following (i) trimmings from sustainable fisheries; (ii) fishmeal/oil from whole fish; and (iii) amino acids obtained by fermentation or other organic procedures.

4. Conclusion

Participative MCDA, which explicitly incorporate stakeholders' engagement at one or more stages of the process [14], has been applied to a wide range of marine multi-objective problems, such as identifying alternatives, estimating consequences or prioritising management alternatives.

MCDA applications in aquaculture have been reported for a wide range of management areas, such as: (i) allocating aquaculture sites; (ii) evaluating pollutants in aquaculture; (iii) optimising feeds for farmed fish; (iv) evaluating stakeholder attitudes towards aquaculture; (v) evaluating marine environment quality; and (vi) managing conflicts in

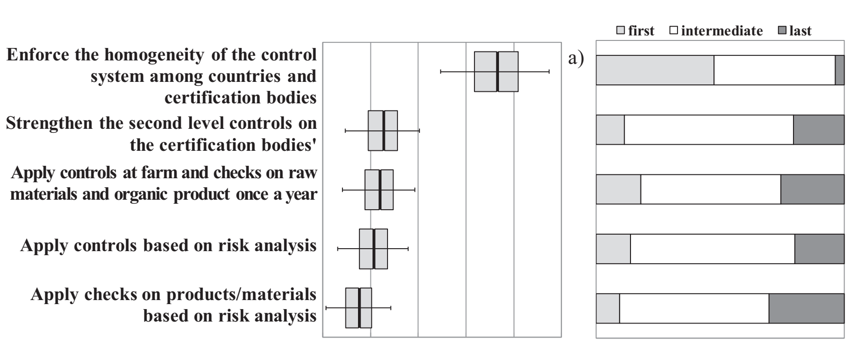

Fig. 6. How to make the organic control system more effective. a) Ranking of the stakeholders' preference in relation to five alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

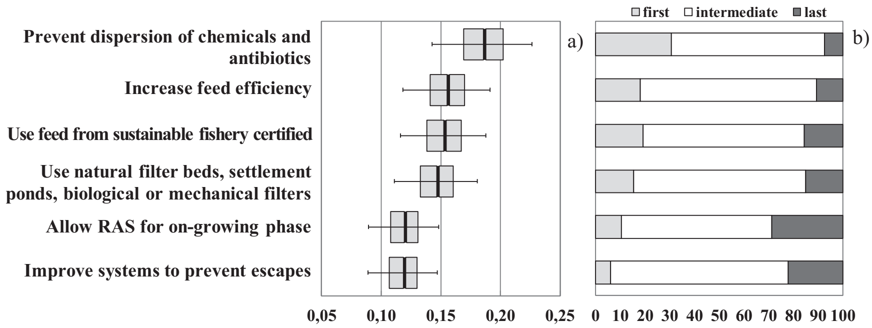

Fig. 7. How to minimise the environmental impact of organic aquaculture. a) Ranking of the stakeholders' preference in relation to six alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

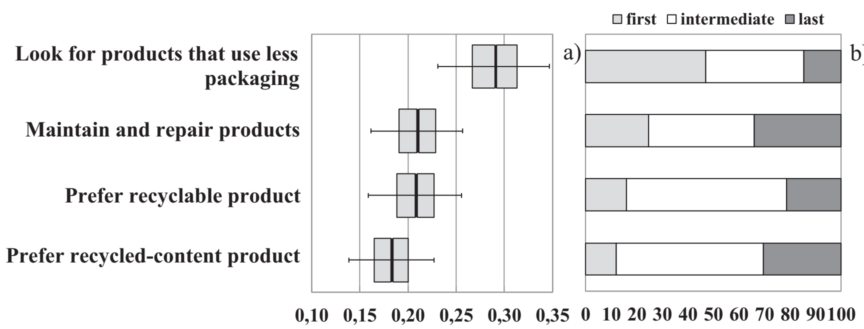

Fig. 8. How to minimise waste production. a) Ranking of the stakeholders' preference in relation to four alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

