Bulgarian Journal of Agricultural Science, 21 (Supplement 1) 2015, 56–60
Agricultural Academy

INLAND AQUACULTURE DEVELOPMENT IN THE NATURA 2000 SITES IN BULGARIA: ECOLOGICAL APPROACH AND AQUA-ENVIRONMENTAL MEASURES

E. UZUNOVA [1], E. RADEVA[2] and R. TZONEV[1]
[1] *Sofia University, Biological Faculty, BG – 1164 Sofia, Bulgaria*
[2] *Regionnal Environmental Center for Central and Eastern Europe – Branch Bulgaria*

Abstract

UZUNOVA, E., E. RADEVA and R. TZONEV, 2015. Inland aquaculture development in the NATURA 2000 sites in Bulgaria: ecological approach and aqua-environmental measures. *Bulg. J. Agric. Sci.,* Supplement 1, 21: 56–60

The aim of this study is to provide environmentally friendly approach to the development of freshwater farms within the protected areas of EU NATURA 2000 ecological network in Bulgaria. To meet this objective the following tasks are formulated and executed: 1) establish the geographical location of freshwater fish farms to the borders of the nationwide ecological network NATURA 2000; 2) formulation of measures to ensure aqua-environmental work in terms of freshwater farms in the territory of the protected areas in Bulgaria, so as to realise the main purpose of protected areas – conservation and restoration of the conservation status of natural the habitats and species.

Key words: Inland aquaculture, biodiversity, NATURA 2000, Bulgaria

Introduction

The role of aquaculture has become increasingly significant as an alternative source for fish extraction because of decreasing natural fish resources, as well as the possibility of restoring natural resources. The aquaculture has undergone a worldwide expansion over the past 20 years and it seems that growth is set to continue (FAO, 2010). Alongside, and perhaps partly due to this rapid expansion, the status of the environment has received increasing attention. The main negative effects of rapid increase of aquaculture production are related to the destruction of ecosystems (e.g. Penczak, 1982; Beveridge, 1993), direct pollution with organic materials, chemicals (e.g. Ackefors and Enell, 1994; Guo and Li, 2003), dissemination of pathogen agents (e.g. Krkošek, 2007), genetic interactions between native fish and escaped fish from farms (e.g. Crozier, 2003), introduction of some invasive species, as well as the aesthetic problems. There is a conflict in many areas between the environmental protection and biodiversity conservation and the increased demand of production.

The European ecological network NATURA 2000 consists of specially protected sites with European importance. They not only preserve target habitats and species but also these objects must to maintain or to restore them in favourable conservation status. These activities are doing in the appropriate bio-geographic region or regions. From the beginning of the 20th century, the natural wetlands in Bulgaria have been reduced significantly and only 1/20 part of them remained from their primary area (Kotchev and Yordanov, 1981). For many animal and plant species, fish ponds have partially compensated for the loss of their natural habitats, and now they are specific refuges for the populations of endangered aquatic flora and fauna. Currently, a significant part of the water basins used for aquaculture in Bulgaria is in protected areas of European Ecological network. However, Bulgaria still has no regulations for the operation of fish farms, falling within protected areas of the NATURA 2000 network, as well as the measures that should be implemented to not conflict with the objectives of the protected areas. Development of aqua-environmental measures and practices

has been the subject of much commentary and discussion in recent years (Martinez-Porchas and Martinez-Cordova, 2012). The drafting of such measures and rules must comply with the specific characteristics of Bulgarian aquaculture, on the one hand, and adequately reflect the needs for conservation of biodiversity of protected areas on the other. The production processes in farms must be consistent with the location of the water body and the presence of target and protected species. The development of such measures would facilitate the work of the farm and help to implement adequate control by the relevant authorities and would allow for long-term conflict-free coexistence of this type of business and the objects of protection in their respective protected areas. This should ensure coherence of economic and social benefits of aquaculture with the objective and purpose of protected areas.

The aim of the current study is to propose a set of recommendations, implementation of which will contribute towards the sustainable management of aquaculture operations on farms falling within the protected areas in the National Ecological Network and fulfilment of the objectives and the purpose of protection in the protected zone.

To achieve this purpose, the following tasks were formulated: 1) establish the geographical location of freshwater fish farms to the borders of the nationwide ecological network NATURA 2000; 2) formulation of measures to ensure aqua-environmental work in terms of freshwater farms in the territory of the protected areas in Bulgaria, so as to realise the main purpose of protected areas – conservation and restoration of the conservation status of the natural habitats and species.

Material and Methods

For the purpose of this study, a register of fish farms in Bulgaria was used (National Agency of Fishery and Aquaculture, April 2014).

