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“Fisheries in the Adriatic Region - a Shared Ecosystem Approach”

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FAIRSEA – Fisheries in the Adriatic Region – a shared Ecosystem Approach

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Acronyms used

CFP	Common Fisheries Policy
Bios	Bimodal Oscillating Systems
EAF	Ecosystem Approach to Fisheries
EAFM	Ecosystem Approach to Fisheries Management
FAIRSEA	Fisheries in the Adriatic Region – a Shared Ecosystem Approach
GFCM	General Fisheries Commission of the Mediterranean and Black Seas
GSA	Geographical Sub Area (of the Mediterranean Sea)
IF	Impact factor
LP	Lead Partner
OGS	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS
PP	Project Partner
RegCM	Regional Climate model
WP	Work packages

Executive summary

The project FAIRSEA has a strong scientific component thus, the dissemination through scientific means is central for the project. The project started as soon as possible with the scientific communication using two approaches: participation to scientific conferences and production of peer-reviewed scientific papers.

The COVID-19 pandemic and the resulting restrictions strongly influenced the conference participation, yet a lot of efforts were done by the partnership to disseminate in scientific for a the project developments and results.

At the end the project produced 5 participation to scientific conferences held in the fields related to FAIRSEA and resulted in 10 scientific papers that contains results or efforts from FAIRSEA. This relevant production is the result of a very active partnership that will continue preparing and sharing products through scientific articles.

INTRODUCTION

The FAIRSEA project aims at developing an highly data-driven and scientific-based approach for supporting Ecosystem Approach to Fisheries (EAF) in the Adriatic and North-western Ionian Seas. The approach is necessarily based on a multidisciplinary integration of information and competences under the Integrated Platform that is developed in WP4, also on the basis of a continuous participatory approach developed in WP5 (stakeholder meetings) and WP3 (technical meetings with policy makers). The developed tools are used in specific testing cases, i.e., analysis of scenarios of potential fisheries management actions (Activity 5.3. Scenarios of fisheries policy application in the Adriatic) and analysis of sub-regional (local) management actions (Activity 5.2. Pilot actions: identification of conflicts and possible solutions).

The scientific dissemination is considered a key element to contribute to the three project specific objectives of FAIRSEA.

Regarding the Project specific objective 1, **Enhance transboundary integrated competence in the field of ecosystem approach to fisheries**, the scientific dissemination will allow enhancing the transnational competencies and skills in the field of EAF in all network's members, by crossing and pooling resources and complementary expertise, exchanging and integrating knowledge and sharing the results. The territorially integrated conceptualization of the EAF beyond existing differences and boundaries is going to be documented in the scientific work in order to strengthen and structure a network for future transnational plans useful in the framework of the Common Fisheries Policy (CFP). This will result in reinforcing cohesion and encourage identification and adoption of shared optimal strategies in the field of fisheries management.

Regarding the Project specific objective 2, **Implement a shared "state of the art" integrated platform for the region**, the scientific dissemination will allow to document the developments of the integrated platform, in the form of an operational spatially explicit platform that integrates the dynamics of water masses and primary production patterns, main components of the ecosystem in terms of target species and their food, main fisheries spatio-temporal dynamics, also accounting for socio-economic impacts. The scientific dissemination of the results obtained from the novel integration of existing information and numerical approaches applied in the Adriatic basin (GSA17 and GSA18 and GSA19) will make scientific community aware of the achievements and facilitate transferring the results to actors higher in the management pyramid.

The scientific communication will be key in the project specific objective 3, **Share benefits and challenges of ecosystem approach to facilitate the achievement of CFP objectives**. In fact scientific arena represent a critical forum for having expert revision of the work done, for sharing the integrated conceptualization of the ecosystem approach to fisheries and the insights obtained from pilot applications. The objective is also to guarantee the best transferring at different levels and to different groups the potentialities and the difficulties of the approach in order to increase its further development in the region and outside the region toward a Mediterranean EAF.

The Scientific Dissemination of the ecosystem approach adopted in FAIRSEA, of the supporting tools developed and the analyses carried out was considered a key activity. In particular, the scientific dissemination is done with the objectives of:

- i) **increasing the strength and reliability of results** by revising the ideas and concepts through peer-review process and conference discussion events;
- ii) favouring **dissemination of results to colleagues** working on the same EAF objective;
- iii) facilitating **comprehension, trust and possible adoption of supporting tools** for management in the future;
- iv) documenting the steps and work done **for ensuring repeatability, reproducibility and transferability**;
- v) furthermore the scientific dissemination is considered an approach for **increasing durability of actions** and results done during FAIRSEA.

