RESEARCH ARTICLE **(Open Access)**

Expected Climate Change Effects on Common Cuttlefish (*Sepia officinalis*) and Brown Shrimp (*Crangon crangon*) Abundance and Catch in Albanian Waters

RIGERS BAKIU[1*]

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

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 it is expected to become warmer and drier with an increase in inter-annual variability due to extreme heat and drought events. In this paper, the general aim is to analyse the expected climate change effects on the abundance and fisheries catch of two invertebrate representatives: European common cuttlefish (*Sepia officinalis*) and brown shrimp (*Crangon crangon*). 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 these species in response to environmental changes. In order to assess the impact of climate change, the status of common cuttlefish and brown shrimp stocks was defined under two climate scenarios based on different Representative Concentration Pathway. The effects of climate change (sea surface temperature increase) and fishing management measures are shown to affect differently on each species abundance and fisheries catch. Proper adaptation and mitigation measures should be applied in order to minimize the effects of climate change on these fishing resources.

Keywords: Climate Change; common cuttlefish; brown shrimp; adaptation measures; mitigation measures.

1. Introduction

Climate change (CC), may act at different biological levels, including individual, population, and ecosystem. In particular, species with a low dispersion ability are highly affected by climate change, which may also lead to local extinctions, greatly contributing to biodiversity loss. The Mediterranean Sea, also due to its geographic position between the temperate climate of central Europe and the arid climate of northern Africa, seems to be one of the most vulnerable regions to global climate change[6, 3].
The Mediterranean climate is expected to become warmer and drier with an increase in inter-annual variability due to extreme heat and drought events [3, 13, 14]. Even though the Mediterranean Sea is probably entirely affected by this warming trend, data on this phenomenon are mainly reported for the north-western Mediterranean [15]. Mediterranean temperature anomalies observed during summer 1999 and 2003 led to catastrophic mass mortality events, in particular of benthic invertebrates (e.g. sponges, gorgonians, bryozoan and molluscs) [17, 10, 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 [6].
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 effects driven by the climate change and illegal

*Corresponding author: Rigers Bakiu; E-mail: rigers.bakiu@ubt.edu.al
(Accepted for publication 10.04.2022)
***ISSN**: 2218-2020, © Agricultural University of Tirana*

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 invertebrate representatives: European common cuttlefish (*Sepia officinalis*) and brown shrimp (*Crangon crangon*). European common cuttlefish or common cuttlefish is a nektobenthic species inhabiting shallow coastal waters (to 200 m depth), ranging from the Baltic Sea to the Mauritania-Senegal border in the Northeast AtlanticOcean and throughout the Mediterranean Sea [11]. According to the national statistics of Albanian fishery catches (2020), this species is listed among the most fished cephalopods (http://www.instat.gov.al/en/themes/agriculture-and-fishery/fishery/#tab2), while the brown shrimp is not listed among the commercial species, though its presentce has been reported by [2].

The brown shrimp (*C. crangon*) is a marine coastal decapod species with a wide distribution range along the European coast from the white sea in the north of Russia to the Mediterranean and Black seas [8]. Within the Mediterranean, the distribution of *C. crangon* is not clear, though only in the Adriatic sea, it is subjected to a small-scale fishery [4]. However, it is important to note that brown shrimp fisheries are economically important in northwestern Europe and especially in The Netherlands, Germany, and Denmark [12].

By analyzing the prediction results presented in the Copernicus EU database, important considerations were evidenced and those could contribute for tailoring climate change adaptation and mitigation measures in fisheries.

2. Material and Methods

In order to estimate the ecological productivity and the fisheries catches regarding common cuttlefish and brown shrimp, as representatives of molluscs and crustaceans, 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 author 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.