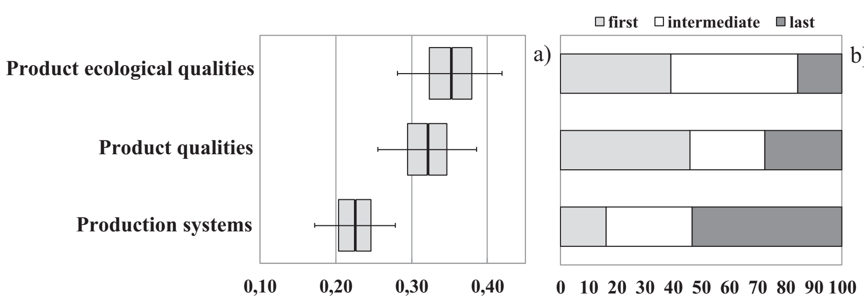

Fig. 9. The most relevant factor influencing consumers' opinion. a) Ranking of the stakeholders' preference in relation to three alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

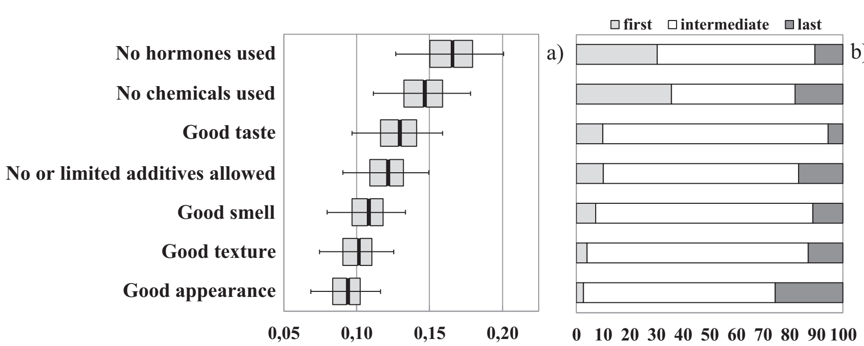

Fig. 10. The most appreciated quality of organic aquaculture products. a) Ranking of the stakeholders' preference in relation to seven alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

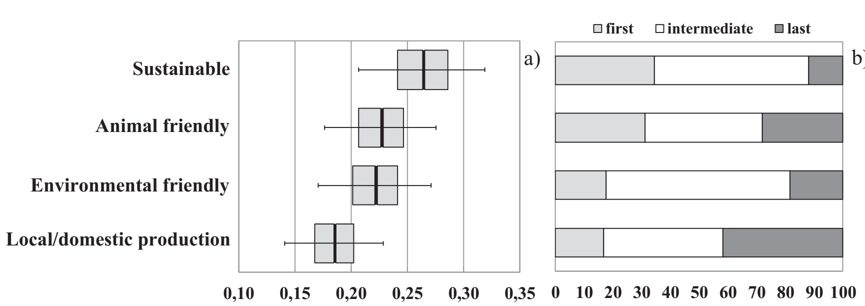

Fig. 11. The most appreciated ecological qualities of organic aquaculture products. a) Ranking of the stakeholders' preference in relation to four alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

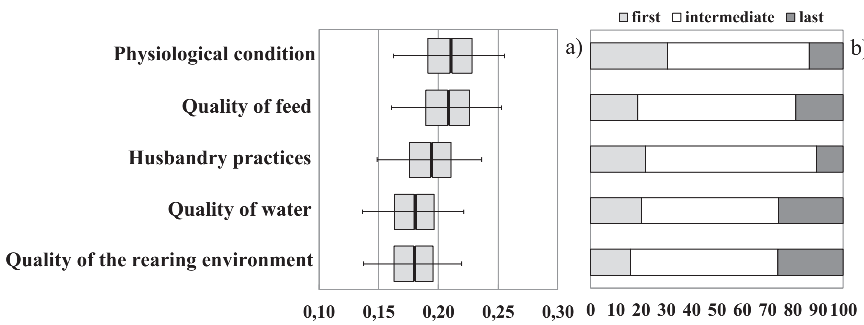

Fig. 12. The most relevant element influencing fish welfare. a) Ranking of the stakeholders' preference in relation to five alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

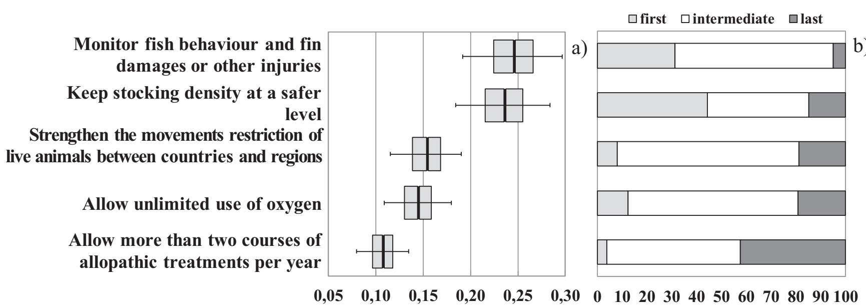

Fig. 13. The most appropriate measures for ensuring the good physiological condition of the fish. a) Ranking of the stakeholders' preference in relation to five alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