For these reasons the FAIRSEA PPs contributed in preparing and delivering scientific products (from papers to slide shows) to be presented to scientific community through journals, conferences and other meetings at national and international level. The aim of this dissemination work is for achieving a good disciplinary and international spread.

STRATEGY OF SCIENTIFIC DISSEMINATION

All partners of FAIRSEA, but in particular the scientific partners, were participating in the scientific dissemination. Two main actions were foreseen: presentations at **conferences** and submission of **papers** to scientific journals.

Contributions to conferences

Conference presentations are an opportunity to interact with academic stakeholders, and to receive direct feedback on project's results from experts. These are considered occasions for having insights and find areas of improvements. Given the nature of the events the conferences were target for activities undergoing, almost complete but still in need of refinements and the conferences were seen as occasions for discussing achievements.

The FAIRSEA project targeted **scientific conference of international relevance**, in particular those carried out in the CBC programme area.

During the project development it was considered to target a set of scientific conferences as medium for presenting the ongoing work.

(1) XXIX Congress of the Italian Society of Ecology (S.It.E), Ferrara, 10-12 September 2019

The following contribution to the conference was presenting the work underdevelopment in the WP 4, under the activity 4.7 Food Web model.

Carlucci R., Ricci P., Cipriano G., Capezzuto F., Sion L., Maiorano P., D'Onghia G., Tursi A., 2019. **An integrate approach to detect change in the natural capital: the case of the deep-water red shrimps in the North-western Ionian Sea.** *XXIX Congress of the Italian Society of Ecology (S.It.E), 10-12 September 2019, Ferrara (Italy).*

(2) 23rd European Elasmobranch Association Meeting 15-18 October 2019, Rende, Italy

The following contribution to the conference was presenting the work underdevelopment in the WP 4, under the activity 4.7 Food Web model.

Carlucci R., 2019. **The ecological role of the demersal sharks and rays within the Calabrian food web of the North western Ionian Sea.** *23rd European Elasmobranch Association Meeting , 15-18 October 2019, Rende (Italy).*

(3) 55th Croatian & 15th International Symposium on Agriculture, February 16 - 21, 2020, Vodice, Croatia.

The following contribution to the conference was presenting the work under development in the project FAIRSEA as a description of the EAF tackled by the project in WP3 (networking and capacity building), WP 4 (integrated platform development) and WP 5 (participatory process).

Svietlana Krstulović Šifner, Jure Brčić, Josip Gugić, Vedrana Nerlović, Mirela Petrić, Frane Škeljo, Željka Trumbić, Giuseppe Scarcella, Nedo Vrgoč, Rosa Caggiano, Danijela Mioković, Simone Libralato (2020). **Ecosystem approach: future of fisheries management in the Adriatic Sea?** 55th Croatian & 15th International Symposium on Agriculture, held on February 16 - 21, 2020 in Vodice (Croatia)

Presented by S. Krstulović Šifner (PP10-UNIST) at section “6. Fisheries, Wildlife Management and Apiculture” on Tuesday 18.02.2020

Abstract

Ecosystem approach has been recognized as an important way of assessing the state of marine resources and health of the marine environment as a whole. It is clear that all marine organisms are inseparable from other parts of the ecosystem and are strongly dependent on the state of populations in the food chain and on environmental factors. Long term sustainable fisheries management should be based on the ecosystem approach which in reality is not the case and currently in most areas relies on the single species assessment which has often been proved as inefficient. Similar has been a practice in the Adriatic basin, but recent Interreg Italy-Croatia initiative through the project FAIRSEA (Fisheries in the Adriatic Region - a Shared Ecosystem Approach) could be a turning-point in the management of fisheries in the area. The project gathers 12 partner institutions and a broad base of stakeholders. The main objective of the project is to develop an integrated platform for ecosystem approach in fisheries encompassing all available information to be further used for testing, modelling and planning of the sustainable fisheries practices. The platform integrates elements as water masses circulation, planktonic production, distribution of main fishery resources, catches and fleet capacity, spatial distribution of effort, food web dynamics, socio-economic impacts and stakeholder’s input. Hopefully this initial step will gradually lead to the broader understanding of the importance of ecosystem approach and change the perspective on successful managing of fisheries in the Adriatic Sea.