The cephalopod fisheries catch composition ((http://www.instat.gov.al/en/themes/agriculture-and-fishery/fishery/#tab2) icludes represented by common octopus, common squid, common cuttlefish and Eledone spp, while the crustaceans fisheries catch composition includes deep-water rose shrimp, Norway lobster, caramote prawn, giant red shrimp, blue crab, blue and red shrimp and Mantis shrimp. It is important to note that the deep-water rose shrimp represents the second most fished species in Albanian marine waters. Unfortunately none of the presented species of crustaceans were included in 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". Based on the facts that satellite data show a steady increase, in the last decades, of the surface temperature (upper few millimetres of the water surface) of the Mediterranean Sea and reports of mass mortalities of benthic marine invertebrates increased in the same period [16], a study was conducted to show the effects of the climate change, here represented by the increased Sea Surface Temperature (SST), on the abundance and fisheries catch of each species, representing the marine invertebrates.

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.

In order to focus the analyses to the Albanian territorial water, were selected the grid cells included in the EEZ of Albania. In the case of common cuttlefish, in Figure 1 and Figure 2 are shown the expected abundance and fisheries catch comparisons, respectively. Regarding the brown shrimp, the relative comparisons are shown in Figure 3 and Figure 4, 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 1, the Global sustainability scenarios, in which the fish stock is managed globally toward sustainability, resulted to be less protective in 2030, while in 2040 and 2050, it resulted to be the most protective to the common cuttlefish 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 common cuttlefish stocks are managed at the national level resulting in overfshing. Consequently the expected abundance of the European seabass resulted to be the lowest in 2040 and 2050, though strangely it resulted to be higher than the Global sustainability in 2030.

In addition, it interesting to note that for the World Markets and National Enterprise scenarios, the expected abundance levels decreased at the same level in the comparisons 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 not influence the common cuttlefish stock in the Albanian waters.

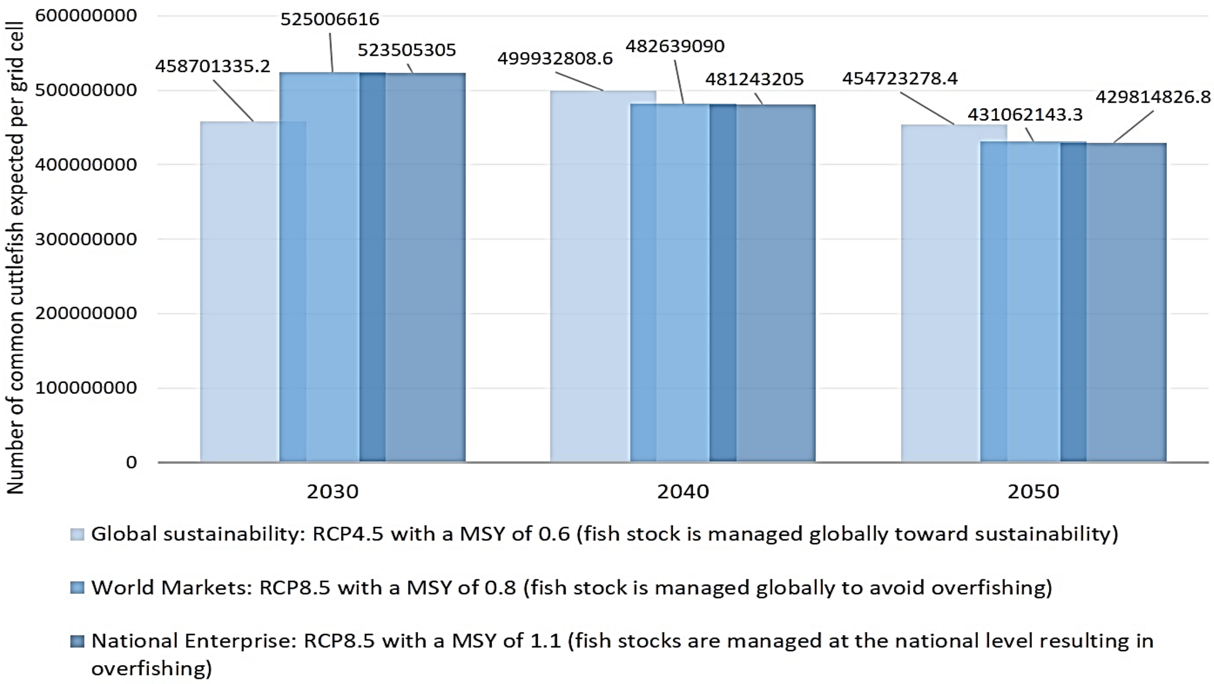

Figure 1. Graphical presentation of the expected abundance comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for common cuttlefish.