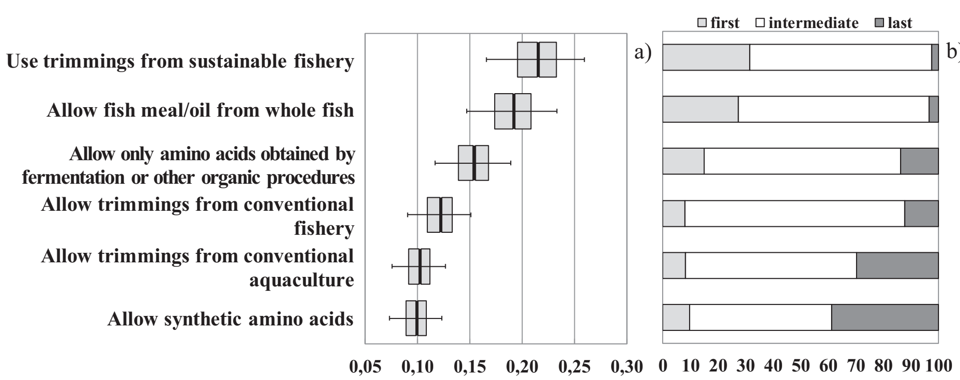

Fig. 14. The most appropriate measure for ensuring feed quality. a) Ranking of the stakeholders' preference in relation to six alternatives (box plot percentiles: 0.05, 0.25, 0.5, 0.75 and 0.95). b) Empirical probability (in percentage), for each alternative, to be ranked as first, intermediate or last preference.

multi-use coastal areas [14]. All these very wide range of applications has led to the evaluation and resolution of complex decisions problems. In this study clear benefits were identified from the use of AHP, such as eliciting priorities and preferences from aquaculture stakeholders, in order to help decision makers in finding "optimal solution" that suits their objective of a comprehensive and rational revision of the organic aquaculture regulation.

However, MCDA can be affected by a range of uncertainties related to multiple value judgments, which are seldom addressed in MCDA studies focused on the management of marine living resources. In this study uncertainty issues have been addressed applying a probabilistic approach via the propagation of a normal error to the weights expressing the relative importance of the elements considered in the AHP [31]. By this way both the uncertainty introduced in the process and the natural variability among the stakeholders' preferences were considered.

Although the adoption of an EU regulation represented a relevant step forward, organic aquaculture is still a relatively niche industry, with many technical issues to be addressed. The results of the survey have shown indeed that there is a significant convergence of stakeholders' views on a number of topics. Particularly, the list of topics was topped by the preference for production systems well-integrated in the natural environment, such as those using synergies and energy outputs of species that occupy different trophic levels (e.g. IMTA). While medium-high density systems and RAS were considered not in line with the organic principles. The stakeholders shared the need to strengthen the separation procedures for organic and non-organic fish in the same farm, but rejected the ban of parallel production. One point of significant importance was the perception of the organic control system as non-homogeneous in the different countries and certification bodies, which might result in unfair competition. Stakeholder opinions revealed both competence in and awareness of the challenging issue of ensuring high quality feed. Indeed, their order of preference was: (i) trimmings from sustainable fisheries; (ii) fishmeal/oil from whole fish; and (iii) amino acids obtained by fermentation or other organic procedures. Last but not least, in their view the organic philosophy does not rely merely on principles of environmental conservation or protection but rather on a holistic concept of sustainability.

However, as in the case of the first regulation on organic agriculture, in the next future, the enhancement of the quality and the widening of the European market for the organic aquaculture will rely on European and national programs supporting production and market, and a targeted communication strategy on the organic aquaculture should be part of such programs, in order to maintain consumer confidence in organic products.

Acknowledgments

This study was undertaken as part of the EU FP7 project OrAqua (European Organic Aquaculture - Science-based recommendations for further development of the EU regulatory framework and to underpin future growth in the sector), grant agreement n° 613547. The funder had no role in the study design, data collection and analysis, decision to publish or preparation of the manuscript. We are grateful to the colleagues from the project partners, who were engaged in stimulating discussions on organic aquaculture issues, as well as to the stakeholders for their proactive participation and collaboration to the survey. We also gratefully acknowledge the comments and suggestions from anonymous referees.

