RESEARCH ARTICLE **(Open Access)**

Climate Change Effects to Aquaculture Production Based on Social and Economic Indicators of the Albanian Marine Aquaculture

RIGERS BAKIU[1,2,3*]

[1]Department of Aquaculture and Fisheries, Faculty of Agriculture and Environment, Agricultural University of Tirana, Koder-Kamez, Tiranë, Albania

[2]Albanian Center for Environmental Protection and Sustainable Development, Tiranë, Albania

[3]Albanian Young Academy – Academy of Sciences of Albania, Tiranë, Albania

*Corresponding author; E-mail: rigers.bakiu@ubt.edu.al

Abstract

In Albania, the most produced species by the aquaculture sectors are represented (at a decreasing order) by gilthead seabream, European seabass, rainbow trout, carp species and Mediterranean mussels. The production of gilthead seabream and European seabass is realized by using the marine cage production systems along the south Adriatic and Ionian coasts of Albania. Like everywhere in the Mediterranean basin, the climate change effects are becoming evident in the marine aquaculture farms, according to the representatives of the aquaculture companies in Albania. Climate change poses increasing challenges to aquaculture, resulting in the need to develop appropriate tools to assess these challenges and support decision-making. By using Decision Support Software (DSS) for the Greek Marine Aquaculture, the aim of the presented study is to simulate the effects of climate change (CC) on aquaculture production and associated socio-economic indicators by considering only the European seabass. In addition were performed the calculations of business economics of the farm for Bay of Vlora climate scenario and management options, based on the input values for the various prices and costs. Though it is a study about the marine aquaculture of Albania, all the hypothetical proposed adaptive measures emerged out based on the biological, physiological data of the European seabass and the relative technology applied in northern Greece marine farms. All these proposed adaptive measures should be seriously considered by the managers at local level and the policymakers at national level.

Keywords: European seabass, Bay of Vlora, simulations, climate change scenarios

1. Introduction

Aquaculture started in Albania about 50 years ago, when the first extensive carp farm was established to ensure that the local population would have a supply of affordable fish products [1]. At present, Albanian aquaculture enterprises employ intensive, semi-intensive, and extensive farming techniques. The main farmed species include trout (*Oncorhynchus mykiss* and *Salmo letnica*), European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and Mediterranean mussel (*Mytilus galloprovincialis*). The total aquaculture production has steadily increased over the recent years from 3450 tons in 2012 to 6258 tons in 2018 of which value was about 22 million USD [1].

According to the National Institute of Statistics in Albania [2], fisheries production never increased significantly from 2014 to 2019, while the aquaculture production increased significantly, where the highest level on increased production was registered from 2013 to 2015, with an increase of 1000 tons.

The most produced species by the aquaculture sectors are represented (at a decreasing order) by gilthead seabream, European seabass, rainbow trout, carp species and Mediterranean mussels [2].

The production of gilthead seabream and European seabass is realized by using the marine cage production systems along the south Adriatic and Ionian coasts of Albania. In Vlora bay there are 7 aquaculture enterprises farming finfish in cages producing, all together, about 75% of national production of European seabass and gilthead seabream.

Notwithstanding the increase in production over the past years, the net trade balance remains negative for Albania, which is a net importer of seafood to meet the domestic demand for fishery products. Therefore, to cover national demand, Albania imports marine

*Corresponding author: Rigers Bakiu; E-mail: rigers.bakiu@ubt.edu.al
(Accepted for publication)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

aquaculture products, mainly European seabass and gilthead seabream from Greece. With a levelling-off of production from capture fisheries which was just over 8 600 tonnes per year, further aquaculture development remains the only way to ensure self-sufficiency and a sustainable production.

Main problems faced by aquaculture sectors at the origin of modernization of this sector is related to the inexistent national inputs to the aquaculture sectors. For the freshwater fish species (trout and carp species) several hatcheries are present in Albania, while regarding the marine aquaculture no hatcheries exist up to now and the fingerlings are imported from Greece and Italy. The fish feed is mainly imported from Italy, France, Germany and Turkey (in the case of KILIC company, which is the biggest producer of trout in Albania). In order to increase the productivity, it should be required the establishment of a national organization of aquaculture producers in order to minimize the costs of the aquaculture inputs, besides other required intervention of the policymakers by following ecosystem based-approach with the involvement of all the stakeholders (including the scientists and the academia).