Key words: ecosystem approach, fisheries management, Adriatic Sea, integrated platform, FAIRSEA

(4) ICES Annual Science Conference 2020, 7–10 September 2020, Øksnehallen, Copenhagen (Denmark)

The following contribution to the conference was presenting the work underdevelopment in the WP 4, under the activity 4.7 Food Web model.

(CONTRIBUTION ACCEPTED BUT CONFERENCE CANCELLED)

Libralato S. , Agnetta D. , Celić I., Cipriano G. , Fiorentino F. , Maiorano P. , Ricci P. , Solidoro C. , Carlucci R. (2020). **Unravelling top predators and fisheries relation using a quantitative ecosystem-based approach in Mediterranean waters.** *ICES Annual Science Conference 2020, 7–10 September 2020, Øksnehallen, Copenhagen (Denmark)*

Abstract

Marine top-predators are considered to regulate the dynamics of preys through top-down controls that propagate through food webs. Although often seen as competitors of fisheries, top predators are thus crucial components for regulating the functioning of marine food webs. Nevertheless, their perceived and actual role might vary depending on the conditions of marine ecosystem, its history of pressures and the consistency of top predators. Here we assess the direct and indirect pressures of apical groups of species (marine mammals, sharks, large pelagic fish, turtles and seabirds) on marine ecosystems and their ecological key role in respect to fisheries using food web models. We compare Mediterranean food webs as modelled for representing the Northern Adriatic, the Northern and Southern Ionian Sea and the Strait of Sicily being characterized by different biological resolution (i.e., number of functional groups), different spatial extension of area represented, and fairly different fishing patterns and pressures. Model outputs are analysed in order to contrast top predators and fisheries in food webs by evaluating the mortalities induced, the flows of consumption/catches, the direct and indirect impacts produced. Top predator's role is also quantified using keystone indexes. Comparing the trophic impacts for top predators and fisheries estimated by input-output analysis with the diet information used in food web permitted a classification of top-down controls and the identification of beneficial predators. Ecological benefits by each top predator for maintaining ecosystem functioning is here contrasted with the economic benefit of each fishing

gear (in some instances distinguished by gear and segment of vessel size) resulting in a potential for evaluating trade-offs for preserving key predators previously neglected or underestimated.

A negative and non-selective impact on the commercial species exploited by the trawling were observed in all the models investigated. In the Northern Ionian Sea the odontocetes had positive impact on some elements of the food web triggering trophic cascades. In the other models, large pelagic fishes, anglers and some demersal sharks played top-down controls characterized by positive impacts on their preys thus resulting as beneficial predators with benefits for fisheries. In the coastal area of the Northern Adriatic sea top predators have low impacts and competitions with fisheries because of their low biomasses, although sharks, rays and large pelagic fishes have some quantified indirect negative effects of competition with small scale fisheries. The available Mediterranean models allowed quantifying direct competition, indirect effects and also beneficial effects between marine top predators and fisheries highlighting a quite complex set of trade-offs to be considered in fisheries management.

Keywords: marine mammals, seabirds, competition, fisheries, food web models, Mediterranean Sea

(5) Metrosea 2021, Virtual Conference October 4-6, 2021

The following contribution to the conference was presenting the work under development in the WP 4, under the activity 4.3 BSTAT (Spatial distribution of exploited resources).

(contribution accepted)

Diego Panzeri, Roberto Carlucci, Giulia Cipriano, Pasquale Ricci, Isabella Bitetto, Maria Teresa Spedicato, Walter Zupa, Giuseppe Scarcella, Francesco Masnadi, Tommaso Russo, Lorenzo D'Andrea, Nedo Vrgoc, Cosimo Solidoro and Simone Libralato (2021). **Defining a procedure for integrating multiple oceanographic variables in ensemble models of marine species distribution.** *Metrosea 2021, Virtual Conference October 4-6, 2021*

Abstract

Marine species distribution models are largely used in ecology and fishery science to support the management of marine exploited resources. This study was focused on defining a procedure to

develop an ensemble model, combining 5 different modeling approaches. For each approach, we implemented spatial training and test data set to evaluate the best performance of 9 models through a set of indicators. These models include a different combination of covariates, starting with the simplest model (depth, year, and spatiotemporal variables) to the most complex one (including also oceanographic variables and effort). We applied this procedure to develop a robust ensemble of models to describe accurately the distribution in space and time of European hake (*Merluccius merluccius*) in the Adriatic and Ionian sea.

