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ADVANCING SHELLFISH AQUACULTURE AS A SUSTAINABLE FOOD PROCUREMENT OPTION IN EMERGING BLACK SEA RIPARIAN COUNTRIES: ROMANIA COUNTRY REPORT

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Abstract

Aquaculture offers great potential for providing sustainable sources of food, thus playing a key role towards achieving food security and nutrition, employment and economic development. Shellfish (mussel) aquaculture offers a great development opportunity or Black Sea riparian countries, however, significant focus should be put on zoo-sanitary conditions and public health.In some countries bordering the Black Sea, mussel culture is relatively well represented, having an obvious increasing development over the last two decades. However, given that mussel culture is little developed in Romania, the promotion of scientific, technical and technological bases for this activity is absolutely necessary. In the frame of the NIMRD - GFCM collaboration, in 2017 the Shellfish Aquaculture Demonstrative Center in Constanta (S-ADC) was established at NIMRD's headquarters. The demonstration module for mussel production form the basis of training activities in the field of mitiliculture and covers all aspects of the production cycle: biology and ecology of Mytilus gallo provincialis; providing brood and collecting larvae from the natural environment; design and construction of the long-line system; mussel growth and handling technologies; mussel processing and purification technologies; production management systems (production costs, market analysis); training in methodological and practical aspects of the sanitary-veterinary classification of mollusks for domestic consumption/export.

Key words *:mariculture, mussels, long-line, food safety, market.*

INTRODUCTION

Aquaculture, the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants, offers great potential for providing sustainable sources of food, thus playing a key role towards achieving food security and nutrition, employment and economic development at regional Black Sea level. So far, mariculture concerns around the Black Sea have been focusing mainly on fin fish species of high economic value, such as turbot and sturgeons (Niță and Nenciu, 2017; Niță et al., 2018c).

In recent years, however, other living resources have started to be targeted for human consumption, such as mussels and the rapa whelk (*Rapana venosa*).

Mytilus gallo provincialis (Lamark, 1819) is the marine mollusk (mussel) with the highest ecological and economic importance in the Black Sea ecosystem (Rosioru et al., 2012).

Due to their organoleptic qualities and the high content of biochemical compounds with nutritional value (amino acids, vitamins, enzymes, proteins, carbohydrates),many species of mollusks are industrially harvested or grown in specialized aquaculture farms (Niță et al., 2018b).

The world production of bivalves has increased over the last 50 years, from 0.9 million tons in 1950 to over 22 million tons in 2010. The increase is largely due to the share of aquaculture, which grew rapidly in the 1990s. World production of farmed bivalves increased from 3.3 million tons in 1990 to nearly 20 million tons in 2010, with an annual average increase of 11% (Zaharia et al., 2017).

Mussel culture has been known since the last century (Ursache et al., 2013). However, the

development of technologies based on scientific observations was possible only a short time after advancing the knowledge of the physiology and ecology of mollusks (Ursache, 2014).
Currently, however, shellfish aquaculture is not developed to its full potential in the Black Sea region (except for Bulgaria) due to, on the one hand, environmental constraints, and, on the other hand, an unclear legislative framework (Niță et al., 2018).
In some countries bordering the Black Sea, mussel culture is relatively well represented, having an obvious increasing development over the last two decades; for example, Ukraine produces about 400 tons per year, while Bulgaria is approaching 4,000 t/year (Zaharia et al., 2017). However, given that mussel culture is little developed in Romania, the promotion of scientific, technical and technological bases for this activity is absolutely necessary.
In Romania, bivalves are not considered a common food, but in the last decade there has been a slight increase in the consumption of mussels and oysters in public nutrition.
The increase in the demand for bivalves for food consumption in recent years has encouraged the harvesting of mussels from natural populations, growing mussels on floating installations (long-line systems) and acclimatization of high-value bivalves - the Japanese oyster, for instance (Zaharia et al., 2017).
The annual quantity of mussels harvested in the Romanian Black Sea coast area amounts to approx. 15 tons (estimated value), and the only existing mariculture farm (with interrupted activity), SC MARICULTURA SRL, can produce annually approx. 5 tons of cultured mussels (Zaharia et al., 2017).
Significant focus should be put on zoo-sanitary conditions and public health of mussel consumption (Nicolae et al., 2015).The European sanitary control of live bivalve mollusks is historically based on the Council Directive (EC) No. 492/91, which had previously set the hygiene rules for the production and marketing of live bivalve mollusks. Currently, food safety monitoring of shellfish production areas in the European Community is regulated by the "Hygiene Package" which entered into force on 1 January 2006, repealing the Directive (EC) No. 492/91. This legislative package includes the Regulations (EC) No. 852/2004 and 853/2004, which are addressed to industry professionals, and Regulations No. 854/2004 and 882/2004, which are addressed to competent authorities, responsible of carrying out official sanitary controls. End product standards required for bivalve mollusks are regulated by Regulations (EC) No. 854/2004 and 2073/2005.
Thus, there is an extensive legislative framework at EU level, however it is poorly implemented (except for Bulgaria, where sanitary classification of shellfish waters was made by private operators, in order to be able to export their products on the Community markets) (Nicolae et al., 2018).