By using Decision Support Software (DSS) for the Greek Marine Aquaculture, the aim of the presented study is to simulate the effects of climate change (CC) on aquaculture production and associated socio-economic indicators by considering only the European seabass. In addition, the calculation of business economics of the farm for Bay of Vlora climate scenario and management options, based on the input values for the various prices and costs, represent another objective of the study.

2. Material and Methods

In the frame of ClimeFish (an EU funded project Horizon 2020) it was developed a Decision Support Software for the Greek Marine Aquaculture [3]. The aim of this software was to simulate the effects of CC on aquaculture production and associated socio-economic indicators by considering only tow species: the European seabass (*Dicentrarchus labrax*, an established species not only in Greece, but also in other countries of the Mediterranean basin) and meagre (*Argyrosomus regius*). Meagre represents an emerging interest species, though there is sufficient interest in Albania and just sea cage farm is growing it in Albania (located in the Bay of Vlora).

In the DDS Greece software the economic model calculates the business economics of the farm for the site selected climate scenario and management options based on the input values for the various prices and costs [3]. Regarding the biological model, individual growth and reproduction was modeled with the application of the Dynamic Energy Budget (DEB) theory by the ClimeFish team – a theory that provides the conceptual and quantitative framework to study individual metabolism throughout the entire life cycle of an organism [3]. Model for European seabass and meagre were developed using physiological data from all life stages and where validated against production growth performance data obtained from farms (the same technology and similar water quality parameters values to Albania). In these models, the bioenergetics of the individual are simulated as a function of temperature and food availability, which in turns allows for the prediction of measurable quantities such as weight, growth rate and feed consumption [3]. The relative clime data were provided from CERES project, (POLCOMS – ERSEM), another EU Horizon 2020 project.

Later on the results are extrapolated to the farm level for a population of fish. Population variability is introduced by subdividing the population into cohorts that differ in their initial body weight and in the values of specific parameters. The main results in the case of Greece marine aquaculture are that fish will grow faster in the future, requiring shorter periods to reach different commercial sizes. Depending on the region, production time may be shortened for up to 3 months by 2050 [3].

Furthermore, extreme events such as storms and heatwaves will negatively affect production by possible increase of mortality rates or disrupting feeding and increasing operational costs. Offshore sites showed high potential since they will promote faster growth in most regions simulated compared to their inshore counterparts. However the effect is highly region-specific. Management options such as site (inshore/offshore), market size, and predominantly the stocking month, will have an overall higher effect on growth than the projected change in climate.

Based on the fact that most of the fingerlings of European seabass (together with other inputs) are coming from the northern Ionian coast of Greece and the relative similarity to south Albanian morphology and hydrology of the coast, it was conducted a survey in the farms of Vlora Bay and Himara (Porto Palermo).

All the acquired real data from the representatives of the farms were used to do the relative economic and biological/production simulations in the two different (RCP 4.5 and RCP8.5) scenarios in a short term time scale.

3. Results and Discussion

The biggest producers were represented by AL-MARINA OR and Alb-Adriatico 2013, which are exporting the product toward EU member countries (mainly Italy, Germany and Poland). The general interest according to them is to produce individual of at least 800g market size, while the mortality from storms and heatwaves resulted to be less than 5%. The seeding months of the European seabass (which is the only species considered in these simualtions) are represented by March, June and September. All the acquired real data from the representatives of the farms were used to do the relative economic (Fig. 1) and biological/production simulations (Fig. 2) in the two different (RCP 4.5 and RCP8.5) scenarios in a short term time scale.

As it is shown in Fig.1A, in the first scenario, when it would be expected an increase of maximum 1.9°C of the Albanian coast, it resulted that costs would increase for growing the fingerlings would increase with the time, while the profits would decrease. In the case of the RCP8.5 (Fig. 1B, increase of 2.8°C) scenario there is no difference in costs and profits between the performed seedings in March, June and September, respectively. In the comparison between the two scenarios (RCP4.5 vs RCP8.5), it results that the costs are higher in the first scenario, while the profits are higher in the second scenario.