The type of technology applied in freshwater farms in Bulgaria was analysed. Establishing the location of each fish farm in the NATURA 2000 was accomplished using a GIS-based internet platform (NATURA2000 viewer, Google Earth, Google Maps and Wikimapia).

The farms which are falling partly in protected areas were added to those that fall within the protected areas.

Results and Discussion

Distribution of fish farms in NATURA 2000 protected areas

The number of officially registered freshwater fish farms in Bulgaria for 2014 was 500, and 159 of them are located on the territory of protected areas of the NATURA 2000 network. A significant part of these farms belong to so-called worm-water fish farms (100), which represent 63% of total farms within NATURA 2000 (Table 1). Many of these farms are situated in small dams, or are located on the river terraces of water bodies that are covered in the NATURA 2000 network. Thirty six or 23% of the total freshwater fish farms in Bulgaria located in NATURA 2000 areas are the cold-water farms. These are mainly farms in mountain or sub-mountain areas. The small number of cold-water farms is possibly due to them being built in urban areas that are usually outside NATURA 2000. The number of freshwater farms occupying an intermediate position in terms of water temperature regime and providing conditions for growing species such as sturgeon, pike and perch was 23 or 14% of the total freshwater farms, within NATURA 2000. Seventy-seven per cent of all farms in the territory of NATURA 2000 in Bulgaria are not fully farm systems, i.e. covered only a separate phase of the life cycle of fish.

Protected sites under Directive 92/43/EEC for the conservation of natural habitats and of wild fauna and flora covered total of 90 farms or 57% of the farms in NATURA 2000 and 18% of the total number of farms in the country (Table 1). Totally 25 farms or 16% of them in NATURA 2000 are within protected sites designed according to the Directive 2009/147/EC on the conservation of wild birds. Forty-four farms are located in protected sites according to both directives, i.e. 8.8% of the total number of farms in

Table 1

Distribution of the freshwater fish farms in Bulgaria according to their typology and target of protected sites

Type of fish farm	Natura 2000 protected areas			
	Directive 92/43	Directive 2009/147	Directive 92/43 &Directive2009/147	Total
Warm-water farms	63	15	22	**100**
Cold-water farms	19	4	13	**36**
Others	8	6	9	**23**
Total	**90**	**25**	**44**	**159**

the country and 27% of the farms falling within NATURA 2000. One hundred warm-water farms falling are within protected sites, 63 are located in the sites designated according to the Directive 92/43EEC on the conservation of habitats of wild fauna and flora, and 15 – within sites designated for the conservation of target bird species. Twenty two farms are within both protected zones.

Half of the 36 cold-water fish farms within NATURA 2000 are located in sites protected according to the Habitats Directive, four fell within protected sites according to the Directive on the conservation of wild birds, and the remaining 13 are in both protected sites and the two Directives. Protected areas with the highest concentration of fish farms were „Lomovete" (14) and „Rodopi – Sredni" (12).

Measures for protection of biodiversity and mitigation of the impact of aquaculture activities

The proposed measures reflect to the activities and practices common to a significant proportion of inland fish farms in Bulgaria, and are mainly directed towards target species that occur with significant frequency in these farms. Most of the proposed measures are applicable mainly in warm-water fish farms, which are the most widespread among those in the NATURA 2000 protected areas in Bulgaria.

(1) Maintaining of a bent of aquatic vegetation. The existence of aquatic vegetation in the fish farm ponds contributes to the formation of biodiversity in the water body, and increases the self-purification ability of the water. Highly dependent from the available aquatic vegetation is a number of target species of avifauna, such as Eurasian Bittern (*Botaurus stellaris*), Little Bittern (*Ixobrychus minutus*), Purple Heron (*Ardea purpurea*), Ferruginous Duck (*Aythya nyroca*), Marsh Harrier (*Circus aeruginosus*) and Crakes (*Porzan*a spp.). The vegetation provides shelter, nesting sites and food recourses for these species, and for most of these species, fish farms are part of the main habitats in Bulgaria. In fish farms, some target animal species found refuge, such as two species of pond turtles (*Emys orbicularis*, *Mauremys rivulata*), Newts (*Triturus dobogicus*, *T. karelinii*), Fire-bellytoads (*Bombina bombina*, *B. variegata*) and Eurasian Otter (*Lutra lutra*). The aquatic vegetation, however, leads to reduction in the territory inhabited by fish and interferes with their capture.