Keywords: species distribution model, model training and test, marine exploited species, oceanographic variables, model ensemble, performance indicators.

Scientific papers

Scientific publications, as a paramount instrument of Science and Research, were considered as the final way to disseminate scientific results of FAIRSEA, were prepared exploiting joint efforts and submitted to peer-reviewed journals. In all the papers produced the acknowledgement of FAIRSEA was explicit by indicating “*This work contributes to the activities of the project FAIRSEA (Fisheries in the Adriatic Region - a Shared Ecosystem Approach) funded by the 2014 - 2020 Interreg V-A Italy - Croatia CBC Programme (Standard project ID 10046951)*”. Papers abstract are reported and each complete paper is available at the Journal webpage (link reported).

(1) Ricci et al., *Ecology and Evolution*. 2019;9:10198–10212

Ricci P., Libralato S., Capezzuto F., D’Onghia G., Maiorano P., Sion L., Tursi A., Solidoro C., Carlucci R., 2019. ***Ecosystem functioning of two marine food webs in the North-Western Ionian Sea (Central Mediterranean Sea)***. *Ecology and Evolution*. 2019;9:10198–10212. (<https://doi.org/10.1002/ece3.5527>)

Abstract

The ecosystem functioning of two marine food webs covering the north-eastern (Salento) and south-western (Calabria) sectors of the North-Western Ionian Sea (NWIS) (Central Mediterranean Sea) was investigated through a food-web model. Data inputs covered a wide set of ecological information applied to 58 functional groups (FGs). The sum of consumption and the mean predation mortality rate were calculated for benthic, demersal, and pelagic subsystems indicating the predator and prey roles of the FGs. A complex system of energy and biomass exchanges characterized the investigated food webs indicating an important benthic-pelagic coupling. In the food webs of both areas, the regulation of flows between the benthic-pelagic coupling seems to occur through the benthopelagic shrimps and the small pelagics due to their wasp-waist control role. Differences were observed concerning the top predators. Odontocetes play this keystone role in the Salento food web. Anglers, bathyal squids, and sharks assume this functional role in Calabria. The geomorphology and hydrography in the NWIS could affect the biomass and energy exchanges in this coupling. The higher flows of consumption of the benthic system observed in the Calabria food web could be influenced by a widespread presence of canyons along the continental edge which increase the benthic productivity. In contrast, the flows of consumption in the Salento food web seem to be driven by the planktonic productivity supporting the pelagic, benthopelagic, and demersal compartments. This condition could be favored by the large extension of the shelf break zone. The foodweb models realized for the NWIS represent ideal platforms for the development of analysis with dynamic simulations. The comparative analysis of the two food webs by means of the FGs and their

functional traits allowed the general pattern of ecosystem structure and functioning in the NWIS to be identified, making it an interesting approach to investigate the marine ecosystem.

Keywords: benthic-pelagic coupling, Ecopath model, functional traits, keystone species, trophic structure

(2) Reale et al., *Climate Research*, 2020, 82: 117-136

Reale, M., Salon, S., Somot, S., Solidoro, C., Giorgi, F., Crise, A., ... & Sevault, F. (2020). *Influence of large-scale atmospheric circulation patterns on nutrient dynamics in the Mediterranean Sea in the extended winter season (October-March) 1961-1999*. *Climate Research*, 82, 117-136.