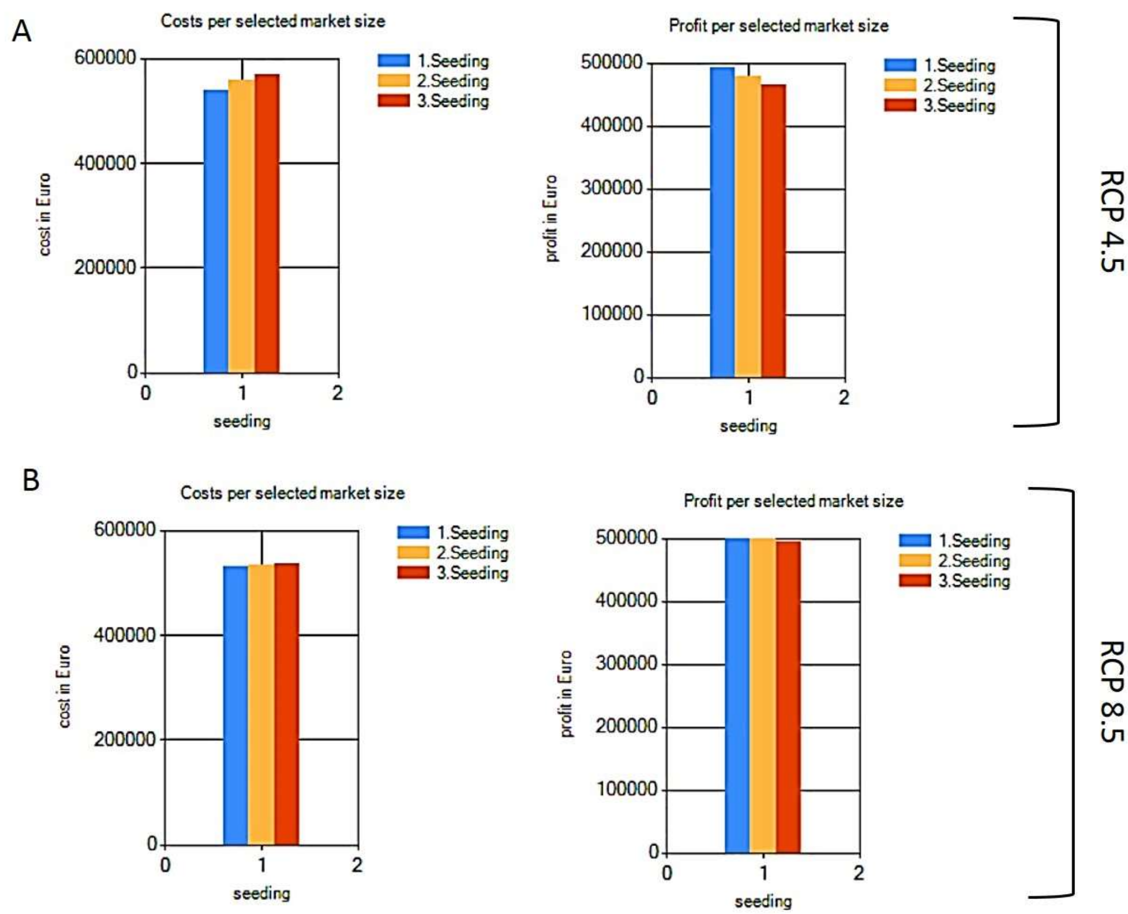

Figure 1. Economic simulations in the inshore farms of Bay of Vlora regarding costs and profits coming from producing European seabass with a market size of 800 g in the RCP4.5 (A) and RCP8.5 (B) scenarios.

Regarding the production/biological simulations (Fig. 2) in the two scenarios (RCP4.5 and RCP8.5), there is a higher growth rate in the first scenario, while the feed consumption (kg/weeks) is considerably higher than the second scenario – it probably creates higher cost to support the growing of the European seabass by the farmers in the Vlora Bay. Furthermore, the total biomass for the same time seems to be lower in the second scenario – this is supported by the fact that the European seabass is considered to be highly vulnerable to SST increase in the Adriatic Sea.