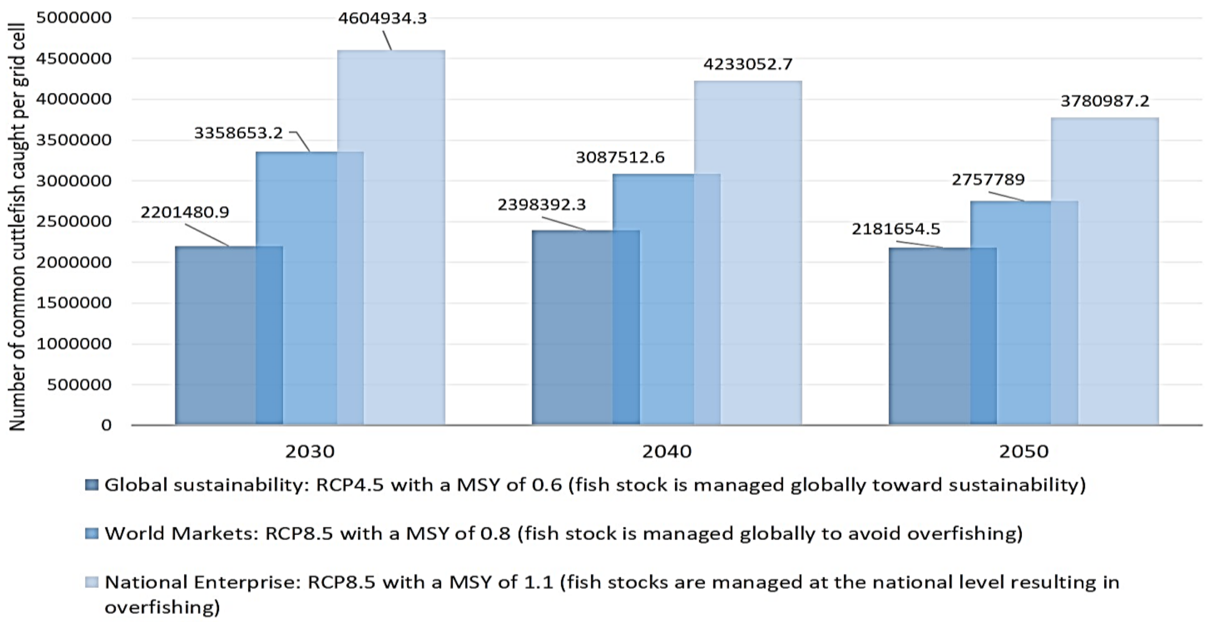

Figure 2. Graphical presentation of the expected fisheries catch comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for common cuttlefish.

Analysing the results corresponding to the European common cuttlefish catches (Figure 2), it seems that the best scenario correspond to the National Enterprise, because it will create higher profitability for the

fisheries, despite the production would decrease due to climate change and overfishing from 2030 to 2050.
In the case of brown shrimp, the first strategy resulted to be the worst in comparison to the other two strategies, because it resulted that if the stock will be managed globally to avoid overfishing, it will decrease the abundance of brown shrimp every 10 years. However, based on the expected abundance results corresponding to the World Markets and National Enterprise scenarios, the level of abundance will remain nearly invariate every 10 years, while it will increase in 2040 and 2050 for the second scenario (RCP8.5) in comparison to the first scenario (RCP4.5). It means that the best strategy would be to manage the brown shrimp to avoid overfishing and the SST increase would increase the abundance of the brown shrimp, though the overfishing would have severe impact on the brown shrimp abundance.