References

[1] DG Agriculture and Rural Development – DG AGRI. Facts and figures on organic agriculture in the European Union. 〈https://ec.europa.eu/agriculture/organic/eu-policy/data-statistics_en〉, 2016.
[2] IFOAM. A succinct definition of organic agriculture. 〈http://www.ifoam.bio/en/what-we-do/organic-landmarks〉.
[3] EUMOFA. EU Organic Aquaculture. Brussels. Directorate-General for Maritime Affairs and Fisheries of the European Commission. 〈http://dx.doi.org/10.2771/610600〉.
[4] S. Bergleiter, U. Censkowsky. History of organic aquaculture. In IFOAM EU Group (2010), Organic Aquaculture, Background, Assessment, Interpretation. Ed. A. Szeremeta, L. Winkler, F. Blake, G. Lembo. 〈http://www.ifoam-eu.org/en/library/dossiers〉.
[5] IFOAM. Norms for organic production and processing. 〈http://www.ifoam.bio/en/ifoam-standard〉.
[6] European Commission. Official Communication from the Commission to the Council and the European Parliament. European Action Plan on Organic Food and Agriculture. 〈https://ec.europa.eu/agriculture/organic/eu-policy/european-action-plan/2004_en〉, 2004.
[7] Council Regulation (EC) No 834/2007 on organic production and labelling of organic products. 〈http://eur-lex.europa.eu/legal-content/EN/TXT/?Qid=1497265508955&uri=CELEX:32007R0834〉.
[8] Commission Regulation (EC) 710/2009 amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007, as regards laying down detailed rules on organic aquaculture animal and seaweed production. 〈http://eur-lex.europa.eu/legal-content/EN/TXT/?Qid=1497267740069&uri=CELEX:32009R0710〉.
[9] Commission Regulation (EC) 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. 〈http://eur-lex.europa.eu/legal-content/EN/TXT/?Uri=CELEX:02008R0889-20170507〉.
[10] EGTOP. Final report on aquaculture (Part A). 〈https://ec.europa.eu/agriculture/organic/eu-policy/expert-advice/documents/final-reports_en〉, 2013.
[11] EGTOP. Final report on aquaculture (Part B). 〈https://ec.europa.eu/agriculture/organic/eu-policy/expert-advice/documents/final-reports_en〉, 2014.
[12] EGTOP. Final report on aquaculture (Part C). 〈https://ec.europa.eu/agriculture/organic/eu-policy/expert-advice/documents/final-reports_en〉, 2016.
[13] D. Whitmarsh, M.G. Palmieri, Social acceptability of marine aquaculture: the use of survey-based methods for eliciting public and stakeholder preferences, Marine Policy 33 (2009) 452–457, http://dx.doi.org/10.1016/j.marpol.2008.10.003.
[14] R.A. Estévez, S. Gelcich, Participative multi-criteria decision analysis in marine management and conservation: research progress and the challenge of integrating value judgments and uncertainty, Marine Policy 61 (2015) 1–7, http://dx.doi.org/10.1016/j.marpol.2015.06.022.
[15] V. Belton, T. Stewart, Multiple Criteria Decision Analysis–An Integrated Approach, Kluwer Academic Press, Boston, 2002.
[16] K. Soma, How to involve stakeholders in fisheries management – a country case study in Trinidad and Tobago, Mar. Policy 27 (2003) 47–58, http://dx.doi.org/10.1016/S0308-597X(02)00050-7.
[17] P.S. Leung, Multiple-criteria decision making ((MCDM)) applications in fishery management, Int. J. Environ. Technol. Manag. 6 (1/2) (2006) 96–110, http://dx.doi.org/10.1504/IJETM.2006.008255.
[18] J.P. Innes, S. Pascoe, A multi-criteria assessment of fishing gear impacts in demersal fisheries, J. Environ. Manag. 91 (2010) 932–939, http://dx.doi.org/10.1016/j.jenvman.2009.11.011.
[19] M. Aanesen, W.C. Armstrong, H.J. Bloomfield, C. Röckmann, What does stakeholder involvement mean for fisheries management?? Ecol. Soc. 19 (4) (2014) 35, http://dx.doi.org/10.5751/ES-06947-190435.