(2) Maintenance of the permanently flooded pools in the fishponds. Desiccation of ponds is a widely applied practice, in order to disinfect their bottoms and to save the water from basins that are temporarily not in use. During the winter months, the freezing of the bottom mud achieves the effect of disinfection, but also destroys many of the plant species, as well as hydrophytes – the floating or submersed aquatic plants, most of which are protected or targets for the sites. Such plants are European White Waterlil (*Nymphaea alba*), Yellow Water-lily (*Nuphar lutea*), European water clover (*Marsilea quadrifolia*), Fringed Water-lily (*Nymphoides peltata*), Water caltrop (*Trapa natans*) and European Frogbit (*Hydrocharis morsus-rannae*). Vulnerable from this practice in the farms are some protected fish species, such as Bitterling (*Rhodeus amarus*). If the farm has several terrestrial ponds, it is recommended that they are not dried simultaneously. Due to the ability of aquatic plants to spread quickly, one or two ponds must to remain flooded. It would help to preserve the aquatic plants. For this reason, it is proposed that unused ponds are charged with water to a depth of 0.5 m.

(3)Preservation of the bottom substrate. Periodic removal of the bottom sediments – a result of the accumulation of silt particles entering with the water current, and the organics produced by the cultured fish, adversely affects the sustainability of biodiversity. In the accumulated substrates, there are microorganisms, plants and their diaspora, mussels (*Unio crassus*), snails, crustaceans and others. Removal of mud will remove a significant part of the organisms inhabited the substrates asaquatic flora, including turions and roots of many hydrophytes (Pondweeds, *Potamogeton* spp., European Frogbit, Water Caltorps, Hornworts, *Ceratophyllum* spp. and Watermilfoils, *Myriophyllum* spp.). Some habitats are pioneer plant communities which develop on the dried bottoms (3130 and 3270). They also could be associated with ponds as fish farms. Preserving the bottom substrate will ensure the protection of diaspora of the valuable species associated with these habitats, such as *Dichostylis micheliana*, *Lindernia procumbens* and *Isolepis supina*. Some of these species are rare and protected according to the Biodiversity Act. Implementation of the measure would be best throughout the farm, but if not technically possible, at least 50% of it. This will ensure the refuges and breeding grounds for many aquatic animals.

(4) Maintaining patches of the floating aquatic vegetation. Generally, the floating aquatic vegetation is undesirable in fish farms, since it causes shading of the lower layers of the water and the bottom of the water basin. At the same time, the floating vegetation is habitat for a number of hydrobionts, is shelter for birds and of itself represents a valuable biological species (*e.g. Nymphaea alba*, *Nuphar luteum, Trapanatans* and *Marsilea quadrifolia*). However, to avoid the excessive development of macro-

phytes some intervention is required but this should not result in the radical removal of the floating plants.

(5) Maintaining the vegetation on dikes. Removing of the vegetation from dikes, such as grass and trees, is carried out in order to improve visibility, prevent settlement and nesting birds and easier passing. However, in most cases, the ponds are surrounded by plant communities that are habitat for feeding, migration or wintering of rare waterfowl and coastal birds, such as Pygmy Cormorant (*Haliaetor pygmeus*), Common reedbunting (*Emberiza schoeniclus*) and Bearded Reeding (*Panurus biarmicus*), as well as small predators (*Lutra lutra* and *Mustela putorius*).

(6) Prevent the escape of cultured species. Availability of facilities preventing escape of cultivated farm species is required, especially in cases in which farms cultivate non-native species with the potential to be invasive in the wild. The main risk for target species in the protected NATURA 2000 areas is from transmission of disease-causing organisms, hybridisation with native species, and competition for space and food.

(7) Use of eco-feeds. Pollutants in the fish-pond effluents are generally the result of uneaten feed and waste products from the fish. The use of high-quality eco-feeds improves not only feed conversion, but usually feed consumption as well.

(8) Decreasing of fish density. Lower stocking rates allow more efficient use of feed and ultimately reduce pollution. The lower levels of fish density will result in a low organic load, and therefore, a better water quality, limiting the algal blooms, reducing the need for the use of chemicals.

(9) Measures to repel predators. The use of electric fences in case of predatory species, such as European Otter (*Lutra lutra*), and other predators (foxes, jackals, European polecat) provoke a conditioned reflex to avoid the electric fence. This activity can suggest the establishing of some distance from predators to the cultured species. Implementation of this measure would reduce the losses of fish without harming the environment and, in particular, of protected species (Otters and fish-farming, 1995).

(10) Measures to reduce damage from fish-eating-birds. Using nets that cover the water area of the water body is a good method for the protection of fish from fish-eating birds. These nets are made of polypropylene material, which does not affect the product quality, the chemical composition of water or the state of the environment. The most effective measure is to put the net below the surface to a depth of at least 6 cm, and to place the net over the water surface at an angle of 45°, in order to prevent birds landing there on (Control of Bird Predation at Aquaculture Facilities: Strategies and Cost Estimates, 1997). To provide food resources for the bird species found in the protected area, stocking of one of the pools on the farm with small fish is recommended. Implementation of the measure will provide food resources for fish-eating birds and at the same time will prevent the loss of species forming the main production of the farm. Establishment of places in the water pool of bundles of twigs, frayed ropes, artificial macrophytes, submerged pipes, etc., where fish can hide from fish-eating birds is also recommended.

