Expected Climate Change Effects on Gilthead Seabream and European Seabass Abundance and Catch in Albanian Waters

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RESEARCH ARTICLE **(Open Access)**

Expected Climate Change Effects on Gilthead Seabream and European Seabass Abundance and Catch in Albanian Waters

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Abstract

Climate change has triggered heterogenous pattern of changes in abundance, survival, growth, reproduction phelogeny and distribution of different aquatic communities. The Mediterranean Sea has been identified as one of the most vulnerable regions, and in absence of management plans the status of fishery resources is likely to deteriorate. This paper presents the expected effcts of climate change, represented by the increased Sea Surface Temperature, on the abundance and catch of gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*), in Albanian waters. The ecological productivity and the fisheries catches of these two speces were estimated using the dataset available at the Copernicus EU database. The model used Size Spectra – Dynamic Bioclimate Envelope Model takes into account the impact of environmental changes and human activities to determine biomass and distribution of fish species in response to environmental changes. In order to assess the impact of climate change, the status of fish stocks is defined under two climate scenarios based on different Representative Concentration Pathway. The effects of climate change and fishing management measures are shown to be insignificant on the abundance of gilthead seabream stock. In the case of European seabream, our results suggest thath the effects of climate change will be severe and the lack of proper management measures would be destructive for the stock. Proper adaptation and mitigation measures should be applied in order to minimize the effects of climate change on these fishing resources.

Keywords: Climate Change, gilthead seabream; European seabass; Adaptation Measures; Mitigation Measures.

1. Introduction

A heterogeneous pattern of change in primary production has been observed in the last decades in the Mediterranean Sea, with some areas showing increasing trends and others degreasing [9]. However, the expected changes in stratification, the decrease in the strength and frequency of local upwelling events, and the decrease in precipitation (and run-off) are expected to reduce the overall primary production in the Mediterranean Sea in the future [4]. With reference to the likely geographic differences in surface stratification, the western basin will become more oligotrophic in association with a surface density decrease, while surface production will increase in the eastern basin linked to a density increase [20]. The Mediterranean zooplankton community is expected to synchronously change over the basin along with a likely decline of species richness [5]. The proliferation of gelatinous species is one of the main ecological consequences anticipated, partially attributed to climate change and largely observed in the Mediterranean [11]. In higher trophic levels, the main effects reported in the Mediterranean Sea across all taxa as a result of warming include changes in abundance, survival, growth, fertility/ reproduction, migration and phenology (reviewed by Marbà et al., 2015 from 464 studies). Mass mortality events induced by progressive warming and heatwave events are robustly attributed to climate change from the early 1980s [17]. Examples of changes in species

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distribution and local abundance related to warming are widespread with two characteristic patterns: 1)Meridionalization: the northward extension, colonization and enhancement of thermophilic species into the colder north Mediterranean regions [18]; and 2) Tropicalization: the increasing introduction and range extension of thermophilic, non-indigenous species, including Lessepsian species from the Red Sea and from the Indo-Pacific region (more than 900 species reported) [6]. Future projections show that regional changes in fish abundance and their distribution will alter species richness, with an expected increase in overall richness by the mid-twenty-first century in the Eastern Mediterranean, and a decrease in the western region [1].

In the absence (or lack) of strong management plans, the deteriorating status of fisheries and their resources in the Mediterranean Sea is likely to aggravate, especially in a climate change context [8]. The Mediterranean Sea has been identified as one of the most vulnerable regions in future climate change projections [10]. Effects of climate change on marine ecosystems are already clearly perceivable, with impacts reported from low (e.g. macrophytes, phytoplankton) to high (e.g. predatory fish) trophic levels, from individual up to the ecosystem scale [7, 21] which could affect biodiversity, commercial fisheries, food web and ecosystem functioning [1, 21, 22, 23].

As one of countries along the coast of the Mediterranean basin, Albania will be subject to all these effects, while marine fisheries will be vulnerable to all these effects driven by the climate change and illegal practices of fishing (overfishing and overexploitation of the marine resources). In this paper, the general aim is to analyse the expected climate change effects on the abundance and fisheries catch of two of the most important (production volume and value) species for the aquaculture in Europe and Mediterranean, gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) [2]. These species are also well priced and listed between the most preferred species not only in Albania, but in all the Mediterranean, though are not listed between the most fished ones in the Albanian territorial waters. By analyzing the prediction results presented in the Copernicus EU database, we evidenced important considerations, which could contribute for tailoring climate change adaptation and mitigation measures in the fishery sectors (fisheries and aquaculture)**..**