(<https://doi.org/10.3354/cr01620>)

Abstract

We investigated the effects of variations in the 4 primary mid-latitude large-scale atmospheric circulation patterns on nutrients potentially limiting phytoplankton growth in the Mediterranean Sea (nitrate and phosphate), with a focus on the key deep convective areas of the basin (Gulf of Lions, Southern Adriatic Sea, Southern Aegean Sea and Rhodes Gyre). Monthly indices of these 4 modes of variability, together with a high-resolution hindcast of the Mediterranean Sea physics and biogeochemistry covering the period 1961–1999, were used to determine the physical mechanisms explaining the influence of these patterns on nutrient distribution and variability. We found a decrease in the concentration of phosphate and nitrate for each unit of increase in the index values of the East Atlantic and East Atlantic/West Russian variability modes in the area of the Gulf of Lions, while a signal of the opposite sign was associated with the North Atlantic Oscillation in the Aegean Sea and Rhodes Gyre. In both cases, the variability observed was related to a significant variation in the mixed layer depth driven by heat losses and wind stress over the areas. The East Atlantic pattern played a major role in driving the long-term dynamics of both phosphate and nitrate availability in the Gulf of Lions, with a particularly pronounced effect in December and January. For both the Aegean Sea and Rhodes Gyre, the most prominent correlations were found between the North Atlantic Oscillation and phosphate, with a highly consistent behavior in the 2 areas associated with common physical forcing and exchange of properties among them.

Keywords: Mediterranean Sea · Large-scale atmospheric circulation patterns · Phosphate Nitrate · Mixed layer depth

(3) Carlucci et al., 2021. *Reviews in Fish Biology and Fisheries*, 31(1), 135-156.
Carlucci, R., Capezzuto, F., Cipriano, G., D'Onghia, G., Fanizza, C., Libralato, S., ... & Ricci, P. (2021). ***Assessment of cetacean–fishery interactions in the marine food web of the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea)***. *Reviews in Fish Biology and Fisheries*, 31(1), 135-156.

(<https://doi.org/10.1007/s11160-020-09623-x>)

Abstract

The exploitation of fishery resources acts as a driving force on cetaceans both directly, by determining their fishing mortality or injury as by-catch species, and indirectly, through the lowering the availability of their prey. This competitive overlap between fishing and cetaceans often results in inadequate solutions so that in some cases there have been cases of intentional cetacean culling to maximize fishing production. A modelling approach applied to investigate the ecological roles of cetaceans in the food web could prove more effective to integrate ecological and fishing aspects and to provide suggestions for management. The comparative analysis carried out in the Gulf of Taranto (Northern Ionian Sea, Central Mediterranean Sea) showed that fishing exploitation provides impacts on the investigated food web greater than those due to cetacean predation. Trawling was estimated to be the most negatively impacting fishing gear considering the mortality rates and consumption flows. On the other hand, the striped dolphin was the main impact on the food web due to its highest consumption flows. Analysis showed a negative and non-selective impact on the exploited species due to the fishing gears, while the odontocetes proved to select their prey species and provide a positive impact in the assemblage. In particular, while the fishing gears are primarily size selective, targeting mostly large and economically valuable fish, the odontocetes seem to follow a co-evolution process with their prey, developing a specialization in their resources, providing control of the meso-consumers and ensuring a trophic stability in the ecosystem.

Keywords: Marine mammals, Trophic cascade, Keystone species, Ecological niche, Ecosystem-based fisheries management

(4) Ricci et al., 2021. *Ecological Modelling*, 444, 109468.

Ricci, P., Sion, L., Capezzuto, F., Cipriano, G., D'Onghia, G., Libralato, S., ... & Carlucci, R. (2021). ***Modelling the trophic roles of the demersal Chondrichthyes in the Northern Ionian Sea (Central Mediterranean Sea)***. *Ecological Modelling*, 444, 109468.

(<https://doi.org/10.1016/j.ecolmodel.2021.109468>)