Conclusions

Freshwater farms in the country within the territory of the NATURA 2000 network make up one-third of the total number of existing farms in 2014. Most significant is the number of warm-water farms, which correlates with the prevalence of this type of farming as a whole in the aquaculture sector in Bulgaria. Eighteen per cent of freshwater farms fall into protected sites under Directive 92/43/EEC for the conservation of natural habitats and of wild fauna and flora, and 5% are in protected sites under Directive 2009/147/EC on the conservation of wild birds. Implementation of appropriate measures allows farms to continue their existence, but fulfil the objectives of protected sites to maintain the favourable conservation status of target species and habitats. The measures are mainly related to the reduction of the intensification of production, the application of extensive ways of working, modern methods of cultivation of hydrobionts and the fight against environmentally unfriendly practices applied so far.

Acknowledgement

Wo would like to thank Lidia Rashkova for being very kind to help us in preparing the present work providing statistical data and information.

References

Ackefors, H. and M. Enell, 1994.The release of nutrients and organic matter from aquaculture systems in Nordic countries. *Journal of Applied Ichthyology*, **10**: 225–241.

Beveridge, M. C. M., Ross, L. G. and L. A. Kelly, 1993.Environmental impact of aquaculture – disturbances of biotops and influence of exotic or local species new in aquaculture. In: world Aquaculture'93 Conference, Spain, p. 494. Special publication N 19.European Aquaculture Society, Ostend, Belgium.

Bodner, M., 1995. Otters and fish-farming: Preliminary experiences of a WWF project in Austria, *WWF Projekt Fischotter*, pp. 223-228.

Crowe, T. P., J. E. Fitch, C. L. J. Frid and P. J. Somerfield, 2011. A framework for managing sea bed habitats in near shore Special Areas of Conservation. A report for the Department of the Environment, Heritage and Local Government, Ireland.

Crozier, W. W., 1993. Evidence of genetic interaction between escaped and farmed salmon and wild Atlantic salmon (*Salmo salar* L.) in a Northern Irish river. *Aquaculture*, **113**: 19–29.

European Commission, 2012. Atecma (N2K Group), national authorities, aquaculture associations and NGOs. Guidance on Aquaculture and Natura 2000. Sustainable aquaculture activities in the context of the Natura 2000 Network, European Commission, **90**: 14–36.

Gowen, R. J., H. Rosenthal, T. Makinen and I. Ezzi, 1990. Environmental impact of aquaculture activities. In: Aquaculture Europe '89-Bussiness Joins Science, de Paw, N. and Billard, R. (eds). EAS, Sp. Publ. No **12**, Belgium, pp. 257–283.

Guo, L. and Z. Li, 2003. Effects of nitrogen and phosphorus from fish cage-culture on the communities of a shallow lake in middle Yangtze River basin of China. *Aquaculture,* **226**: 201–212.

ICES, 2005.Report of the Working Group on Environmental Interactions of Mariculture (WGEIM), 11– 15 April 2005, Ottawa, Canada. CM 2005/F:04. 112 pp.

http://www.marlin.ac.uk/. Marine life protection. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom.

Fernandes, T. F., A. Eleftheriou, H. Ackefors, M. Eleftheriou, A. Ervi, A. Sanchez-Mata, T. Scanlon, P. White, S. Cochrane, T. H. Pearson and P. A. Read, 2001. The scientific principles underlying the monitoring of the environmental impacts of aquaculture. *J. Appl. Ichthyol*ogy, **17**: 181–193.

Kotchev, H. and D. Yordanov, 1981. Vegetation in the water basins in Bulgaria. Ecology, protection and economical significance. S., 183 pp. (Bg).

Krkošek, M., S. Ford, A. Morton, S. Lele, R. A. Myers and M. A. Lewis, 2007. Declining wild salmon populations in relation to parasites from farm salmon. *Science*, **318** (5857): 1772–1775.

Martinez-Porchas, M. and L. R. Martinez-Cordova, 2012. World Aquaculture: Environmental Impacts and Troubleshooting Alternatives. The Scientific World Journal, Article ID 389623, 9 pages doi:10.1100/2012/389623.

Penczak, T., W. Galicka, M. Molinski, E. Kusto and M. Zalewski, 1982. The enrichment of a mesotrophic lake by carbon, phosphorus and nitrogen from the cage aquaculture of rainbow trout, *Salmo gairdneri. Journal of Applied Ecology*, **19**: 371–393.