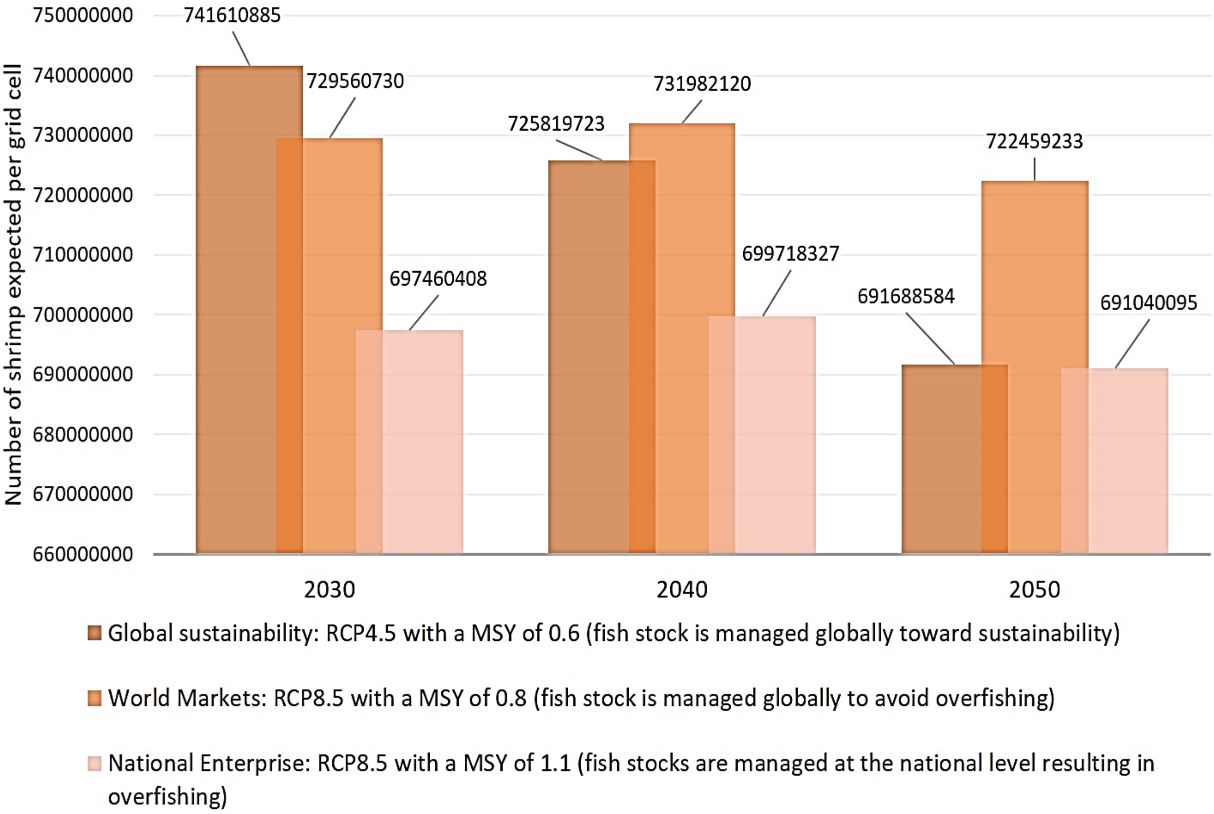

Figure 3. Graphical presentation of the expected abundance comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for brown shrimp.

Regarding the expected fisheries catch (Figure 4), even this case the worst scenario is represented by the Global Sustainability, while the catches will increase in the RCP8.5 scenarios, suggesting again that the fisheries production will be favoured by the increased SST increase.