[20] S. Kavadas, I. Maina, D. Dalamas, I. Dokos, M. Pantazi, V. Vassilopoulou, Multi-criteria decision analysis as a tool to extract fishing footprints: application to small scale fisheries and implications for management in the context of the Maritime Spatial Planning Directive, Medit. Mar. Sci. 16 (2) (2015) 294–304, http://dx.doi.org/10.12681/mms.1087.
[21] M. Rossetto, I. Bitetto, M.T. Spedicato, G. Lembo, M. Gambino, Accadia, et al., Multi-criteria decision-making for fisheries management: a case study of Mediterranean demersal fisheries, Mar. Policy 53 (2015) 83–93, http://dx.doi.org/10.1016/j.marpol.2014.11.006.
[22] R. Banuelas, J. Antony, Modified analytic hierarchy process to incorporate uncertainty and managerial aspects, Int. J. Prod. Res. 42 (18) (2004) 3851–3872, http://dx.doi.org/10.1080/00207540410001699183.
[23] R. Levary, K. Wan, A simulation approach for handling uncertainty in the analytic hierarchy process, Eur. J. Oper. Res. 106 (1998) 116–122, http://dx.doi.org/10.1016/S0377-2217(97)00134-3.
[24] W. Lee, H. Lau, T. Samson, A fuzzy analytic hierarchy process approach in modular product design, Expert Syst. 18 (2001) 32–42, http://dx.doi.org/10.1111/1468-0394.00153.
[25] A. Arbel, L. Vargas, Preference simulation and preference programming: robustness issues in priority derivation, Eur. J. Oper. Res. 69 (2) (1993) 200–209, http://dx.doi.org/10.1016/0377-2217(93)90164-I.
[26] T.L. Saaty, The Analytical Hierarchy Process, RWS Publications, Pittsburgh, PA, 1980.
[27] T.L. Saaty, Decision-making with the AHP: why is the principal eigenvector necessary, Eur. J. Oper. Res. 145 (2003) 85–91, http://dx.doi.org/10.1016/S0377-2217(02)00227-8.
[28] T.L. Saaty, Decision making with the analytic hierarchy process, Int. J. Services Sci. 1 (1) (2008) 83–98, http://dx.doi.org/10.1504/IJSSci.2008.01759.
[29] G.M. Berge, A. Jokumsen, G. Lembo, M.T. Spedicato. Challenges in sourcing of feed ingredients for organic production of carnivorous fish. Presentation at Organic Session at Aquaculture Europe 2015, 20 – 23 October 2015, Rotterdam, The Nederlands.
[30] N. Pelletier, P. Tyedmers, Feeding farmed salmon: is organic better?? (https://doi.org/), Aquaculture 272 (1–4) (2007) 399–416, http://dx.doi.org/10.1016/j.aquaculture.2007.06.024.
[31] G. Lembo, J.M. Bellido, I. Bitetto, M.T. Facchini, T. García-Jiménez, M. Stithou, V. Vassilopoulou, M.T. Spedicato, Preference modelling to support stakeholder outreach towards the common fishery policy objectives in the north Mediterranean Sea, Front. Mar. Sci. (2017), http://dx.doi.org/10.3389/fmars.2017.00328.
[32] S. Katranidis, E. Nitsi, A. Vakrou, Social acceptability of aquaculture development in coastal areas: the case of two Greek Islands, Coastal Management 31 (2003) 37–53, http://dx.doi.org/10.1080/08920750390168291.
[33] D. Whitmarsh, P. Wattage, Public attitudes towards the environmental impact of salmon aquaculture in Scotland, Eur. Env. 16 (2006) 108–121, http://dx.doi.org/10.1002/eet.406.
[34] I. Olesen, A.I. Myhr, G.K. Rosendal, Sustainable aquaculture: are we getting there?? Ethical perspectives on salmon farming, J. Agric. Environ. Ethics 24 (2011) 381–408, http://dx.doi.org/10.1007/s10806-010-9269-z.
[35] B. Aarset, S. Beckmann, E. Bigne, M. Beveridge, T. Bjørndal, J. Bunting, P. McDonagh, C. Mariojouls, J. Muir, A. Prothero, L. Reisch, A. Smith, R. Tveteras, J. Young, The European consumers' understanding and perceptions of the "organic" food regime: the case of aquaculture, Br. Food J. 106 (2004) 93–105.
[36] H.N.J. Schifferstein, P.A.M. Oude Ophuis, Health-related determinants of organic food consumption in the Netherlands, Food Quality and Preference 9 (3) (1998) 119–133.
