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DEVELOPMENT PERSPECTIVES OF FISH FARMING IN MONTENEGRO

SUMMARY

By FAO definition (1990), aquaculture includes all activities related to the farming of aquatic organisms (fish, molluscs, crustaceans and algae), while the term "mariculture" describes aquaculture in marine or brackish water in coastal areas and in the open sea. Marine fish farming in Montenegro began to develop in 1998, when started with work the company "MegaFish" from Kotor, which is currently the most successful farming company in Montenegro. In this study, the fish farming technology used in Montenegro will be described, as well as the possibility of development of this sector, which should be based on the principles of sustainable development and good environmental status.

Keywords: aquaculture, cage farming, multitrofic aquaculture

INTRODUCTION

Farming of sea bass (Sparus aurata) and sea bream (Dicentrarchus labrax) in Montenegro implies a closed breeding cycle in floating cages in the sea. Although farming of white fish in Montenegro shows a slight increase over the last few years, it is still very low, especially when compared with countries that belong to the countries with low production (Croatia, Albania, Morocco and Tunisia). Two fish farms, which are located in the area of Boka Kotorska Bay has an annual production of about 120 t (FAO Sipam Database, 2011). All production is sold on the domestic market, which shows an increasing interest for the sea farm products, due to the fact that the biomass of fish from fisheries decreases, and because of better prices and the availability of farmed fish throughout the year.

Farming of fish and other marine organisms, is carried out according to the Law on Marine Fisheries and Mariculture (Official Gazette No. 56 of 14.08.2009), the Spatial Plan for the Special Purpose for Coastal Zone Enterprise (Official Gazette. No. 30 of 30.05.2007), the Law on Environment (Official Gazette, no. 48/08 of 11.08.2008.), the Law on environmental Impact assessment (Official Gazette of Montenegro, No. 80/05 and 28.12.2005.), Law on Environmental Protection (Official Gazette, no. 51/08, 21/09), and the by laws that applies on the basis of the above mentioned Laws.

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State, prospects and strategic guidance of Montenegrin mariculture development Aquaculture is an increasingly important industry in the world because it compensates reduced potential from natural resources. The development of this sector could provide a multifunctional connection with tourism, and open the possibility of organizing touristic offer which is closely related to fisheries and aquaculture. Aquaculture and tourism are actually compatible activities and cooperation between these two sectors might produce significant development opportunities (gastronomic contribution to tourism offer, the increase in the national consumption of healthy foods from the sea, reducing fishing pressure on existing resources and create jobs). Having in mind the growing need in the world for healthy ecological food, and concurrently facing with the increasing overfishing, the world market have growing demand for fish from farming.

One of the main reasons for the insufficient development of this sector is the lack of new sites for farming, especially at the open part of Montenegrin coast. In resolving this key issue, spatial planning have the most important role in the site selection process, for the purpose of resolving any conflicts with other activities that are carried out at sea, but also to provide security to investors. Problems with fouling organisms, predatory fish species, the existence of unregistered farms, lack of organized markets, no dispatch centers and active depuration center are just some of the problems we facing, but the realization of solving them has started. Unused possibilities of farming of other indigenous species of shellfish, lack of information and lack of educational workshops for farmers and people who work in the sector are also problems which should be solved in cooperation with institutions working in the sector.

The most significant threats are possible fecal contamination and bio-toxins with which many countries in the region are still facing. The total production of sea bass and sea bream in Montenegro is about 120 t (FAO Sipam Database, 2011) and is carried out in two existing fish farms that are located in the area of Boka Kotorska Bay (Orahovac and Stoliv). Production shows growth in recent years, thanks to decisive management of one of the two existing farms. However, the development of this sector is stagnant, as there are no defined locations for aquaculture in the open sea of the Montenegrin coast, which should be an integral part of the spatial plan of the coastal zone management and which should constitute security for investors to invest in cage farming. There is a growing interest in recent years by various investors for growing not only sea bass and sea bream, but the also tuna (Thunnus thynnus). Poor development of aquaculture in Montenegro contributes to the conflict of this sector with tourism and ecology, and ignorance of the actual situation and the possibility of linking these sectors. Although fish farming can significantly affect the ecological and biological condition of water, proper and sustainable management of production, regular monitoring of the environment and regular control to prevent the risk and disease could make the development of this sector viable and environmentally sound. On the basis of previous studies conducted by the Institute of Marine

Biology, potential locations for aquaculture in the open part of the Montenegrin coast have been proposed (Figs. 1, 2 and 3). In order to ensure proper and final site selection, it is necessary to perform additional studies that would include an analysis of the sediment (granulometry, organic matter) benthic fauna, water quality (salinity, dissolved oxygen, temperature, chlorophyll a, suspended solids, nutrients), organograpic conditions (wave height, direction and speed of sea currents), sanitary control and monitoring of biotoxins. Besides these, environmental characteristics, it is important to take into account the administrative and socio-economic data (underwater cables, administrative areas, marine protected areas, military zones, etc.).