2. Material and Methods

In order to estimate the ecological productivity and the fisheries catches regarding gilthead seabream and European seabass in the marine water of Albania, it was used the dataset available at the Copernicus EU database named "Fish abundance and catch data for the Northwest European Shelf and Mediterranean Sea from 2006 to 2098 derived from climate projections"

The dataset contains model projections of fish catch and abundance in European seas out to 2098 produced using the Size Spectra – Dynamic Bioclimate Envelope Model (SS-DBEM). The SS-DBEM is a mechanistic model, which means that it takes into account aspects of ecology (e.g. habitat preference, migration) and physiology (e.g. growth and reproduction) to determine biomass and distribution of fish species in response to changes in the environment (e.g. temperature, competition with other species, food availability). The SS-DBEM projects the impact of changes in the environment (e.g. warming, deoxygenation) and human activity (fishing pressure) on the abundance and biomass of modelled species. All this makes it a state of the art model in regard to projecting fish distribution and trends in both abundance and catch in response to climate change. Model outputs consist of fish abundance (number of fish per grid cell) and fish catch (number of fish caught per grid cell) considering three different fishing activity scenarios, termed the Maximum Sustainable Yield (MSY).

Whilst the model units are expressed as "Number of individuals", they are not to be used to predict actual future stocks, but rather numbers relative to the initial starting values of the model, which correspond to year 2006. This is because the model was not intialised with actual fish numbers and subsequently the significance of this dataset is to show temporal and geographical trends, relative to other years and other grid points, in response to changes in the climate and the applied Maximum Sustainable Yield (MSY).

In order to assess the impact of climate change, simulations under two future climate scenarios based on different Representative Concentration Pathways (RCP) for future greenhouse gas concentrations are conducted:

1. the intermediate scenario, RCP4.5, in which greenhouse gas concentrations peak around 2040 before declining mainly due to successful mitigation measures in place;
2. and the more pessimistic scenario, RCP8.5, where greenhouse gas concentrations continue to rise throughout the century.

Fishing activity was defined according to the MSY under these environmental conditions. The combination of MSY and RCP scenarios included in this dataset are:

• Global sustainability: RCP4.5 with a MSY of 0.6 (fish stock is managed globally toward sustainability)
• World Markets: RCP8.5 with a MSY of 0.8 (fish stock is managed globally to avoid overfishing)
• National Enterprise: RCP8.5 with a MSY of 1.1 (fish stocks are managed at the national level resulting in overfishing)

The simulations (the relative results are present in the Copernicus EU database) were run using inputs from two marine hydrodynamic-biogeochemical models (the POLCOM-ERSEM and NEMO-ERSEM models), though the authors of the paper used one of the models, the POLCOM-ERSEM which has been previously used in neighbor countries (Greece and Turkey).

These models were driven by one Coupled Model Inter-comparison Project Phase 5 (CMIP5) global climate model (GCM) projections with downscaled atmospheric data from a regional climate model (RCM), the Swedish Meteorological and Hydrological Institute (SMHI) Rossby Centre Regional Atmospheric Model (RCA4).

Furthermore, In order to have an estimation of the relative species in Albanian marine waters, it was used Panoply (www.giss.nasa.gov/tools/panoply) to view the used Copernicus EU dataset and later select the cells corresponding to the Albanian Exclusive Economic Zone (EEZ).

3. Results and Discussion

Albania is a country rich in water resources, with a 380 km coastline, of which 284 km stretches along the Adriatic Sea in the north and the remaining 96 km faces the Ionian Sea. The fisheries sector in Albania is relatively small, but it is important from a socio-economic point of view as it is a significant source of jobs in coastal and remote areas. The marine and coastal fisheries are the most important sub-sectors of the national fisheries. Marine resources in Albanian waters are shared Adriatic stocks. Marine fisheries are divided into professional industrial fisheries and professional artisanal fisheries.

Gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*), though don't represented the most fished species in Albanian marine and coastal waters (including lagoons) according to the recent reports of the National Institute for Statistics, both of them are included in the list of preferred species for consumtion by the local consumers.

In the Figure 1 are shown the relative catches coming out from the capture fisheries activities in the Republic of Albania from 2014 to 2019. It becomes evident that the gilthead seabream fisheries production has increased from 2014 and it reached the maximum production value in 2016, while later it was registered a slow decrease, though in the recent years it seems to have increased a bit (from 57 to 59 tonnes). Differenlty happened with the European seabass fisheries production. From 2014 to 2018 were observed some variations (increases and drops), while the average production value was roughly 44 tonnes. An increase of 33 percent was registered in 2019, which equalized to the production value of gilthead seabream (similarly to year 2014, when the corresponding species production levels were nearly the same). It is important to note that marine aquaculture sector of both species has been developed in the recent years along the coast of Southern Albania by providing considerable gilthead seabream and European seabass quantities not only for the local consumption, but even for exporting toward the EU countries [3].