Abstract

The maintenance of natural capital and the stability of regulation services of marine ecosystems has proved to be linked to the conservation of key species supporting the ecosystems function. Chondrichthyes are key top predators and their removal from marine ecosystems due to fishing exploitation could lead to changes in species interactions and biomass that can negatively influence the provision of ecosystems services. The ecological role of the demersal Chondrichthyes living in the marine food web of the Calabrian area in the Northern Ionian Sea (Central Mediterranean Sea) was analysed by means of ecological indicators derived from Ecopath massbalance food web models estimated in their stationary states during the periods 1995–1997, 2003–2005 and 2013–2015. The trophic web model was described by 57 functional groups (7 of which representing the demersal Chondrichthyes), which were described by their Biomass (t/km²), Production and Consumption rate, Diet, Landings (t/km²) e Discards (t/km²). Remarkable changes in biomass were recorded for shark and rays, as a consequence of changes in fishing patterns and oceanographic regime shift named Bimodal Oscillating Systems (BiOS). Demersal Chondrichthyes occupy high trophic positions in the Calabria food web showing trophic levels higher than 4.1, with the *D. licha* identified as the main apex predators, while *E. spinax* and *G. melastomus* as meso-predators. The pattern of the consumption flows highlighted a potential sensitivity of *E. spinax* and *G. melastomus* to the changes in deep waters circulation caused by the BiOS acting on the entire ecosystem of the Ionian Sea. *D. licha* was identified as the main keystone predators in all the investigated periods. The analysis of the trophic indirect and direct impacts shows the role of the demersal Chondrichthyes as beneficial predators, with positive effects on several preys. Results also showed that *G. melastomus* and the Shelf Elasmobranchs group (e.g. *Raja asterias*, *Mustelus mustelus*, etc....) were overexploited in 1995 and that all groups of sharks and rays underwent to a decrease of exploitation rate over time. Chondrichthyes showed medium-low values of overlap with the fishing gears (<0.50), with the more relevant values estimated between the shelf elasmobranch group and passive nets and other gears. According to the findings of this work, the protection of Chondrichthyes could combine biodiversity conservation and fisheries management objectives. Therefore it is envisaged the implementation of appropriate spatial planning and conservation measures for these top-predators to guarantee valuable and sustainable flows of ecosystem goods and services.

(5) Ricci et al., 2021. Data in Brief, 36, 106964.

Ricci, P., Sion, L., Capezzuto, F., Cipriano, G., D'Onghia, G., Libralato, S., ... & Carlucci, R. (2021). ***Dataset and species aggregation method applied to food-web models in the Northern Ionian Sea (Central Mediterranean Sea)***. Data in brief, 36, 106964.

DOI: 10.1016/j.ecolmodel.2021.109468

Abstract

The ecological roles of the species in the food web are studied through the Ecopath with Ecosim modelling approach. In this modelling approach, the food web is described by means of functional groups, each representing a species, a life stage of a species, or a group of species with similar trophic, ecological and physiological features. Links between the groups are formally described by a set of linear equations, informed with ecological and fishing data. Here, the data input collected to implement 3 Ecopath models in the Northern Ionian Sea (Central Mediterranean Sea) from 1995 to 2015 are reported. This dataset applied to study the ecological roles of the demersal Chondrichthyes in the study area could be useful to explore different fishing management scenarios. A large dataset of over 300 taxa is shown detailing the ecological inputs, such as Biomass (kg km^{-2}), Production and Consumption rates (y^{-1}), Diet information (weight in %), and fishing data represented by Landings and Discards ($\text{t km}^{-2} \text{y}^{-1}$). In particular, the fishery data described the catches of trawls, longlines, passive nets, other gears and purse seine. In addition, a description of the aggregation method of the species is shown.

Keywords: Ecopath with ecosim Demersal chondrichthyes Marine food webs Fishery data Diet information

(6) Panzeri et al., 2021. , Journal of Operational Oceanography, 14:sup1, s114–s123

Panzeri D., Bitetto I., Carlucci R., Cipriano G., Cossarini G., D'Andrea L., Masnadi F., Querin S., Reale M., Russo T., Scarcella G., Spedicato M.T., Teruzzi A., Vrgoč N., Zupa W. and Libralato S. (2021). **Developing spatial distribution models for demersal species by the integration of trawl surveys data and relevant ocean variables.** In: Copernicus Marine Service Ocean State Report, Issue 5, Journal of Operational Oceanography, 14:sup1, s114–s123;