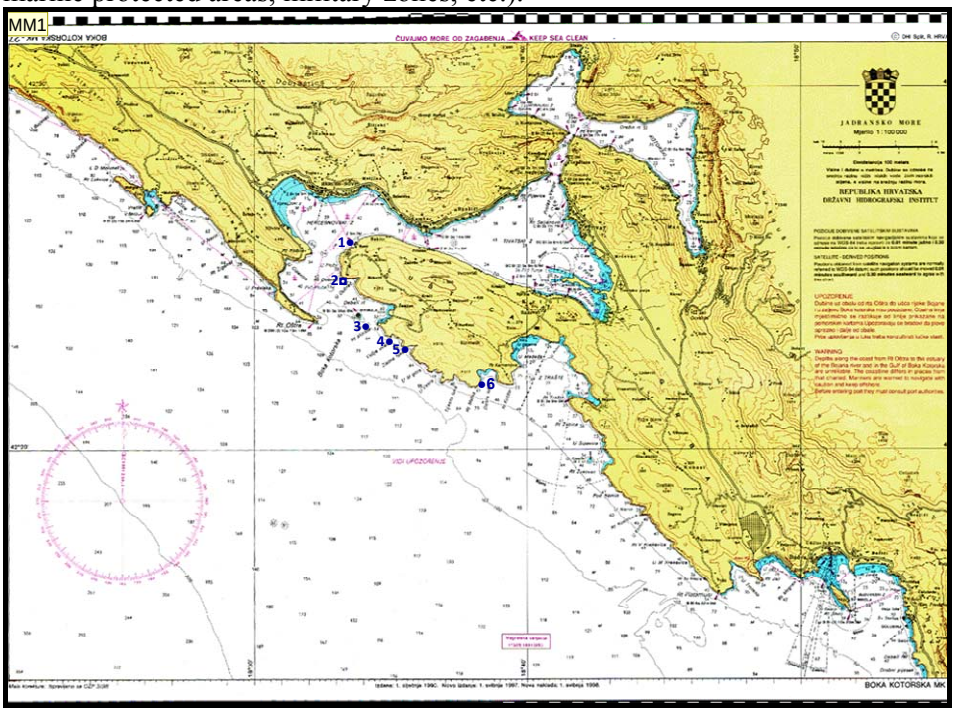

Figure 1. Potential aquaculture sites (1 - "Rose" 2 - "Uvala Dobreč", 3 - "Rt Mirišta", 4 – "Vučja vala", 5 - "Zlatna luka", 6 - "Dobra luka") (◘ - shellfish, ● - fish farming, ▲ - tuna farming)

In the Boka Kotorska Bay, there are two fish farms which using floating cages for fish farming (Fig. 4). Farming implies closed cycle whose first phase taking place in the hatchery, and then in floating cages in the sea. Existing farms are located in a protected area of the bay, and the maximum amount of farmed fish should not exceed 100 tons per farm, which would ensure the preservation of environmental quality to the extent that is possible, given that this type of farming is intensive. The limitation of biomass per cage under conditions of Boka Kotorska Bay would prevent an increase in the level of eutrophication and impact on the trophic status of the ecosystem. Due to the fact that fish farming is intensive, attention should be focused on developing semi off-shore aquaculture.