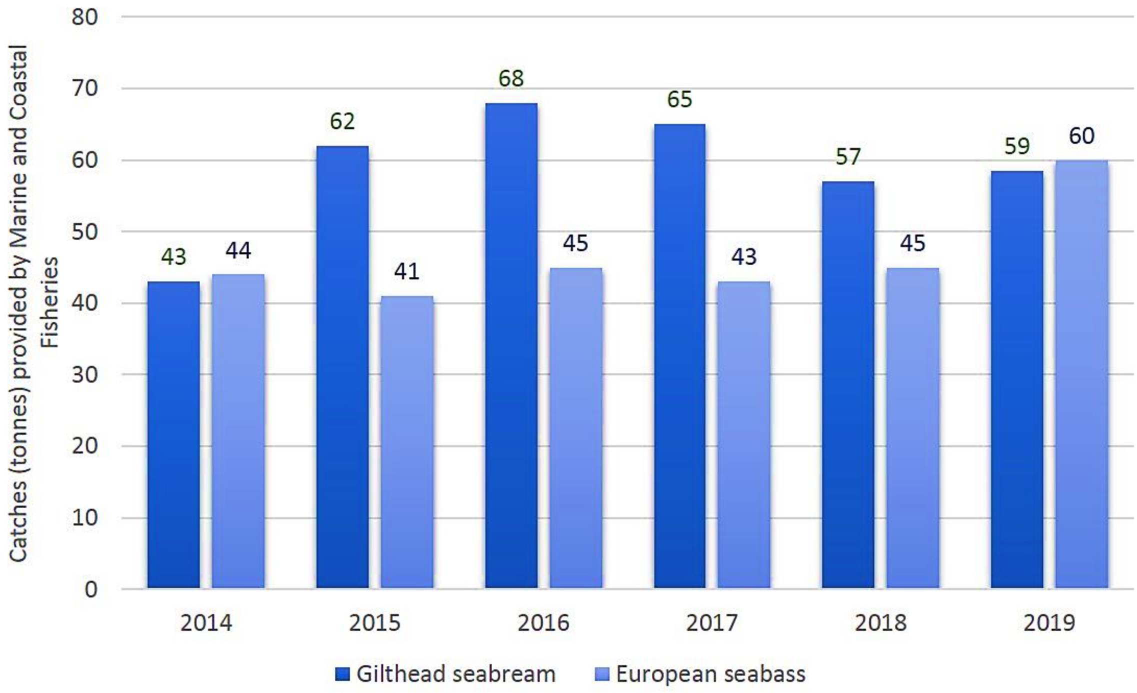

Figure 1. Graphical presentation of the gilthead seabream and European seabass catches provided by the marine and coastal fisheries from 2014 to 2019, according to the INSTAT 2020 reports.

Both species, gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) belonging to the family Sparidae and Moronidae respectively, are euryhaline and eurythermic species, which reproduce in marine environment but inhabit mostly coastal waters and lagunar areas with extreme salinity and temperature changes during their juvenile stages [24]. In this paper are shown the effects of the climate change, here represented by the increased Sea Surface Temperature (SST) on the abundance and fisheries catch of each species. In Figures 2 and 3 are shown the expected changes in abundance and catch values regarding the gilthead seabream in all the Mediterranean basin.

In the RCP4.5 scenario tha average temperature increase value is 1.5°C, while in the RCP8.5 scenario the average temperature change value is 2.0°C at the Albanian coasts, according to Albania's Third National Communication (2016), which provides temperature and precipitation projections for 2050 and 2100 based on RCP 2.6, 4.5 and 8.5 using SimClim2013.

As it is shown in Figure 2, in the Mediterranean basin no apparent big differences were observed regarding the expected gilthead seabream abundance between the RCP4.5 scenario (Figure 2 A, B and C) and the RCP8.5 scenario (Figure 2 D, E and F) in 2030, 2040 and 2050. Similarly to the abundance estimations for different scenarios, even in the case of the predicted catches of gilthead seabream (Figure 3 D, E and F) no apparent big differences were observed in the comparison between the relative values per grid cell in different years (2030, 2040 and 2050) for the same scenario (RCP4.5).