MATERIALS AND METHODS

The methodology used in order to draw-up an accurate overview of the mussel culture in Romania was applying modern analysis tools during the *"Demonstrative Training on Mussel Farming"*, carried-out during 17-28 September 2018 in Constanta, Romania. This training was organized in the frame of the Shellfish Aquaculture Demonstrative Center, operating within NIMRD "Grigore Antipa" under coordination of the General Fisheries Commission for the Mediterranean/Working Group for the Black Sea (Niță et al., 2018b).

Figure 1. S.W.O.T. and P.E.S.T.E.L. analyses during the "Demonstrative Training on Mussel Farming", 17-28 September 2018, Constanta (Photo by M.I. Nenciu)

The course involved trainees from Bulgaria, Georgia, Turkey, Ukraine and Romania, from research organizations, authorities and the

business sector. Representatives from the sanitary-veterinary authorities also attended and were engaged in discussions regarding certification aspects of shellfish waters. The aim of the training was to enhance the theoretical and practical knowledge, focusing on legal and administrative issues.

During this training, S.W.O.T. and P.E.S.T.E.L. analyses were performed, aiming at obtaining the inputs and feedback of trainees (Figure 1).

S.W.O.T. (Strengths, Weakness, Opportunities and Threats) analysis is a methodological approach to problem formulation and the mapping of possible management strategy solutions (Rauch, 2007). As a knowledge-based tool, it has been recommended for strategic planning in small and medium-sized enterprises (Houben et al., 1999), as well as for a whole-industry sectors such as fisheries (Stead, 2005) and aquaculture (Theodorou et al., 2015; Theodorou and Tsovenis, 2018). Strengths and weakness are frequently internally-related, while opportunities and threats commonly focus on the external environment.

A P.E.S.T.E.L. analysis is an acronym for a tool used to identify the macro (external) forces acting on an organization/activity. The letters stand for Political, Economic, Social, Technological, Environmental and Legal. The P.E.S.T.E.L. framework is an analytical tool used to identify key drivers of change in the strategic environment (Narayan and Fahey, 2001).

RESULTS AND DISCUSSIONS

The results collected were organized in the following tables (Table 1 for S.W.O.T. and Table 2 for P.E.S.T.E.L.), thus summarizing the issues Romanian mussel aquaculture is facing.

Table 1. S.W.O.T. analysis for Romanian mussel aquaculture

STRENGTHS (Internal)	OPPORTUNITIES (External)
- Extensive scientific knowledge on mariculture: NIMRD "Grigore Antipa"'s expertise (qualified staff, existing infrastructure); - Existing and future partnerships between fishery/aquaculture stakeholders and other sectors of the public and private sector (Fisheries Local Action Groups - FLAGs, fisheries associations/organizations); - Previous small-scale experience (private operator who already implemented the long-line culture system); - Mussels have a short life cycle and require no added food; - Closeness to the EU markets and possibility for exports.	- Improving and equipping NIMRD's Laboratory for aquaculture microbiology and its subsequent accreditation, in order to the classification of mussel harvesting areas (Class A, Class B, Class C); - Support in the implementation of Allocated Zones for Aquaculture(AZA) in Romania with direct implications in mussel culture; - Develop - European funding opportunities (developing) projects in the field of shellfish mariculture.
WEAKNESSESS (Internal)	**THREATS (External)**
- Constraints related to environmental factors (climate, salinity, exposed coastline, no sheltered areas), which cannot be controlled; - Major coordination problems between institutions (Sanitary Veterinary Directorate, Public Health Directorate, Romanian Waters Administration).	- Difficulties in integrating mariculture with other uses of the marine and coastal environment (transport, tourism, etc.) = conflicts on maritime space use; - Potential harmful algal blooms (HAB) and bacterial outbreaks (food safety).