<https://doi.org/10.1080/1755876X.2021.1946240>

Abstract

Demersal species play a fundamental role in fisheries, thus understanding their distribution and abundance through bottom trawl surveys is crucial for stock and fisheries management. Oceanographic (e.g. biogeochemical, physical) and fishing covariates might be considered, in addition to spatio-temporal variables (latitude, longitude, depth, year and month), to better explain trawl survey data. Here, we analyse biomass indices (kg/km²) for European hake, common sole, mantis shrimp, red mullet and common cuttlefish from scientific trawl surveys carried out in the Adriatic Sea and the Western Ionian Sea. We used three different Generalised Additive Model (GAM) approaches (Gaussian, Tweedie and Delta) to fit and predict species biomass distribution. In order to evaluate trade-offs in using different covariates, we compared the results obtained from GAM approaches based only on spatiotemporal variables and GAMs including also oceanographic and fishing effort covariates. The Delta-GAM approach performed better for European hake, mantis shrimp and common cuttlefish, while GAMs based on Gaussian and Tweedie were performing better for the red mullet and common sole, respectively. The results highlighted that adding specific oceanographic and effort covariates to spatiotemporal variables improved the performances of spatial distribution models especially for European hake, mantis shrimp and red mullet. Significant additional explanatory variables were bottom temperature, bottom dissolved oxygen, salinity, particulate organic carbon, and fishing effort for European hake; the same variables and pH for mantis shrimp; chlorophyll-a, pH, sea surface temperature, bottom dissolved oxygen, nitrate and effort for the red mullet; phosphate and salinity for common sole; bottom temperature, bottom dissolved oxygen, and phosphate for the common cuttlefish. The findings highlight that more accurate estimates of spatial distribution of demersal species biomass from trawl survey data can generally be obtained by integrating oceanographic variables and effort in GAMs approaches with potential impacts on stock assessment and essential fish habitats identification.

(7) Panzeri et al., 2021. IEEE. 2021, pp. 360-365

Panzeri, D., Libralato, S., Carlucci, R., Cipriano, G., Bitetto, I., Spedicato, M. T., ... & Solidoro, C. (2021, October). ***Defining a procedure for integrating multiple oceanographic variables in ensemble models of marine species distribution.*** In 2021 International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters (MetroSea) IEEE. 2021, pp. 360-365, doi: 10.1109/MetroSea52177.2021.9611559

Abstract

Marine species distribution models are largely used in ecology and fishery science to support the management of marine exploited resources. This study was focused on defining a procedure to develop an ensemble model, combining 5 different modeling approaches. For each approach, we implemented spatial training and test data set to evaluate the best performance of 9 models through a set of indicators. These models include a different combination of covariates, starting with the simplest model (depth, year, and spatiotemporal variables) to the most complex one (including also oceanographic variables and effort). We applied this procedure to develop a robust ensemble of models to describe accurately the distribution in space and time of European hake (*Merluccius merluccius*) in the Adriatic and Ionian sea.

Furthermore, a series of works even if not central to FAIRSEA were produced with direct or indirect partial support that was acknowledged. These additional papers are reported below.

(8) Reale et al., Journal of Advances in Modeling Earth Systems, 2020, 12(9),
e2019MS001812

Reale, M., Giorgi, F., Solidoro, C., Di Biagio, V., Di Sante, F., Mariotti, L., ... & Sannino, G. (2020). ***The regional Earth system Model RegCM-ES: Evaluation of the Mediterranean climate and marine biogeochemistry.*** Journal of Advances in Modeling Earth Systems, 12(9), e2019MS001812.

(DOI: 10.1029/2019MS001812)

Abstract

We introduce a new version of the Earth System Regional Climate model RegCM-ES and evaluate its performances for the first time over the Mediterranean region. The novel aspect of this coupled system is the possibility to simulate the dynamics of the marine ecosystem through a biogeochemical model, BFM (Biogeochemical Flux Model), coupled online with the ocean circulation model MITgcm (MIT general circulation model). The validation of atmosphere and ocean components has shown that the model is able to capture interannual and intermonthly variabilities of the atmospheric heat fluxes and spatial patterns of land surface temperature, precipitation, evaporation, and sea surface temperature with a general improvement compared to previous versions. At the same time, we diagnosed some prominent deficiencies as a warm and dry bias associated in summer with the resolution of the atmospheric module and the tuning of the boundary layer and convective precipitation scheme. On the biogeochemical side, RegCM-ES shows good skills in reproducing mean values and spatial patterns of net primary production, phosphate, and horizontal/vertical patterns of chlorophyll-a. Limitations in this case include deficiencies mainly in the simulation of mean values of nitrate and dissolved oxygen in the basin which have been associated with too large vertical mixing throughout the water column, deficiencies in the boundary conditions, and solubility computations. Overall, RegCM-ES has the potential to become a suitable tool for the analysis of the impacts of climate change on the ocean and marine biogeochemistry in the Mediterranean region and many other domains.