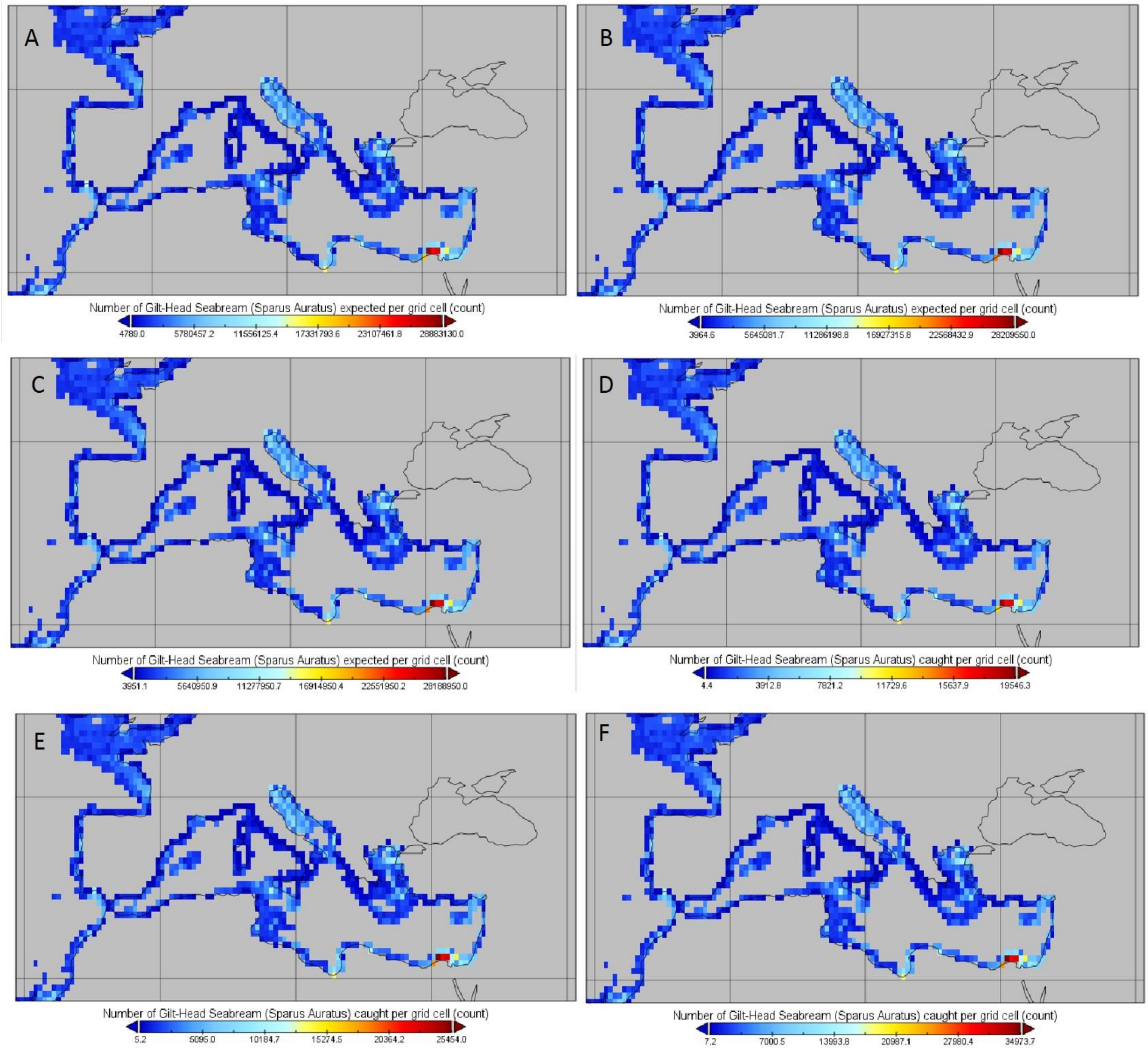

Figure 2. Graphical presentation of the expected abundance of gilthead seabream for the RCP4.5 scenario in 2030 (A), 2040 (B) and 2050 (C); for the RCP8.5 scenario in 2030 (D), 2040 (E) and 2050 (F) in Mediterranean basin; according to POLCOM-ERSEM model.