Table 2. P.E.S.T.E.L. analysis for Romanian mussel aquaculture

POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL	ENVIRONMENTAL	LEGAL
- there is willingness for the development of aquaculture/ mariculture.	- there is demand/ market for mussels.	- this activity is well accepted by the community.	- there is theoretical documentation for the development of the sector; - lack of practical expertise.	- marine shellfish aquaculture is beneficial for the environment (biofilters).	- major coordination problems between institutions (Sanitary Veterinary Directorate, Public Health Directorate, Romanian Waters Administration).

The S.W.O.T. analysis revealed that the main strengths for developing shellfish aquaculture in Romania are represented by the extensive scientific knowledge in this field, through the expertise and existing infrastructure of NIMRD ”Grigore Antipa”, as well as the practical experience of a private operator who has already implemented the long-line system (Figure2). Moreover, the willingness and cooperation between the public and private sector are favourable factors, fostering the development of this activity in the area. From the economic point of view, the fact that mussels have a short life cycle and require no added food is very attractive for potential investors, as well as the closeness to the EU markets and possibility for exports.

The weaknesses and constraints limiting marine aquaculture in Romania are mainly related to environmental factors. Water temperature has wide variations from one season to another and, in shallow areas, negative temperatures are recorded in winter time, while in summer water temperature can overcome 28°C for quite long periods of time. Salinity is variable, in many areas, mainly in those subjected to river input, salinity may drop considerably during certain periods of the year, which can be fatal for mussels (Figure 2).

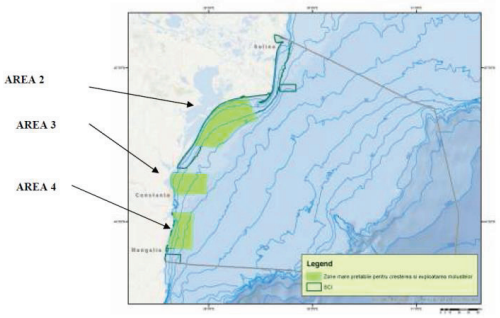

Figure 2.Map with the designated marine areasfor growth and economic exploitation of marine mollusks in Romania

This is the reason why, in 2015, by ministerial order, one of the four initially designated areas for exploitation of shellfish at the Romanian coast (according to Directive 2006/113 EC), was removed due to its closeness to the Danube mouths (Sulina-Sf. Gheorghe, with salinity values below the minimum recommended threshold of 12‰) (M.O. no. 983/2015). Severe storms must also be considered (high waves and strong currents), as well as seabed topography, when setting-up long-line installation (Figure 3). The absence in many areas of the Black Sea coast of the sheltered areas, suitable for aquaculture, is another limiting factor.

Concerning biotic factors (plankton, fouling, predators etc.), they are rather favorable to the development of aquaculture in the region; fouling, however, may cause problems if regular maintenance works on installations are not performed.

One key aspect concerning mussel aquaculture is the zoo-sanitary and food safety issue. The concept of food hygiene, according to FAO/WHO(Niță et al., 2018a), includes precautions and measures which, if adopted in the right way, during production, handling, storage and distribution of food, lead as a result to a salubrious and marketable product.

The production chain of bivalve molluscs begins with breeding or collection of different species of mollusks in the production areas.

Figure 3. Long-line system suitable for Black Sea mussel culture (Photo by M. Crivăț, MARICULTURA S.R.L.)