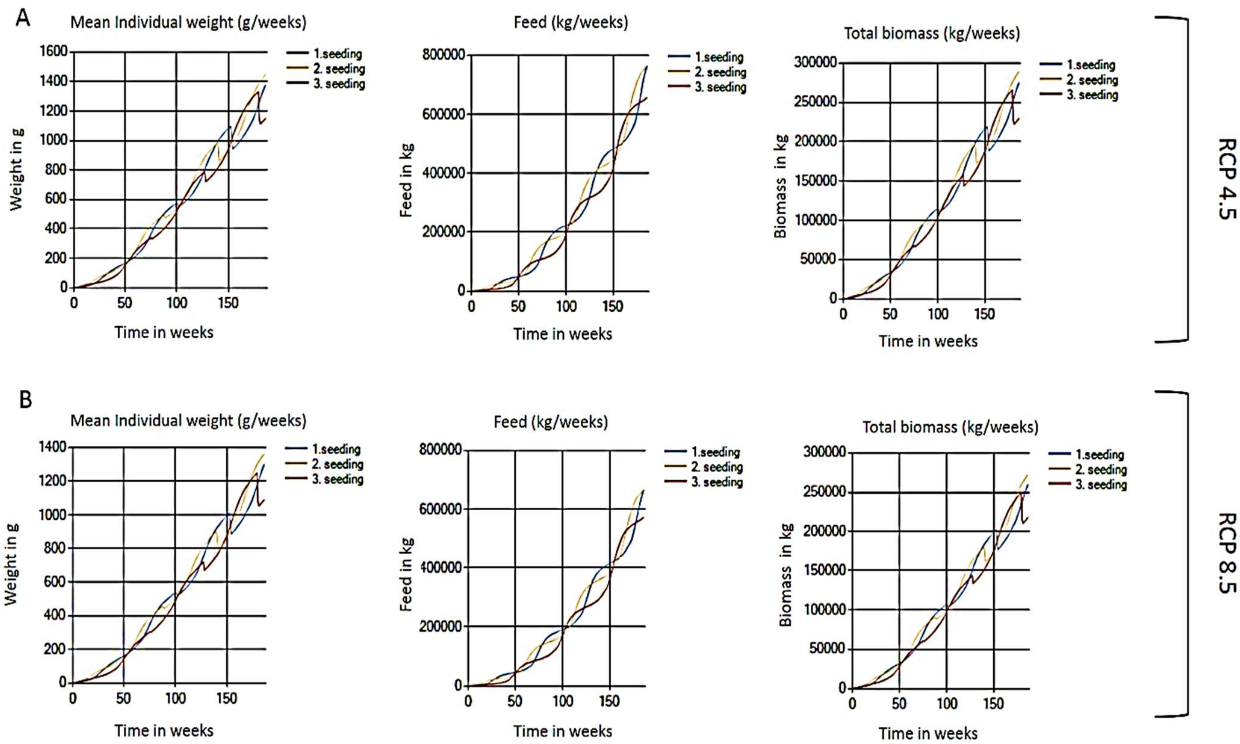

Figure 2. Biological/production simulations in the inshore farms of Bay of Vlora regarding growth rate, feed consumption and total biomass increase by growing European seabass upt to a market size of 800 g in the RCP4.5 (A) and RCP8.5 (B) scenarios.

Furthermore, a risk assessment analyses has been conducted by using software based on real available data from inshore aquaculture farms and considering biological, socio-economic, production and ecological/ environmental categories, while the main change driver is the temperature increase. It was based just on the input data provided by the inshore aquaculture farms, because the only offshore farm present in Albania is not growing anymore European seabass in the sea cages.

The relative outputs/results (considering biological indicators) about the risks and opportunities are rated at higher level in the RCP8.5 in comparison to the RCP4.5 scenario, while the potential adaptation measures to the impacts related to the risks are identical. The potential adaptation measures, considering the biological indicators are represented by 1) integration of farm-specific monitoring data in a monitoring program at a ZODA level; 2) research into fish response to higher temperatures; 3) develop and adopt more robust feeding infrastructures (automation and remote controls); 4) increase use of fouling resilient materials and upgrade of infrastructures to reduce negative effects of biofouling; 5) intensification and automation of the onsite cleaning processes in line with increased biofouling and 6) control health and quality of all imports to the farm.