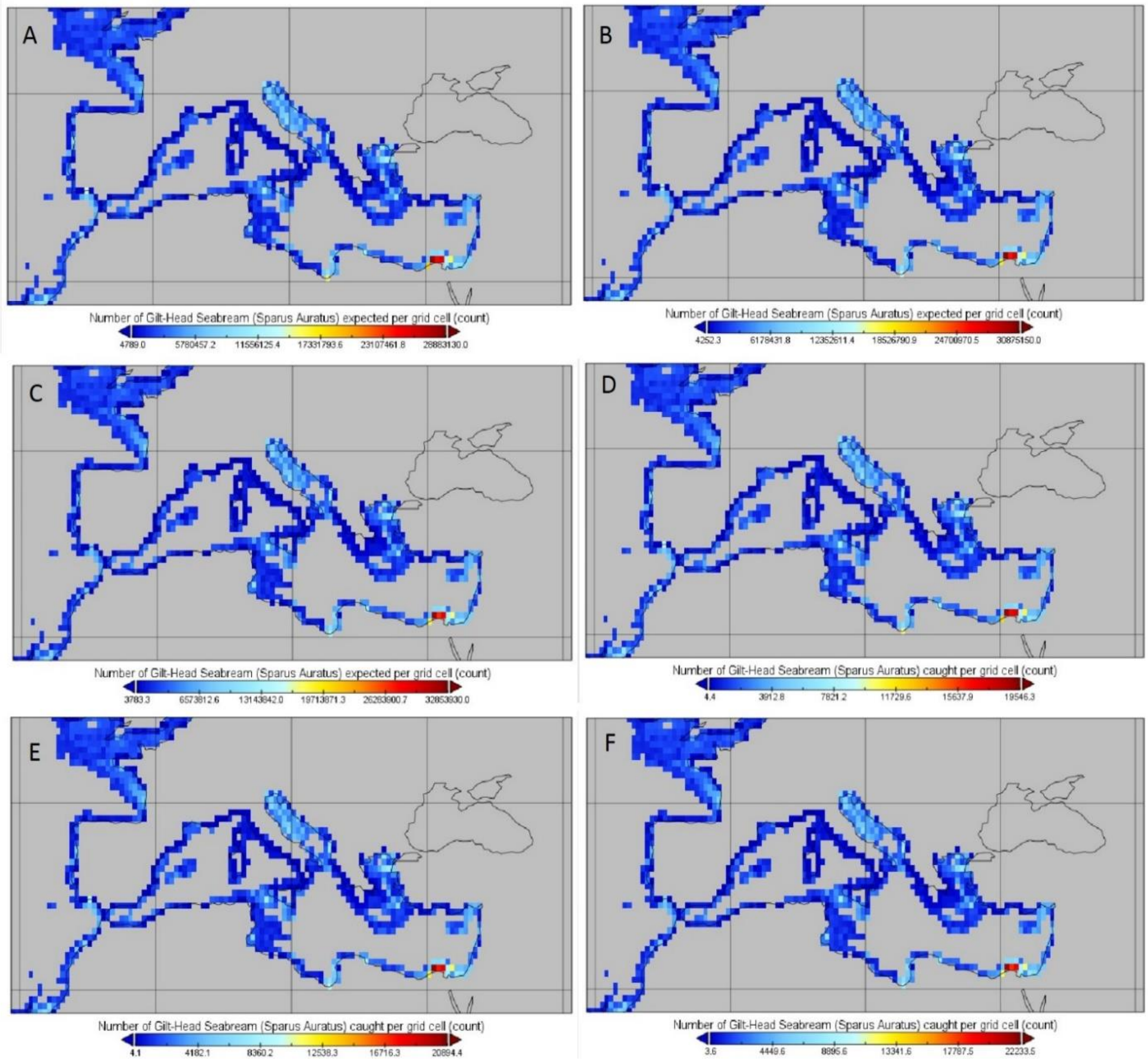

Figure 3. Graphical presentation of the comparisons between the expected abundance in 2030 (A), 2040 (B) and 2050 (C) and the relative catches in 2030 (D), 2040 (E) and 2050 (F) for the RCP4.5 scenario of POLCOM-ERSEM model, in the Mediterranean basin.

In order to focus our analyses to the Albanian territorial water, we selected the grid cells included in the EEZ of Albania and the relative results are shown in Figures 4 and 5 for European seabass and Figure 6 and 7 for the gilthead seabream, respectively. As it is shown in each of the figures are not included just the scenarios in relations to SST increase, but in each of the scenarios are integrated the fisheries management measures to mitigate the effects from climate change on abundance and catch of each considered species. As it is shown in Figure 4, the Global sustainability scenarios, in which the fish stock is managed globally toward sustainability, resulted to be the most protective to the European seabass stock, because the expected abundance was the highest in comparison to all the other scenarios (World Markets and National Enterprise). In the National Enterprise scenario the fish tocks are managed at the national level resulting in overfshing. Consequently the expected abundance of the European seabass resulted to be the lowest. In addition, it interesting to note that expected abundance levels remained nearly invariate in comparison between 2030, 2040 and 2050. Probably, it suggests that the effects of climate change in the comparsion between the two temperature scenarios (RCP4.5 in Global Sustaibility and RCP8.5 in World Markets) will be severe, but the overfishing due to lack of proper management measures (National Enterprise) added to the SST increase due to global warming would be destructive for the European seabass stock in the Albanian waters.