EU regulations exist to control the public health risks associated with consumption of microbiologically contaminated shellfish. The risk of contamination of shellfish with bacterial and viral pathogens is evaluated by reference to

(i) the sources and types of fecal contamination (human and animal) in the vicinity of the shellfish production areas and (ii) the results obtained, based on the indicator bacteria *Escherichia coli*, from samples taken in these areas. Areas are classified following a full assessment of this risk and the classification given to an area determines whether shellfish harvested in that area require post-processing treatment and, where appropriate, the level of such treatment (Nițǎ et al., 2018a).

As previously mentioned, there is an extensive legislative framework at EU level, however in Romania it is poorly implemented due to major coordination problems between various institutions, concerning both zoo-sanitary classification and water concession.

In this context, there is urgent need to provide an updated scientific based legal and procedural framework for developing shellfish aquaculture in Romania, as an opportunity for development. This can be done by equipping the laboratories in compliance with the required framework for shellfish quality and food safety (Regulation (EC) No 854/2004),skill-development and capacity building in order to perform high accuracy analyses, and developing a shellfish water and meat quality monitoring protocol for the implementation of classification and monitoring programmes of bivalve harvesting and culture areas.

Moreover, it must be taken into account that aquaculture mostly takes place in common spaces, where different uses and users co-exist, if not always amicably, this being one of the threats identified. Further effort is required to enhance multiple use, in order to better understand co-location and co-existence perceptions with tourism and other marine uses. There is, therefore, a need for active aquaculture spatial planning and area management that accounts for the range of uses of marine space, and human interactions in general, focused on a core requirement to increase space for aquaculture. In the Black Sea area there has been an expansion of aquaculture in recent years, but comprehensive regulation has been slower to develop. The site selection process, as well as the allocation of zones for aquaculture is a relatively recent focus of the General Fisheries Commission for the Mediterranean (GFCM), which in 2012 adopted a resolution (i.e. Res. GFCM/36/2012/1) that provides guidelines on allocated zones for aquaculture (AZA). It is not a mandatory regulation, but the resolution acts as a basic framework to guide GFCM contracting parties (Romania included) in the establishment of a spatial management of aquaculture, to avoid any potential contamination and/or conflicts with other uses of the maritime space (Nițǎ et al., 2018a).

Potential harmful algal blooms (HAB) and bacterial outbreaks, with serious consequences for food safety, are also to be considered as a significant external threat to developing mussel aquaculture.

The P.E.S.T.E.L. model of analysis showed that, from the political point of view, in Romania there is willingness to support and promote the development of aquaculture, in general, and mariculture in particular, as an alternative for providing nutritious food. Moreover, economically, in Romania the market demand for mussels has increased in recent years, as many restaurants/catering facilities have included them in their menu and they are promoted as a healthy dish. This leads to a rather good social acceptance of the product (Figure 4).

Figure 4. Mussels are becoming more and more socially accepted by Romanian consumers (Photo by M.I. Nenciu)

From the technological perspective, it was acknowledged that there is theoretical documentation for the development of the sector, yet a lack of practical expertise, with only one active operator, cannot guarantee its success of implementation.

The environmental benefits of bivalve cultures are scientifically demonstrated: by their filter-

feeding technique, mussels contribute to the natural depuration of marine areas, acting as bio-filters and clearly improving water quality (Ursache et al., 2013).
Legally, the most significant aspect identified is the lack of coordination between institutions (Sanitary Veterinary Directorate, Public Health Directorate, Romanian Waters Administration).

CONCLUSIONS

At a first glance, the Romanian Black Sea coast does not seem suitable for developing shellfish aquaculture activities, mostly due to the environmental constraints (variable salinity, storms, absence of sheltered areas etc.) and legislative/administrative gaps, which may prevent investors from marketing their production. However, the establishment of the Shellfish Aquaculture Demonstrative Center in Constanta (S-ADC), in the frame of the NIMRD - GFCM collaboration, will lead to the promotion of scientific, technical and technological bases for this activity, by providing focused training for targeted beneficiaries: on the one hand, national and local management authorities/administration involved in aquaculture planning, management, sanitary control, and, on the other hand, representatives of the private sector, especially the small-scale producers with limited investment capacity, as well as potential and existing investors.

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