The potential adaptations measures to the impacts related to the opportunities are also identical in both scenarios, which are represented by 1) funding and operation breeding programs for improved and more robust fish; 2) adaptive stocking planning; 3) adaptation of feeding strategies in line with monitoring

*Corresponding author: Rigers Bakiu; E-mail: rigers.bakiu@ubt.edu.al
(Accepted for publication)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

results; 4) investments in developing and adopting new offshore technologies; 5) develop marketing plans; 6) update of marine spatial planning framework (integrate aquaculture spatial planning into the existing framework); 7) research on feed consumption and efficiency in higher temperatures; 8) development of models for forecasting growth at the shifted temperature regime; 9) monitoring and mapping infections and diseases and 10) development of vaccines for emerging new pathigens and alternative preventive treatments to avoid establishment of diseases.

In the risk assessments for both scenarios by using production indicators, the rating value of the risks and opportunities were identical in both scenarios (RCP4.5 and RCP8.5). The potential risks and related impacts are represented by increase on aqua-feed price (including inhibition of growth, increased size variability and increase mortality). In the case of European seabass, the increased size variability create the conditions for the cannibalism appearance inside the sea cage, with consequently increases on mortality rate.

The relative potential adaptation measures are represented by 1) adaptation of feeding strategies in line with monitoring results; 2) develop marketing plans; 3) research on feed consumption and efficiency in higher temperatures and 4) development of models for forecasting growth at the shifted temperature regime.

Regarding the opportunities in both scenarios by an increased temperature, it is expected a moderate increase of production, which could increase employment and aquaculture share in national economy. The relative adaptation measures to the related impacts to these new opportunities are represented by 1) funding and operation breeding programmes for improved and more robust fish; 2) adaptive stocking planning; 3) adaptation of feeding strategies in line with monitoring results; 4) investments in developong and adopting new offshore technologies; 5) develop marketing plans; 6) update of marine spatial planning framework (integrate aquaculture spatial planning into the existing framework); 7) research on feed consumption and efficiency in higher temperatures; 8) development of models for forecasting growth at the shifted temperature regime; 9) monitoring and mapping infections and diseases and 10) development of vaccines for emerging new pathogens and alternative preventive treatments to avoid establishment of diseases.

Regarding the risk assessment based on ecological and environmental indicators showed differences of the rating index values in the comparisons between RCP4.5 and RCP8.5 scenarios; a higher risk would result by the increased organic discharge in the second scenario in comparison to the first one (RCP4.5), while even the opportunities (though at minor level) would be higher in the case of the RCP8.5 scenarios.

In both scenarios were not registered adaptive measures (as results of relative simulations) toward the related impacts to potential opportunities. The relative adaptation measures to the related impacts to potential risks are represented by 1) investments in developong and adopting new offshore technologies; 2) monitoring and mapping infections and diseases; 3) development of vaccines for emerging new pathigens and alternative preventive treatments to avoid establishment of diseases; 4) integration of farm-specific monitoring data in a monitoring programme at a ZODA level; 5) increase use of fouling resilent materials and upgrade of insfrastructures to reduce negative effects of biofouling and 6) control health and quality of imports to the farm.

All the hypothetical proposed adaptive measures emerged out based on the biological, physiological data of the European seabass and the relative technology applied in northern Greece marine farms. Based on the similarities of the coast and the identical technology applied in the marine aquaculture sector, all these proposed adaptive measures should be seriously considered by the managers at local level and the policymakers at national level.

4. Acknowledgements

This study was supported by the Food and Agriculture Organisation during the preparation of the national document about climate change effects to the agriculture sectors.

5. References

1. FAO 2011-2020. **Fisheries and aquaculture software**. FishStatJ - Software for Fishery and Aquaculture Statistical Time Series. In: FAO Fisheries Division [online]. Rome. Updated 22 July 2020. [Cited 14 October 2020].

2. INSTAT, 2020. **Fishery Statistics 2020**. http://www.instat.gov.al/en/themes/agriculture-and-fishery/fishery/ [Cited 25 May 2022].
3. Stavrakidis-Zachou O, Sturm A, Lika A, Wätzold F, Papandroulakis N: **ClimeGreAq: A software-based DSS for the climate change adaptation of Greek aquaculture.** Environmental Modelling & Software 2021, 143https://doi.org/10.1016/j.envsoft.2021.105121.