[37] S. Naspetti, R. Zanoli, Organic food quality and safety perception throughout Europe, J. Food Prod. Market. 15 (3) (2009), http://dx.doi.org/10.1080/10454440902908019.
[38] N. Ayers, P. Midmore, Consumption of Organic Foods from a Life History Perspective: An Exploratory Study among British Consumers, University of Wales, Aberystwyth, 2009〈http://orgprints.org/15609〉.
[39] J.K. O'Doherty, S. Denver, R. Zanoli, Actual and potential development of consumer demand on the organic food market in Europe, NJAS - Wageningen J. Life Sci. 58 (2011) 79–84, http://dx.doi.org/10.1016/j.njas.2011.01.005.
[40] Y. Feucht, K. Zander. Consumers' knowledge and information needs on organic aquaculture. Proceedings of the 4th ISOFAR Scientific Conference. 〈http://orgprints.org/23766/〉.
[41] Y. Feucht, K. Zander, Of earth ponds, flow-through and closed recirculation systems - German consumers' understanding of sustainable aquaculture and its communication, Aquaculture 438 (2015) 151–158, http://dx.doi.org/10.1016/j.aquaculture.2015.01.005.
[42] CODEX. Guidelines for the production, processing, labelling and marketing of organically produced foods: organic aquaculture. 〈http://www.fao.org/fao-who-codexalimentarius/codex-home/en/〉.
[43] J. Colt, Water quality requirements for reuse systems, Aquacultural Eng. 34 (2006) 143–156, http://dx.doi.org/10.1016/j.aquaeng.2005.08.011.
[44] A. Jokumsen, L. Svendsen, Farming of freshwater rainbow trout in Denmark. DTU Aqua Report no. 219-2010. ISBN 978-87-7481-114-5, 2010.
[45] J.S. Gieseler. Inspection and certification systems for aquaculture products under the new rules. In IFOAM EU Group (2010). Organic Aquaculture, Background, Assessment, Interpretation. Ed. A. Szeremeta, L. Winkler, F. Blake, G. Lembo. 〈http://www.ifoam-eu.org/en/library/dossiers〉.
[46] G. Lembo, W. Zupa. Fish welfare - a key issue for organic system standards. In IFOAM EU Group (2010). Organic Aquaculture, Background, Assessment, Interpretation. Ed. A. Szeremeta, L. Winkler, F. Blake, G. Lembo. 〈http://www.ifoam-eu.org/en/library/dossiers〉.
[47] R.W. Hardy, Utilization of plant proteins in fish diets: effects of global demand and supplies of fishmeal, Aquaculture Res. 41 (2010) 770–776.
[48] E. Mente, V. Karalazos, I.T. Karapanagiotidis, C. Pita, Nutrition in organic aquaculture: an inquiry and a discourse, Aquaculture Nutr. 17 (2011) e798–e817, http://dx.doi.org/10.1111/j.1365-2095.2010.00846.x.
[49] I. Lund, J. Dalsgaard, J.H. Hansen, C. Jacobsen, J. Holm, A. Jokumsen, Effects of organic plant oils and role of oxidation on nutrient utilization in juvenile rainbow trout (*Oncorhynchus mykiss*). International, J. Animal Biosci. (2012) 1–10, http://dx.doi.org/10.1017/S1751731112001693.
[50] European Commission, Facts and Figures of the Common Fisheries Policy: Basic Statistical Data, 2014. Edn. Luxembourg Publication Office of the European Union. 〈https://ec.europa.eu/fisheries/facts-and-figures-common-fisheries-policy-basic-

statistical-data_en⟩, 2014.
[51] FAO. The State of Mediterranean and Black Sea Fisheries. General Fisheries Commission for the Mediterranean. Rome, Italy. ⟨http://www.fao.org/gfcm/news/detail/en/c/411491/⟩.
[52] Commission implementing regulation (EU) 1358/ amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 as regards the origin of organic aquaculture animals, aquaculture husbandry practices, feed for organic aquaculture animals and products and substances allowed for use in organic aquaculture. ⟨http://eur-lex.europa.eu/eli/reg_impl/2014/1358/oj⟩.