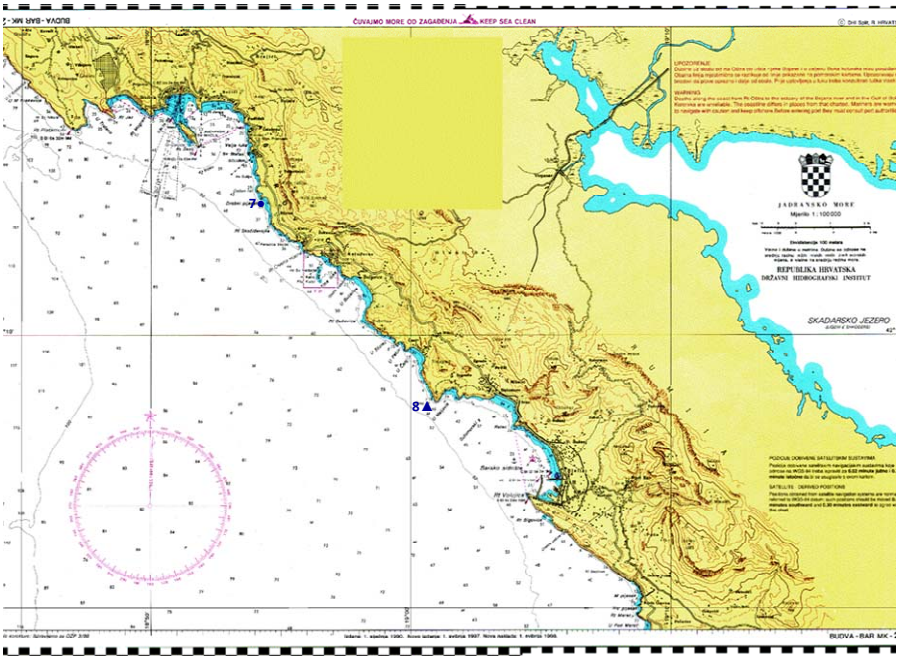

Figure 2. Potential aquaculture sites (7- "Drobni pijesak", 8-"Crni rt").
(◘ - shellfish, ● - fish farming, ▲ - tuna farming)

Figure 3. Potential aquaculture sites (9- "Uvala Valdanos", 10- mouth of Bojana river)
(◘ - shellfish, ● - fish farming, ▲ - tuna farming)

Development of semi off-shore and off-shore aquaculture

Cage farming implies primarily the appropriate site selection, depending on the species that wants to be farmed. The presence of natural shelters, such as bays, can significantly influence to prevent a possible breakup of the cages due to high waves and storms, which are common in the open sea. For this reason, after site selection, when link cages with anchorage, one should bear in mind the worst case scenario of weather conditions, which means that in order to prevent a possible breakup of the cages, they should be linked in an appropriate manner, taking into account the maximum wave height, current velocity, wind speed and tide amplitudes.

Semi off-shore farming is farming in areas that are partially protected from high waves. In this type of aquaculture production should be limited to a maximum of 500 tons per year, which provides a limited impact on the environment and ecosystem structure.

Off-shore farming is farming at the open sea, where the farming cages are exposed to much worse conditions than the previous one, and that is increasingly emphasized in recent time due to the lack of sites, and partly due to conflicts with other activities in the coastal zone. This type of farming involves much greater investment than previous one, primarily because of the need for top quality cages, necessary boats and adequate coastal infrastructure.

Figure 4. Floating cage for fish farming

There are four basic types of farming cages: floating, fixed, submersible and submerged. The choice depends on the species that wants to be farmed, the characteristics of the environment, farming technology, the estimated cost and the desired production. Following steps should consider during the selection of the cage type:

-Provide a rational and stable shape of the cage, which will not affect the stress of the stock and which can allow a stable working environment and equipment handling.
-Ensure good water exchange, in order to ensure the exchange of metabolic requirements of the stock and waste removal from the cage.
-Reducing capital and operating costs to a minimum (Scott and Muir, 2000)

Farming of white fish (sea bass or sea bream) in the open sea, in the area which is semi-protected, usually medium size cages are used (diameter 12-20 m). Fish farming in bays or other similar protected locations is usually performed in smaller cages (10 or 12 m in diameter) which require a smaller depth. Tuna farming is usually carried out in large cages (diameter more than 30 m).

Technological process of fish farming

Basic equipment necessary for the operation of small fish farm:

-Round cages in diameter up to 12 m
-Pools (cages) for transport, diameter 4x4 m
-Blocks and ropes for anchoring
-Ropes for the net
-Chains and buoys.