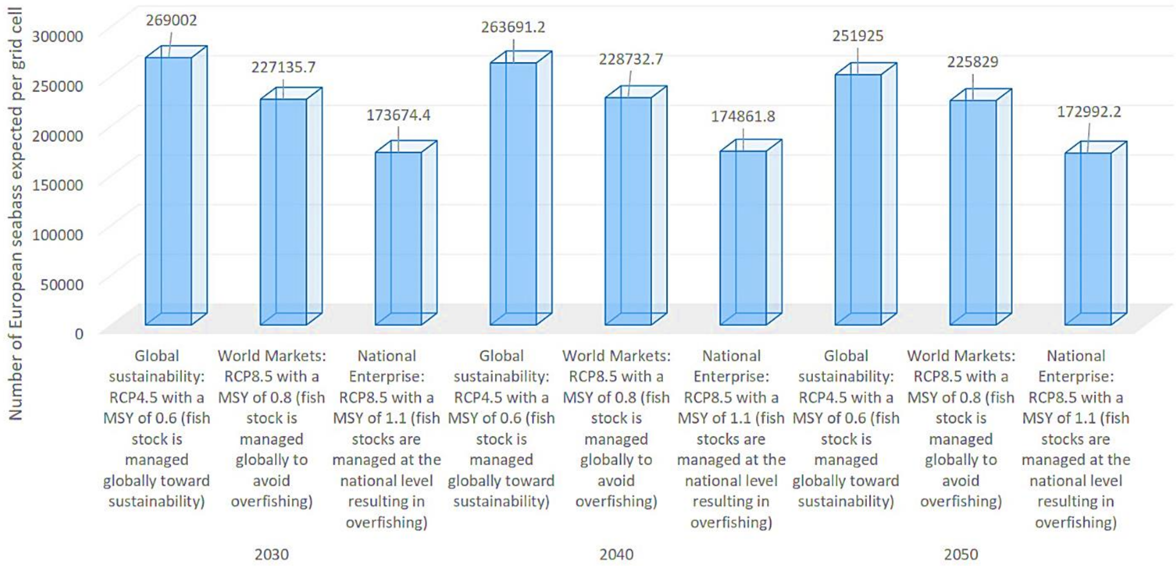

Figure 4. Graphical presentation of the expected abundance comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for European seabass.