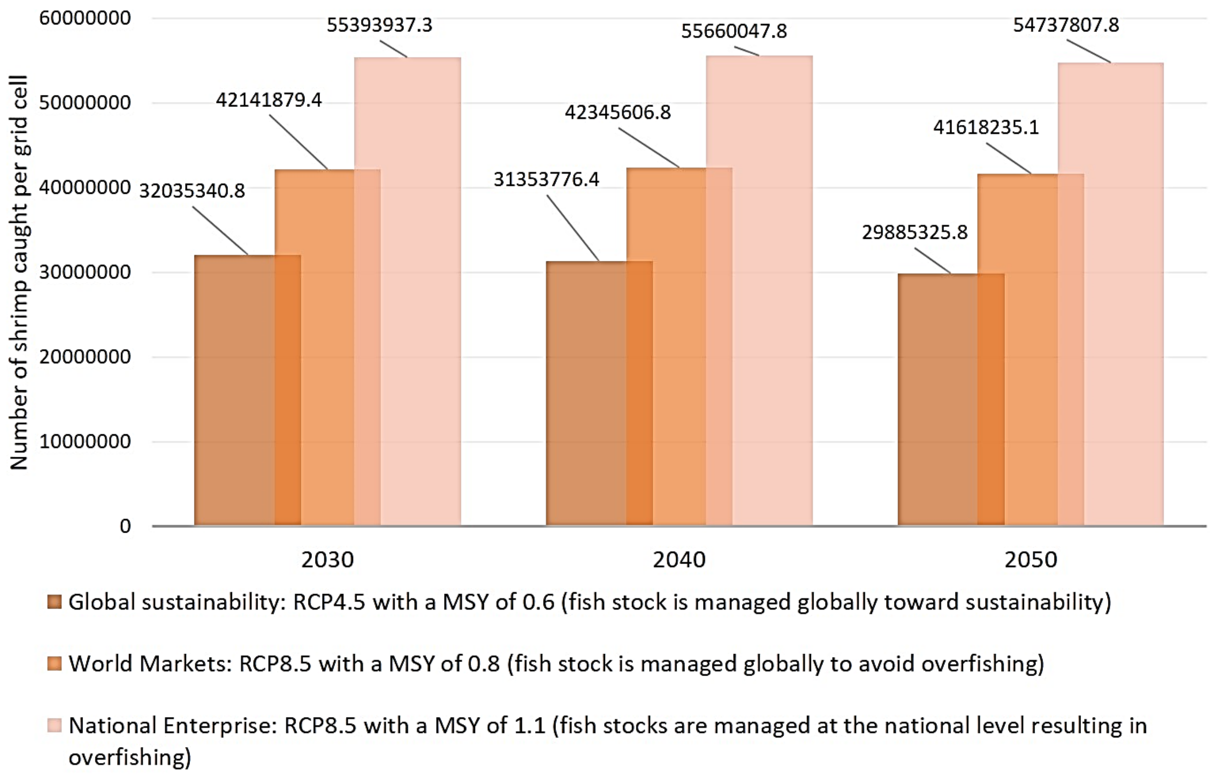

Figure 4. Graphical presentation of the expected fisheries catch comparisons between the three scenarios (Global sustainability, World Markets and National Enterprise) in each of considered years (2030, 2040 and 2050) for brown shrimp.

Climate change will have several eff ects on species by changing their suitable distributions and may aff ect their persistence, though it depends on the species life characteristics, strictly linked to the relative vulnerability [18]. For instance, in the Northern Adriatic, zooplankton relic cold-water species such as *Pseudocalanus elongatus* are restricting their winter appearance due to fall temperature increase [7]. In Tunisia, the distribution area of the mussel *Mytilus galloprovincialis* is increasingly restricted toward colder areas, less influenced by sea warming [10]. Since slow-growing, benthic suspension feeders efficiently extract and process energy from planktonic ecosystems [9], mortalities affecting this functional group may induce long-term effects on both planktonic and benthic communities. In this situation, the biota represent a reliable proxy for ecological responses to global change [16]. In this paper, the response of this two invertebrate species was different to the CC and even the adaptation and mitigation measures should be different to minimize the effects of climate change on these fishing resources, though the brown shrimp fisheries is less important in comparison to the common cuttlefish fisheries for Albania. Probably, these analyses results suggest that global warming effects makes the recover of organisms stock more efficient after properly applied fisheries management measure.