Technological process of farming begins with seeding of fingerlings with individual biomass of 2-5 g. Seeding is usually performed in the spring months, and a commercial size is achieved within 16-28 months.At the beginning of farming, stock density is relatively high and fish fry is placed in the cages with a small mesh size. Cages are placed on the floating platform which has a path on the edge for access to the cage, control of nutrition, mortality and exchange of the nets (Fig. 5). Usually four smaller cages are interconnected, although their number depends on the desired biomass. In a recent years, only round cages are used due to the better use of space and behaviour of fish. For first phase, net with a mesh size of 5 mm is most commonly used. After 6-7 months, or at the end of the first year of farming, farmed fish should be thinning by transferring to other cages with mesh size of 14 mm. During this period, the fish has a weight of 50-70 grams. When the fish reaches a weight of about 200 g it should be transferred to the consumption cages, where it continued its growth to the commercial weight. Fish are fed manually with different winter and summer feeding regime.

Fish farming demands significant financial investment, so it is necessary to choose the species with a relatively high growth rate, which is resistant to a variety of viruses, particularly in the warmer periods of the year, and species with high feed conversion ratio (FCR).

When setting up the cage it is necessary to ensure adequate depth below the cages, in order to increase the exchange of water, avoiding depletion of oxygen, accumulation of metabolic products and the formation of harmful gases that are generated by the decomposition of waste disposed (Loka et al., 2012).

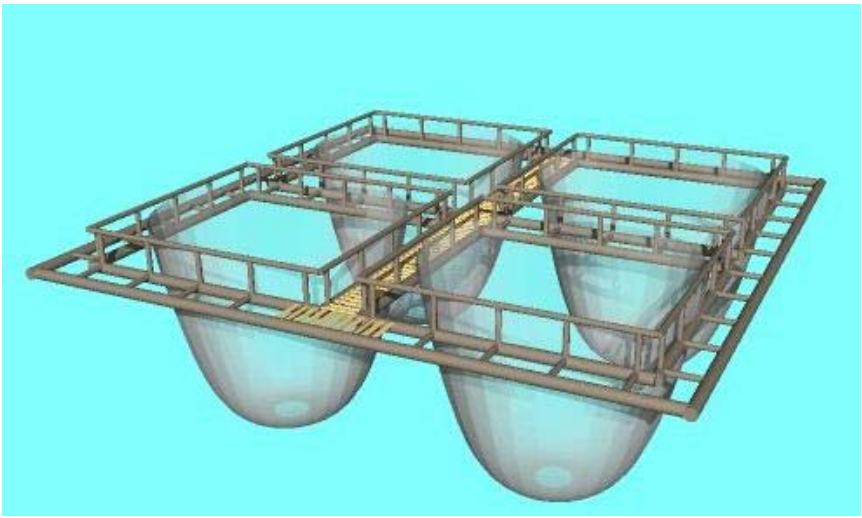

Figure 5. Cage composed of four segments

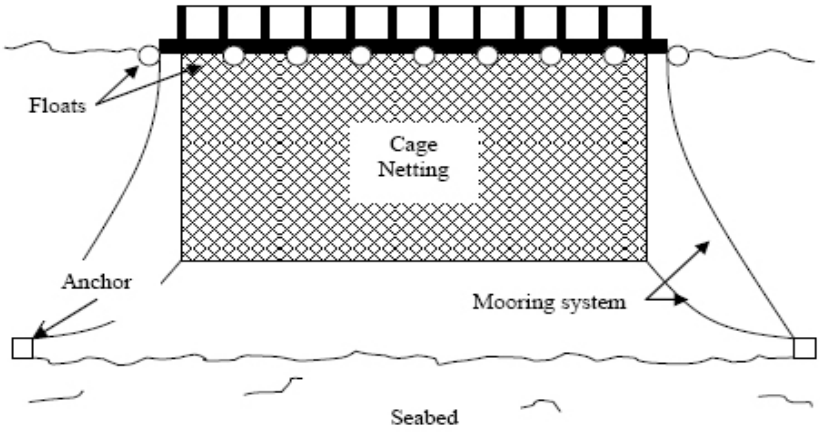

Figure 6. Shematic presentation of installation of sea cage (Birt *et al*, 2009)