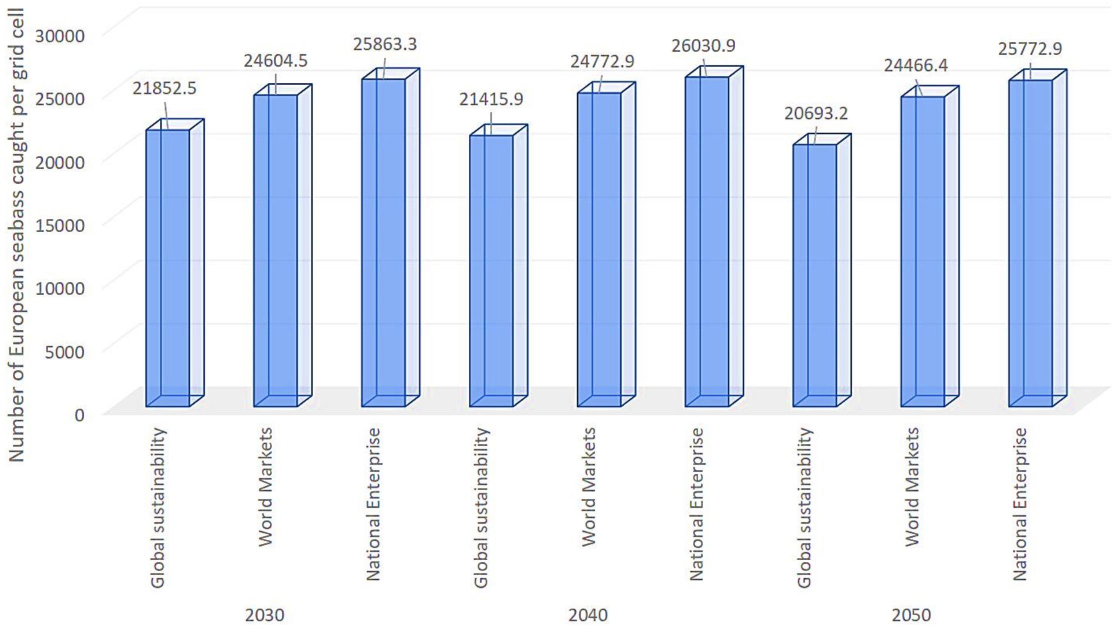

Figure 5. Graphical presentation of the expected fisheries catch comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for European seabass.

Analysing the results corresponding to the European seabass catches (Figure 5), it seems that the best scenario correspond to the National Enterprise, because it will create higher profitability for the fisheries, despite the abundance would decrease due to climate change and overfishing.

Like it was expected from the results of Figures 2 and 3, in the case of gilthead seabream, though the highest level of expected abuandance was observed in the global sustaibility, no significant difference was observed in comparison to the two scenarios of RCP8.5. Probably, the effects of climate change and fishing management measures are insignificant on the abundance of gilthead seabream stock, including the observations that these effects are not cumulative). It is also interesting to note that abundance of gilthead is expected to increase every ten years in the same way in all the scenarios. It can suggest that due to the highest increase of SST in 2050, the expected abundance of gilthead will increase roughly 19 percent from 2030 to 2050 according to the POLCOM-ERSEM model.

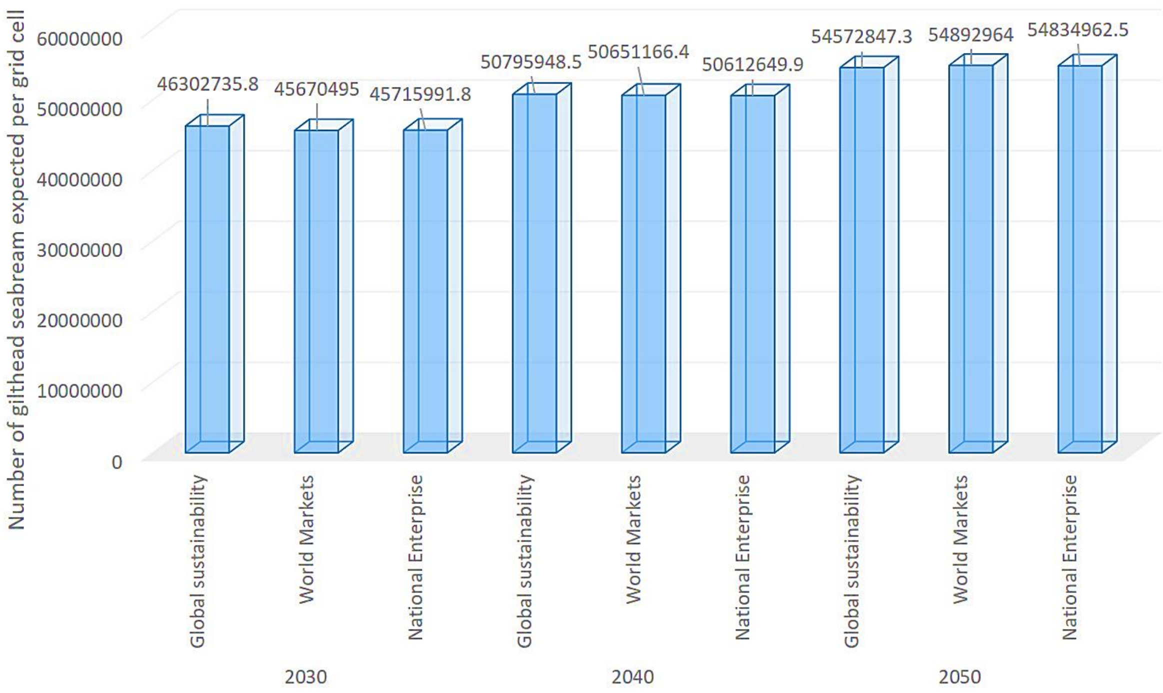

Figure 6. Graphical presentation of the expected abundance comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for gilthead seabream.

The increased abundance every 10 years, will minimize the effects of the fisheries management measures, because even in the worst scenario for the biodiversity (National Enterprise), the gilthead seabream catches will increase about 20 percent from 2030 to 2050. The relative possible explanations about this phenomen are prived below and probably it can be related to the different preference toward temperature of these two considered fish species, gilhead sea bream and European seabass.