5. References

1. 1. Bensoussan, N., Romano, J.C., Harmelin, J.G., Garrabou, J. (2010). **High resolution characterization of northwest Mediterranean coastal waters thermal regimes: To better understand responses of benthic communities to climate change.** *Estuarine, Coastal and Shelf Science*, 87: 431-441. DOI: 10.1016/j.ecss.2010.01.008
2. Beqiraj, S., Kashta, L., Kuci, M., Kasemi, D., Mato, Xh., Gace, A. (2008). **Benthic macrofauan of Posidonia oceanica meadows in the Albanian coast.** *Natura Montenegrina, Podgorica*, 7(2): 55-69.
3. Boero, F., Fe´ral, J.P., Azzurro, E., Cardin, V., Riedel, B., et al. (2008). **Climate warming and related changes in Mediterranean marine biota. In**: Briand F, editor. *Climate Warming and Related Changes in Mediterranean Marine Biota: CIESM Workshop Monographs* N˚ 35. Monaco. pp. 5–21.
4. Campos, J., Van der Veer, H. (2008). **Autoecology of Crangon crangon with an**

emphasis on latitudinal trends. *Oceanography and Marine Biology: An Annual Review*, 2008, 46: 65-104

5. Cerrano, C., Totti, C., Sponga, F., Bavestrello, G. (2006). **Summer disease in *Parazoanthus axinellae* (Schmidt, 1862) (Cnidaria, Zoanthidea).** *Italian Journal of Zoology*, 73(4): 355-361.
6. Cheung, W., Watson, R. Pauly, D. (2013). **Signature of ocean warming in global fisheries catch**. *Nature*, 497: 365–368.
7. Fonda Umani, S., Conversi, A. (2008). **Possible climate impacts on the northern Adriatic pelagic ecosystem. In**: Briand F, editor. *Climate Warming and Related Changes in Mediterranean Marine Biota: CIESM Workshop Monographs* N˚ 35. Monaco. pp. 59–64.
8. Gelin, A., Crivelli, A.J., Rosecchi, E., Kerambrun, P. (2000). **Is the brown shrimp *Crangon crangon* (l.) popu-lation of the vaccarès lagoon (camargue, France, Rhône delta) an annual population?** *Comptes Rendusde l'Academie des Sciences Serie III-Sciences de la Vie/Life Sciences* 323: 741–748.
9. Gili, J.M., Coma, R. (1998). **Benthic suspension feeders: their paramount role in littoral marine food webs**. *Trends Ecol Evol,* 13: 316–321.
10. Giorgi, F., Lionello, P. (2008). **Climate change projections for the Mediterranean region**. *Global and Planetary Change*, 63: 90-104. DOI: 10.1016/j.gloplacha.2007.09.005
11. Guerra, A. (2006). **Ecology of *Sepia officinalis*.** *Life and Environment*, 46: 97-107.
12. ICES. (2014). **Report of the Working Group on Beam Trawl Surveys (WGBEAM)**, 6–9 May 2014, Hamburg, Germany. *ICES Document CM 2014/SSGESST*: 09. 168 pp.
13. IPCC Climate Change (2007). **The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change**. *Cambridge: Cambridge University Press*; 2007. p. 996
14. IPCC Climate Change (2013). **The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change**. *Cambridge: Cambridge University Press*; 2013. p. 1535
15. Lejeusne, C., Chevaldonne, P., Pergent-Martini, C., Boudouresque, C.F., Perez, T. (2010). **Climate change effects on a miniature ocean: The highly diverse, highly impacted Mediterranean Sea**. *Trends in Ecology and Evolution*, 25: 250-260. DOI: 10.1016/j.tree.2009.10.009
16. Rivetti, I., Fraschetti, S., Lionello, P., Zambianchi, E., Boero, F. (2014). **Global warming and mass mortalities of benthic invertebrates in the Mediterranean Sea**. *PLoS ONE* 9(12): e115655. doi:10.1371/journal.pone.0115655
17. Rodolfo-Metalpa, R., Bianchi, C.N., Peirano, A., Morri, C. (2005). **Tissue necrosis and mortality of the temperate coral *Cladocora caespitosa*.** *Italian Journal of Zoology*, 72: 271-276.
18. Vélez, M., Abellan, P. (2022). **Effects of climate change on the distribution of threatened invertebrates in a Mediterranean hotspot.** *Insect Conservation and Diversity* /Volume 15, Issue 3 / p. 370-379 https://doi.org/10.1111/icad.12563