(9) Reboita et al., *Climate Dynamics*, 2021. 57(5), 1533-1549

Reboita, M. S., Reale, M., da Rocha, R. P., Giorgi, F., Giuliani, G., Coppola, E., ... & Cavazos, T. (2021). ***Future changes in the wintertime cyclonic activity over the CORDEX-CORE southern hemisphere domains in a multi-model approach.*** *Climate Dynamics*, 57(5), 1533-1549.

Abstract

Changes in the characteristics of austral winter (June–July–August) synoptic activity in three domains (Africa, Australia and South America) of the extratropical Southern Hemisphere projected with the Regional Climate Model version 4 (RegCM4) are presented. The model is nested in three global climate models (GCMs) from the Coupled Model Intercomparison Project phase 5 (CMIP5) under the Representative Concentration Pathway 8.5. The model grid spacing is 25 km and the simulations cover the period 1970–2100. Synoptic activity is analyzed using both Eulerian and Lagrangian approaches. The Eulerian analysis shows an increase of the synoptic activity south of 40° S in the RegCM4 and GCMs ensembles for the future (2080–2099) compared to the present (1995–2014), but this signal does not necessarily indicate an increase in the cyclone frequency since it includes cyclonic and anticyclonic features. The Lagrangian analysis, however, indicates a decrease in the frequency of cyclones, with a positive tendency towards stronger systems, although the latter is not statistically significant at 95% confidence level. Lifetime, traveled distance and mean speed of the cyclones do not present statistically significant changes in the future climate. On the other hand, a significant increase in both intensity and extension of areas affected by precipitation associated with cyclones is found. As a consequence, there is a statistically significant trend of individual cyclones to produce more rainfall in the future.

Keywords: Extratropical southern hemisphere · Cyclones · Precipitation · Cyclone tracking scheme · RegCM4 · CORDEXCORE

(10) Torres-Alavez et al., *Climate Dynamics*, 2021. *Climate Dynamics*, 1-25.

Torres-Alavez, J. A., Glazer, R., Giorgi, F., Coppola, E., Gao, X., Hodges, K. I., ... & Sines, T. (2021). ***Future projections in tropical cyclone activity over multiple CORDEX domains from RegCM4 CORDEX-CORE simulations.*** *Climate Dynamics*, 1-25.

Abstract

The characteristics of tropical cyclone (TC) activity over five TC basins lying within four Coordinated Regional Downscaling Experiment (CORDEX) domains are examined for present and future climate conditions using a new ensemble of simulations completed as part of the CORDEX-CORE initiative with the regional climate model RegCM4. The simulations are conducted at a 25 km horizontal grid spacing and are driven by three CMIP5 general circulation models (GCMs) under two Representative

Concentration Pathways (RCP2.6 and RCP8.5). The RegCM4 captures most features of the observed TC climatology, except for the TC intensity, which is thus statistically adjusted using a bias correction procedure to account for the effect of the coarse model resolution. The RegCM4 exhibits an improved simulation of several TC statistics compared to the driving GCMs, over most basins analyzed. In future climate conditions we find significant increases in TC frequency over the North Indian Ocean, the Northwest Pacific and Eastern Pacific regions, which are consistent with an increase in mid-tropospheric relative humidity. The North Atlantic and Australasia regions show a decrease in TC frequency, mostly associated with an increase in wind shear. We also find a consistent increase in future storm rainfall rates associated with TCs and in the frequency of the most intense TCs over most domains. Our study shows robust responses often, but not always, in line with previous studies, still implying the presence of significant uncertainties in the projection of TC characteristics, which need to be addressed using large ensembles of simulations with high-resolution models.

Keywords Regional climate model · CORDEX-CORE · Tropical cyclones · Climate change

Works in progress

The production of scientific articles, however, is always a slow process and giving some late results of the project, some papers are still under completion and preparation. These include:

- A paper on hot spots determination for demersal species in the Adriatic Sea, resulting from integration of module HYDRO, BGC, BSTAT and EFFORT, by Panzeri et al.
- A paper on food web models developed within FAIRSEA for GSA 17, 18 and 19, as the result of the module FWM of the integrated platform, by Ricci et al.,
- A paper on simulations done with the Ecospace model, by Serpetti et al.

These papers are going to be submitted in the coming months and will be out potentially in the first part of 2022.