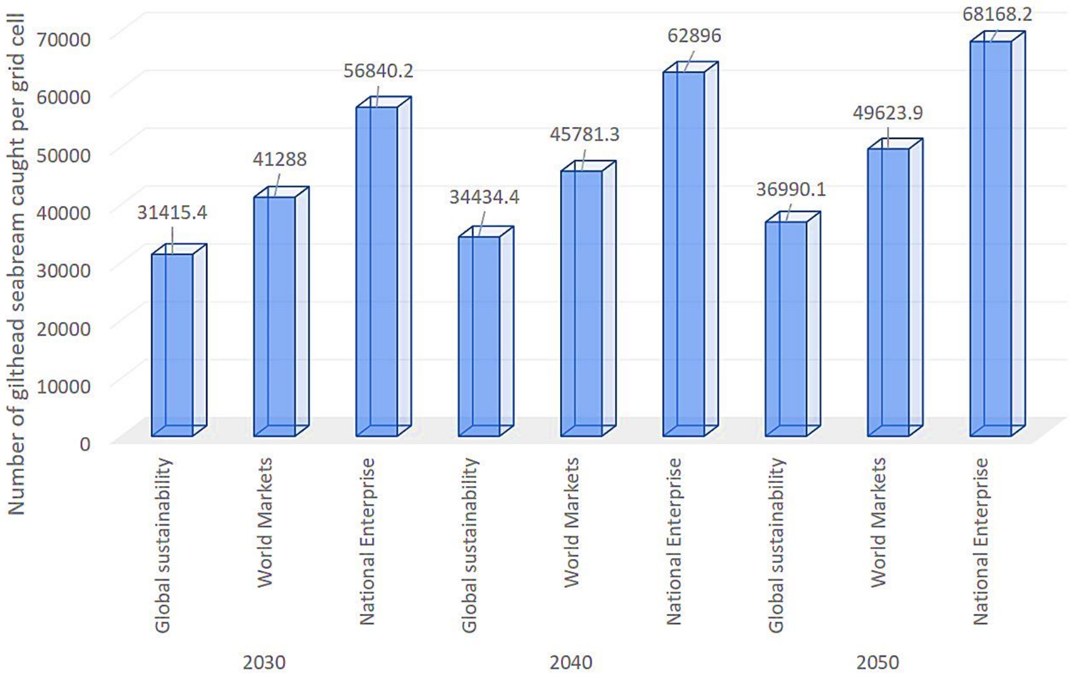

Figure 7. Graphical presentation of the expected fisheries catch comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for gilthead seabream.

Temperature and salinity are two of the most important environmental factors effecting survival and growth performance of marine organisms [19]. Temperature tolerance in fish varies according to species, acclimation temperature and acclimation time [12] and salinity [15, 16]. Therefore, knowing the effects of acclimation temperature and salinity on critical temperatures is important to understand how a species' biology can respond to spatial or temporal temperature during cold winter or dry hot summer months particularly in subtropical areas. Most of the results about the effects of the temperature on the growth and survival rates of gilthead seabream and European seabass are coming from experiments or trials mainly related to aquaculture sector interest [13, 14]. For instance the results of Yilmaz et al. (2020) revealed that the interaction between temperature and salinity have significant effects on growth and feed intake of juvenile European sea bass and the Mediterranean strain are more sensitive to high rather than low temperatures. It was also suggested that necessary precautions should be taken when this species is farmed in the southern parts of the Mediterranean with high ambient temperatures (>33-34 °C) during summer months, which suggested the preference of this species for lower temperature in comparison to the gilthead seabream, which are particularly sensitive to low temperature. Especially in the northern Mediterranean area, cold affects gilthead seabream health and decreases fish-farm production, and may even cause mortality through what is known as ‘Winter Disease’ or ‘Winter Syndrome’ [14]. All these experimental results from other research groups suggest that gilthead seabream and European seabass show differents preferences toward water temperature. In addition, from our analyses results it emerged out a positive correlation between the increased expected abundance of gilthead seabream and the increased SST every 10 ears.

It is also important to note that it should be clear that adaptation and mitigations measures should be taken to minimize the effects of climate change on the fishing resources (including the two considered species), though there are fish species like the gilthead seabream, which seems to be more abundant in the Albanian territorial waters in comparison to European seabass after 30 years. Although other evidences are needed, these analyses results suggest global warming effects makes the recover of this fish stock more efficient after properly applied fisheries management measure.

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