A very important factor in fish farming is changing and cleaning of the nets, especially during the summer, when increased amount of fouling organisms is expected. In this case it is necessary to periodically treat fouling with specific products. Permanent control of farmed organisms by divers, is very important, especially in the case if it comes to mortality of individuals. One of the main issues in fish farming is variability in quality of fish fry. Special attention should be paid to the choice of hatchery in which fryes will be purchased. Although there is a large number of hatcheries in the region (Italy, Turkey, Greece, Croatia) the choice of hatcheries is, at the moment, decision of the investor. Detailed conditions for purchasing fish fry should be perscribed, in order to

prevent the entry of foreign genetic material. In this regard, the best choices are hatcheries from Italy or Croatia due to genetic similarities. In fact, genetic studies have shown that the crossbreeding of different subspecies (strains) can cause artificial gene flow, especially in the cases when individuals escape from their cages and crosses with the local wild population. Practices such as the crossing of different strains and the eastward transfer of broodstocks, eggs, larvae and fry over large distances can involve the risk of causing artificial gene flow from escapees to local populations; this could induce a biodiversity decline or outbreeding depression (Haffray et al., 2006).

Escaping from the fish cages can affect the transmission of diseases and pathogens, increasing the range of distribution in wild populations (Arechavala-Lopez et al. 2013). Many risks to the ecosystem through the escape of fish from aquaculture are evident, and management measures should be taken through which these risks will be reduced to a minimum or even eliminated. Improving existing legislation in aquaculture is necessary, not only to reduce the risk to the ecosystem, but also to preserve human health, food safety and ensuring efficient development of aquaculture.

CONCLUSIONS

Fish farming in Montenegro includes the use of standard technologies of farming, floating cage system, which is used in the region. It is important to note that one fish farm that is located in the Boka Kotorska Bay and that has significant production, applying the principle of integrated multitrophic aquaculture. In particular case, besides sea bream (Sparus aurata) and sea bass (Dicentrarchus labrax) farming, mussels are farmed, as well. This is an example of good practice that should be continued and which we suggest to all fish farms. Studies have shown that the condition index of mussels (Mytilus galloprovincialis), which is farmed in the same location with sea bream and sea bass, is slightly higher throughout the year than in the condition index of mussels that are farmed in monoculture (Peharda *et al*., 2007). Research on mussel growth near the fish farms in the Tyrrhenian Sea have shown that bivalves recycled allochthonous organic matter and contribute to the reduction of environmental pollution, increasing the profitability of farming (Sara *et al*., 2009).

In order to improve the aquaculture sector, a detailed analysis of all proposed potential new sites should be performed. In this way it would be possible to select the most appropriate location and concentrate on small-scale aquaculture, which means the farming of reasonable quantities of fish, which would not represent risk to the quality of the environment. It is also necessary to zone aquatorium based on detailed site studies. For each new fish farm, it is obligatory to make assessment on the environmental impact, and based on the zero state of the site and detailed characteristics of the sites it is possible to estimate the minimum distance between locations for mariculture. Our proposal is to perform detailed study of the entire area of the open sea of the Montenegrin coast, and based on the results of that study problem with new aquaculture sites will be solved.

Mariculture sector in Montenegro needs improvement and technological development, which would be based on the safety standards and the preservation, enhancement and promotion of quality food from the sea, in accordance with modern production and market trends while preserving the natural values of the area.

We propose the introduction of organic farming of shellfish, especially oysters and mussels. Although there is sstill no rulebook to define organic farming of shellfish in Montenegro, it can be carried out applying the European legislation (Commission Regulation (EC) No 710/2009 from 5 August 2009). Introducing of organic farming of mussels and oysters would result in the diversification of products with an emphasis on quality, and the ultimate goal - the branding of products from aquaculture in Montenegro.

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PERSPEKTIVE RAZVOJA KAVEZNOG UZGOJA RIBE U CRNOJ GORI

SAŽETAK

Po definiciji FAO (1990) akvakultura podrazumijeva sve aktivnosti koje se odnose na uzgoj akvatičnih organizama (ribe, mekušci, rakovi i alge), dok termin „marikultura“ označava akvakulturu u morskoj ili brakičnoj vodi u priobalnim zonama ili na otvorenom moru. Kavezni uzgoj morske ribe u Crnoj Gori se počinje razvijati 1998 godine, kada je započela sa radom kompanija „Megafish“ iz Kotora, trenutno najuspješnija kompanija za uzgoj morske ribe u Crnoj Gori. U ovom radu će biti opisana tehnologija kaveznog uzgoja koja se koristi u Crnoj Gori, kao i mogućnosti razvoja sektora marikulture, koje se baziraju na principima održivog razvoja i dobrog sredinskog stanja.

Ključne riječi: marikultura, kavezni uzgoj, multitrofička akvakultura